

CROCODILE SPECIALIST GROUP NEWSLETTER

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NEWSLETTER

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COVER PHOTOGRAPH: Adult Mugger (*Crocodylus palustris*) at Kamal Daha pond, Nepal (see pages 8-10).
Photograph: Pratik Pandeya.

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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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Editorial

Once again saddened that a dear personal friend and long-term CSG member, Dr. Giam Choo Hoo from Singapore, passed away peacefully on 25 May 2021. A pioneer of the veterinary community in Singapore since the 1960s, a key player in CITES, a strong and pragmatic advocate of science-based conservation management of wildlife, an important bridge between the CSG and Singapore's vibrant crocodile industry, and a master at explaining the culturally different mind-sets between the Asian and Western world - so important for advancing conservation in a respectful manner. Dr. Giam will be sadly missed, but has left a lasting legacy (see Obituary on page 4).

The last two months has seen a range of CSG members working together to reviews a draft report on "sustainable use" from The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) (www.ipbes.net/about). IPBES was established under the umbrella of the United Nations Environment Programme (UNEP) and Convention on Biological Diversity, to create a forum of global scientists and other experts for reviewing and updating issues linked to biodiversity conservation. The draft "sustainable use" report (1500 pages), will find its way into national and international policies, and it was important that insights from crocodylians be included.

The draft IPBES report recognizes clearly the need to focus more attention on rural and Indigenous peoples – the landowners responsible for an estimated 80% of the world's biodiversity. This has long been a CSG focus, often misunderstood, but is strengthened by another two recent reports, The state of Indigenous Peoples' and Local Communities' lands and territories (https://www.fint.awsassets.panda.org/downloads/report_the_state_of_the_indigenous_peoples_and_local_communities_lands_and_territories.pdf) and "An Eco-wakening" (<https://explore.panda.org/eco-wakening#full-report>). The times are changing.

Some tremendous news is that despite COVID-19, Winter CrocFest 2020 took place on 12 December 2020, and was attended by around 150 people and raised \$US45,000 to support research and conservation efforts for Saltwater crocodiles (*Crocodylus porosus*) in Timor-Leste (see page 5 for details). Our thanks to Curt Harbsmeier, Colette Adams and Flavio Morrissiey and all who helped. But even more stunning was that Summer CrocFest 2021, held at Zoo Tampa, Florida, on 26 June 2021, with active participation of CSG member Savannah Boan in its promotion. It was attended by some 1300 people, and raised over \$US100,000 for Indian Gharial (*Gavialis gangeticus*) research! A full report will be included in the next Newsletter. CrocFest has become an

institution for crocodilian conservation!

The IUCN World Conservation Congress is now going to take place on 3-11 September 2021, in Marseille, France. It will offer both in-person and virtual participation. Over and above avoiding risks with Covid-19, the virtual participation provides a unique opportunity for CSG members who want to know more about how the IUCN operates, to participate without the large costs involved in actually attending the meeting. See www.iucncongress2020.org/congress-essentials-virtual-experience for details.

The Managing Director of the Papua New Guinea Conservation and Environment Protection Authority (CEPA) recently announced the drafting of a Bill to amend the Crocodile Trade (Protection) Act 1974. This process will involve a review of the current legislation and a series of consultations to assess the needs and priorities of Papua New Guinea's crocodile skin trade (see page 17). Despite being demonstrably sustainable, Papua New Guinea is one of the countries that has been adversely affected by supply chains being shortened and rationalized, to try and counter the adverse effects of campaigns by animal rights activists, opposed to use and trade. From a conservation and livelihoods perspective, it seems a glowing example of the road to hell being paved with good intentions.

Given the current and ongoing difficulty for international travel, we are most grateful to the Government of Quintana Roo State, Mexico, which has indicated that it is still willing to host the 26th CSG Working Meeting, now tentatively postponed to July 2022. Organisers will continue to monitor the situation with the COVID-19 pandemic, and will provide confirmation by November 2021, as to whether the meeting will be able to proceed as planned. So many CSG members are eagerly awaiting the next Working Meeting!

Professor Grahame Webb, *CSG Chair*.

CSG Student Research Assistance Scheme

The Student Research Assistance Scheme (SRAS) and Fritz Huchzermeyer Veterinary Science Student Research Assistance Scheme (FHVS-SRAS) provided funding to three students in the April-June 2021 quarter, and one additional application is under review.

1. Kyla Beguesse (USA): New approach for identifying pathologic bone in crocodilian species.
2. Devon Veldsman (South Africa): Assessing temperature and behaviour of farmed Nile crocodiles in South Africa.
3. Albert Myburgh (South Africa): Population demographics of Nile crocodile (*Crocodylus niloticus*) populations in southern Africa.

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

Obituary

Giam Choo Hoo (1935-2021)



Dr. Giam Choo Hoo, a pioneer of the veterinary community in Singapore in the 1960s, an advocate of science-based conservation management of wildlife, and a long-serving member of the CSG Steering Committee, passed away peacefully on 25 May 2021, surrounded by family.

Dr. Giam received a Doctor of Veterinary Medicine from the University of Liverpool in the United Kingdom. He served in the Singapore Public Service in the former Primary Production Department, retiring as the Deputy Director of Primary Production. He was responsible for developing the Veterinary Laboratory Services, and contributing to the Veterinary Regulatory Services in the former Department. He was an active member of the veterinary community and contributed to enhancing the overall professional development of veterinary practitioners.

During his career, Dr. Giam was actively involved in many national, regional and international organisations. On completing his studies at the University of Liverpool, in 1961 he became a member of the Royal College of Veterinary Surgeons of England. He had a long association with the Jurong Bird Park in Singapore, being a founding Board member and retiring as its Deputy Chairman in 1996. He served as President of the Association of Veterinary Surgeons Malaysia/Singapore, the Singapore Veterinary Association, was a Regional Representative of the Commonwealth Veterinary Association (CVA), and represented Singapore on the Commonwealth Veterinary Association. He clearly had a distinguished veterinary career.

Giam's involvement with the Crocodile Specialist Group was directly linked to his involvement with the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), and the role that the Singapore Reptile Skin Trade Association (SRSTA) was playing in international trade in crocodilians. As Deputy Director of the Singapore Primary Production Department, the Singaporean CITES Management Authority up to April 2000, Giam was

instrumental in guiding and coordinating the SRSTA in preparation for Singapore joining CITES in 1986. He needed to ensure industry members were both well prepared and capable of complying with CITES regulations and national legislation. He was head of Singapore's delegation to four CITES Conferences of the Parties [Ottawa (1987), Lausanne (1989), Kyoto (1992) and Fort Lauderdale (1994)], and always sought the views of the SRSTA on issues associated with trade. Under his leadership, Singapore played a key role in initiating and implemented efficient and practical administrative systems, such as Universal Tagging System and pre-signed CITES permits for retailers.

For myself personally, a close friendship with Dr. Giam started at the 1994 Fort Lauderdale CITES meeting, when he was elected to represent the Asian Region on the CITES Animals Committee. He brought to the Animals Committee a serious ability to synthesise and analyse trade and conservation issues, and ability to define problems objectively and identify potential solutions. Ideologically, Dr. Giam embraced the concept that sustainable use of species, and considered sustainable use was critically linked to conservation and livelihoods. He was fearless in representing the interests of the Asian Region in this regard - often in the face of strong opposition by anti-use organisations - and was greatly respected for it. He was re-elected on numerous occasions, either as a Representative or Alternate Representative on the Animals Committee.

Following his retirement from the Singaporean Government service in 1995, Dr. Giam continued his personal interest and involvement in the reptile industry, and was always ready and willing to assist and advise the SRSTA on conservation and trade matters. He attended many CSG meetings, and provided sound advice on regional priorities. He also played a significant role in representing Singapore and other Asian countries in issues involving other wildlife in regional trade. For me personally, he became a valued friend, teacher and confidante over many years.

On a lighter note, despite his busy professional schedule, Dr. Giam was an avid amateur golfer, and always managed to find time to chase a little white ball around a golf course at the diverse places in the world we ended up working.

Dr. Giam will be fondly remembered and sadly missed by all members of the SRSTA, who owe so much to him. The CSG has lost a valued adviser, mentor and friend to many. Dr. Giam is survived by wife Grace, daughter Andrea, and son Yean Ann.

Vale old friend ... you may be gone, but you will not be forgotten.

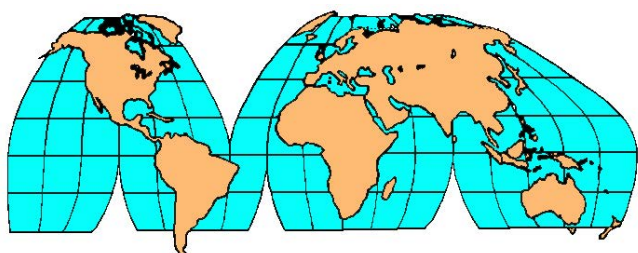
Hank Jenkins, *ex-Chair of CITES Animals Committee and ex-CSG Steering Committee member (for CITES)*.

26th CSG Working Meeting Postponed Again

The ongoing COVID-19 pandemic has forced organisers to again postpone the 26th CSG Working Meeting to be held in Chetumal, Quintana Roo, Mexico. Tentative new dates are 3-9 July 2022, but organisers will continue to track the situation and confirm these dates by November 2021.

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

Regional Reports



North America

USA

WINTER CROCFEST 2020. Winter CrocFest 2020 took place on 12 December 2020, at Wild Florida in Kenansville, Florida, USA. The event, attended by around 150 people, raised \$US45,000, which will be used to support research and conservation efforts for Saltwater crocodiles (*Crocodylus porosus*) in Timor-Leste.

The protection of *C. porosus* in Australia and other Range States has led to a conservation success story, leading to the rapid recovery of this iconic ecologically and culturally important predator. In Timor-Leste, one of the world's poorest countries, located just 600 km to the north of Australia, the recovery of *C. porosus* populations has been associated with a 23-fold increase in the rate of crocodile attacks on people. It has been hypothesized that the highly successful crocodile conservation program in Australia may be responsible for the increased rate of human-crocodile conflict (HCC) in Timor-Leste due to increased emigration rates associated with resource competition in northern Australian habitats as these areas approach carrying capacity. If this is correct and dispersal by *C. porosus* regularly occurs across international borders, the management of those populations for conservation, human safety and other purposes must be coordinated among neighbouring countries.

CrocFest fundraisers are family-friendly events geared to increase awareness of and raise funds for international crocodilian conservation. Participants at Winter CrocFest 2020 were treated to alligator and crocodile demonstrations, tours of Wild Florida's exhibits, and a barbeque dinner prepared and donated by the chefs at Wild Florida! As always, the evening wound up with a rousing live auction conducted by well-known Florida naturalist, Joe Wasilewski.

Winter CrocFest 2020 recognized Ken and Sharon Earnest for their longstanding commitment and contributions to crocodilian captive husbandry and conservation, with the presentation of the Ralf Sommerlad Crocodile Conservation Award.

Over the past 10 years, thanks to the generosity and commitment of the private sector, zoos, academia, and corporate sponsors, CrocFest fundraisers have generated over \$US500,000 for *in-situ* crocodilian conservation projects worldwide. CrocFest has no employees and no paid workers ... every person involved is a volunteer. All funds are collected and accounted for by Gladys Porter Zoo in Brownsville, Texas. 100% of all donations go directly to crocodilian conservation, with event expenses covered by event organizers and sponsors.

Details on Winter CrocFest 2020, the project being funded, and Ken and Sharon Ernest, can be download from a full report available on the homepage of the CSG website (www.iucncsg.org).

Event organizers: Curt Harbsmeier (*ZooTampa at Lowry Park*), Flavio Morrissiey (*You Name It Tours*) and Colette Adams (*Gladys Porter Zoo*).

South Asia and Iran

India

RECORD OF CAPTIVE GHARIAL (*GAVIALIS GANGETICUS*) PREYING ON A BIRD. The Gharial (*Gavialis gangeticus*) is considered to be primarily piscivorous (Bustard 1984; Whitaker and Basu 1983). Shortt (1921) and Biswas (1970) both report Gharial consuming soft-shelled turtles, and Gharial Ecology Project staff recently documented a large male Gharial consuming a juvenile narrow-headed softshell turtle (*Chitra indica*) on the Chambal River (CSG 2018). However, there is little information on other prey taken by Gharial.

The Gharial breeding enclosure at the Madras Crocodile Bank contains one mature male and seven mature females. Substrate of the enclosure is predominantly large-grained sand, in addition to leaf litter. The enclosure is roughly ovoid-rectangular in shape, measuring 42 m by 25 m. The natural aquifer, measuring 30 m long and 8 m wide, is at the base of gradually sloping banks, and water depth varies between 1.5 and 2.5 m seasonally (Andrews and Whitaker 2004). The bank on the northern side of the enclosure is almost 4 m above water level, and is used as a colonial nesting site. Gharials are fed fish (*Oreochromis mosambica*) 2-3 times per week, and Mole Crabs (*Emerita* sp.) are occasionally provided.

Nesting colonies of egrets and herons inhabit the trees in the enclosure during the winter months. On the evening of 10 January 2020, a female Gharial captured a fledgling Little Egret (*Egretta garzetta*) on land, and returned to the water to

consume it. The sequence of events was recorded on CCTV (Figs. 1-4), and represent the first documented report of a Gharial catching and consuming a bird.



Figure 1. Gharial rapidly ascending the North bank towards the egret.



Figure 2. Gharial captures egret in jaws after it had fallen to the ground.



Figure 3. Gharial with egret in jaws, turning towards the pond.



Figure 4. Gharial manipulates egret with quick jerking movements, and consumes it.

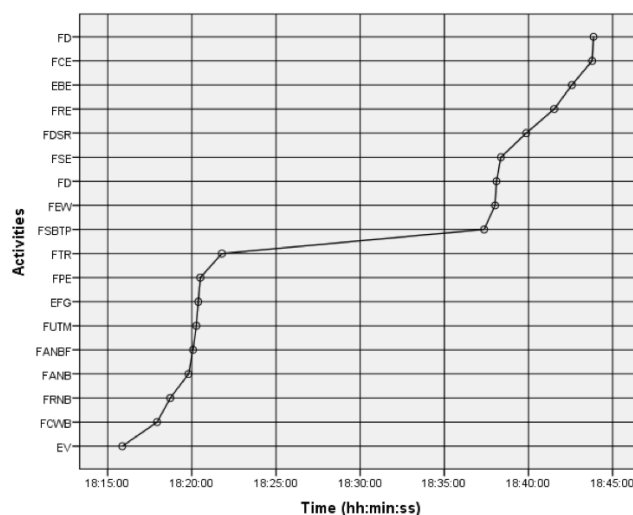


Figure 5. Timeline of actions associated with capture and consumption of egret. Acronyms are as follows: EV - Egret observed by Gharial in the water; FCWB - Gharial orients towards egret and climbs West bank; FRNB - Gharial re-orients towards North bank; FANB - Gharial has neck out of water begins now to ascend N bank, appears to be attracted by egret flapping wings; GANBF - Gharial begins ascent of North bank in earnest; FUTM - Gharial pauses and begins “undulating tail” movements, increases speed; EFG - Egret falls from perch to ground and Gharial grabs it with lateral jaw movements; FPE - Gharial pauses with egret in jaws; FTR - Gharial turns right and orients West to East, pauses; FSBTP - Gharial orients to South, and heads to pond; FEW - Gharial enters water with egret in jaws; FD - Gharial dives; FSE - Gharial surfaces with egret in jaws; FDSR - Gharial submerges and surfaces repeatedly; FRE - Gharial raises head out of water and repositions egret; FBE - Gharial begins eating egret with several lifts of snout; FCE - Gharial consumes egret; FD - Gharial dives.

The Gharial climbed 7 m, at approximately 25° angle, to reach the site where the egret was (see Fig. 5). Whilst all Gharial (both males and females) defend nests in the enclosure, there were no nests laid at this time, and the actions are interpreted as capture of prey for food.

Acknowledgements

Thanks to Ambika Yelahanka for helping with measuring the angle and slope of the Gharial’s ascent. We also thank the Trustees of the Madras Crocodile Bank Trust/Centre for Herpetology for their support and encouragement.

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Nikhil Whitaker and Rom Whitaker, *Madras Crocodile Bank Trust/Centre for Herpetology, P.O. Box 4, Mamallapuram, Tamil Nadu 603104, India (Nikhil@madrascrocodilebank.org)*.

INTERSPECIFIC CONFLICT BETWEEN GHARIAL (*GAVIALIS GANGETICUS*) AND MUGGER (*CROCODYLUS PALUSTRIS*) IN THE MAHANADI RIVER, ODISHA, INDIA. The Gharial (*Gavialis gangeticus*) and Mugger (*Crocodylus palustris*) are sympatric species that appear to live together peacefully, often sharing the same habitat. During implementation of the “Species Recovery of Gharial (*Gavialis gangeticus*) in the River Mahanadi Project”, we did not observe any direct interaction/competition (eg chasing, fighting) between Gharial and Mugger basking side by side on sandbars. However, the following observations provide some insights on possible interspecific and/or intraspecific conflict between these two species.

1. On 10 January 2021, a dead, 5-year-old head-started Gharial (2.3 m TL) was found. The post-mortem examination revealed wide bite marks on the body and deep wounds in the viscera, the nature of which suggested that they were most likely caused by a large Mugger.
2. On 11 January 2021, an adult Mugger basking on a large rock-outcrop in the river was noted to have a freshly “amputated” right forelimb (Fig. 1). The loss of a limb on this large individual is considered attributable to a large crocodile (species unknown).
3. On 30 May 2021, an 8-year-old head-started Gharial (around 3.3 m TL) was observed with a large part of its tail missing (Fig. 2).
4. On 22 May 2021, a Gharial nest hatched on the Mahanadi River (the first record of nesting in 40 years). On 27-31 May 2021, a female Gharial (around 2.3 m TL and 10 years of age) guarding the 28 hatchlings was observed chasing a Mugger away.

During the 1970s, low numbers of Muggers were seen in the Satkoshia Gorge of the Mahanadi River. In the intervening period, the population appears to have increased, and now

dominates the major portion of the gorge. A census in January 2021 recorded 95 Muggers and only 11 Gharials in Satkoshia Gorge. The historical decline in the Gharial population has been mainly attributed to factors such as loss of habitat, being swept away during high floods, and as incidental catch in gill nets.

Notwithstanding the limited number of observations, Muggers may now have become a potential threat to the survival of Gharial in the Mahanadi River. Although Gharial and Mugger have been reported to have a peaceful coexistence in Katarniagharh Wildlife Sanctuary (Choudhary *et al.* 2018), Sharma and Singh (2015) reported on the dominance of Mugger in National Chambal Sanctuary.



Figure 1. Mugger with recently amputated right forelimb.



Figure 2. Gharial missing part (all single vertical scutes) of its tail.

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Nepal

LIVING WITH MUGGER CROCODILES (*CROCODYLUS PALUSTRIS*): A CASE STUDY FROM KAMAL DAHA, KOSHI TAPPU WILDLIFE RESERVE, NEPAL. The Mugger crocodile (*Crocodylus palustris* Lesson, 1831) is listed as "Vulnerable" on the IUCN Red List (Choudhury and de Silva 2013), and the population in Nepal is estimated to comprise between 400 and 500 individuals (Baral and Shah 2013). Human-crocodile conflict (HCC) with Muggers has been documented in the various Range States (India, Sri Lanka, Nepal, Pakistan, Bangladesh, Iran) (Stevenson *et al.* 2014).

The presence of Muggers in human settlements, especially in farmers' fishponds, sometimes leads to a conflict with local people. In most places, the sight of a single crocodile would be enough to make people scurry in fear. However, in Kamal Dahan, a small village situated in a buffer zone area of Koshi Tappu Wildlife Reserve (KTWR), we documented a peculiar scenario in a pond named "Kamal Dahan". Here, we report a case of community acceptance and tolerance to Muggers in Kamal Dahan.

Kamal Dahan is situated in Saptari District, Saptakoshi Municipality-10, and is within the Kamalpur buffer zone. This is a community-managed pond. As it is situated on one of the tributaries of Koshi River, it is prone to flooding. Kamal Dahan was restored post-flood with the support of the National Trust for Nature Conservation, and the KTWR authority handed over the pond to the local community for fish farming. The pond was developed as a livelihood support scheme for the beneficiary households, which are significantly affected by human-elephant conflict. A total of 25 households from the Mallah community, which is traditionally a fishing community, manage Kamal Dahan.

As a part of our study on Muggers in KTWR, we visited Kamal Dahan on 14 February 2021. Kamal Dahan (26.682783N, 86.957765E) covers an area of 1.10 ha. It has a length of 300 m, a maximum width of 20 m, a perimeter of 955 m, and a depth of approximately 3-4 m. We spent three days collecting

information on the status of Muggers, and the perception of the local people towards them in the study area.

Walking along the banks, we observed 7 Muggers in Kamal Dahan during the day (1000-1600 h), whose total length (TL) was estimated visually within broad size/age categories: hatchlings (<30 cm TL; <1 year); yearlings (30-50 cm TL; 1<2 years); juveniles (N=2; 50-125 cm TL); sub-adults (N=2; 125-180 cm TL); and, adults (N=3; >180 cm TL) (Khadka *et al.* 2014). No hatchlings were observed. Previous surveys in the Koshi River within KTWR reported 21 individuals (Goit and Basnet 2011) and 16 individuals (Baral and Shah 2013).

All Muggers were observed to be basking, with 6 of them basking on the banks of the pond and one on a mud island inside the pond (Table 1). Three of the Muggers displayed mouth-gaping (Table 1), although whether this represented a thermoregulatory behaviour (Spotila *et al.* 1977) is not known.

Table 1. Details on Muggers sighted at Kamal Dahan.

No.	Size Class	Activity	Orientation
1.	Sub-adult	Basking	South
2.	Adult	Basking, mouth-gaping	North
3.	Juvenile	Basking	North
4.	Adult	Basking	East
5.	Adult	Basking	West
6.	Sub-adult	Basking, mouth-gaping	North
7.	Juvenile	Basking, mouth-gaping	West

The smallest Muggers sighted were 70 and 150 cm TL. Notwithstanding that daytime surveys are biased towards larger animals in the population, that no hatchlings were sighted suggest little/no successful recruitment over the previous year. Indeed, it is not known whether nesting occurs at Kamal Dahan. After restoration of Kamal Dahan (see later), Muggers moved in from other areas, suggesting that recruitment may be from other nearby areas.

The Muggers in Kamal Dahan, appear to be very tolerant of human presence, whereas in other parts of KTWR, Muggers will immediately submerge when they sense human presence. Venugopal *et al.* (2003) recorded less wariness in the Muggers in Ranganthittu Bird Sanctuary (RBZ), as they had become accustomed to humans and boats, and could be approached closely. Webb and Messel (1979) used the distance that an animal could be approached before it attempted to escape as an index of wariness.

At Kamal Dahan pond, Muggers continued to bask and remained unperturbed, even when humans approached from a nearby distance. We observed local people crossing the pond less than 5 m from a basking crocodile, without it moving. The residents revealed that these Muggers are habituated to disturbance and don't readily attempt to escape. Our observation was that Mugger could to be approached to

within 4 m before they went into the water.

The pond is an integral component of the daily life of residents, as they use it for laundry purposes, washing their cattle, and the kids swim there daily. The crocodiles rely on fish as their source of food. They bask on small isolated muddy islands in the pond, and on the grassy banks of the pond - the latter of which are a recurrent travel route for residents, children, herders and grazing cattle. During our visit, children were observed swimming at the opposite bank of the pond. We found this to reflect a unique co-existence between Muggers and local people.

We interviewed 30 local people to understand their perceptions of Muggers, and to quantify any conflict with Muggers to date. All respondents revealed that there have not been any damage caused by Muggers to people in the area. Out of the 30 respondents, 7 (23%) showed a somewhat negative attitude towards their presence - the concern was for what may happen in the future. They also said that if Mugger's food source declines in the future, then they might attack livestock and children. So they suggested shifting these crocodiles from Kamal Daha pond to other undisturbed places as a preferred option. However, most (77%) respondents showed a positive attitude towards Muggers, and were happy to see them in the pond. Respondents also revealed that local people have stopped fishing activities in Kamal Daha pond to prevent scarcity of food for the Muggers.

The Kamal Daha pond was restored by the National Trust for Nature Conservation (NTNC) and KTWR to reduce fishing and other anthropogenic pressures in the reserve (NTNC 2018). During the restoration, sediment was removed, and improvements were made on the embankment to enlarge the pond size (NTNC 2018). After restoration, the community had a moral obligation to the reserve and to protect the Muggers that visited the pond, alongside economic benefits from the pond. The community began to protect the Muggers accordingly. The level of tolerance of the people might have increased, as they did not have to make any economic contribution to the pond's restoration. The incentives received for fish farming in Kamal Daha and no direct economic burden to the communities may have helped them to live with crocodiles. This has become an exemplary livelihood support scheme, which generated community ownership along with the conservation of Muggers in the buffer zone of KTWR. The nearby Range post and Army post have also assisted with continuous monitoring and protection of crocodiles.

In the village, the Mallah community regards crocodiles as their Clan deity. Each year in July, a huge religious worship program is organized and a religious offering is made to the crocodiles to maintain peace and harmony with them. The Mallah community offers 3-4 pairs of pigeons, four goats, and dried fish to the crocodiles as part of this cultural ritual. This religious belief, prevalent among the residents, places huge importance on long-term conservation of the species.

Although human-Mugger conflict is increasing in Nepal, Kamal Daha has set an example of coexistence between



Figure 1. Muggers basking in the vicinity of livestock and people. Photographs: Pratik Pandeya.

Muggers and people in eastern Nepal. In addition to the economic incentives to the community, their religious beliefs have aided Mugger conservation in the buffer zone area. The provision of economic incentives for the management of community fishponds might be a suggestive measure for

increasing the community's tolerance level to Muggers. We suggest the replication of such incentives in other communities and long-term studies on drivers of communities' tolerance for Mugger conservation.

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Latin America and the Caribbean

Cuba

DO CROCODILES NEED ULTRAVIOLET LIGHT? VOLUNTARY EXPOSURE LEVELS OF CUBAN CROCODILES (*CROCODYLUS RHOMBIFER*). Providing the appropriate environmental conditions to captive crocodilians is critical for their health and welfare. While generally very forgiving to inadequate husbandry, the long-term effects of less than ideal environmental parameters can manifest in reduced life spans, poor reproductive output and increased susceptibility to disease.

Offering heat to crocodilians for sufficient thermoregulation is common practice, as basking behavior in reptiles has long been associated with exposure to infrared light and thermoregulation (Cowles and Bogert 1944; Huey and Slatkin 1976; Sievert and Hutchison 1988). However, sunlight is more than just a source of heat, full spectrum lighting provides ultraviolet (UV) light, to which basking reptiles are exposed in nature. Natural sunlight consists of short wavelengths (UV-B, 290-320 nm) and long wavelengths (UV-A, 320-400 nm), and the provision of UV lighting to captive reptiles is widely recommended (Carmel and Johnson 2014; Rossi 2006). Furthermore, in many taxa, such as turtles, lizards and amphibians, the benefits are well-documented (Acierno *et al.* 2008; Adkins *et al.* 2003; Alien *et al.* 1999; Ferguson *et al.* 1996; 2002; Gehrmann *et al.* 1991; Karsten *et al.* 2009; Pritchard and Greenhood 1968; Tapley *et al.* 2015). However, information regarding the provisioning of UV lighting to crocodilians is lacking.

Exposure of skin to UV-B light allows for the bioconversion of 7-dehydrocholesterol to previtamin D₃, in capable species, which can be thermally converted into vitamin D₃, which is necessary for the development of organs, maintenance of calcium homeostasis, and embryogenesis (Klaphake 2010). Critical for many physiological processes, vitamin D₃ can also be obtained through an animal's diet (Carman *et al.* 2000; Ferguson *et al.* 1996, 2003; Holick 1995; Klaphake 2010; Tian *et al.* 1994). Research on the UV-B requirements of reptiles has shown considerable variation among species, and between dietary and endogenously produced vitamin D₃ (Ferguson *et al.* 2002). Because crocodilians are carnivorous, it is generally assumed that they derive vitamin D₃ from their diet and not from UVB photobiosynthesis. This, however, warrants further investigation, because vitamin D₃ provides many benefits that have not been widely studied in crocodilians. For example, vitamin D₃ metabolizes into calcitriol intercellularly throughout the body, and in mammals it controls the transcription of genes that influence functions such as growth, insulin production and the immune system

(Hossein-nezhad and Holick 2013). Some evidence suggests that these benefits may also occur in reptiles, because vitamin D pathways are comparable in most terrestrial vertebrates (Antwis and Browne 2009; Bidmon and Stumpf 1996; Holick *et al.* 1995). Furthermore, a vitamin D3 deficiency in vertebrates, including reptiles, can negatively impact overall health and reproduction (Ferguson *et al.* 1996; Narbaitz and Tsang 1989; Packard and Clark 1996). Vitamin D3 supplementation is recommended for crocodilians housed without direct access to sun light to assist with calcium homeostasis (Manolis and Webb 2016).

Some reptiles can see UV-A light, which is invisible to humans, and which plays an important role in how they perceive their environment, conspecifics and prey species (Alberts 1989; Fleishman *et al.* 1993; Gehrmann 1994; Govardovskii and Zueva 1974; Honkavaara *et al.* 2002; Moehn 1974; Whiting *et al.* 2006). Additionally, UVA light wavelengths can penetrate the body cavity and get absorbed as energy (Porter 1967). For these reasons, lighting containing UVA is an essential part of herpetological husbandry, yet the provisioning of this spectrum of light has not been studied widely.

Considering that data on natural UV exposure in free-living reptiles is lacking, experts recommend that UV levels offered to reptiles in captivity be based on a species' basking behaviour, skin permeability to UV radiation, and response to UV-B in the context of vitamin D production (Baines *et al.* 2016). Each species can then be assigned a range of Ferguson Zones for recommended UV exposure levels when in captivity (Ferguson *et al.* 2010).

Collecting data on voluntary UV exposure of reptiles in nature can provide data from which to develop and guide husbandry standards (Augustine *et al.* 2021). Herein, we report UV exposure of five captive-bred Cuban crocodiles (*Crocodylus rhombifer*): two adults housed at Zapata Crocodile Farm (ZCF) in Matanzas Province, Cuba (Fig. 1); and, three free-living juveniles in habitat surrounding ZCF (Fig. 2).

Unitless ultraviolet index (UVI) readings were opportunistically collected on 4-8 November 2019 using a Solarmeter Model 6.5R Reptile UV Index Meter (Solar Light Company Inc., Glenside, Pennsylvania 19038, USA) at the exact location of each animal. Surface temperature was measured using an Etekcity Lasergrip 774 Non-contact Digital Laser Infrared Thermometer Temperature Gun

(Etekcity, Anaheim, CA 92806, USA).



Figure 1. Adult crocodile enclosures at ZCF. Photograph: Lauren Augustine.

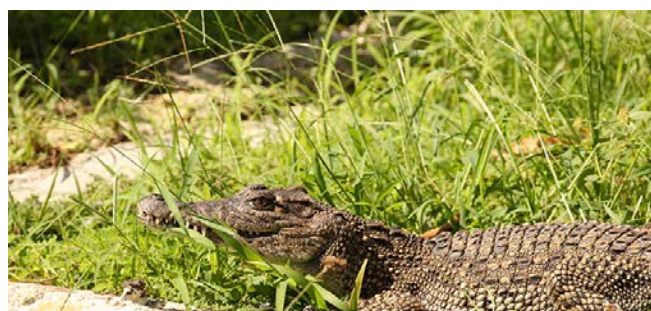


Figure 2. Free-living, captive-bred juvenile Cuban crocodile at ZCF. Photograph: Karl Guyton.

Cuban crocodiles at ZCF were exposed to UVI levels ranging from 0.4 to 2.6 (Table 1). These levels fall within Ferguson zones 2 and 3, similar to those recommended for other crocodilians (Table 2). The adult crocodile enclosures at ZCF hold multiple animals and are fenced in open areas with large pools and natural plantings (Fig. 1). The basking behaviour of these adults could have been influenced by

Table 1. Ultraviolet Index (UVI) readings for five Cuban crocodiles at Zapata Crocodile Farm in Cuba.

Date	Time	Age Class	Activity	Surface Temperature (°C)	UVI	Details
11 May 2019	1150 h	Juvenile	Basking	33.8	1.8	Free-living at ZCF (Fig. 1)
11 May 2019	1352 h	Juvenile	Foraging	30.6	0.4	Free-living at ZCF
11 June 2019	1454 h	Juvenile	Basking	30.1	2.3	Free-living at ZCF
11 July 2019	0922 h	Adult	Basking	30.2	2.6	In a ZCF pen
11 July 2019	0923 h	Adult	Basking	30.2	1.8	In a ZCF pen

several facets of captivity, including social dynamic, diet, overall health, reproductive status and age to name a few. While opportunistic data collection has some drawbacks, and this sample size is small, we consider this an important starting point for understanding the levels of UV to which crocodilians are voluntarily exposed in semi-natural settings.

Table 2. Ferguson Zone and Ultraviolet Index Range recommendations for five species of crocodilian (adapted from Baines *et al.* 2016).

Species	Ferguson Range	UVI Range
<i>Caiman crocodilus</i>	2-3	0.7-2.6
<i>Crocodylus mindorensis</i>	2-3	0.7-2.6
<i>Crocodylus moreletii</i>	2	0.7-1.0
<i>Osteolaemus tetraspis</i>	2-3	0.7-2.6
<i>Paleosuchus palpebrosus</i>	2-3	0.7-2.6

As we strive to improve standards of care and welfare for reptiles, the provisioning of UV light is a critical aspect of herpetological husbandry. Standard management practice for some species now includes providing a range of UV light by which the animals have the ability to behaviourally regulate their exposure (Baines *et al.* 2016; Selleri and Girolamo 2012; Ferguson *et al.* 2010). This is important because both under- and overexposure of UV light can have deleterious effects (Ferguson *et al.* 2002; Gehrmann 2006; Baines 2007; Gardiner *et al.* 2009). While the benefits are difficult to assess, particularly with long-lived species, data-driven evidence that crocodilians are exposed to a range of UV light in their natural environments should encourage its use with captive crocodilians. There is no “one size fits all” approach to caring for such complex species. The provisioning of UV light, therefore, should be considered in relation to the other components of animal care such as diet, thermal biology and behaviour.

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Brazil

JACARÉ PROJECT AND THE REPRODUCTIVE ECOLOGY PROGRAM OF *CAIMAN LATIROSTRIS* (DAUDIN, 1802) IN A PROTECTED AREA OF NORTHEAST BRAZIL. The “Ecology and Preservation of Crocodilians in the Atlantic Rainforest of Pernambuco” Project, better known as the “Jacaré Project”, is being carried out by the research team from the Interdisciplinary Laboratory of Amphibians and Reptiles (LIAR), Federal Rural University of Pernambuco (UFRPE). LIAR is supervised by Professor Jozélia Correia and Professor Ednilza Maranhão, who are responsible for teaching, research and university extension activities with regard to the preservation of herpetofauna and the management of human resources in the area of herpetology, to assist in the training of undergraduates and post-graduate students, as well as producing qualified professionals.

The Jacaré Project began in 2013 with the support of the CSG (Luís Bassetti, Mark Merchant, Pablo Siroski) and formed partnerships with some government departments involved in the management of fauna. Its aim was to investigate the ecological features of *Caiman latirostris*

and *Paleosuchus palpebrosus* of the Atlantic Rainforest in Pernambuco. This entailed conducting a survey to obtain information about the abundance of the population, spatial distribution, reproduction, health, feeding habits, and genetic factors, as well as the presence of contaminants, with a view to monitoring the species and providing assistance for its preservation and the protection of its habitats in the region.

This is a pioneering scheme for the long-term surveillance of crocodile populations in northeast Brazil, which covers an area of 1,558,196 km², spread over 9 States (IBGE 2017), since there is a serious lack of research studies on crocodilians. Georg Marcgrave (1648) was probably the first naturalist to describe *Caiman latirostris* (Daudin, 1802), and he made inferences about its reproductive biology. However, it was only in 2008 that the presence of natural populations of *Paleosuchus palpebrosus* (Cuvier, 1807) and *Caiman crocodilus* (Linnaeus, 1758) was first recorded in specific locations in the States of Ceará and Piauí (Borges-Nojosa and Lima 2008; Lima *et al.* 2011). Until now, there are about 70 publications on the species of crocodilians in the northeast. However, most of them are only concerned with making occasional records of the appearance of the species or compiling inventories (Correia *et al.* 2021) and only two focus on reproductive factors (Verdade 2001; Correia *et al.* 2019).

The line of research related to biology and reproductive ecology started in 2018, and took place around the Tapacurá Dam, an area of Atlantic Forest biome located in the town of São Lourenço da Mata, Pernambuco, northeast Brazil (8°03'S, 35°10'W). The area consists of private properties, where agricultural activities are carried out such as fishing, cattle ranching and the rearing of goats - and the remains of the Atlantic Rainforest are included in the protected areas (Fig. 1). The research involved systematic monitoring of nests and the factors that determine the environmental influences on female preferences, parental care, hatching success, predating (with the aid of camera trap) and incubation temperature (through data loggers) (Fig. 2). This specific study is headed by PhD student Rafael Barboza, who monitored nests for the entire duration of incubation and followed standard procedures for data collection when making studies of the crocodilian nests (Webb *et al.* 1977; Charruau and Hénaut 2012; Campos *et al.* 2019).

Preliminary Results

The area has been affected by serious anthropic disturbances including logging, farming, cattle ranching, hunting and predatory fishing (Mascarenhas-Junior *et al.* 2018, 2020). The protected areas with the remnants of the forests showed how important they are as preferred nesting habitats. The nesting season is February-March, and the hatching occurs in April-June. All the nests (N= 31) were found in forested areas that had some very peculiar features. The average distance from the water to the nests was long (109.76 m - Table 1) with higher values in periods of dry weather (2019), when the distance ranged from 87 m to 253 m. In periods of drought, the level of water increasingly moved further from the edge

of the forest. As a result of drought, there was a greater degree of nest predation in these years, which led to almost zero hatching rates.

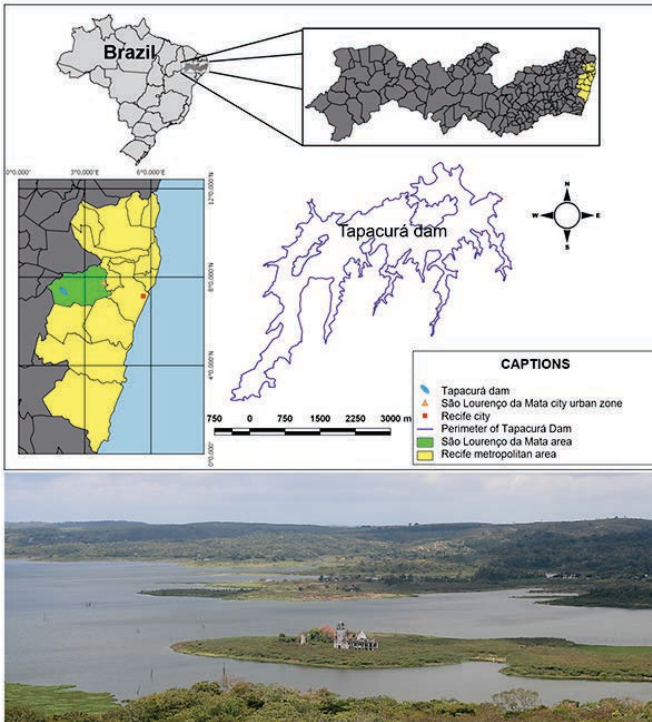


Figure 1. Location of Tapacurá Dam (from Anjos 2019).



Figure 2. Natural surroundings and some procedures made during field research of Project Jacaré: A) caiman nest; B) female *C. latirostris*; C) eggs with data logger; D) hatchlings. Part of the team before and during the COVID-19 pandemic: E) Ednilza Maranhão, Rafael Barboza, Maria Laura, Jozélia Correia; F) Paulo Braga, Jozélia Correia, Carlos Rodrigues, Rafael Barboza.

The lack of parental care of nests by females was also a striking feature in the region. The long distances between the nests and water, and the lack of parental care, can be attributed

to anthropic disturbances such as hunting and predatory fishing in the region. Thus, females may have been seeking to make themselves less vulnerable by avoiding being seen on the riverbanks denuded of vegetation, which are the areas of greatest exposure.

Results showed that some nests were formed with solid waste (Barboza *et al.* 2020) and exotic plants (eg *Dracaena trifasciata* - St. George's sword or "espada de São Jorge" in Portuguese), and with communal nesting (Rodrigues *et al.* 2021) and nest-site fidelity in these areas.

Table 1. *Caiman latirostris* nest variables at Tapacurá Dam.

Variable	Mean ± SD (range)
Distance to water (m)	109.76 ± 109.41 (14-445)
Nest height in relation to water (m)	10.57 ± 8.04 (1.64-38.41)
Distance to edge of forest (m)	21.9 ± 25.73 (0-99)
Number of eggs/nest	29.19 ± 6.72 (13-44)
Egg length (mm)	61.91 ± 5.29 (32.4-112.8)
Egg width (mm)	39.78 ± 2.97 (31.4-66.9)
Egg weight (g)	57.61 ± 9.37 (32-78)
Incubation period (d)	60.89 ± 10.43 (44-75)
Hatching success (%)	71.54 ± 32.38 (0-100)
Female SVL (cm)	80.87 ± 5.54 (75-86.66)

There were no reports of nests being lost through flooding, which was largely due to the height above water of the nesting sites. Over a historical period of 42 years, the water level of the dam has only reached the minimum height of the nesting grounds in the nesting season on 4 occasions (May 1911, May 1981, February 1990, May 1997; Fig. 3).

A wide range of predators and visitors were detected by camera traps (Bushnell #119436), notably *Salvator merianae*, *Nasua nasua*, *Leopardus pardalis*, *Dasypodidae* spp., *Cuniculus paca*, *Dasyprocta prymnolopha*, *Hydrochoerus hydrochaeris*, *Caracara plancus*, *Canis familiaris*, *Bos taurus*, passerine birds and small rodents.



Figure 4. Images from camera traps at nests: A) female caiman on the nest, B) *Bos taurus*; C) *Canis familiaris*; D) *Leopardus pardalis*; E) *Salvator merianae*.

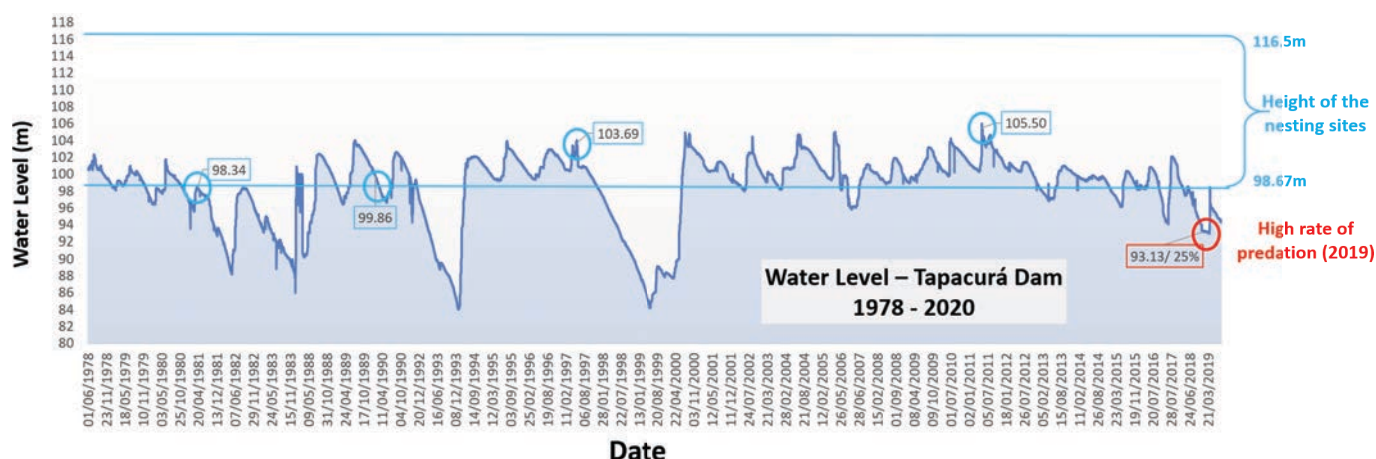


Figure 3. Water levels at Tapacurá Dam, 1978-2020, together with height of nesting area (blue line) and water level during hatching (blue circles). Also shown is the critical level of low water as a result of low rainfall, when there is a greater rate of nest predation (red circle) (data from www.apac.gov.br).

Future perspectives

The breeding season is at the end and we are waiting for the last hatchlings to emerge (June 2021). We are still in the planning stage for the next breeding season as a result of some restrictions caused by the COVID-19 pandemic, but this will include new features such as bioacoustics of newborn *Caiman latirostris* in the nests and ecological knowledge of crocodilians among the local community.

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Australia & Oceania

Papua New Guinea

MEDIA RELEASE - 21 JUNE 2021: CROCODILE TRADE PROTECTION ACT AND ITS REGULATIONS TO BE AMENDED. The drafting of a Bill to amend the *Crocodile Trade (Protection) Act 1974* was announced by the Managing Director for Conservation and Environment Protection Authority today. This process will involve a review of the current legislation and a series of consultations to assess the needs and priorities of Papua New Guinea's crocodile skin trade.

"The proposed amendments will achieve more efficient and cost-effective administration of the crocodile farming industry and its crocodile skin trade to satisfy Papua New Guinea's CITES obligations," the Director said. Since the last update of the 1974 Act, over 35 years ago, the approach to management and commercial use of crocodiles has changed considerably in Papua New Guinea. The Act was designed to regulate the trade of crocodile skins and protect wild crocodile populations.

The structure of the industry has also changed significantly, evolving into a more efficient and quality controlled system in which the roles and responsibilities of the various participants have become more stringently defined and the cultural and socio-economic profiles of the individuals involved in the different sectors of the industry better understood.

The proposed amendments to the legislation will reflect these industry changes as well as changes to approaches to management and conservation of crocodiles in Papua New Guinea.

In summary the proposed changes will: improve licensing arrangements and fee collections for crocodile skins and eggs, provide for regulations of skin processing and exports, update enforcement provisions (such as forms and penalties), and transfer the export permit provisions of the Act under the International Trade (Fauna and Flora) Act.

The review of the Crocodile Management Plan will envisage to eliminate wild hunting in the future, and there will also be a review of the existing exemptions on sales, export of crocodile meat and by-products from registered crocodile farms. The amendments will also enable improvements to the quality of information provided by the industry to the Conservation

and Environment Protection Authority. "This will strengthen the scientific base of future management decisions that will reinforce overall sustainability of management and conservation of the wild resources," the Director noted.

Supported by a crocodile expert, the Conservation and Environment Protection Authority will consult with provincial government, community leaders, industry and local conservation and NGO groups on the proposed changes before the amended *Crocodile Trade (Protection) Act 1974* and *Crocodile Trade (Protection) Regulation (1980)* and Schedules are submitted to the National Executive Council and Parliament for endorsement.

The review of the Act and consultations are being supported by the By-catch and Integrated Ecosystem Management (BIEM) Initiative implemented by the Secretariat of the Pacific Regional Environment Programme (SPREP) under the Pacific-European Union Marine Partnership (PEUMP) programme funded by the European Union and the Government of Sweden.

Background information: CITES - the Convention on International Trade in Endangered Species of Wild Fauna and Flora - commits parties to the Convention to regulating and managing the trade and commercial use of species listed under the Convention. PNG's two species of crocodiles (Saltwater Crocodile (*Crocodylus porosus*) and Freshwater Crocodile (*Crocodylus novaeguineae*) are both listed under CITES and therefore strict regulations need to be followed to enable the legal trade of crocodile products internationally.

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Recent Publications

Kuzmin, I.T. and Zvonok, E.A. (2021). Crocodylian assemblage from the middle Eocene Ikovo locality (Lugansk Province, Ukraine), with a discussion of the fossil record and geographic origins of crocodyliform fauna in the Paleogene of Europe. *Geobios* (<https://doi.org/10.1016/j.geobios.2021.02.002>).

Abstract: The known fossil record of crocodyliforms in Europe during the Paleogene is significantly biased, in that the fauna of Western Europe is far better sampled and understood compared to that of Eastern Europe. We describe in detail all known crocodyliform remains from the middle Eocene (Lutetian) Ikovo locality in Ukraine. We conclude that at least two taxa were present: a moderate to large-sized *Tomistominae* indet. similar to the basalmost known *tomistomines*, and the small-sized basal alligatoroid

cf. *Diplocynodon* sp. Despite its scarcity, this is the first basal alligatoroid material reported from Eastern Europe (as part of post-Soviet countries) and the easternmost record of diplocynodontines in Europe so far. An allegedly freshwater cf. *Diplocynodon* sp. contributes a rare faunal element to the vertebrate assemblage of the Ikovo locality, otherwise dominated by resident or facultative marine taxa. The fossil record and historical paleobiogeography of crocodyliforms from the Paleocene and Eocene of Europe are reviewed. As it has been already known, the middle Eocene fauna of crocodyliforms proves to be taxonomically diverse and complex. Its constituent lineages geographically originated in Asia or North America (Diplocynodontinae, *Asiatosuchus*-like crocodyloids, Planocraniidae), North America (derived alligatorines), Africa (Tomistominae), and Gondwana (ziphodont mesoeucrocodylians *Iberosuchus* and *Bergisuchus*), with possible subsequent speciation in Europe. We propose a novel hypothesis of Asian origins of European diplocynodontines, which will be explicitly tested in future studies. The revealed similarities between crocodylians and turtles from the Ikovo locality and those from Western Europe support the presence of a single Pan-European biogeographical zone during the middle Eocene, distinct from that of Asia.

Capila, P. (2021). A chorus, a census and other antidotes to pessimism. *Sanctuary Asia* 41(1): 50-53.

Srimangkornkaew, P., Suwannasaroj, K., Siruntawineti, J., Chaeychomsri, W. and Chaeychomsri, S. (2021). The chronic oral toxicity testing of Siamese crocodile (*Crocodylus siamensis*) bile in Sprague Dawley rats. *Bulletin of the Department of Medical Science* 63(1): 1-12.

Abstract: In Thailand, Siamese crocodile (*Crocodylus siamensis*) is an economic animal and dried form of Siamese crocodile bile was used as traditional medicine and exported for a long time but safety information including toxicity testing is limited. For previous study, an oral acute and sub chronic toxicity study was conducted and the results showed that the Siamese Crocodile bile was classified in GHS category 4, the LD50 cut off at 500 mg/kg body weight and the no observed adverse effect level (NOAEL) of Siamese crocodile bile was considered to be 250 mg/kg body, respectively. Nevertheless, the study to provide information the possible major toxic effects, indicate target organs and the possibility of accumulation and estimation of a no-observed-adverse-effect level (NOAEL) for a long enough period to realize for chronic effects have not been carried out. Therefore, this study was done to support information as above for Siamese crocodile bile in Sprague Dawley rats in compliance with OECD Guidelines for the testing of chemicals 452, Chronic Toxicity Studies. The Siamese crocodile bile was not shown treatment related mortality and clinical signs of toxicity in Sprague Dawley rats including the treatment-relates changes were not observed in necropsy findings and histopathological finding in both sexes based on a result. The significantly different results of hematological tests and clinical biochemistry tests were not considered as a treatment-related toxicity effect but these results were recovered in recovery period (28 days). Thus, the NOAEL of Siamese crocodile bile in chronic oral toxicity studies were considered to be 250 mg/kg body weight per day for Sprague Dawley rats.

Bennett, G.A., Mead, A., and Patterson, D. (2021). Carbon and oxygen isotope analysis of Pleistocene American alligator teeth “in progress”. *Georgia Journal of Science* 79(1): Article 21.

Abstract: Isotopic samples from fossilized American alligator (*Alligator mississippiensis*) teeth were used to infer aspects of the paleoenvironment of Georgia's Coastal Plain during the Late Pleistocene. The teeth were recovered from Clark Quarry which has been dated to the late Pleistocene. $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ isotopic values are typically used to distinguish ecosystem-level variations in the floral community and climate (precipitation and temperature),

respectively. Carbon isotope values from fossil herbivore enamel reflect ingested vegetation from the environment with more positive values ($>-1\%$) indicating an increased prevalence of C4 plants (eg warm growing season grasses and sedges) in the diet, while more negative values ($<-8\%$) indicate elevated quantities of C3 plants (eg trees, shrubs, and cool growing season grasses). Oxygen isotope values from fossil enamel correlate to the aridity of an environment with positive values associating with increased evaporation (ie warmer conditions) and more negative values indicating cooler, less-evaporative conditions. In this study, we obtained the $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ values from fossil alligator teeth collected at Clark Quarry and modern teeth from Jekyll Island, GA, and Aiken, SC. The samples were analyzed using gas bench chromatography at the Center for Applied Isotopic Sciences at the University of Georgia. Although this study is ongoing, we hypothesize that the paleoenvironment of Clark Quarry was similar to the environments of the contemporary Coastal Plain of Georgia. Comparable isotopic data from the teeth of wide-ranging herbivorous megafauna at Clark Quarry (*Mammuthus columbi* and *Bison latifrons*) indicate a seasonally variable diet. New isotopic data presented here will; 1) help illuminate the dietary patterns of carnivorous taxa from Clark Quarry, and 2) due to alligators' dependence on local aquatic environments, provide a highly detailed record of water sources around Clark Quarry.

Muslim, T. and Suba, R.B. (2021). A preliminary survey of Siamese crocodile habitat preferences: Floating vegetation on Lake Mesangat, Muara Ancalong, East Kutai, Indonesia. *Proceedings of the Joint Symposium on Tropical Studies (JSTS-19)* (<https://doi.org/10.2991/absr.k.210408.061>).

Abstract: Floating vegetation is one of the biotic components in the Mesangat Lake ecosystem, which plays an essential role for Siamese crocodiles. Floating plants in the Mesangat Lake can be used as an indicator of habitat preferences and Siamese crocodiles' success rate in nesting. This research aimed to find out floating plants that dominate Mesangat Lake, especially when the probability of encountering the crocodile is high. A visual encounter survey with patch sampling was used in this research. We found 12 main species of floating plant species in Mesangat Lake, dominated by *Leersia hexandra* (36%), followed by *Cyperus rotundus* (19%) and *Eichhornia crassipes* (15%). *L. hexandra* and *C. rotundus* are potential resources of nesting materials for Siamese crocodiles. On the other hand, *E. crassipes* is possibly not an option for nesting. *E. crassipes* is considered an invasive aquatic plant and could represent disrupted habitats in the wetland. Since the presence of this plant species is not dominant in Lake Mesangat, we predict that the habitat is still relatively suitable to support the Siamese crocodiles population.

Muslim, T. and Susanto, H. (2021). Assessment Report to Crocodile Occupancy in Oil Palm Plantation of Kemilau Indah Nusantara. Technical Report.

Abstract: The population of estuary crocodiles is not known until now, whether it has increased when viewed from the many conflicts of crocodile attacks against humans or decreased due to damage and reduced habitat. The case of habitat invasion and control that occurred in the area of PT KIN oil palm plantation shows that the area has been harvested by crocodile populations as breeding ground and feeding ground. From 41 locations out of 45 crocodile encounters, it can be shown that the spread of crocodiles on palm plantation blocks is relatively even assuming the individual position of crocodiles does not move and some encounter points indicate areas relatively far from the main waters. Crocodile detection results in PT KIN area showed the number of adolescents and young adults (1.5-2 m) higher than productive adults (2.5-3 m). The frequency of crocodile encounters is highest in March and December, while the frequency of the other 5 months is relatively low even in October is not detected. The high frequency of encounters of productive adult crocodiles measuring 2.5-3 m on palm plantation blocks is suspected

to be mating and nesting. The area of palm oil which was originally a swamp area is suspected as a habitat for crocodiles to build nests and forage. There have been at least 2 (two) fatal cases in the last 2 years, namely in the waters of the Bengalon River and the location of owned oil palm plantations. The inclusion of crocodile populations into the plantation area is thought to be because previously the plantation area included territorial crocodiles as a breeding and foraging place. In addition, water circulation systems and aquatic connectivity can affect the ecology of crocodile populations related to habitat occupancy and increasing population trends.

Santana, F.L., Arenas, I., Haney, E.F., Estrada, K., Hancock, R.E.W. and Corzo, G. (2021). Identification of a crocodylian β -defensin variant from *Alligator mississippiensis* with antimicrobial and antibiofilm activity. Peptides 136 (doi: 10.1016/j.peptides.2021.170549).

Abstract: β -defensin host defense peptides are important components of the innate immune system of vertebrates. Although evidence of their broad antimicrobial, antibiofilm and immunomodulatory activities in mammals have been presented, β -defensins from other vertebrate species, like crocodylians, remain largely unexplored. In this study, five new crocodylian β -defensin variants from *Alligator mississippiensis* and *Crocodylus porosus* were selected for synthesis and characterization based on their charge and hydrophobicity values. Linear peptides were synthesized, folded, purified and then evaluated for their antimicrobial and antibiofilm activities against the bacterial pathogens, *Salmonella enterica* serovar *Typhimurium*, *Staphylococcus aureus*, *Enterobacter cloacae* and *Acinetobacter baumannii*. The Am23SK variant (SCRFSGGYCIWNWERCGRSGHFLVLCPRKRCK) from *A. mississippiensis* displayed promising activity against both planktonic cells and bacterial biofilms, outperforming the human β -defensin 3 under the experimental conditions. Moreover, Am23SK exhibited no cytotoxicity towards mammalian cells and exerted immunomodulatory effects *in vitro*, moderately suppressing the production of proinflammatory mediators from stimulated human bronchial epithelial cells. Overall, our results have expanded the activity landscape of crocodylian and reptilian β -defensin in general.

Nie, H., Zhang, R., Yu, X., Zhang, Y., Yan, P., Li, E., Wang, R. and Wu, X. (2021). Molecular cloning, Immunological Characterization, and expression analysis of Gonadotropin-releasing hormone (GnRH) in the brain of the Chinese alligator during different stages of reproductive cycle. Gene (https://doi.org/10.1016/j.gene.2021.145672).

Abstract: The neurohormone gonadotropin-releasing hormone (GnRH) plays an essential role in the control of reproductive functions in vertebrates. However, the full-length complementary DNA (cDNA) encoding the GnRHs precursor and its role in the reproductive cycles regulating has not been illustrated in crocodylian species. In the present study, full-length cDNAs encoding GnRH1 forms, its predominant localization within brain and peripheral tissues, and GnRH1 peptide concentrations in the hypothalamus and pituitary in relation to seasonal gonadal development of Chinese alligator were investigated. The cDNA of GnRH1 is consisted of 282 bp open reading frame encoding 93 amino acids. The deduced amino acid sequence of alligator GnRH1 contains several conserved regions and shows a closer genetic relationship to the avian species than to other reptile species. The GnRH1 immunopositive cells were not only detected widely in cerebrum, diencephalon, medulla oblongata but also observed in peripheral tissues, these widespread distribution characteristics indicated that GnRH1 possibly possess the multi-functionality in Chinese alligator. GnRH1 peptide concentration within hypothalamus were observed to be the highest in RP group ($P < 0.05$), in association with an peak value in GSI and emerging of late vitellogenic follicles in the ovary. Taken together, our results suggested that GnRH1 was predominantly involved in the vitellogenesis process of seasonal gonadal development of

Chinese alligator.

Cidade, G.M. and Rincon, A.D. (2021). The first occurrence of *Agresuchus* (Alligatoroidea, Caimaninae) from the Urumaco Formation of Venezuela and the late Miocene crocodylian fauna of northern South America. Journal of South American Earth Sciences 110 (https://doi.org/10.1016/j.jsames.2021.103344).

Abstract: The late Miocene Urumaco Formation of Venezuela has one of the richest and ecologically diverse crocodylian fossil faunas of the Cenozoic of South America. This diversity includes several different genera and species of crocodylians that held many distinct ecological niches, such as those of generalist predators, durophagous predators, giant predators and longirostrine piscivorous, among others. This paper offers a significant addition to this already remarkable fauna by describing the first occurrence of *Agresuchus pachytemporalis* Souza-Filho *et al.* 2018 for the Urumaco Formation. This record consists of the specimen MCNUSB-PB-02FU-RS43, which is a posterior portion of the skull, consisted mostly by the skull table and the braincase, with incomplete mandibular rami associated. The specimen also represents the first occurrence of *A. pachytemporalis* outside the late Miocene Solimões Formation of Brazil, from which it has been originally described. As such, the occurrence of *A. pachytemporalis* in the Urumaco Formation recorded by this contribution is another evidence of the large taxonomical and paleoecological similarity between the crocodylian faunas of this unit and the Solimões Formation, which share many similar taxa at generic and specific levels and exhibit similar ecological niches being held by fossil crocodylians.

Darlim, G., Montefeltro, F.C. and Langer, M.C. (2021). 3D skull modelling and description of a new baurusuchid (Crocodyliformes, Mesoeucrocodylia) from the Late Cretaceous (Bauru Basin) of Brazil. Journal of Anatomy (doi: 10.1111/joa.13442).

Abstract: Baurusuchidae is one of the most diverse groups of South American notosuchians, unambiguously recorded in Late Cretaceous deposits of Brazil and Argentina. The group is characterized by a reduced tooth formula, a lateromedially compressed rostrum, and a verticalized quadrate, representing one of the top predators of their faunas. Historically, skull morphology is the most employed tool to investigate the relationships of baurusuchids, as most of the species have been primarily based on cranial remains. The present study describes a new baurusuchid species from the Bauru Basin of Brazil, based on the first tridimensional digital reconstruction of individualized skull bones for Notosuchia, and discusses its phylogenetic position within the group. The new species differs from all the other known baurusuchids by a depression on the posterior portion of the nasal bearing a crest, an infraorbital crest of the jugal that extends until the anterior margin of the lacrimal, the dorsal surface of the frontal lacking a longitudinal crest or depression, and the lateral convexity of the squamosal prongs participating in the occipital wall. The new taxon is consistently positioned as sister to the remaining baurusuchines, with *Aplestosuchus sordidus* and *Stratiotosuchus maxhechti*, as successive sister-taxa to a monophyletic *Baurusuchus* (*Ba. albertoi*, *Ba. Salgadoensis*, and *Ba. pachecoi*). Our updated phylogenetic analysis helps to differentiate the two major Baurusuchidae lineages, Baurusuchinae and Pissarrachampsinae. Yet, the new species shares morphological features with both groups, suggesting the occurrence of “Zones of Variability” in the radiation of Baurusuchidae.

Edmands, S. (2021). Sex ratios in a warming world: Thermal effects on sex-biased survival, sex determination, and sex reversal. Journal of Heredity 2021: 155-164.

Abstract: Rising global temperatures threaten to disrupt population sex ratios, which can in turn cause mate shortages, reduce population growth and adaptive potential, and increase extinction

risk, particularly when ratios are male biased. Sex ratio distortion can then have cascading effects across other species and even ecosystems. Our understanding of the problem is limited by how often studies measure temperature effects in both sexes. To address this, the current review surveyed 194 published studies of heat tolerance, finding that the majority did not even mention the sex of the individuals used, with <10% reporting results for males and females separately. Although the data are incomplete, this review assessed phylogenetic patterns of thermally induced sex ratio bias for 3 different mechanisms: sex-biased heat tolerance, temperature-dependent sex determination (TSD), and temperature-induced sex reversal. For sex-biased heat tolerance, documented examples span a large taxonomic range including arthropods, chordates, protists, and plants. Here, superior heat tolerance is more common in females than males, but the direction of tolerance appears to be phylogenetically fluid, perhaps due to the large number of contributing factors. For TSD, well-documented examples are limited to reptiles, where high temperature usually favors females, and fishes, where high temperature consistently favors males. For temperature-induced sex reversal, unambiguous cases are again limited to vertebrates, and high temperature usually favors males in fishes and amphibians, with mixed effects in reptiles. There is urgent need for further work on the full taxonomic extent of temperature-induced sex ratio distortion, including joint effects of the multiple contributing mechanisms.

Wüster, W., Thomson, S.A., O'Shea, M. and Kaiser, H. (2021). Confronting taxonomic vandalism in biology: Conscientious community self-organization can preserve nomenclatural stability. *Biological Journal of the Linnean Society* XX: 1-26.

Abstract: Self-published taxon descriptions, bereft of a basis of evidence, are a long-standing problem in taxonomy. The problem derives in part from the Principle of Priority in the *International Code of Zoological Nomenclature*, which forces the use of the oldest available nomen irrespective of scientific merit. This provides a route to 'immortality' for unscrupulous individuals through the mass-naming of taxa without scientific basis, a phenomenon referred to as taxonomic vandalism. Following a flood of unscientific taxon namings, in 2013 a group of concerned herpetologists organized a widely supported, community-based campaign to treat these nomina as lying outside the permanent scientific record, and to ignore and overwrite them as appropriate. Here, we review the impact of these proposals over the past 8 years. We identified 59 instances of unscientific names being set aside and overwritten with science-based names (here termed aspidonyms), and 1087 uses of these aspidonyms, compared to one instance of preference for the overwritten names. This shows that when there is widespread consultation and agreement across affected research communities, setting aside certain provisions of the *Code* can constitute an effective last resort defence against taxonomic vandalism and enhance the universality and stability of the scientific nomenclature.

Rodrigues, C.F.S.N., Barboza, R.S.L., Dos Santos, E.M. and Correia, J.M.S. (2021). Communal nesting of broad-snouted caiman, *Caiman latirostris* (Daudin, 1802), in a protected area of Atlantic Forest in northeastern Brazil. *Herpetology Notes* 14: 677-680.

Fish, F.E., Rybczynski, N., Lauder, G.V. and Duff, C.M. (2021). The role of the tail or lack thereof in the evolution of tetrapod aquatic propulsion. *Integrative and Comparative Biology* (<https://doi.org/10.1093/icb/icab021>).

Abstract: Secondary aquatic vertebrates exhibit a diversity of swimming modes that use paired limbs and/or the tail. Various secondarily aquatic tetrapod clades, including amphibians, reptiles, and mammals employ transverse undulations or oscillations of the tail for swimming. These movements have often been classified according to a kinematic gradient that was established for fishes,

but may not be appropriate to describe the swimming motions of tetrapods. To understand the evolution of movements and design of the tail in aquatic tetrapods, we categorize the types of tails used for swimming and examine swimming kinematics and hydrodynamics. From a foundation of a narrow, elongate ancestral tail, the tails used for swimming by aquatic tetrapods are classified as tapered, keeled, paddle, and lunate. Tail undulations are associated with tapered, keeled, and paddle tails for a diversity of taxa. Propulsive undulatory waves move down the tail with increasing amplitude toward the tail tip, while moving posteriorly at a velocity faster than the anterior motion of the body indicating that the tail is used for thrust generation. Aquatic propulsion is associated with the transfer of momentum to the water from the swimming movements of the tail, particularly at the trailing edge. The addition of transverse extensions and flattening of the tail increases the mass of water accelerated posteriorly and affects vorticity shed into the wake for more aquatically adapted animals. DPIV (Digital Particle Image Velocimetry) reveals differences were exhibited in the vortex wake between the morphological and kinematic extremes of the alligator with a tapering undulating tail and the dolphin with oscillating wing-like flukes that generate thrust. In addition to exploring the relationship between shape of undulating tails and swimming performance across aquatic tetrapods, the role of tail reduction or loss of a tail in aquatic-tetrapod swimming was also explored. For aquatic tetrapods, reduction would have been due to factors including locomotor and defensive specializations and phylogenetic and physiological constraints. Possession of a thrust-generating tail for swimming, or lack thereof, guided various lineages of secondarily aquatic vertebrates into different evolutionary trajectories for effective aquatic propulsion (ie speed, efficiency, acceleration).

Ford, A.T., Ali, A.H., Colla, S.R., Cooke, S.J., Lamb, C.T., Pittman, J., Shiffman, D.S. and Singh, N.J. (2021). Understanding and avoiding misplaced efforts in conservation. *FACETS* 6: 252-271.

Abstract: Conservation relies on cooperation among different interest groups and appropriate use of evidence to make decisions that benefit people and biodiversity. However, misplaced conservation occurs when cooperation and evidence are impeded by polarization and misinformation. This impedance influences actions that directly harm biodiversity, alienate partners and disrupt partnerships, waste resources, misinform the public, and (or) delegitimize evidence. As a result of these actions, misplaced conservation outcomes emerge, making it more difficult to have positive outcomes for biodiversity. Here we describe cases where a failed appreciation for cooperation, evidence, or both have eroded efforts to conserve biodiversity. Generally, these case studies illustrate that averting misplaced conservation requires greater adherence to processes that elevate the role of evidence in decision-making and that place collective, long-term benefits for biodiversity over the short-term gains of individuals or groups. Efforts to integrate human dimensions, cooperation, and evidence into conservation will increase the efficacy and success of efforts to conserve global biodiversity while benefiting humanity.

Barão-Nóbrega, J.A.L. (2021). Habitat and Population Structure of the Morelet's Crocodile (*Crocodylus moreletii*) in Calakmul Biosphere Reserve, Campeche, Mexico. PhD thesis, University of Salford, UK.

Abstract: The Yucatan Peninsula (YP) is one of the most recognizable parts of Mexico and is well known as one of the significant areas in Mesoamerica which supported the Mayan civilization. In the southern portion of the Peninsula, natural aquatic habitats occur at relatively low densities across the region in the form of semi-temporary ponds (aguadas) sustained by rainfall, and constitute the only local source of standing water during most of the year to both the fauna and human communities. The Morelet's crocodile (*Crocodylus moreletii*) is an apex predator and a flagship species inhabiting these aquatic environments, but only rudimentary information about this species exists in the region. This PhD project contributes

to current knowledge on aquatic habitat in Calakmul Biosphere Reserve (CBR) and characterizes aguada habitats across the region through information on their general structure and water quality. Such inferences provide a baseline to investigate the population structure of *C. moreletii* within and around CBR through N-mixture modelling to estimate local abundances and population sizes, and population genetic analyses using SNPs generated through a double-digest RADseq approach (dd-RADseq). A total of 85 waterbodies were located and described throughout CBR, out of which 64 were annually monitored for water level and vegetation cover from 2016 to 2019, providing detailed data on shape and size variation in response to fluctuations in annual precipitation. A citizen science project was also designed for long-term monitoring of aguadas using standardised data entry forms and information uploaded through a mobile app to a centralized online database. N-mixture models applied to count data (n= 1105 crocodiles) from 256 spotlight surveys conducted across 50 representative aguada locations have resulted in estimates of crocodylian detection and abundance, with covariates enabling insights into population responses to local environmental conditions. Extrapolating abundance estimates across Calakmul yielded in ~12,000 *C. moreletii* present, demonstrating that the region is an important global stronghold for this species. Population structure assessment of *C. moreletii* showed that CBR still harbours genetically pure individuals, whereas genetic pollution through increased hybridization with the American crocodile (*Crocodylus acutus*) is common across other parts of its range. This assessment also revealed that the six main geographical regions within Calakmul where samples originated from to a large extent represent own genetic clusters, and spatial population structure is highly linked to extended family networks within each region. Taken together, the findings of this PhD will play an essential role in management actions towards the conservation of *C. moreletii* populations in aguadas, establishing *C. moreletii* as an umbrella species for the biodiversity that occurs in them.

Hekkala, E., Gatesy, J., Narechania, A., Meredith, R., Russello, M., Aardema, M.L., Jensen, E., Montanari, S., Brochu, C., Norell, M. and Amato, G. (2021). Paleogenomics illuminates the evolutionary history of the extinct Holocene “horned” crocodile of Madagascar, *Voay robustus*. *Communications Biology* 4: 505.

Abstract: Ancient DNA is transforming our ability to reconstruct historical patterns and mechanisms shaping modern diversity and distributions. In particular, molecular data from extinct Holocene island faunas have revealed surprising biogeographic scenarios. Here, we recovered partial mitochondrial (mt) genomes for 1300–1400 year old specimens (n= 2) of the extinct “horned” crocodile, *Voay robustus*, collected from Holocene deposits in southwestern Madagascar. Phylogenetic analyses of partial mt genomes and tip-dated timetrees based on molecular, fossil, and stratigraphic data favor a sister group relationship between *Voay* and *Crocodylus* (true crocodiles). These well supported trees conflict with recent morphological systematic work that has consistently placed *Voay* within Osteolaeminae (dwarf crocodiles and kin) and provide evidence for likely homoplasy in crocodylian cranial anatomy and snout shape. The close relationship between *Voay* and *Crocodylus* lends additional context for understanding the biogeographic origins of these genera and refines competing hypotheses for the recent extinction of *Voay* from Madagascar.

Hekkala, E., Gatesy, J., Narechania, A., Meredith, R., Russello, M., Aardema, M.L., Jensen, E., Montanari, S., Brochu, C., Norell, M. and Amato, G. (2021). **Author Correction:** Paleogenomics illuminates the evolutionary history of the extinct Holocene “horned” crocodile of Madagascar, *Voay robustus*. *Communications Biology* 4(1): 648.

Gonçalves-Carneiro, D., Takata, M.A., Ong, H., Shilton, A. and Bieniasz, P.D. (2021). Origin and evolution of the zinc finger antiviral protein. *PLoS Pathogens* 17(4): e1009545.

Abstract: The human zinc finger antiviral protein (ZAP) recognizes RNA by binding to CpG dinucleotides. Mammalian transcriptomes are CpG-poor, and ZAP may have evolved to exploit this feature to specifically target non-self viral RNA. Phylogenetic analyses reveal that ZAP and its paralogue PARP12 share an ancestral gene that arose prior to extensive eukaryote divergence, and the ZAP lineage diverged from the PARP12 lineage in tetrapods. Notably, the CpG content of modern eukaryote genomes varies widely, and ZAP-like genes arose subsequent to the emergence of CpG-suppression in vertebrates. Human PARP12 exhibited no antiviral activity against wild type and CpG-enriched HIV-1, but ZAP proteins from several tetrapods had antiviral activity when expressed in human cells. In some cases, ZAP antiviral activity required a TRIM25 protein from the same or related species, suggesting functional co-evolution of these genes. Indeed, a hypervariable sequence in the N-terminal domain of ZAP contributed to species-specific TRIM25 dependence in antiviral activity assays. Crosslinking immunoprecipitation coupled with RNA sequencing revealed that ZAP proteins from human, mouse, bat and alligator exhibit a high degree of CpG-specificity, while some avian ZAP proteins appear more promiscuous. Together, these data suggest that the CpG-rich RNA directed antiviral activity of ZAP-related proteins arose in tetrapods, subsequent to the onset of CpG suppression in certain eukaryote lineages, with subsequent species-specific adaptation of cofactor requirements and RNA target specificity.

Nöthling, J.O., Myburgh, J.G. and Harper, C.K. (2020). Polygamous farmed Nile crocodiles (*Crocodylus niloticus*): Foetal membranes tell the story. *Suid-Afrikaanse Tydskrif vir Natuurwetenskap en Tegnologie* 39(1) (<https://doi.org/10.36303/SATNT.2020.39.1.750>).

Abstract: Multiple paternity in crocodylian broods would increase effective population size and slow down the loss of genetic variation due to inbreeding and random genetic drift in real populations. Multiple paternity may also explain variation among offspring of the same brood with respect to characteristics of commercial interest to crocodile farmers. Foetal membranes may provide a non-invasive source of DNA from which to determine the genotypes of Nile crocodile (*Crocodylus niloticus*) hatchlings. The aims of this study were to determine the effectiveness of using the foetal membranes remaining inside the hatched eggs to determine the genotypes of Nile crocodile hatchlings, and to determine whether a brood (the hatchlings from a clutch of eggs) from a communal breeding pond on a commercial farm may have more than one sire. DNA profiles were determined on 4–6 (mean 4.4) foetal membrane specimens (FMSs) from each of 25 broods from the same breeding pond on a commercial Nile crocodile farm. Eleven microsatellite loci were used. DNA amplification occurred at all 11 loci in 95 of the 110 genotyped individuals, at 1–10 loci in 13 and at no locus in two. Three to 20 alleles were found per locus. Single-locus assessment showed that 13 broods had at least two sires. A multilocus programme (Colony) inferred that 19 broods had at least two sires, with polyandry and polygyny being common. Further research is necessary to determine the utility of foetal membranes as a source of DNA from nests in the wild and, using more FMSs per brood, to more precisely determine the extent of polyandry and polygyny in farmed and wild Nile crocodiles.

Okoh, G.R., Horwood, P.F., Whitmore, D. and Ariel, E. (2021). Herpesviruses in reptiles. *Frontiers in Veterinary Science* 8: 642894.

Abstract: Since the 1970s, several species of herpesviruses have been identified and associated with significant diseases in reptiles. Earlier discoveries placed these viruses into different taxonomic groups on the basis of morphological and biological characteristics, while advancements in molecular methods have led to more recent descriptions of novel reptilian herpesviruses, as well as providing insight into the phylogenetic relationship of these viruses. Herpesvirus infections in reptiles are often characterised by non-pathognomonic signs including stomatitis, encephalitis,

conjunctivitis, hepatitis and proliferative lesions. With the exception of fibropapillomatosis in marine turtles, the absence of specific clinical signs has fostered misdiagnosis and underreporting of the actual disease burden in reptilian populations and hampered potential investigations that could lead to the effective control of these diseases. In addition, complex life histories, sampling bias and poor monitoring systems have limited the assessment of the impact of herpesvirus infections in wild populations and captive collections. Here we review the current published knowledge of the taxonomy, pathogenesis, pathology and epidemiology of reptilian herpesviruses.

Liew, J.H., Kho, Z.Y., Lim, R.B.H., Dingle, C., Bonebrake, T.C., Sung, Y.H. and Dudgeon, D. (2021). International socioeconomic inequality drives trade patterns in the global wildlife market. *Science Advances* 7: eabf7679.

Abstract: The wildlife trade is a major cause of species loss and a pathway for disease transmission. Socioeconomic drivers of the wildlife trade are influential at the local scale yet rarely accounted for in multinational agreements aimed at curtailing international trade in threatened species. In recent decades (1998–2018), approximately 421,000,000 threatened (ie CITES-listed) wild animals were traded between 226 nations/territories. The global trade network was more highly connected under conditions of greater international wealth inequality, when rich importers may have a larger economic advantage over poorer exporting nations/territories. Bilateral trade was driven primarily by socioeconomic factors at the supply end, with wealthier exporters likely to supply more animals to the global market. Our findings suggest that international policies for reducing the global wildlife trade should address inequalities between signatory states, possibly using incentive/compensation-driven programs modeled after other transnational environmental initiatives (eg REDD+).

Howell, H.J., Delgado, G.L., Wood, A.C., Thompson, L.M., Cline, E.A. and Searcy, C.A. (2021). A dry future for the Everglades favors invasive herpetofauna. *Biological Invasions* (<https://doi.org/10.1007/s10530-021-02562-z>).

Abstract: The Greater Everglades Ecosystem is a globally important ecoregion, home to 68 threatened or endangered species and the largest designated wilderness area in the Eastern United States. Anthropogenic manipulations of the natural hydrology have led to widespread degradation of this ecosystem and monitored population declines across multiple taxa. Simultaneous introductions of hundreds of non-native species into South Florida and their subsequent invasion into the Everglades has further impacted native Everglades communities. Predictions for future climate change suggest that the Everglades is headed towards a drier future, making it crucial to understand how changes in hydrological regimes will impact both native and non-native fauna. Our study combines the results of a landscape-scale experimental manipulation conducted to assess the impact of differing hydrological regimes at the Loxahatchee Impoundment Landscape Assessment between 2018 and 2020 with a community composition analysis of data collected across multiple habitat types throughout Everglades National Park between 2000 and 2002. Both datasets used a variety of survey methods to extensively characterize the amphibian and reptile amphibian assemblage across habitat types and hydrological regimes. An NMDS analysis indicated that variation in hydrology is the primary axis structuring reptile and amphibian habitat usage across the Everglades, with non-native species more likely to be indicators of drier habitat types. This result concurred with those from the landscape-scale manipulation, in which non-native species were significantly favored by drier hydrological conditions. Taken together, these results suggest that a drier future within the Greater Everglades Ecosystem may facilitate further spread of South Florida's diverse non-native amphibian and reptile assemblage.

Drumheller, S.K., Adams, T.L., Maddox, H. and Noto, C.R. (2021). Expanded sampling across ontogeny in *Deltasuchus motherali* (Neosuchia, Crocodyliformes): Revealing ecomorphological niche partitioning and Appalachian endemism in Cenomanian crocodyliforms. *Elements of Paleontology* ([doi 10.1017/9781009042024](https://doi.org/10.1017/9781009042024)).

Abstract: New material attributable to *Deltasuchus motherali*, a neosuchian from the Cenomanian of Texas, provides sampling across much of the ontogeny of this species. Detailed descriptions provide information about the paleobiology of this species, particularly with regards to how growth and development affected diet. Overall snout shape became progressively wider and more robust with age, suggesting that dietary shifts from juvenile to adult were not only a matter of size change, but of functional performance as well. These newly described elements provide additional characters upon which to base more robust phylogenetic analyses. The authors provide a revised diagnosis of this species, describing the new material and discussing incidents of apparent ontogenetic variation across the sampled population. The results of the ensuing phylogenetic analyses both situate *Deltasuchus* within an endemic clade of Appalachian crocodyliforms, separate and diagnosable from goniopholidids and pholidosaurs, herein referred to as Paluxysuchidae.

Hirschfeld, S.E. and Simmons, B. (2021). The non-dinosaur tracks at the Late Cretaceous tracksite, Colorado. *New Mexico Museum of Natural History and Science Bulletin* 82: 121–140.

Abstract: The Cherryvale tracksite, a Maastrichtian age Laramie Formation site discovered in 2016 southeast of Boulder, Colorado, has yielded dozens of dinosaur tracks reported by Lockley and the present authors. This article, “the subsequent publication,” reports the non-dinosaur tracks at the site, which are usually preserved on the top bedding planes of case-hardened ripple-marked sandstone layers. Identified tracks include those of turtles, crocodiles, and champsosaurs (*Champsosaurichnus*), plus traces made by invertebrates. Descriptions, including photographs and discussions about some of the over 500 remaining tracks of uncertain affinities and probable tracks of uncertain affinities, suggest that most of the trackmakers were probably turtles or crocodiles, and the footprint structures were not created by inorganic processes. The entire site has added to the diversity of tracks known from the Laramie Formation in the Denver Basin and contributes to information about other sites in the country and around the world.

Pocklington, K. (2021). *Beast, Guardian, Island: The Saltwater Crocodile (Crocodylus porosus Schneider, 1801) in Singapore, 1819–2017*. Lee Kong Chian Natural History Museum: Singapore.

Nelson Falcón-Espitia, A.J. (2021). Cranial characters in *Caiman crocodilus* (Crocodylia: Alligatoridae) with emphasis on the subspecies distributed in Colombia. *Cuadernos de herpetología* 35(1): 131–146.

Abstract: Studies on the biology of *Caiman crocodilus* have drawn attention to its biology with emphasis on systematic, taxonomy and ecology. However, anatomical aspects, such as skull characteristics, have not been studied in detail throughout its geographic range. In this study the skull characteristics for *C. crocodilus* subspecies, *C. c. fuscus*, *C. c. chiapasius*, *C. c. crocodilus*, and *C. c. apaporiensis* were analyzed using geometric morphometrics and descriptive morphology, including geographic and ontogenetic variation. Variation in skull morphology was found between the subspecies analyzed. Trans-Andean subspecies, *C. c. fuscus* and *C. c. chiapasius*, exhibit brevirostrine skulls but they are different in the contact between frontal and nasal bones and the size of the palatine process of the maxilla; therefore, populations in Colombia correspond to *C. c. fuscus* and, *C. c. chiapasius* is not distributed in Colombia. Although cis-Andean subspecies, *C. c. apaporiensis* and

C. c. crocodilus, have longirostrine skulls, both subspecies differ in the shape of the skull and in osteological characters; then, adults of *C. c. apaporiensis* present frontal and nasal in contact and, V-shape maxillary-premaxillary suture; while *C. c. crocodilus* specimens exhibit a high geographic and ontogenetic variation, supporting the hypotheses that there at least two clades of such subspecies for Colombia. These morphological differences should be considered in future systematics studies and policies on global conservation of the different *C. crocodilus* subspecies.

Bautista, N.M., Damsgaard, C., Fago, A. and Wang, T. (2021). Carbon dioxide and bicarbonate accumulation in caiman erythrocytes during diving. *Journal of Experimental Biology* 224 (9): jeb242435.

Abstract: The ability of crocodilian haemoglobins to bind HCO_3^- has been appreciated for more than half a century, but the functional implication of this exceptional mechanism has not previously been assessed *in vivo*. Therefore, the goal of the present study was to address the hypothesis that CO_2 primarily binds to haemoglobin, rather than being accumulated in plasma as in other vertebrates, during diving in caimans. Here, we demonstrate that CO_2 primarily accumulates within the erythrocyte during diving and that most of the accumulated CO_2 is bound to haemoglobin. Furthermore, we show that this HCO_3^- binding is tightly associated with the progressive blood deoxygenation during diving; therefore, crocodilians differ from the classic vertebrate pattern, where HCO_3^- accumulates in the plasma upon excretion from the erythrocytes by the $\text{Cl}^-/\text{HCO}_3^-$ exchanger.

Ramdani, Kusriani, M.D. and Prasetyo, L.D. (2021). Mapping the distribution of Saltwater Crocodile (*Crocodylus porosus*) and risks of Human-Crocodylide Conflicts in settlements around Kutai National Park, East Kalimantan. *Media Konservasi* 26(1): 52-62.

Abstract: Human-Crocodile Conflicts (HCC) are problems affecting crocodile conservation. Scientific publications on crocodile attack cases in Indonesia are few with low validation which hinder optimal conflict mitigation efforts. The estuarine river of Kutai National Park is a natural habitat for saltwater crocodiles and mostly nearby dense settlements. This study aims to map the distribution of saltwater crocodiles and potential conflicts in the Kutai National Park area. To predict the distribution of saltwater crocodiles, we used Maximum Entropy MAXENT with its environmental predictors, ie slope, altitude, distance from shore, distance from river, temperature, and habitat types (mangrove forest, freshwater swamp, and shrubs). MAXENT prediction showed that elevation was the most influential variable with AUC (Average Under Curve) value of 0.952. Settlements with activities occurring within one kilometer from the river and those adjacent to coastal areas proved to be the highest in human conflicts with crocodiles.

Young, B., Cramberg, M. and Greer, S. (2021). Functional morphology of the crocodilian diaphragm. *The FASEB Journal* (<https://doi.org/10.1096/fasebj.2021.35.S1.00152>).

Abstract: In the American alligator (*Alligator mississippiensis*) there is an intracoelomic septum, herein termed the diaphragm, which anatomically partitions the intracoelomic cavity. The diaphragm adheres to the capsule of the liver caudally and to the visceral pleura of the lung cranially; the ventrolateral portions of the diaphragm are invested with smooth muscle, the remainder is tendinous. Differential pressure transducers were implanted into the intrathoracic and intraperitoneal cavities; these allowed for the direct recording of intrathoracic (ITP) and intraperitoneal (IPP) pressures, and the determination of transdiaphragmatic pressure (TDP). Sub-adult specimens were anesthetized with isoflurane, then a mechanical ventilator delivered discrete pulses of oxygen (and isoflurane) to the lungs. Each ventilatory pulse resulted in a pulse in ITP and in IPP; however, the IPP pulses had significantly

lower amplitude, meaning that a TDP was established, and that the diaphragm was functionally capable of isolating the pleural and peritoneal cavities. Power spectral analysis of the ITP and IPP pressure traces revealed the same dominant frequency (the frequency of the ventilatory pulses) and similar harmonics which appear to be oscillations of the diaphragm. Crocodilians, including *Alligator*, have a highly mobile liver that can function in ventilation. The anesthetized alligators were tilted 30° head-up or head-down in order to displace the liver caudally or cranially. Head-up rotations caused a significant increase in IPP, and a significant decrease in ITP (which became negative). Head-down rotations caused a significant increase in ITP, and a significant decrease in IPP (which became negative). These rotations were maintained for a duration of 30s during which the ITP and IPP were always stable. During these rotations, the diaphragm maintained opposite pressures (positive or negative) in the pleural and peritoneal cavities, and established TDPs greater than have been reported for some mammals. Analysis of the IPP traces before and after rotation revealed shifts in the power spectral density in opposite directions depending on the direction of rotation; these shifts appear to reflect changes in the tensile state of the diaphragm. During these experiments the specimens would occasionally make voluntary movements similar to a breath. Two types of “breaths” were seen. The first was interpreted as a contraction of the diaphragmaticus muscle, which displaces the liver caudally; these breaths had the same effect as the head-up rotations. The second type of breath was interpreted as constriction of the thoracic and abdominal body walls; this type of breath produced pronounced, long-duration, roughly parallel, increases in ITP and IPP. These experiments demonstrate that the coelomic cavity of *A. mississippiensis* is functionally separated by a dynamic diaphragm. The presence of smooth muscle within the diaphragm indicates the possibility of higher-order adjustment or tuning of the tensile state of the diaphragm. These experiments focused on the ability of the diaphragm to maintain separate pressures in the peritoneal and pleural cavities, they were not intended to document the ventilatory, or non-ventilatory, functional role(s) of the diaphragm.

Ochoa, A., Elsey, R. and Eme, J. (2021). Effects of egg mass, hatchling size and clutch on growth of female American alligators (*Alligator mississippiensis*). *The FASEB Journal* (<https://doi.org/10.1096/fasebj.2021.35.S1.04521>).

Abstract: Growth of young American alligators (*Alligator mississippiensis*; N= 119 total animals) was measured for five clutches (N= 4-11 animals per clutch) for each of three distinct years (hatched summer 2017, 2018, or 2019). We measured egg mass within two weeks of oviposition, and all eggs were artificially incubated in the lab at 30°C and 85-95% relative humidity, which produced only female alligators. Eggs were individually numbered and labeled, and clutch identity was determined on initial collection from wild nests. Egg survival was >96%. Hatchling wet body mass, snout-to-vent length (SVL) and head length (HL) were measured within 4 days of hatching, prior to yolk absorption and first feeding. Upon hatching, alligators’ dorsal sides were photographed for identification of each hatchling’s unique markings, which allowed for matching each individual animal’s egg and hatching data with subsequent growth. We measured wet body mass, SVL and HL every 2 weeks for ~150 days (5 months) for each animal. Within each year, animals were group housed under identical thermal conditions (27-30°C) and fed a matching *ad libitum* diet of 56% protein alligator food (LoneStar, Nacogdoches, TX). Analyses indicate that egg mass and initial hatchling size, and not clutch, are the most important factors determining growth in young alligators.

Kay, D., O’Brien, H. and Gignac, P. (2021). Alveolar trough: Formalizing an *arcus alveolaris* analog in a sauropsid model. *The FASEB Journal* (<https://doi.org/10.1096/fasebj.2021.35.S1.05014>).

Abstract: Mammals and crocodylians share thecodont tooth implantation, wherein bony sockets (alveoli) enclose tooth roots.

Mammalian alveoli are composed of a thin layer of remodeled haversian bone forming the socket, and cancellous bone filling the space between the socket and the jaw elements, together forming an arcus alveolaris. The sockets act as an anchoring attachment for the periodontal ligament and support the dentition, and recent research has shown that alveoli have a role in tooth formation. Complexity in mammal heterodonty depends, in part, on alveoli mechanically constraining the developing crown: high alveolar constraint produces more complex crowns. Previously, we have shown a significant relationship between alveolar and dental crown morphologies in *Alligator mississippiensis*: as each new tooth contributes tissue to the socket wall, the alveoli limit shape variation of subsequent crown generations. In yearling caimans, alveolar bone type is identified as lamellar bundle bone; however, there is to-date no complete morphological description of the alveolar anatomy of crocodylians. In this study, we describe the unique alveolar anatomy in extant crocodylians and evaluate the need for specific anatomical terminology based on deviations from the mammalian standard. From micro-computed tomography (μ CT) data, we digitally reconstructed the jaws of embryonic, hatching, juvenile, and subadult life stages of *Alligator*, parsing alveolar bone from other jaw elements. We compared these μ CT datasets with those of model rodent species (*Microtus*, *Rattus*, *Napaeozapus*) and to the dental literature. Our results show alligators lack the mammalian-type arcus alveolus. Instead, they have a thick trough of lamellar bundle bone connected to adjacent jaw elements by thin osseous struts and direct fusion on buccal and lingual contacts. Notably, cancellous bone is absent. The trough is retained throughout ontogeny and is the foundation onto which interdental septa are added. Both trough and septa thicken with age as replacement-tooth size increases. Current anatomical terminology for alveoli fits the integrated mammalian jaw type well, but the crocodylian type is markedly different. The crocodylian alveolar condition is principally composed of a thickened trough of lamellar bundle bone, indicating a need for sauropsid-specific terminology to reflect this analogous configuration. The term alveolar trough is suggested as it has been used previously to describe alveolar features in fossil reptiles but lacks a formal definition, which we now erect. *Alveus alveolaris* (L., “alveolar trough”) - a thick channel of lamellar bundle bone in the jaws of, for example, crocodylians that provides the surface for gomphotic thecodonty and connects to jaw elements through direct fusion, but without cancellous bone. The delineation of the alveolar trough has far-reaching implications to dental form and function. Primarily, it calls attention to this apparently unique feature of crocodylian jaws, which should inform future research directions to more discretely address its development, function, and evolution. In addition, the trough - alongside interdental septa and rootedness - may help to clarify the role of tooth socket configurations as potential key innovations in tetrapod dental evolution.

Turner, M.L. and Gatesy, S.M. (2021). Alligators employ intermetatarsal reconfiguration to modulate plantigrade ground contact. *Journal of Experimental Biology* (<https://doi.org/10.1242/jeb.242240>).

Abstract: Feet must mediate substrate interactions across an animal’s entire range of limb poses used in life. Metatarsals, the ‘bones of the sole,’ are the dominant pedal skeletal elements for most tetrapods. In plantigrade species that walk on the entirety of their sole, such as living crocodylians, intermetatarsal mobility offers the potential for a continuum of reconfiguration within the foot itself. Alligator hindlimbs are capable of postural extremes from a belly sprawl to a high walk to sharp turns - how does the foot morphology dynamically accommodate these diverse demands? We implemented a hybrid combination of marker-based and markerless X-ray Reconstruction of Moving Morphology (XROMM) to measure 3-D metatarsal kinematics in three juvenile American alligators (*Alligator mississippiensis*) across their locomotor and maneuvering repertoire on a motorized treadmill and flat-surfaced arena. We found that alligators adaptively conformed their metatarsals to the ground, maintaining plantigrade contact throughout a spectrum of limb

placements with non-planar feet. Deformation of the metatarsus as a whole occurred through variable abduction (two-fold range of spread) and differential metatarsal pitching (45° arc of skew). Internally, metatarsals also underwent up to 65° of long axis rotation. Such reorientation, which correlated with skew, was constrained by the overlapping arrangement of the obliquely expanded metatarsal bases. Such a proximally overlapping metatarsal morphology is shared by fossil archosaurs and archosaur relatives. In these extinct taxa, we suggest that intermetatarsal mobility likely played a significant role in maintaining ground contact across plantigrade postural extremes.

Cavalier, R. (2021). Decision Modeling and Analysis of Micro-level Alligator Management: Application and Lessons Learned. MSc thesis, Texas State University, San Marcos, Texas.

Abstract: The need for legitimate management policies that promotes coexistence becomes critical as interactions between humans and carnivores intensify as a result of human encroachment depleting carnivore habitat and populations. Carnivores most intensely impact those living in their midst, demanding increased attention by local decision makers who are often best suited to catering to the needs of communities most affected, and yet are often overlooked in the decision-making process. Furthermore, the structure of decision-making for carnivore management at the local level is largely unexplored. The purposes of this study were to apply decision analysis to understand how carnivore management decisions are made at the local level, and develop lessons learned based on the results of this application. Multi-criteria decision analysis (MCDA) was applied to a case study of American alligator (*Alligator mississippiensis*) conservation in 10 coastal North Carolina counties to enhance the socio-political legitimacy of alligator management. Twenty-five local formal and informal decision makers who were or would be responsible for alligator management decisions as a part of their job were surveyed. Results indicate that decision makers placed nearly equal importance on wildlife- and human-specific factors when making alligator management decisions, and were most focused issues concerning public safety, alligator welfare, and public educational opportunities. Survey respondents also favored balanced and highly managed alternative management practices. Additionally, six lessons learned highlighted that investigating the structure of decision-making among local-level decision makers should enhance legitimacy of carnivore management via a concerted effort to include often-overlooked stakeholders’ perspectives on the gaps that threaten and trade-offs necessary to enhance the likelihood of humans willingly sharing space with alligators. At its core, this research addresses the potential of governing wildlife entities to develop large-scale governance processes and outcomes that increase the likelihood of coexistence between humans and crocodylian species in fast-growing coastal regions.

Pratt, E.N. (2021). Analysis of Drivers of Spring Alligator Hunting in Texas and Policy Implications. MSc thesis, Texas State University, San Marcos, Texas.

Abstract: Human-wildlife conflict, and more specifically human-carnivore conflict is a matter of particular salience among wildlife decision-makers. As conflict between large carnivores and humans increase with habitat destruction and urbanization, managers are faced with finding a balance between carnivore conservation and human appeasement. Large carnivore hunters are often the hardest group to bring on board new management decisions, as they have the most to lose. Understanding their views, hunting motivations, and acceptability of management actions can provide agencies and managers with the necessary tools to make wildlife policy changes a more seamless process. However, hunter acceptability is often overlooked in the decision-making process. To address this gap, we applied the principle-policy paradox (PPP) and potential for conflict index (PCI2) to a case study on American alligator (*Alligator mississippiensis*) hunters in non-core counties in Texas.

We surveyed 318 spring alligator hunters who had legally taken an alligator within the last five years and asked them to evaluate and indicate the level of acceptability of proposed management actions regarding the spring alligator hunting season. Results indicate that spring alligator hunters strongly oppose the removal of the spring hunting season and alternative management action show a lack of consensus among hunters. These results demonstrate that hunters exhibit a paradox between concern for alligator populations and sustainability, and policy acceptance to help achieve these conservation goals. Hunters obviously want healthy alligator populations so as to be able to continue hunting, but at the same time they may not be in favor of policies that curtail or limit hunting. We conclude that policy managers, specifically Texas Parks and Wildlife Department (TPWD) should seize this opportunity to work with hunter cognitions of alligators to introduce a policy that has positive impacts on both alligators and future alligator hunters. Future research should further explore human, ecological, climatic, and urbanizing factors and their impact on alligator dynamics as human populations continue to increase in coastal areas inhabited by alligators. Since alligators are one of the few large carnivores that can thrive in a semi-urban and suburban landscape, contemporary management of alligators no longer fits the bill.

Finger Jr., J.W., Kelley, M.D., Zhang, Y., Hamilton, M.T., Elsey, R.M., Mendonca, M.T. and Kavazis, A.N. (2021). Antioxidant enzymes in destructible and non-destructible tissues in American alligators (*Alligator mississippiensis*). *South American Journal of Herpetology* 20(1): 33-41.

Abstract: Anthropogenic-derived stressors represent an ever-increasing risk to organisms worldwide. To understand the effects of stressors on organisms, many studies measure an organism's oxidative status. American alligators (*Alligator mississippiensis*) are long-lived, top trophic carnivores that have been suggested to serve as an indicator of environmental quality. Raised tail scutes on crocodilians are often marked to enable easy subsequent identifications. Recent studies have illustrated scutes can also serve as indicators of stress or toxicant exposure. In this study, we investigated another role of scutes: as potential non-destructive (i.e., not requiring euthanasia to obtain) indicators of oxidative status. Three antioxidant enzymes, superoxide-dismutase (SOD)-1, SOD2, and glutathione peroxidase (GPX), were measured in non-destructible (ie tail scutes) and destructible tissues using Western blot. Enzyme levels were then compared with body condition and health using principal component analysis (PCA). Linear mixed models revealed that tissue had a significant effect on relative enzyme level (all $P < 0.05$). PCAs revealed significant groupings (eigenvalues > 1) of both tail scutes and destructible tissues. Levels of GPX1 in tail scutes were positively related with body condition and organ mass. Our results suggest antioxidant enzyme levels in alligator tail scutes may serve as important, non-destructive indicators of internal organ and whole-body oxidative status. In addition, tail scute antioxidants may also provide insight into alligator body condition and health. Future studies involving captive or wild individuals should incorporate measuring tail scute antioxidant enzyme levels, along with more traditional stress parameters, to better understand how stressors affect crocodilians.

Finger Jr., J.W., Kelley, M., Zhang, Y., Hamilton, M., Elsey, R., Mendonca, M. and Kavazis, A. (2021). Short-term capture stress and its effects on corticosterone levels and heat shock proteins in captive American alligators (*Alligator mississippiensis*). *Canadian Journal of Zoology* (<https://doi.org/10.1139/cjz-2021-0014>).

Abstract: Heat shock proteins (HSPs) are important mediators of the normal cellular function and the cellular stress response. As such, HSPs are often utilized to measure the effects of stressors on organisms *in vivo*. However, multiple variables can influence their expression, including time or season, confounding results. To investigate the utility of HSPs in measuring effects of stressors

in a top trophic carnivore, we captured 20 American alligators, *Alligator mississippiensis* (Daudin, 1802), placed them in burlap sacks for 2 hours and collected blood samples over four time points (baseline, 1 and 2 hours after placement into burlap sacks, and 24 hours after initial capture) to measure plasma corticosterone (the main crocodilian glucocorticoid) and levels of HSP60, HSP70, and HSP90. Time point significantly affected plasma corticosterone levels in alligators ($p < 0.0001$), with levels significantly elevated at 1, 2, and 24 hours, relative to baseline (all $p < 0.05$). However, capture stress did not affect HSP60, HSP70, or HSP90 in red blood cells (all $p > 0.05$). Our results suggest HSPs may be important biomarkers for investigating the impacts of stressors on captive and wild crocodilians, since they are not acutely elevated by capture or handling stress.

Chook, C.Y.B., Chen, F.M., Leung, F.P., Zhen-Yu Chen, Z.Y. and Wong, W.T. (2021). Potential of crocodile blood as a medication and dietary supplement: A systemic review. *Clinical and Experimental Pharmacology and Physiology* ([doi: 10.1111/1440-1681.13524](https://doi.org/10.1111/1440-1681.13524)).

Abstract: Crocodile blood has long been used as a traditional medicine in many Asian countries to treat diseases such as asthma, allergies, and many others. Yet, only recently has the safety and effectiveness of using crocodile blood as medicine been examined using modern scientific methods; with both conserved and novel active components identified from crocodile blood. Further *in vitro* and *in vivo* investigations found that crocodile blood can have a wide range of beneficial effects, including anti-microbial, anti-viral, anti-oxidative, anti-inflammatory, anti-tumour effects, anti-anaemia, and enhancement of wound healing. A systematic research of literature published in English-language journals up to April 2020 was conducted in PubMed, Google Scholar, and Web of Science. Based on the biological and chemical knowledge of crocodile immunity and crocodile blood, this article aims to: provide a critical review on the proposed properties of crocodile blood, identify the knowledge gap and offer some insights for future investigations regarding the use of crocodile blood as a medication or dietary supplement.

Tavaleri, Y.E., Alarcón, R., Tschopp, M.V., Canesini, G., Luque, E.H., Muñoz-de-Toro, M. and Galoppo, G.H. (2021). Exposure to xenoestrogens alters the expression of key morphoregulatory proteins of oviduct adenogenesis in the broad-snouted caiman (*Caiman latirostris*). *Aquatic Toxicology* ([doi: 10.1016/j.aquatox.2021.105817](https://doi.org/10.1016/j.aquatox.2021.105817)).

Abstract: Endocrine disrupting compounds (EDCs) are contaminants ubiquitously found in the environment, which pose a potential threat to aquatic and wetland ecosystems. *Caiman latirostris*, a crocodilian species that inhabits South American wetlands, is highly sensitive to EDC exposure. Previously, we reported that early postnatal exposure to EDCs such as Bisphenol A (BPA) and 17 β -Estradiol (E2) alters *C. latirostris* oviduct differentiation. The aim of this work was to elucidate the molecular mechanisms behind this alteration. To accomplish this, we established the ontogenic changes in histological features and the expression of Wnt-7a, Wnt-5a, β -catenin, FoxA2, desmin, and alpha smooth muscle actin (α -SMA) in the oviduct of *C. latirostris*. Then, we evaluated the effects of BPA and E2 exposure on these histological features and protein expressions. Our results showed that during the postnatal differentiation of the oviduct the presence of histological features related to adenogenesis is associated with the levels of expression of FoxA2, β -catenin, Wnt-5a and Wnt-7a. Early postnatal exposure to BPA and E2 decreased the presence of histological features related to adenogenesis and altered the levels of expression of FoxA2, β -catenin, Wnt-5a and Wnt-7a, as well as the desmin/ α -SMA ratio. These findings suggest that altered levels of Wnt-7a, Wnt-5a, β -catenin and FoxA2 could play a role in the BPA and E2-induced alteration in oviduct differentiation in *C. latirostris*. Thus, impaired adenogenesis and, probably, impaired reproduction in wildlife naturally exposed to BPA and other estrogenic agonists cannot be

completely ruled out.

Herndon, C., Astley, H.C., Owerkowicz, T. and Fenton, F.H. (2021). Defibrillate you later, alligator: Q10 scaling and refractoriness keeps alligators from fibrillation. *Integrative Organismal Biology* 3(1) (doi: 10.1093/iob/obaa047).

Abstract: Effective cardiac contraction during each heartbeat relies on the coordination of an electrical wave of excitation propagating across the heart. Dynamically induced heterogeneous wave propagation may fracture and initiate reentry-based cardiac arrhythmias, during which fast-rotating electrical waves lead to repeated self-excitation that compromises cardiac function and potentially results in sudden cardiac death. Species which function effectively over a large range of heart temperatures must balance the many interacting, temperature-sensitive biochemical processes to maintain normal wave propagation at all temperatures. To investigate how these species avoid dangerous states across temperatures, we optically mapped the electrical activity across the surfaces of alligator (*Alligator mississippiensis*) hearts at 23°C and 38°C over a range of physiological heart rates and compare them with that of rabbits (*Oryctolagus cuniculus*). We find that unlike rabbits, alligators show minimal changes in wave parameters (action potential duration and conduction velocity) which complement each other to retain similar electrophysiological wavelengths across temperatures and pacing frequencies. The cardiac electrophysiology of rabbits accommodates the high heart rates necessary to sustain an active and endothermic metabolism at the cost of increased risk of cardiac arrhythmia and critical vulnerability to temperature changes, whereas that of alligators allows for effective function over a range of heart temperatures without risk of cardiac electrical arrhythmias such as fibrillation, but is restricted to low heart rates.

Briggs-Gonzalez, V.S., Basille, M., Cherkiss, M.S. and Mazzotti, F.J. (2021). American crocodiles (*Crocodylus acutus*) as restoration bioindicators in the Florida Everglades. *PLoS One* 16(5): e0250510.

Abstract: The federally threatened American crocodile (*Crocodylus acutus*) is a flagship species and ecological indicator of hydrologic restoration in the Florida Everglades. We conducted a long-term capture-recapture study on the South Florida population of American crocodiles from 1978 to 2015 to evaluate the effects of restoration efforts to more historic hydrologic conditions. The study produced 10,040 crocodile capture events of 9865 individuals and more than 90% of captures were of hatchlings. Body condition and growth rates of crocodiles were highly age-structured with younger crocodiles presenting with the poorest body condition and highest growth rates. Mean crocodile body condition in this study was 2.14 ± 0.35 SD across the South Florida population. Crocodiles exposed to hypersaline conditions (>40 psu) during the dry season maintained lower body condition scores and reduced growth rate by 13% after one year, by 24% after five years, and by 29% after 10 years. Estimated hatchling survival for the South Florida population was 25% increasing with ontogeny and reaching near 90% survival at year six. Hatchling survival was 34% in NE Florida Bay relative to a 69% hatchling survival at Crocodile Lake National Wildlife Refuge and 53% in Flamingo area of Everglades National Park. Hypersaline conditions negatively affected survival, growth and body condition and was most pronounced in NE Florida Bay, where the hydrologic conditions have been most disturbed. The American crocodile, a long-lived animal, with relatively slow growth rate provides an excellent model system to measure the effects of altered hydropatterns in the Everglades landscape. These results illustrate the need for continued long-term monitoring to assess system-wide restoration outcomes and inform resource managers.

Staniscuaski, F., Kmetzsch, L., Soletti, R.C., Reichert, F., Zandonà, E., Ludwig, Z.M.C., Lima, E.F., Neumann, A., Schwartz, I.V.D., Mello-Carpes, P.B., Tamajusuku, A.S.K., Werneck, F.P.,

Ricachenevsky, F.K., Infanger, C., Seixas, A., Staats, C.C. and de Oliveira, L. (2021). Gender, race and parenthood impact academic productivity during the COVID-19 pandemic: From survey to action. *Frontiers in Psychology* 12: 663252.

Abstract: The coronavirus disease 2019 (COVID-19) pandemic is altering dynamics in academia, and people juggling remote work and domestic demands - including childcare - have felt impacts on their productivity. Female authors have faced a decrease in paper submission rates since the beginning of the pandemic period. The reasons for this decline in women's productivity need to be further investigated. Here, we analyzed the influence of gender, parenthood and race on academic productivity during the pandemic period based on a survey answered by 3345 Brazilian academics from various knowledge areas and research institutions. Productivity was assessed by the ability to submit papers as planned and to meet deadlines during the initial period of social isolation in Brazil. The findings revealed that male academics - especially those without children - are the least affected group, whereas Black women and mothers are the most impacted groups. These impacts are likely a consequence of the well-known unequal division of domestic labor between men and women, which has been exacerbated during the pandemic. Additionally, our results highlight that racism strongly persists in academia, especially against Black women. The pandemic will have long-term effects on the career progression of the most affected groups. The results presented here are crucial for the development of actions and policies that aim to avoid further deepening the gender gap in academia.

Ragaza, J.A., Velasquez, S.F., Asuncion, M.S.M., Torres, E.M.F., Manalo, R. and Freitag, H. (2021). Serum biochemical profile of captive-bred Philippine crocodiles (*Crocodylus mindorensis* Schmidt, 1935) sub-adults. *Philippine Journal of Science* 150(3): 941-946.

Abstract: The Philippine crocodile (*Crocodylus mindorensis* Schmidt, 1935) is a critically endangered species that necessitate minimally invasive diagnostic tools for their physiological state and health assessment. In the current study, we determined the reference ranges for the serum biochemistry of male and female captive-bred *C. mindorensis* sub-adults. We collected blood samples from the post-occipital venous sinus of 6 male and 7 female captive-bred sub-adult crocodiles at the Palawan Wildlife Rescue and Conservation Center and quantified the serum biochemical values for cholesterol, triglycerides, uric acid, glucose, creatinine, aspartate aminotransferase (AST), alanine aminotransferase (ALT), albumin, total protein, and globulin. We defined reference ranges through the central 95% of the concentration values obtained. The uric acid concentrations were significantly different between male and female *C. mindorensis* sub-adults. Uric acid levels were higher ($P=0.035$) in male sub-adults because of their higher food intake resulting from dominance and aggression during feeding times. Serum biochemical values of *C. mindorensis* exhibited similarities with and variations from other crocodile species. We briefly discussed the differences with other species and the influence of factors such as field and laboratory methodologies, environmental conditions, nutritional status, and size class.

Economist Intelligence Unit (2021). *An Eco-wakening: Measuring Global Awareness, Engagement and Action for Nature*. The Economist Intelligence Unit Limited: London. 50pp. (Report commissioned by WWF).

“An Eco-Wakening: Measuring global engagement, awareness and action for nature” is an Economist Intelligence Unit (EIU) report commissioned by the World Wide Fund for Nature (WWF). The findings are based on an extensive literature review, insights from an expert panel and a modelling exercise conducted by the EIU between May and December 2020. The EIU bears sole responsibility for the content of this report. The findings and views expressed do not

necessarily reflect the views of partners, sponsors or experts. The Economist Intelligence Unit convened a panel of experts on August 26th, 2020 to discuss the research framework and project goals.

Dave, U. and Bhatt, N. (2021). Basking behavior of Marsh crocodiles (*Crocodylus palustris*) in Pond Deva, Anand District, Gujarat, India. *Reptiles & Amphibians* 28(1): 26-29.

Gonzalez-Desales, G.A., Sigler, L., Garcia-Grajales, J. Charruau, P., Zarco-Gonzalez, M.M., Balbuena-Serrano, A. and Monroy-Vilchis, O. (2021). Factors influencing the occurrence of negative interactions between people and crocodilians in Mexico. *Oryx* (doi:10.1017/S0030605319000668).

Abstract: Negative interactions between people and crocodilians have increased worldwide, but in Mexico there have been few systematic reports and no rigorous evaluation of this problem. We compiled information on negative interactions between people and the Spectacled caiman *Caiman crocodilus* and American crocodile *Crocodylus acutus* from the Worldwide Crocodilian Attack Database for 1993-2018, and we investigated interactions in greater depth, through interviews with people in La Encrucijada Biosphere Reserve. We examined the relationship between the occurrence of negative interactions between people and *C. acutus* and the species' nesting season and abundance, and presence records. In Mexico, the frequency of negative interactions increases when anthropogenic activities occur close to nesting sites (<30 km) and during the nesting season (February-September). In La Encrucijada, following negative interactions with crocodiles, the local inhabitants killed 30 crocodiles measuring >2.5 m long in 2011-2012. The frequency of negative human-crocodilian interactions was not correlated with the abundance of crocodilians but was correlated with the number of presence records of crocodiles. Strategies to minimize these interactions include warnings at nesting sites, increased monitoring of anthropogenic activities during the nesting season, and management of nests to prevent them being destroyed by people.

Fernández Dumont, M.L., Pereyra, M.E., Bona, P. and Apesteguía, S. (2021). New data on the palaeosteohistology and growth dynamic of the notosuchian *Araripesuchus* Price, 1959. *Lethaia* (https://doi.org/10.1111/let.12423).

Abstract: Notosuchian crocodyliforms represent an intriguing group since they are mainly terrestrial forms and therefore with completely different lifestyles than extant crocodylian, which is reflected in their particular skeletal anatomy. Although there are some inferences in the literature related to the palaeoecology of notosuchian, little is known about their biology (eg metabolism, growth dynamics). The palaeohistology allows us to perform interpretations about the growth dynamics and strategies of growth in these extinct forms. Here, we worked on specimens of *Araripesuchus* Price, 1959 (Notosuchia, Uruguaysuchidae), coming from La Buitrera Palaeontological Area, Río Negro Province (northern Patagonia, Argentina). We described for the first time the osteohistology of this taxon, based on thin sections of the stylopodium shaft (femur and humerus) of four specimens, providing an assumption of its growth dynamics. A general slow growth rate is inferred for *Araripesuchus*, based on the poorly vascularized parallel-fibred/lamellar bone matrix. An unusual pattern of bone deposition was observed in two specimens; we consider this tissue as evidence of a rapid growth event at some point in the ontogeny of these individuals. Finally, it can be interpreted that in *Araripesuchus*, sexual maturity could be reached at least between 8 to 13 years old. This study is a first step to provide insight into the life history of these terrestrial notosuchids and to provide new empirical evidence for the osteohistological variability and palaeoecology of this peculiar group of extinct crocodyliforms.

Latip, M.Q.A., Azizan, T.R.P.T., Ahmad, H., Hassim, H.A., Noor,

M.H.M. and Mikail, M. (2021). Blood profiling of captive and semi-wild False Gharial in Peninsular Malaysia. *Animals* 11 (https://doi.org/10.3390/ani11061481).

Abstract: The involvement of veterinary medicine in wildlife research has played an important role in understanding the health status of various wildlife species. Health status is a very important aspect of species conservation. However, it requires a widely employed knowledge of veterinary clinical pathology, as a diagnostic tool in diagnosing the various disease conditions of wildlife species. Notwithstanding, a gap exists in the literature about the clinical pathology of the False Gharial (*Tomistoma schlegelii*), due to the lack of normal reference values for hematological and serum biochemical analysis. The present study investigated the normal blood profile of 10 healthy False Gharials, from two different zoos, and wildlife conservation centers located in three different states of Peninsular Malaysia. Blood samples were collected from the lateral caudal vein and divided into a vacutainer without anticoagulant for biochemical analysis, and a lithium heparin vacutainer (containing sodium heparin) for hematological studies. The results of the study indicated that the False Gharial has a smaller erythrocyte dimension compared to other crocodilian species. At the same time the study revealed that the false gharial in a natural captive pond showed more leukocytes than False Gharial kept in zoos, hence, habitat and environmental factors significantly affect hematological values. The biochemistry values also showed differences between the False Gharial in different environmental conditions. Total protein, albumin (Alb), globulin (Glob), and Alb: Glob ratio were higher in False Gharials kept in wildlife conservation centers than in False Gharials kept in zoos. The values obtained in this study provide baseline data of hematological and serum biochemical values of the False Gharial for future research and routine clinical diagnosis.

Balaguera-Reina, S.A., Vargas-Castillo, A. and Densmore, L.D. (2021). Population ecology of the spectacled caiman (*Caiman crocodilus*) in the Apaporis River middle basin. *Ecosphere* 12(5): e03532.

Abstract: Population ecology studies on spectacled caimans (*Caiman crocodilus*) in Colombia have been few and far between with many covering short periods and defining population parameters based on relative indices (ie individuals/km). This reflects a lack of information on the general effects that environmental variables have on annual cycles of population dynamics, as well as a bias in abundance estimations due to the uncertainty of detection error. Keeping this in mind, we assessed the abundance and demographic structure of the spectacled caiman population inhabiting the Apaporis River middle basin over a year, based on robust hierarchical model that accounts for imperfect detection. We recorded a total of 1156 caiman observations between December 2018 and November 2019, estimating an average predicted value for abundance across all surveys of 29.99 ± 13.17 individuals, slowly increasing as the transect length increases and increasing variation as months passed by. The average detection probability was 0.69 ± 0.25 across all surveys, with no apparent effect as water temperature and relative humidity change across space-time and slowly decreasing as months go through. The population size estimated based on the topperforming model was 1763 ± 786 caimans across ~ 7.1 km² assessed. We estimate the commonly used relative abundance (encounter rate) index as well as a generalized linear model and discuss how those relate with the values predicted by N-mixture models. We also discuss the relevance and cautions researchers should have when using N-mixture models to better understand spectacled caiman ecology.

Gao, H., Lin, J., Jia, X., Zhao, Y., Wang, S., Bai, H. and Ma, Q. (2021). Real-time authentication of animal species origin of leather products using rapid evaporative ionization mass spectrometry and chemometric analysis. *Talanta* (doi: 10.1016/j.talanta.2020.122069).

Abstract: Increasing accounts of fraud and persistent labeling problems have brought the authenticity of leather products into question. In this study, we developed an extremely simplified workflow for real-time, in situ, and unambiguous authentication of leather samples using rapid evaporative ionization mass spectrometry (REIMS) coupled with an electric soldering iron. Initially, authentic leather samples from cattle, sheep, pig, deer, ostrich, crocodile, and snake were used to create a chemometric model based on principal component analysis and linear discriminant analysis algorithms. The validated multivariate statistical model was then used to analyze and generate live classifications of commercial leather samples. In addition to REIMS analysis, the microstructures of leathers were characterized by scanning electron microscopy to provide complementary information. The current study is expected to provide a high-throughput tool with superior efficiency and accuracy for authenticating the identity of leathers and other consumer products of biogenic origin.

Pritz, M.B. (2021). Thalamic reticular nucleus in *Alligator mississippiensis*: Soma and dendritic morphology. *Journal of Comparative Neurology* (doi: 10.1002/cne.25194).

Abstract: The thalamic reticular nucleus (TRN) is a critical structure influencing information transfer to the forebrain. In crocodilians, the TRN shares many features with its mammalian counterpart. One area that has not been explored is how individual neurons in the crocodilian TRN compare with those found in mammals. In mammals, TRN neurons are aligned parallel to the external border of the dorsal thalamus, have their dendrites oriented perpendicular to the fibers in the internal capsule, have fine, filamentous dendritic appendages, are either bipolar or multipolar, and are commonly considered to be a homogeneous morphological population of cells. To investigate the cellular morphology of the TRN complex, a Golgi analysis was undertaken in *Alligator mississippiensis*. This study examined features that have been used in mammals. In *Alligator*, the 4 TRN divisions are the dorsal peduncular nucleus, the perireticular nucleus, the interstitial nucleus, and the neurons in the medial forebrain bundle associated with the interstitial nucleus. In crocodilians, the dorsal peduncular nucleus is homologous to the TRN of mammals. From the 1787 drawn neuron profiles in the traditional 3 planes of section, the following were concluded. First, neurons in each part of the TRN complex in *Alligator* were similar in morphology. Second, each part of the TRN complex of *Alligator* contained a heterogeneous population of cells. These variations between the cellular morphology of the dorsal peduncular nucleus of crocodilians and the TRN of mammals are speculated to partly result from differences in forebrain organization.

De Buffrénil, V., Quilhac, A. and Castanet, J. (2021). Cyclical growth and skeletochronology. *In* *Vertebrate Skeletal Histology and Paleohistology*, ed. by V. de Buffrénil, A.J. de Ricqlès, L. Zylberberg and K. Padian. CRC Press: Boca Raton.

Abstract: Skeletochronology is a method for the absolute determination of individual age in vertebrates. It is based on the use of the cyclical growth marks shown by cross sections in long bone cortices and teeth. This method is usable in extant as well as extinct taxa and allows absolute age estimates, in number of years. Cyclical growth marks are also excellent indicators of the growth pattern and local morphogenetic development of skeletal elements. The present review exposes the structural characteristics of these marks, their ecophysiological meaning, the kind of data they can yield and the methodological and technical requirements of their use. An overview of the practical results of skeletochronology is presented.

De Buffrénil, V., Laurin, M. and Jouve, S. (2021). Archosauromorpha: The Crocodylomorpha. *In* *Vertebrate Skeletal Histology and Paleohistology*, ed. by V. de Buffrénil, A.J. de Ricqlès, L. Zylberberg and K. Padian. CRC Press: Boca Raton.

Abstract: The Crocodylomorpha, one of the three main archosaurian clades, form a large and diversified group spanning from the early Late Triassic (Carnian) to the present. During its long evolutionary history, Crocodylomorphs developed three broad adaptations: terrestrial and cursorial in the earliest taxa (the Sphenosuchia) and the Cenozoic Notosuchia; amphibious in many taxa since the Middle Jurassic, especially the Eusuchia and marine in the Mesozoic Thalattosuchia and Tethysuchia. Bone microstructures in crocodilian are relatively consistent among taxa. At a microanatomical level, long bones are tubular and robust, with high corticodiaphyseal index and compactness values. However, in the most specialized Thalattosuchia, the Metriorhynchids, the bones are much more cancellous. Histologically, periosteal cortices in all groups, except the Notosuchia, consist of lamellar-zonal tissue with very conspicuous cyclical growth marks. This tissue generally displays abundant, geometrically variable vascular networks and is submitted to active Haversian remodeling that can locally create dense Haversian bone. Conversely, bone cortices of the Notosuchia are made of poorly vascularized parallel or lamellar tissues void of significant Haversian remodeling. After describing in detail the microstructures of crocodilian bones, this chapter considers the issue in terms of habitat and ecophysiological adaptations.

Clarac, F. (2021). Bone ornamentation: Deciphering the functional meaning of an enigmatic feature. *In* *Vertebrate Skeletal Histology and Paleohistology*, ed. by V. de Buffrénil, A.J. de Ricqlès, L. Zylberberg and K. Padian. CRC Press: Boca Raton.

Abstract: Bone ornamentation consists of regular sculptural patterns on the outer surface of dermal bones in vertebrates. The first occurrence of this feature traces back to the Paleozoic and might have been linked to the regression of cosmine in early vertebrates, when the odontodes were replaced by bony tubercles forming repetitive reliefs on bone surface. The phenotypic expression of bone ornamentation persisted in nonteleost actinopterygians, stem tetrapods and stem amphibians but was lost in other taxa, although some teleosts and crown tetrapods secondarily evolved bone sculpture during the Mesozoic. Bone ornamentation may result either from local differences in accretion rate or from a specific (imbalanced) remodeling pattern on the outer cortex of dermal bones. The function of this feature has been debated. Recent studies in crocodylomorphs supported the existence of a link between ecophysiological adaptations, ie heat transfers during basking and probably also acidosis buffering during long apnea, and bone ornamentation, via the superficial vascular networks located between the sculptural reliefs. Further investigations are needed to understand the actual role(s) of bone ornamentation in species adaptations and evolution.

Padian, K. and Woodward, H.N. (2021). Archosauromorpha: Avemetatarsalia - Dinosaurs and their relatives. *In* *Vertebrate Skeletal Histology and Paleohistology*, ed. by V. de Buffrénil, A.J. de Ricqlès, L. Zylberberg and K. Padian. CRC Press: Boca Raton.

Abstract: The histological features of Dinosauria and its relatives (Pan-Aves, the stem-group for birds, comprising also pterosaurs and a variety of other basal avemetatarsalians) are surprisingly varied in tissue type and expression, notably with ontogenetic stage and with adult size of the taxon in question. As a group, compared to other archosauromorphs and other reptiles, this clade generally expresses higher growth rates, characterized by the predominance of the fibrolamellar complex, extensive resorption of inner cortical tissue (and hence generally larger medullary cavities), higher osteocyte density and higher density of vascular canals, with a predominance of radial and circumferential canals, frequently anastomosing, especially present at younger ontogenetic stages. Secondary (Haversian) osteons can be found, especially in smaller elements of the skeleton (metapodials, ribs) and in the inner cortices of larger elements (femur, tibia) at later stages of growth. Birds inherited the growth patterns of small theropod dinosaurs from which they arose

and tended to evolve thinner bone walls and flight-adaptive bone tissues. An increase in growth rate, reflecting rapid development and skeletal maturation before the onset of reproductive maturity, appears to have evolved in the latest Cretaceous at or shortly before the origin of crown-group birds. In describing the osteohistological patterns of Archosauromorpha for this book, we have divided the group into three stages, the first necessarily paraphyletic. We begin with “non-archosaurian archosauromorphs,” that is, those outside the crown-group Archosauria, which comprises birds and crocodylians plus all descendants of their most recent common ancestor. The crocodile stem-group is Pan-Crocodylia, called Pseudosuchia (Gauthier 1984), and the bird stem-group (Pan-Aves) was named Ornithosuchia by Gauthier (1984). Some objected that Ornithosuchia was an inappropriate name when the Ornithosuchidae was found to belong within Pseudosuchia, and the name Avemetatarsalia was suggested as a substitute. Within Avemetatarsalia, a node-taxon that unites Pterosauria and Dinosauria is called Ornithodira; the two stems of this group are Pterosauromorpha and Dinosauromorpha, the latter comprising dinosaurs (including birds) and several taxa close to dinosaurs. Most work has been done on the Ornithodira, particularly dinosaurs. We try to document, in a very preliminary way, some of the osteohistological patterns that seem to emerge from work that has so far been published on all these lineages.

Chaiwattanarungruengpaisan, S., Thongdee, M., Anuntakarn, S., Payungporn, S., Arya, N., Punchukrang, A., Ramasoota, P., Singhakaw, S., Atitthep, T. and Sariya, L. (2021). A new species of *Chlamydia* isolated from Siamese crocodiles (*Crocodylus siamensis*). PLoS ONE 16(5): e0252081.

Abstract: Chlamydia is a known pathogen in both saltwater and freshwater crocodiles. However, the exact species/strain has not been clearly identified. In this study, we successfully cultivated Siamese crocodile *Chlamydia* in McCoy cells at a temperature of 30°C. Electron microscopy; phylogeny based on 9 conserved taxonomically informative markers, on ompA, or on 7 housekeeping genes; and whole-genome sequencing and analysis of the isolate confirmed the identity of the isolate as a new member of the genus *Chlamydia*, a new species that we name *Chlamydia crocodili*.

Rainwater, T.R., Woodward, H.N., Woodward, A.R. and Wilkinson, P.M. (2021). Evidence of determinate growth in an American alligator (*Alligator mississippiensis*) based on long-term recapture and osteohistological confirmation. Anatomical Record (Hoboken) (doi: 10.1002/ar.24688).

Abstract: Despite the general perception that crocodilians exhibit indeterminate growth, recent long-term field studies and laboratory investigations have independently suggested that growth in these animals is determinate. In this study, we had the unique opportunity to examine skeletal growth in a wild adult American alligator (*Alligator mississippiensis*) based on change in body length measurements (snout-vent length) in the field and confirm these findings using osteohistological analyses (presence/absence of an external fundamental system [EFS]) of long bones. The alligator was captured and measured five times over 7 years and exhibited no discernable growth during that period, suggesting skeletal maturity had been attained at or prior to its first capture. Our field assessment of determinate growth in this alligator was osteohistologically confirmed by the presence of an EFS in the animal's humerus, femur, tibia, and fibula. To our knowledge, this study is the first to report determinate growth in a wild crocodilian using both field and laboratory methods, providing further evidence of this growth pattern in crocodilians.

Lara, R.B., Grajales, J.G. and Ramírez, E.M. (2021). Nest temperature assessment in an American crocodile (*Crocodylus acutus*) population on the central coast of Oaxaca, Mexico. Journal of Thermal Biology (https://doi.org/10.1016/j.jtherbio.2021.103012).

Abstract: The temperatures at which eggs of crocodilians are incubated plays an important role in embryo survival, rate of embryonic development and sex definition. The aim of this study was to assess the nest temperatures of an American crocodile (*Crocodylus acutus*) population on the central coast of Oaxaca state in Mexico. The fieldwork was carried out from February to June 2018 at Palmasola Lagoon, Oaxaca. Ten natural nests of *C. acutus* were carefully excavated to determine clutch size. When putting the eggs back in the nests, we placed a data logger in the center of the egg mass to determine the temperature parameters in the nest chamber environment, as well as the variation in temperature during the incubation period. All nests were revisited to count the number of hatched eggs (NHE) and to determine the hatching success (HS), along with the duration of the incubation period (IP). Hatching success was 89.04%. The mean clutch size in the American crocodile nests was 30.7 ± 7.83 eggs (ranging from 17 to 46 eggs), and the mean incubation period was 77.6 ± 5.89 days. The mean nest incubation temperature throughout the reproductive season was significantly different among nests. Based on the average temperature during the middle third of the incubation period, the nests should have produced both sexes, but with a higher proportion of males. This study tried to elucidate the impact of nest temperatures during the incubation period on embryo survival, as well as hatchling sex ratio in a local climate on the central coast of Oaxaca.

Knight, K. (2021). Alligators' metatarsals rotate and skew as they twist and turn. Journal of Experimental Biology 224 (doi:10.1242/jeb.242786).

Siddiqui, R., Soares, N.C. and Khan, N.A. (2021). Crocodile gut microbiome is a potential source of novel bioactive molecules. ACS Pharmacology and Translational Science 4(3): 1260-1261.

Abstract: Here, it is proposed that the crocodile gut microbiome is a valuable biomaterials resource to counter threats posed by environmental and infectious hazards to the existence of *Homo sapiens*.

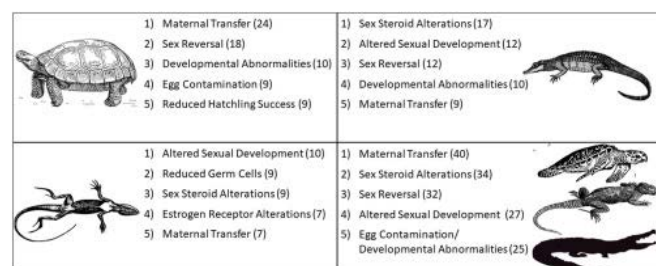
Okamoto, K., Dopkins, N. and Kinfu, E. (2021). A draft genome sequence of the common, or spectacled caiman *Caiman crocodilus*. 2021. HAL (https://hal.archives-ouvertes.fr/hal-03241670).

Abstract: The common, or spectacled, caiman *Caiman crocodilus* is an abundant, widely distributed Neotropical crocodilian exhibiting notable morphological and molecular diversification. The species also accounts by far for the largest share of crocodilian hides on the global market, with the *C. crocodilus* hide trade alone valued at about \$US86.5 million per year. We obtained 239,911,946 paired-end reads comprising approximately 72 G bases using Illumina sequencing of tissue sampled from a single *Caiman crocodilus* individual. These reads were de-novo assembled and progressively aligned against the genomes of increasingly related crocodilians; liftoff was used to annotate the draft *C. crocodilus* genome assembly based on an *Alligator mississippiensis* (a congeneric species) annotation. The draft assembly and annotation are available at: doi.org/10.5281/zenodo.4755063.

Barraza, A.D., Finlayson, K.A., Leusch, F.D.L. and Van de Merwe, J.P. (2021). Systemic review of reptile reproductive toxicology to inform future research directions on endangered or threatened species, such as sea turtles. Environmental Pollution (https://doi.org/10.1016/j.envpol.2021.117470).

Abstract: Threatened or endangered reptiles, such as sea turtles, are generally understudied within the field of wildlife toxicology, with even fewer studies on how contaminants affect threatened species reproduction. This paper aimed to better inform threatened species conservation by systematically and quantitatively reviewing

available research on the reproductive toxicology of all reptiles, threatened and non-threatened. This review found 178 studies that matched our search criteria. These papers were categorized into location conducted, taxa studied, species studied, effects found, and chemicals investigated. The most studied taxa were turtles (n= 87 studies, 49%), alligators/crocodiles (n= 54, 30%), and lizards (n= 37, 21%). Maternal transfer, sex steroid alterations, sex reversal, altered sexual development, developmental abnormalities, and egg contamination were the most common effects found across all reptile taxa, providing guidance for avenues of research into threatened species. Maternal transfer of contaminants was found across all taxa, and taking into account the foraging behavior of sea turtles, could help elucidate differences in maternal transfer seen at nesting beaches. Sex steroid alterations were a common effect found with contaminant exposure, indicating the potential to use sex steroids as biomarkers along with traditional biomarkers such as vitellogenin. Sex reversal through chemical exposure was commonly found among species that exhibit temperature dependent sex determination, indicating the potential for both environmental pollution and climate change to disrupt population dynamics of many reptile species, including sea turtles. Few studies used *in vitro*, DNA, or molecular methodologies, indicating the need for more research using high-throughput, non-invasive, and cost-effective tools for threatened species research. The prevalence of developmental abnormalities and altered sexual development and function indicates the need to further study how anthropogenic pollutants affect reproductive output in threatened reptiles.



Blas, X.P.I., Baddeley, R. and Fennell, J. (2021). Testing the utility of Gaussian Mixture Models in parataxonomic classification of fossil eggs. *Palarch's Journal of Vertebrate Palaeontology* 17(3): 1-13.

Abstract: Fossil eggs and eggshells are very seldom associated with skeletal or dermal remains and can rarely be assigned taxonomically. This has resulted in oologists creating an alternative classification system for fossil eggs and eggshells: the parataxonomy of fossil eggs. Under parataxonomy, fossil eggs are classified in oospecies, oogenera and oofamilies according to qualitative microstructural characters (eg shape of the shell units and ornamentation) and highly heritable quantitative characters (eg height of unit, HU, and width of unit, WU). *Megaloolithus* oospecies is an egg type previously partially attributed to both titanosaurian and hadrosaurid dinosaurs. These oospecies are defined by the shape of their units and the quantification of the morphometric variation and variability of their microstructures (HU and WU of eggshell units). Two competing interpretations of the observed morphological variation of the eggshell units have been proposed: 1) different megaloolithic morphologies are indicative of different dinosaur species; and 2) the same dinosaur species was responsible for all the variation seen in megaloolithic eggshell units. In this study, a Gaussian mixture model was applied to test both interpretations. This probabilistic model assumes all the data points are generated from a mixture of a finite number of Gaussian distributions with unknown parameters. We compared the morphometric distributions of HU and WU in eggshells, eggs and clutches belonging to six *Megaloolithus* oospecies from Catalonia to the defined morphometric variation seen in the eggshell microstructures of two extant turtle species and two crocodile species. The resulting Gaussian model was best defined for four distributions of HU and WU representing the extant turtle and crocodile oospecies, and three distributions

consisting of one or more *Megaloolithus* oospecies. It was inferred that *Megaloolithus* oospecies from the Late Cretaceous of Catalonia depict the polymorphism of a monotypic taxon and were laid by a single dinosaur species.

Ruane, S. (2021). New data from old specimens. *Ichthyology & Herpetology* 109(2): 392-396.

Abstract: Museums provide a wealth of scientific information via preserved natural history specimens, including but not limited to dietary, morphological, and geographic distributions of organisms. In the modern molecular age, however, fluid-preserved museum collections have not always been at the frontline for generating useable data, despite the fact that for some species, only museum specimens are known, with no fresh genetic materials available. We are now at a major shift in our ability to use museum specimens for molecular phylogenetics, where modern subgenomic sequencing techniques better allow for successfully sequencing hundreds to thousands of phylogenetically informative loci for historical specimens, including formalin- and fluid-preserved amphibians and reptiles. Here, I review the current state of the field, with respect to studies which have successfully generated high-throughput molecular datasets using fluid-preserved specimens for herpetofauna, particularly for systematic studies. Although only six publications fitting the search criteria were found, these studies provide a wealth of knowledge on the uses of museum herpetological specimens for modern work and illustrate just how important historical specimens are for enhancing our current understanding of species genetic structure, phylogenetic placements, and for disentangling taxonomic conundrums. In an age where both museums and general collecting come under critique from the general public, this review emphasizes the continued importance of museum specimens across all subfields in the study of amphibians and reptiles.

Amoah, E., Danquah, E. and Ross, J.P. (2021). Nesting ecology of West African Dwarf Crocodiles in a heavily disturbed landscape in Chirehin, Ghana. *International Journal of Ecology* 2021 (<https://doi.org/10.1155/2021/8871631>).

Abstract: West African dwarf crocodiles (*Osteolaemus* sp. nov. cf. *tetraspis*) are among the most threatened crocodylians in the world due to unregulated hunting and habitat loss-related population decline. Despite this, many questions about their basic ecology remain unanswered and this inadequate data hampers effective dwarf crocodile management. We describe incubation temperature, nesting success, hatching rate, and clutch size of West African dwarf crocodiles. We monitored 18 nests from the 2017 and 2018 nesting seasons in the Chirehin Community Land - a highly disturbed agricultural matrix in the climatic transition zone of Ghana. We used Hobo tidbit® data loggers to monitor egg chamber temperature and the effect of ambient temperature on nest temperature. The daily mean incubation temperature recorded during the study was 30.7°C (\pm SD= 0.8°C, n= 240, range= 28-33°C) and it is congruent with the reported value for the species. The findings from this study suggest a weak positive to no correlation between dwarf crocodile incubation temperature and ambient temperature indicating nest temperature is almost independent of ambient temperature. We found a mean clutch size of 8 eggs per nest (SD= \pm 2; range= 5-13; n= 17) supporting previous reports that this genus has a low clutch size. The mean nesting success and hatching success across the two seasons were 77.8% and 75.3% (SD= \pm 41.9, n= 18), respectively. Three nests were destroyed by flood and one by an unknown predator suspected to be a West African Nile monitor lizard. Generally, dwarf crocodiles selected forest patches within the highly disturbed landscape for nesting indicating the need to protect the remaining forest patches. Efforts should be made to repeat the study across this species' range for an improved understanding of its nesting ecology.

Oliveira, V.C.S., Altmanová, M., Viana, P.F., Ezaz, T., Bertollo,

L.A.C., Ráb, P., Liehr, T., Al-Rikabi, A., Feldberg, E., Hatanaka, T., Scholz, S., Meurer, A. and de Bello Cioffi, M. (2021). Revisiting the karyotypes of alligators and caimans (Crocodylia, Alligatoridae) after a half-century delay: Bridging the gap in the chromosomal evolution of reptiles. *Cells* 10(6): 1397 (<https://doi.org/10.3390/cells10061397>).

Abstract: Although crocodylians have attracted enormous attention in other research fields, from the cytogenetic point of view, this group remains understudied. Here, we analyzed the karyotypes of 8 species formally described from the Alligatoridae family using differential staining, fluorescence *in situ* hybridization with rDNA and repetitive motifs as a probe, whole chromosome painting (WCP), and comparative genome hybridization. All Caimaninae species have a diploid chromosome number (2n) 42 and karyotypes dominated by acrocentric chromosomes, in contrast to both species of Alligatorinae, which have 2n= 32 and karyotypes that are predominantly metacentric, suggesting fusion/fission rearrangements. Our WCP results supported this scenario by revealing the homeology of the largest metacentric pair present in both *Alligator* spp. with two smaller pairs of acrocentrics in Caimaninae species. The clusters of 18S rDNA were found on one chromosome pair in all species, except for *Paleosuchus* spp., which possessed three chromosome pairs bearing these sites. Similarly, comparative genomic hybridization demonstrated an advanced stage of sequence divergence among the caiman genomes, with *Paleosuchus* standing out as the most divergent. Thus, although Alligatoridae exhibited rather low species diversity and some level of karyotype stasis, their genomic content indicates that they are not as conserved as previously thought. These new data deepen the discussion of cytotaxonomy in this family.

Bae, J., Bertucci, E.M., Bock, S.L., Hale, M.D., Moore, J., Wilkinson, P.M., Rainwater, T.R., Bowden, J.A., Koal, T., PhamTuan, H. and Parrott, B.B. (2021). Intrinsic and extrinsic factors interact during development to influence telomere length in a long-lived reptile. *Molecular Ecology* (doi: 10.1111/mec.16017).

Abstract: The mechanisms connecting environmental conditions to plasticity in biological aging trajectories are fundamental to understanding individual variation in functional traits and life history. Recent findings suggest that telomere biology is especially dynamic during early life stages and has long-term consequences for subsequent reproduction and survival. However, our current understanding is mostly derived from studies investigating ecological and anthropogenic factors separately, leaving the effects of complex environmental interactions unresolved. American alligators (*Alligator mississippiensis*) are long-lived apex predators that rely on incubation temperature during a discrete period during development and endocrine cues to determine sex, making them especially vulnerable to current climatic variability and exposure to anthropogenic contaminants interfering with hormone function. Here, we combine field studies with a factorial design to understand how the developmental environment, along with intrinsic biological variation contribute to persistent telomere variation. We find that exposure to a common endocrine disrupting contaminant, DDE, affects telomere length, but that the directionality is highly dependent upon incubation temperature. Variation in hatchling growth, underlies a strong clutch effect. We also assess concentrations of a panel of glucocorticoid hormones and find that contaminant exposure elicits an increase in circulating glucocorticoids. Consistent with emerging evidence linking stress and aging trajectories, GC levels also appear to trend with shorter telomere length. Thus, we add support for a mechanistic link between contaminants and glucocorticoid signaling, which interacts with ecological aspects of the developmental environment to alter telomere dynamics.

Meccarelli, M. (2021). Discovering the Long: Current theories and trends in research on the Chinese dragon. *Frontiers of History in China* 16(1): 123-142.

Abstract: After the 1980s, the world started addressing the challenges posed by economic globalization, and the protection of cultural diversity became a widely discussed topic. Today, China is experiencing problems in defining the relationship between the past and present, as well as that between tradition and modernity. Since the 1990s, China's opening-up policy, the advent of globalization, and an increase in cross-cultural communications strengthened the country's need to preserve its cultural heritage. Many Chinese scholars reflected on the past and examined the potential of archaeological materials, inscriptions, myths, and ancient legends to explain the relationship between tradition and modernity. The birth and evolution of the "long", or the Chinese dragon, remains at the core of such international studies. These studies highlighted the necessity of promoting discussions on and demystifying the long. This new perspective facilitates a connection between various theories on the origin of the Chinese dragon and the contemporary identity discourse, which has attracted the attention of Chinese scholars. This paper bridges the gap by introducing reliable theories on the origin of the mythical animal and focusing on typology issues, classification, latest debates on the distinction between the long and the dragons of other cultures, and finally, main theories on the visual representation of the Chinese long.

Scavezzoni, I. and Fischer, V. (2021). The postcranial skeleton of *Cerrejonisuchus improcerus* (Crocodyliformes: Dyrosauridae) and the unusual anatomy of dyrosaurids. *PeerJ* 9: e11222.

Abstract: Dyrosauridae is a clade of neosuchian crocodyliforms that diversified in terrestrial and aquatic environments across the Cretaceous-Paleogene transition. The postcranial anatomy of dyrosaurids has long been overlooked, obscuring both their disparity and their locomotive adaptations. Here we thoroughly describe of the postcranial remains of an unusually small dyrosaurid, *Cerrejonisuchus improcerus*, from the middle-late Paleocene Cerrejón Formation of Colombia, and we provide a wealth of new data concerning the postcranial anatomy of the key dyrosaurids: *Congosaurus bequaerti* and *Hyposaurus rogersii*. We identify a series of postcranial autapomorphies in *Cerrejonisuchus improcerus* (an elliptic-shaped odontoid laterally wide, a ulna possessing a double concavity, a fibula bearing a widely flattened proximal end, a pubis showing a large non-triangular distal surface) as well as functionally-important traits such as a relatively long ulna (85% of the humerus' length), short forelimb (83% of hindlimb's length), or thoracic vertebra bearing comparatively large lateral process (with widened parapophysis and diapophysis) along with strongly arched thoracic ribs allowing a more sturdy and cylindrical rib cage. These indicate a more terrestrial lifestyle for *Cerrejonisuchus* compared to the derived members of the clade. We also built a dataset of 187 traits on 27 taxa, that extensively samples the cranial and postcranial architectures of exemplar crocodyliforms. We analyze these data in via Principal Coordinate Analysis (PCoA) to visualize the postcranial morphospace occupation of Dyrosauridae, Thalattosuchia, and Crocodylia. Our data reveal the existence of a distinctive postcranial anatomy for Dyrosauridae that is markedly distinct from that of crocodylians. As a result, modern crocodylians are probably not good functional analog for extinct crocodyliformes. Postcranial data should also be more widely used in phylogenetic and disparity analyses of Crocodyliformes.

Erb, A. and Turner, A.H. (2021). Braincase anatomy of the Paleocene crocodyliform *Rhabdognathus* revealed through high resolution computed tomography. *PeerJ* 9: e11253.

Abstract: Dyrosaurids were highly specialized, largely marine, relatives of living crocodylians, and one of the few archosaur lineages to survive the K-Pg extinction. Dyrosaurids lived during the Cretaceous to the Eocene and represent a unique combination of morphology and ecology not seen in living crocodylians. Little is known about their endocranial anatomy, leaving many questions about their neurosensory adaptations unaddressed. Recently, μ CT

(micro-computed tomography) scans were made of a well-preserved skull of *Rhabdognathus*, a Paleocene dyrosaurid from Mali. This marks the first time the braincase and neurosensory features of a dyrosaurid have been examined using CT. We focus our attention to three specific internal structures: the cranial endocast; the inner ear; and the paratympanic sinuses. The cranial endocast of *Rhabdognathus* revealed novel features including a unique conformation of its paratympanic system, a prominent dorsal venous system that communicates with the external skull table, extremely enlarged tympanic vestibules that meet at the midline of the endocranium, a prominent spherical cerebrum, and elongate olfactory tracts accounting for half the total endocast length. The bizarre laterally facing lateral Eustachian foramen of dyrosaurids is now understood to be a complex fossa including both a ventrally directed lateral Eustachian foramen and a laterally directed foramen for the basioccipital diverticulum. A novel median pterygopharyngeal canal was discovered connecting the pharynx to the adductor chamber. These revelations require a reinterpretation of the associated external foramina visible on the posterior of the skull in dyrosaurids and potentially their close relatives the pholidosaurids. The olfactory tract terminates in an enlarged olfactory region possessing complex bony projections - a unique morphology perhaps serving to increase surface area for olfaction. The inner ear of *Rhabdognathus* exhibits characteristics seen in both *Pelagosaurus* and *Gavialis*. The vestibule is spherical, as in *Gavialis*, but is significantly expanded. The semicircular canals are enlarged but pyramidal in shape as in the thalattosuchian *Pelagosaurus*. The proportion of the cochlear length to total endosseous labyrinth height is roughly 0.5 in *Rhabdognathus* implying that the hearing capabilities resemble that of thalattosuchians. A suite of expanded sense organs (eg bony olfactory lamina; hypertrophied vestibule of the inner ear), and the clear expansion of the cerebrum to a more symmetrical and spherical shape suggest that dyrosaurids possess neuroanatomical modifications facilitating an agile predatory near-shore ecology.

Boucher, M., Tellez, M. and Anderson, J.T. (2021). Activity budget and behavioral patterns of American crocodiles (*Crocodylus acutus*) in Belize. *Herpetological Conservation and Biology* 16(1): 86-94.

Abstract: American Crocodiles (*Crocodylus acutus*) are broadly distributed throughout coastal and low-elevation tropical wetlands in the Americas and Caribbean. Despite years of ecological research on this species, there is still a dearth of behavioral data on wild American Crocodiles. Our project established diurnal time-activity budgets for American Crocodiles in Belize and evaluated behavioral patterns in relation to season (wet and dry) and time of observation (morning and afternoon). Crocodiles are dynamic and alter activity budgets in response to seasonal, temporal, and climatic changes, thus the use of time-activity budgets can be significant for documenting behavioral patterns, and a tool to quantify bioenergetic investment. We collected behavioral observations of wild crocodiles from multiple sites in Belize from May 2015 to August 2017. American Crocodiles allotted the greatest amount of time performing maintenance activities, including basking and floating on the surface of the water with head or body exposed. We found time allotment for other behaviors, particularly agonistic and social displays, were proportionally greater during the dry season in conjunction with the breeding season. Overall, our research creates a current baseline from which further studies could investigate changes in activity budgets in relation to mounting threats from climate change and anthropogenic activity.

Zucoloto, R.B., Bomfim, G.C., Fernandes, F.M.C., Schnadelbach, A.S., Piña, C.I. and Verdade, L.M. (2021). Effective population size of broad-snouted caiman (*Caiman latirostris*) in Brazil: A historical and spatial perspective. *Global Ecology and Conservation* 28: e01673.

Abstract: *Caiman latirostris* has a large geographic distribution, that includes Argentina, Bolivia, Brazil, Paraguay, and Uruguay. In

Brazil illegal hunting and land use change have caused population decline, relatively well documented in the last three decades. At such circumstances, the estimate of the species effective population size might help its viability analysis. Single-sample estimator has been developed to estimate current effective population size (N_e). Its main advantage over former methods is that it requires a single sampling, whereas temporal methods require at least two in distinct periods. Such method has been used to estimate N_e of broad-snouted caiman populations in the present study over representative areas of the species range in Brazil. As a result, we learned that in most populations only a relatively low number of adults effectively contribute to genetic variation. The following measures are proposed as management actions to mitigate such problem: (1) an update of population sampling on the main river basins where the species lives; (2) definition, delimitation and conservation of natural habitats for the conservation of the species in the wild, to guarantee its reproduction; and (3) new conservation genetic studies to determine current genetic diversity and its monitoring on the main river basins of the species range, with special attention to genetic diversity recovery.

Marroquín-Flores, R.A., Bowden, R.M. and Paitz, R.T. (2021). Brief exposure to warm temperatures reduces intron retention in *Kdm6b* in a species with temperature-dependent sex determination. *Biology Letters* (<https://doi.org/10.1098/rsbl.2021.0167>).

Abstract: Animals with temperature-dependent sex determination (TSD) respond to thermal cues during early embryonic development to trigger gonadal differentiation. TSD has primarily been studied using constant temperature incubations, where embryos are exposed to constant male- or female-producing temperatures, and these studies have identified genes that display sex-specific expression in response to incubation temperature. *Kdm6b*, a histone demethylase gene, has received specific attention as it is among the initial genes to respond to incubation temperature and is necessary for testis development. Interestingly, *Kdm6b* retains an intron when eggs are incubated at a constant male-producing temperature, but the role of thermal variability in this developmental process is relatively understudied. Species with TSD regularly experience thermal cues that fluctuate between male- and female-producing temperatures throughout development but it is unclear how *Kdm6b* responds to such variable temperatures. In this study, we investigate temperature-sensitive splicing in *Kdm6b* by exposing embryos to male- and female-producing thermal conditions. We show a rapid decrease in levels of the intron retaining transcript of *Kdm6b* upon exposure to female-producing conditions. These results demonstrate that, under ecologically relevant conditions, temperature-sensitive splicing can differentially regulate genes critical to TSD.

Schwab, J.A., Young, M.T., Herrera, Y., Witmer, L.M., Walsh, S.A., Katsamenis, O.L. and Brusatte, S.L. (2021). The braincase and inner ear of '*Metriorhynchus*' cf. '*M. brachyrhynchus*' - implications for aquatic sensory adaptations in crocodylomorphs. *Journal of Vertebrate Paleontology* (<https://doi.org/10.1080/02724634.2021.1912062>).

Abstract: During their long evolutionary history crocodylomorphs achieved a great diversity of body sizes, ecomorphotypes and inferred feeding ecologies. One unique group of crocodylomorphs are the thalattosuchians, which lived during the Jurassic and Cretaceous (ca. 191-125 Ma). They transitioned from shallow marine species, like teleosauroids, into fully pelagic forms with paddle shaped limbs and a vertically orientated tail fluke, the metriorhynchids. The osteological adaptations that allowed metriorhynchids to live in the water are generally well understood, but less is known about their neurosensory and endocranial systems, such as the brain, inner ears, sinuses and cranial nerves and how they relate to their aquatic lifestyle. Based on micro-computed tomography (μ CT) data and three-dimensional models, we here describe the braincase and endocranial anatomy of a fully marine metriorhynchid,

'*Metriorhynchus*' cf. '*M. brachyrhynchus*' (NHMUK PV OR 32617). We found several neuroanatomical features that likely helped this species function in its marine environment. These include a unique flexure in the brain endocast not seen in other thalattosuchians. Other features that have previously been seen in thalattosuchians include enlarged cerebral hemispheres, a hypertrophied venous sinus system, enlarged internal carotid arteries and foramina, and closed/absent lateral pharyngotympanic foramina. The specimen also possesses a pelagic metriorhynchid bony labyrinth morphology, with a compact and dorsoventrally short shape, thick semicircular canals, an enlarged vestibule and potentially a short cochlear duct. A review of character distribution confirms that some of these features evolved at the base of Thalattosuchia in semiaquatic species, long before metriorhynchids became pelagic, suggesting that endocranial anatomy helped allow metriorhynchoids colonize the ocean realm.

Stout, J.B. (2021). Some thoughts on interspecific mandibular morphology in fossil and modern alligator. *Journal of North American Herpetology* 2021(1): 50-55.

Abstract: *Alligator* is diagnosed in the fossil record using discrete morphological characters. These characters are used with systematic analyses to determine hypothetical phylogenetic relationships. Examined here are two such characters for applicability in fossil species determination and relationship. One is the curvature of the dentary between the fourth and tenth alveoli (observed in several taxa), while the other is a further investigation into the anterior extent of the splenial (in modern *Alligator mississippiensis* and the early Pleistocene *A. hailsensis*). In a small sample size, the curvature of the dentary exhibits wide variability in character states both intraspecifically and interspecifically, bringing into question its utility in fossil crocodylian systematic applications. The anatomy of the anterior extent of the splenial is phylogenetically informative, and a new method for inferring its presence as a basal or derived state (as a scar on the dentary) is described.

Blanco, A. (2021). Importance of the postcranial skeleton in eusuchian phylogeny: Reassessing the systematics of allodaposuchid crocodylians. *PLoS ONE* 16(6): e0251900.

Abstract: Our current knowledge on the crocodyliiform evolution is strongly biased towards the skull morphology, and the postcranial skeleton is usually neglected in many taxonomic descriptions. However, it is logical to expect that it can contribute with its own phylogenetic signal. In this paper, the changes in the tree topology caused by the addition of the postcranial information are analysed for the family Allodaposuchidae, the most representative eusuchians in the latest Cretaceous of Europe. At present, different phylogenetic hypotheses have been proposed for this group without reaching a consensus. The results of this paper evidence a shift in the phylogenetic position when the postcranium is included in the dataset, pointing to a relevant phylogenetic signal in the postcranial elements. Finally, the phylogenetic relationships of allodaposuchids within Eusuchia are reassessed; and the internal relationships within Allodaposuchidae are also reconsidered after an exhaustive revision of the morphological data. New and improved diagnoses for each species are here provided.

De Oliveira, D.F., Soares de Castro, B., Nery do Nascimento Recktenvald, M.C., Aleixo da Costa Júnior, W., Ximenes da Silva, F., De Menezes Alves, C.L., Froehlich, J.D., Rodrigues Bastos, W. and Teixeira Ott, A.M. (2021). Mercury in wild animals and fish and health risk for indigenous Amazonians. *Food Additives & Contaminants: Part B* (<https://doi.org/10.1080/19393210.2020.1849410>).

Abstract: Total mercury (T-Hg) was determined in fish and wild animal meat consumed in indigenous villages in the Brazilian Amazon region, where there is no history of gold mining. The

analyses were performed in an atomic absorption spectrophotometer by generation of cold vapour. Regardless of the dietary habit, 42.0% of the fish had levels of T-Hg higher than the values considered as safe for human health by the World Health Organisation. Exposure to mercury in the villages was higher due to the consumption of fish compared to the consumption of meat of wild animals. Carnivorous species showed a higher concentration of T-Hg, both in fish and in wild animals. It is preferred to consume meat from fish and non-predatory wild animals, which can reduce the risk of diseases resulting from high concentrations of mercury in the body of the studied indigenous people.

Azzara, B., Boschian, G., Brochu, C.A., Delfino, M., Iurino, D.A., Kimambo, J.S., Manzi, G., Masao, F.T., Menconero, S., Njau, J.K. and Cherin, M. (2021). A new cranium of *Crocodylus anthropophagus* from Olduvai Gorge, northern Tanzania. *Rivista Italiana di Paleontologia e Stratigrafia* 127(2) (doi: <https://doi.org/10.13130/2039-4942/15771>).

Abstract: Olduvai Gorge (northern Tanzania) is one of the best known and most iconic palaeontological and archaeological sites in the world. In more than a century of research it has yielded an impressive record of fossils and stone tools which stands as a compendium of human evolution in the context of environmental changes of East Africa in the last 2 Ma. Recent field work in the DK site at Olduvai lead to the retrieval of a partial crocodile cranium nicknamed Black Sun because it was discovered during an annular solar eclipse. The specimen is here described and compared with extinct and extant African crocodylids. The new cranium can be referred to *Crocodylus anthropophagus*, a Pleistocene species hitherto found only in Olduvai Gorge. Thanks to the good preservation of the skull table, its morphology is here characterised for the first time. Black Sun represents to date the earliest (ca. 1.9-1.85 Ma) and the most informative cranium of *C. anthropophagus* in the fossil record. Our phylogenetic analysis supports a strict relationship between *C. anthropophagus* and *Crocodylus thorbjarnarsoni*, a large species from the Plio-Pleistocene of the Turkana Basin (Kenya). These two sister taxa share a combination of characters which places them at the base of *Crocodylus*, providing an intriguing element to the debate on the African or extra-African origin of this genus.

Hamidy, R. and Siregar, Y.I. (2020). Rapid assessment of the ecological value of Buaya Lake in Bandar Alai Kari, Kuantan Tengah, Kuantan Singingi Regency, Riau. *ECOTONE* 1(2): 57-65.

Abstract: In Bandar Alai Kari, Kuantan Tengah Sub-district, Kuantan Singingi Regency, Riau, there is a Buaya Lake. According to the history, the Buaya (crocodiles) Lake, used to be a place for river crocodiles to live (an area of approximately 4.5 ha). To obtain data on the value of the lake's conservation status (ecological value), a rapid assessment method is used using the ECELS index. Observations in the field and with the help of drones to observe the components of the ECELS index assessment, the index value is less than 30. From this value it can be concluded that the Bandar Alai Kari crocodile lake is in a very bad conservation status and needs to be restored.

Bock, S.L., Hale, M.D., Rainwater, T.R., Wilkinson, P.M. and Parrott, B.B. (2021). Incubation temperature and maternal resource provisioning, but not contaminant exposure, shape hatchling phenotypes in a species with temperature-dependent sex determination. *The Biological Bulletin* 241 (doi: [10.1086/714572](https://doi.org/10.1086/714572)).

Abstract: The environment experienced during embryonic development is a rich source of phenotypic variation, as environmental signals have the potential to both inform adaptive plastic responses and disrupt normal developmental programs. Environment-by-embryo interactions are particularly consequential for species with temperature-dependent sex determination, a mode

of sex determination common in non-avian reptiles and fish, in which thermal cues during a discrete period of development drive the formation of either an ovary or a testis. Here we examine the impact of thermal variation during incubation in combination with developmental exposure to a common endocrine-disrupting contaminant on fitness-related hatchling traits in the American alligator (*Alligator mississippiensis*), a species with temperature-dependent sex determination. Using a factorial design, we exposed field-collected eggs to five thermal profiles (three constant temperatures, two fluctuating temperatures) and two environmentally relevant doses of the pesticide metabolite dichlorodiphenyldichloroethylene; and we quantified incubation duration, sex ratios, hatchling morphometric traits, and growth (9–10 days post-hatch). Whereas dichlorodiphenyldichloroethylene exposure did not generally affect hatchling traits, constant and fluctuating temperatures produced diverse phenotypic effects. Thermal fluctuations led to subtle changes in incubation duration and produced shorter hatchlings with smaller heads when compared to the constant temperature control. Warmer, male-promoting incubation temperatures resulted in larger hatchlings with more residual yolk reserves when compared to cooler, female-promoting temperatures. Together, these findings advance our understanding of how complex environmental factors interact with developing organisms to generate phenotypic variation and raise questions regarding the mechanisms connecting variable thermal conditions to responses in hatchling traits and their evolutionary implications for temperature-dependent sex determination.

Nieto, M.N., Degrange, F.J., Sellers, K.C., Pol, D. and Holliday, C.M. (2021). Biomechanical performance of the cranio-mandibular complex of the small notosuchian *Araripesuchus gomesii* (Notosuchia, Uruguaysuchidae). *Anatomical Record* (Hoboken) (doi: 10.1002/ar.24697).

Abstract: Notosuchia is a clade of crocodyliforms that was highly successful and diverse in the Cretaceous of Gondwana. *Araripesuchus gomesii* is a small notosuchian from the Early Cretaceous of Brazil that belongs to Uruguaysuchidae, one of the subgroups of notosuchians that first radiated, during the Aptian-Albian. Here we present a finite element analysis of *A. gomesii* based on a model reconstructed from CT scans and performed using published bone properties for crocodiles. The adductor musculature and their respective attachment areas were reconstructed based on Extant Phylogenetic Bracket. Different functional scenarios were tested applying an estimated 158 N bite force: unilateral bite, bilateral bite, pullback, head-shake, and head-twist. The results obtained were compared with those of *Alligator mississippiensis*, one of its closest living relatives. In the different simulations, the skull and lower jaws of *Araripesuchus* suffers more stress in the head-shake movement, followed by the unilateral and pullback bites with stress focalized in the premaxillary region. In contrast, the head-twist is the one with smaller stress values. *Araripesuchus* possess an oreinirostral skull that may provide greater overall resistance in the different scenarios on average, unlike *Alligator* that has a platyrostral skull with less resistance to dorsoventral mechanical loads. Previous hypotheses that considered *A. gomesii* as omnivorous coupled with our results, its small size, and likely limited bite force, suggest this taxon probably fed on small prey and other trophic items that could catch and handle entirely with its mouth, such as insects and small vertebrates.

Cramberg, M., Greer, S. and Young, B.A. (2021). The functional morphology of the postpulmonary septum of the American alligator (*Alligator mississippiensis*). *Anatomical Record* (Hoboken) (doi: 10.1002/ar.24692).

Abstract: The American alligator (*Alligator mississippiensis*) has a postpulmonary septum (PPS) that partitions the intracoelomic cavity. The PPS adheres to the capsule of the liver caudally and to the visceral pleura of the lung cranially; the ventrolateral portions

of the PPS are invested with smooth muscle, the remainder is tendinous. Differential pressure transducers were used to record the intrathoracic (ITP) and intraperitoneal (IPP) pressures, and determine the transdiaphragmatic pressure (TDP). Each ventilatory pulse resulted in a pulse in ITP and a significantly lower pulse in IPP; meaning that a TDP was established, and that the pleural and peritoneal cavities were functionally isolated. The anesthetized alligators were tilted 30° head-up or head-down in order to displace the liver. Head-up rotations caused a significant increase in IPP, and a significant decrease in ITP (which became negative); head-down rotations produced the opposite effect. During these rotations, the PPS maintained opposite pressures (positive or negative) in the pleural and peritoneal cavities, and established TDPs greater than have been reported for some mammals. Two types of “breaths” were recorded during these experiments. The first was interpreted as a contraction of the diaphragmatic muscle, which displaces the liver caudally; these breaths had the same effect as the head-up rotations. The second type of breath was interpreted as constriction of the thoracic and abdominal body walls; this type of breath produced pronounced, long-duration, roughly parallel, increases in ITP and IPP. The smooth muscle within the PPS is suggestive of higher-order adjustment or tuning of the PPS’s tensile state.

Gholamhosseini, A., Sharifyazdi, H., Rakhshaninejad, M., Soltanian, S., Salighehzadeh, R. and Kordestani, H. (2021). A study on the oral and cloacal bacterial flora of Mugger crocodiles (*Crocodylus palustris*) in the Negour protected area, Iran. *Veterinary Research Forum* (doi: 10.30466/VRF.2019.108417.2571).

Abstract: Mugger crocodile is the only crocodilian existing in Iran. The present study was aimed to investigate the bacterial flora in the oral and cloacal cavities of wild Mugger crocodiles in Negour protected area, Iran. Twenty-two captured crocodiles were isolated and the molecular characterization of their oral and cloacal bacterial flora was performed. We recovered 10 bacterial species from the oral samples and 6 bacterial species from the cloacal samples. The most common bacteria in oral samples were *Burkholderia contaminans* and *Lactococcus garvieae* whereas in the cloacal samples, it was *Lactococcus lactis*. It is likely that the isolated bacteria would pose a threat to both crocodiles’ and humans’ health. They can threaten crocodiles during stressful conditions while humans would be susceptible if they are bitten by crocodiles, consume their meat, or spend time near their natural environment. This study provides useful information on bacterial diversity carried by *C. palustris* in Iran which could help us select the most appropriate antibacterials when dealing with intoxication or infections caused by crocodiles’ meat or bites.

Lemaire, J., Bustamante, P., Mangione, R., Marquis, O., Churlaud, C., Brault-Favrou, M., Parenteau, C. and Brischoux, F. (2021). Lead, mercury and selenium alter physiological functions in wild caimans (*Caiman crocodilus*). *Environmental Pollution* (doi: 10.1016/j.envpol.2021.117549).

Abstract: Environmental contaminants affect ecosystems worldwide and have deleterious effects on biota. Non-essential mercury (Hg) and lead (Pb) concentrations are well documented in some taxa and are described to cause multiple detrimental effects on human and wildlife. Additionally, essential selenium (Se) is known to be toxic at high concentration but, at lower concentrations, Se can protect organisms against Hg toxicity. Crocodilians are known to bioaccumulate contaminants. However, effects of these contaminants on physiological processes remain poorly studied. In the present study, we quantified Hg, Pb and Se concentrations in spectacled caimans (*Caiman crocodilus*) and investigated effects of these contaminants on several physiological processes linked to osmoregulatory, hepatic, endocrine and renal functions measured through blood parameters in 23 individuals. Mercury was related to disruption of osmoregulation (sodium levels), hepatic function (alkaline phosphatase levels) and endocrine processes

(corticosterone levels). Lead was related to disruption of hepatic functions (glucose and alanine aminotransferase levels). Selenium was not related to any parameters, but the Se:Hg molar ratio was positively related to the Na⁺ and corticosterone concentrations, suggesting a potential protective effect against Hg toxicity. Overall, our results suggest that Hg and Pb alter physiological mechanisms in wild caimans and highlight the need to thoroughly investigate the consequences of trace element contamination in crocodilians.

Aubert, C., Le Moguédéc, G., Assio, C., Blatrix, R., Ahizi, M.N., Hedegbetan, G.C., Kpera, N.G., Lapeyre, V., Martin, D., Labbé, P. and Shirley, M.H. (2021). Evaluation of the use of drones to monitor a diverse crocodylian assemblage in West Africa. *Wildlife Research* (<https://doi.org/10.1071/WR20170>).

Abstract: West African crocodylian populations are declining and in need of conservation action. Surveys and other monitoring methods are critical components of crocodile conservation programs; however, surveys are often hindered by logistical, financial and detectability constraints. Increasingly used in wildlife monitoring programs, drones can enhance monitoring and conservation efficacy. Aims. This study aimed to determine a standard drone crocodylian survey protocol and evaluate the drones as a tool to survey the diverse crocodylian assemblage of West Africa. We surveyed crocodile populations in Benin, Co'te d'Ivoire and Niger in 2017 and 2018, by using the DJI Phantom 4 Pro drone and via traditional diurnal and nocturnal spotlight surveys. We used a series of test flights to first evaluate the impact of drones on crocodylian behaviour and determine standard flight parameters that optimise detectability. We then, consecutively, implemented the three survey methods at 23 sites to compare the efficacy of drones against traditional crocodylian survey methods. *Crocodylus suchus* can be closely approached (>10 m altitude) and consumer-grade drones do not elicit flight responses in West African large mammals and birds at altitudes of >40-60 m. Altitude and other flight parameters did not affect detectability, because high-resolution photos allowed accurate counting. Observer experience, field conditions (eg wind, sun reflection), and site characteristics (eg vegetation, homogeneity) all significantly affected detectability. Drone-based crocodylian surveys should be implemented from 40 m altitude in the first third of the day. Comparing survey methods, drones performed better than did traditional diurnal surveys but worse than standard nocturnal spotlight counts. The latter not only detected more individuals, but also a greater size-class diversity. However, drone surveys provide advantages over traditional methods, including precise size estimation, less disturbance, and the ability to cover greater and more remote areas. Drone survey photos allow for repeatable and quantifiable habitat assessments, detection of encroachment and other illegal activities, and leave a permanent record. Overall, drones offer a valuable and cost-effective alternative for surveying crocodylian populations with compelling secondary benefits, although they may not be suitable in all cases and for all species. We propose a standardised and optimised protocol for drone-based crocodylian surveys that could be used for sustainable conservation programs of crocodylians in West Africa and globally.

Clement, V.F. and Rodder, D. (2021). Playing favourites - a review and discussion on the allocation of vertebrate orders and foci in home range and habitat selection studies. *North-Western Journal of Zoology* 17(1): e203801.

Abstract. Home range and habitat selection are key subjects when studying animal ecology. Defining the space use and resource management of an animal establishes a solid basis for further behavioural and ecological research, as well as conservation management. Studies focusing on determining home range and habitat selection often include further questions regarding for example conservation, animal movement, population dynamics, and inter- or intraspecific interactions. It is therefore unsurprising that home range and habitat selection have been the focus of numerous

studies on different vertebrate taxa over the years. We have reviewed 903 publications, on all extant vertebrate clades focusing on these topics from 1980 to the first quarter of 2018. We have observed that allocation of vertebrate orders are independent of species richness, relatedness, and portion of threatened species within the order. We have highlighted the relation between publication numbers and species richness and offer ideas for future research in proposing possible causes for the observed allocation and in highlighting understudied clades. Furthermore, we have observed that topics often studied in concordance with home range and habitat selection are conservation and human influence, intraspecific differences, and home range shifts/exploratory behaviour. Meanwhile, topics like population density, reproductive behaviour, territoriality/aggressive behaviour, and interspecific interactions seem to be less studied. This review highlights and discusses the current distribution of focal points in studies concerning home range and habitat use while identifying less studied fields and taxa - thereby emphasizing potential opportunities for further research.

De Souza, L.G., Bandeira, K.L.N., Pegas, R.V., Brum, A.S., Machado, R., Guilherme, E., Loboda, T.S. and De Souza-Filho, J.P. (2021). The history, importance and anatomy of the specimen that validated the giant *Purussaurus brasiliensis* Barbosa-Rodrigues 1892 (Crocodylia: Caimaninae). *Annals of the Brazilian Academy of Sciences* 93(Suppl. 2): e20200369.

Abstract: The Solimões Formation is a southwest geological unit of the Brazilian Amazon, being well-known for the Cenozoic giant eusuchian fossils. Among the 8 species of Crocodylia described for this formation, the alligatoroid *Purussaurus brasiliensis* is the best known worldwide due to its enormous size. The holotype was described in 1892 by Barbosa-Rodrigues, composed by a right hemimandible. Later, two other species were assigned to the genus, but the loss of the type specimen brought a series of doubts and discussions about genus and species validity. Here, we provide a historical reconstruction of the genus *Purussaurus*, especially with a new description of the specimen DGM 527-R, which was first described by L.I. Price. We also provide a review of *Purussaurus brasiliensis* as a valid species, highlighting the importance of the paleontologist Diogenes de Almeida Campos to the preservation, study availability and divulgation of the specimen. From the six mandibular features discussed, at least two are putative synapomorphies for the genus: the false ziphodont teeth and the thinning of the medial surface of the mandible posterior to the fourteen alveoli, while the lateral surface become laterally expanded from ninth alveoli to behind. The review of the other species of the genus was aggravated due to little sampling of photos and low quality of those contributions. Finally, the curatorial efforts initiated by Price and kept for decades by Campos turned possible the revision of DGM 527-R, an important specimen for understanding the paleobiology and evolution of the genus, and, consequently *P. brasiliensis*. Such importance was recognized here scientifically and by Campos when considered this specimen as the center-piece of the exhibition in honor of the centenary anniversary of Price.

Pinheiro, A.E.P., De Souza, L.G., Bandeira, K.L.N., Brum, A.S., Pereira, P.V.L.G.C., De Castro, L.O.R., Ramos, R.R.C. and Simbras, F.M. (2021). The first notosuchian crocodyliform from the Araçatuba Formation (Bauru Group, Paraná Basin), and diversification of sphagesaurians. *Annals of the Brazilian Academy of Sciences* 93(Suppl. 2): e20201591.

Abstract: The mesoeucrocodylian record from the Bauru Group (Paraná Basin, Brazil) comes from three formations: Adamantina (Late Turonian-Early Maastrichtian), Presidente Prudente (Early Campanian-Early Maastrichtian) and Marília (Maastrichtian). These records are restricted to the Early Coniacian-Early Maastrichtian. Here, we report a new crocodyliform record from the Bauru Group, which was the first of the Araçatuba Formation, from a new locality of Coronel Goulart district, in Álvares Machado municipality.

Coronelsuchus civali gen. nov. et sp. nov. comprises two related specimens - FFP PG 13 and FFP PG 14 recovered close to each other and on the same muddy sandstone level. We perform a phylogenetic analysis with 392 characters (five new added) and 88 taxa. Our analyses supported the new clades: Sphagesauria, Sphagesaurinae and Caipirasuchinae. Our phylogenetic results suggest *C. civali* as a basal Sphagesauria. Regarding the Crocodyliform Assemblage Zones (CAZ), the new species is correlated to the CAZ 1, together with small sphagesaurians, *Caryonosuchus* and itasuchids. The *C. civali* reveals an older appearing (pre-Turonian) and diversification of Sphagesauria. The specimens also expand the stratigraphic range for Notosuchia in the Bauru Group.

Marschang, R.E., Meddings, J.I. and Ariel, E. (2021). Viruses of reptiles. Chapter 13. Pp. 449-510 in *Studies in Viral Ecology*, Second Edition, ed. by C.J. Hurst. John Wiley & Sons: New Jersey, USA.

Abstract: Although reptiles have often been overlooked in research, information on viruses of reptiles has been growing steadily in recent decades as has our understanding of the importance of these animals in the ecosystem. As ectotherms, their immune systems are dependent on temperature, among other factors, and interactions between infection and disease are complex and dependent on host, pathogen, and environmental factors. This chapter provides an overview of the viruses described in reptiles so far, as well as insight into some of the diseases caused by viruses in this group of animals. It also discusses the reptile immune system and the host reaction to infection. Influences of the environment on development of disease are in many cases not well understood, and this chapter includes a discussion of some important progress in this field. Studies of the effects of viruses on wild, pet, and farmed reptiles are limited, but indicate that viral disease can strongly affect individual populations in the wild, and that human action and the animal trade likely play a role in disease epidemiology.

Platt, S.G., Rainwater, T.R. and McMurry, S.T. (2021). Fauna associated with the nests of *Crocodylus moreletii* and *Crocodylus moreletii* × *acutus* in Belize. *Journal of Natural History* 55(3-4): 133-149.

Abstract: Morelet's crocodile (*Crocodylus moreletii*) and hybrid crocodiles (*C. moreletii* × *acutus*) are mound-nesting crocodilians found in the lowlands of northern and southern Belize, respectively. Nests of both crocodilians consist of large mounds of soil, vegetation, leaf litter, and in some cases sand. We here report on the fauna associated with nest mounds of *C. moreletii* and *C. moreletii* × *acutus*, and describe the associations between crocodiles and commensal fauna. Our data were collected during various ecological studies conducted from 1992 through 2000, and we examined 138 active (containing eggs) nests of *C. moreletii* and 11 active nests of *C. moreletii* × *acutus*. We noted the occurrence of at least 14 species of fauna associated with 45 (32.6%) *C. moreletii* and three (27.2%) *C. moreletii* × *acutus* nests. Nest-associated fauna included ants, bees, termites, turtles, squamates, birds, and mammals. Associations included five species dwelling within crocodile nest mounds, four species that deposited eggs in crocodile nest mounds, and five species nesting in close proximity to crocodile nests. Nest-associated fauna presumably benefit from the protection afforded by nest attendance and aggressive defence behaviour of female crocodiles, although these benefits have yet to be empirically established.

Whitfield, A.K. (2021). When the flathead mullet left St Lucia. *African Journal of Marine Science* (<https://doi.org/10.2989/1814232X.2021.1927179>).

Abstract: The St Lucia estuarine system on the east coast of South Africa is a declared World Heritage Site and Ramsar Site of International Importance. A major ecological feature of St Lucia during the last century was the annual spawning migration of the

flathead mullet *Mugil cephalus* down the system in the first half of each year. Top predators, such as the African fish eagle *Haliaeetus vocifer*, white pelican *Pelecanus onocrotalus*, Nile crocodile *Crocodylus niloticus* and Zambezi shark *Carcharhinus leucas*, have made extensive use of adult *M. cephalus* as a food resource. With the advent of prolonged closure of the St Lucia mouth in the first decade of the 21st century, caused by the lack of St Lucia system connectivity with the Mfolozi River and a prolonged drought, this spawning migration has ceased to exist. The almost complete disappearance of *M. cephalus* was reinforced in the second decade of this century by a continued lack of any estuarine-marine connectivity. This loss of connectivity between Lake St Lucia and the sea for more than 12 years is longer than the normal life cycle of *M. cephalus*, and the possibility exists that the putative subpopulation of this species that occupied the system prior to the turn of the century may have been rendered locally extinct. In January 2021, the berm at the mouth of the estuary was artificially breached and the outflow of St Lucia estuarine waters into the sea occurred for the first time since 2002. However, it remains to be seen whether the recovery of the *M. cephalus* population to pre-2000 levels will occur over the short term (year) or longer term (decade). It is strongly recommended that an adaptive management strategy, rather than a fixed management approach, be adopted for the sake of future connectivity of the St Lucia system to the marine environment.

Thiry, D., Billen, F., Boyen, F., Duprez, J.-N., Quenault, H., Touzain, F., Blanchard, Y., Clercx, C. and Mainil, J.G. (2021). Genomic relatedness of a canine *Lactococcus garvieae* to human, animal and environmental isolates. *Research in Veterinary Science* 137: 170-173.

Abstract: *Lactococcus* (*L.*) *garvieae* is a zoonotic fish pathogen that can also cause bacteraemia and endocarditis in humans and has been isolated from healthy or diseased domestic animals. Nevertheless *L. garvieae* is more an opportunistic, than a primary pathogen since most affected humans have predisposing conditions and comorbidities. *L. garvieae* is also present in other animal species, most frequently cattle, but also sheep, goats, water buffaloes, and pigs, and much more rarely dogs, cats, horses, camel, turtle, snake and crocodile. The purpose of this study was to genomically (i) confirm the identification by MALDI-TOF MS® of a *L. garvieae* from the nasal discharge of a dog with chronic respiratory disorders and (ii) compare this canine isolate with human and animal *L. garvieae* isolates. According to the BLAST analysis after Whole Genome Sequencing, this canine isolate was more than 99% identical to 3 *L. garvieae* and belonged to a new Multi-Locus Sequence Type (ST45). MLST and whole genomes-based phylogenetic analysis were performed on the canine isolate and the 40 genomes available in Genbank. The canine *L. garvieae* was most closely related to an Australian camel and an Indian fish *L. garvieae* and more distantly to human *L. garvieae*. Twenty-five of the 29 putative virulence-associated genes searched for were detected, but not the 16 capsule-encoding genes. The heterogeneity of the *L. garvieae* species is reflected by the diversity of the MLSTypes and virulotypes identified and by the phylogenetic analysis.

Mialon, H.M., Klumpp, T. and Williams, M.A. (2021). International Trade and the Survival of Mammalian and Reptilian Species. Working Paper, Emory University.

Abstract: The Convention on International Trade in Endangered Species (CITES) bans international trade in species threatened with extinction. We investigate the effects of these bans on species' endangerment, as assessed by the International Union for Conservation of Nature (IUCN). Our dataset includes all mammalian and reptilian species for which IUCN has recorded an endangerment status in one or more years between 1982 and 2018. Using double-difference and triple-difference estimation methods, we find that CITES bans lead to subsequent improvements in mammalian species' IUCN status, relative to species in which trade

was not banned. These effects are primarily due to improvements in the status of commercially targeted species. On the other hand, CITES bans lead to subsequent deteriorations in reptilian species' IUCN status. We find that major spikes in trade volume occurred in anticipation of the bans on reptilian species but not in anticipation of those on mammalian species. One implication of our findings is that CITES trade bans should be implemented at endangerment levels at which anticipatory trade spikes are less likely to cause irreparable harm.

Bock, S.L., Hale, M.D., Leri, F., Rainwater, T.R., Wilkinson, P.M. and Parrott, B.B. (2021). Post-transcriptional mechanisms respond rapidly to ecologically relevant thermal fluctuations during temperature-dependent sex determination. Integrative Organismal Biology (doi:10.1093/iob/obaa033).

Abstract: An organism's ability to integrate transient environmental cues experienced during development into molecular and physiological responses forms the basis for adaptive shifts in phenotypic trajectories. During temperature dependent sex determination (TSD), thermal cues during discrete periods in development coordinate molecular changes that ultimately dictate sexual fate and contribute to patterns of inter- and intra-sexual variation. How these mechanisms interface with dynamic thermal environments in nature remain largely unknown. By deploying thermal loggers in wild nests of the American alligator (*Alligator mississippiensis*) over two consecutive breeding seasons, we observed that 80% of nests exhibit both male- and female-promoting thermal cues during the thermosensitive period, and of these nests, all exhibited both male- and female-promoting temperatures within the span of a single day. These observations raise a critical question - how are opposing environmental cues integrated into sexually dimorphic transcriptional programs across short temporal scales? To address this question, alligator embryos were exposed to fluctuating temperatures based on nest thermal profiles and sampled over the course of a daily thermal fluctuation. We examined the expression dynamics of upstream genes in the temperature-sensing pathway and find that post-transcriptional alternative splicing and transcript abundance of epigenetic modifier genes JARID2 and KDM6B respond rapidly to thermal fluctuations while transcriptional changes of downstream effector genes, SOX9 and DMRT1, occur on a delayed timescale. Our findings reveal how the basic mechanisms of TSD operate in an ecologically relevant context. We present a hypothetical hierarchical model based on our findings as well as previous studies, in which temperature-sensitive alternative splicing incrementally influences the epigenetic landscape to affect the transcriptional activity of key sex-determining genes.

Kohno, S. (2021). Can xenobiotics alter the sex ratio of crocodilians in the wild? Sexual Development (doi: 10.1159/000515724).

Abstract: All crocodilians exhibit temperature-dependent sex determination without sex chromosomes. This temperature dependency can be overridden by exposure to estrogen via estrogen receptor 1. Thus, the sex ratio of crocodilian species is vulnerable to estrogenic xenobiotics. Multiple investigations of the mechanism and effects of xenobiotics in crocodilian species have been conducted since the early 1990s. This review focuses on the impact of xenobiotics on sex determination rather than gonadal functions in crocodilians. The thermosensitive and estrogen-sensitive periods that commit the bipotential gonad to develop as an ovary end by stages 24.5 and 25.3, respectively. In contrast, it is ambiguous when the estrogen-sensitive stage begins for ovarian development, although the thermosensitive period for ovarian development initiates around developmental stage 15 at an extreme female-producing temperature of 30°C. To accurately assess the effect of xenoestrogens on sex ratio in crocodilians, it is critical to collect eggs before the sex-determining period and to incubate them under precisely controlled temperatures. A well-studied system of xenobiotic effects on crocodilians is Lake Apopka (FL, USA), an

EPA superfund clean-up site heavily contaminated with Dieldrin, Endrin, and p,p'-DDE. The sum of estimated estrogenicity of xenobiotics measured in Lake Apopka was insufficient to activate the estrogen receptor 1 of *Alligator mississippiensis*, which is an essential receptor to induce ovarian development. Although juvenile *A. mississippiensis* showed gonadal alterations in sex hormone production and histology, the environmentally relevant concentration of xenobiotics in Lake Apopka was unlikely to alter the sex ratio of *A. mississippiensis*. Experimental exposure to xenobiotics such as 17 α -ethynylestradiol, p,p'-dichlorodiphenyldichloroethylene, and 2,3,7,8-tetrachlorodibenzodioxin at environmentally relevant concentrations in ovo induced more female offspring in *A. mississippiensis* as compared with the control group. Bisphenol-A, atrazine, 2,4-dichlorophenoxyacetic acid, endosulfan, and Corexit did not alter the sex ratio of *A. mississippiensis* or *Caiman latirostris* under the tested conditions. Egg-incubation temperature has pronounced effects on estrogen sensitivity in crocodilian sex determination. Therefore, crocodilians are vulnerable to xenobiotic contamination and climate change in the wild. It is vital to further investigate the detailed mechanism and effects of environmental xenobiotics in crocodilian sex determination to mitigate their effect on sex ratio and conserve this ancient lineage.

Deoli, N.T., Mikolajczyk, A., Fusilier, Z., Zappi, M. and Whitlow, H.J. (2021). Elemental composition of alligator eggshell and eggshell membrane using micro-PIXE. Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms 502: 80-84.

Abstract: Over the past years there has been a notable lack of success with regard to breeding alligator in commercial facilities. Farm-raised alligator eggs exhibit lower hatch rate in comparison with wild alligator eggs. Additionally, the hatch rates of the alligator eggs decrease in captivity until zero production is reached. This decline in production has been documented in over a 20-year study at Rockefeller Wildlife Refuge. The lack of reproductive performance is attributed to the maternal diet and transfer of nutrients to the egg. Previous investigation on the eggshell and eggshell membrane of these reptiles lack comparisons between diet groups. The elemental compositions of the eggshell and eggshell membrane of wild and farm-raised *A. mississippiensis* were investigated using micro-PIXE. Eggs analyzed for this study were viable and the analysis showed that the major elements of the eggshell included calcium and aluminum, and that of membrane included sulfur and chlorine.

Janssen, J. (2021). A primer to the global trade of reptiles: Magnitude, key challenges, and implications for conservation. Pp. 439-461 in Wildlife Biodiversity Conservation, ed. by S.C. Underkoffler and H.R. Adams. Springer: Cham.

Abstract: Reptiles are among the most intensively harvested and traded species groups globally. The global trade of reptiles includes the trade of live reptiles as pets, as well as the trade of reptiles or their parts for use in traditional medicine, for reptile skins, or for human consumption. Reptiles have been widely used to treat a large variety of ailments, and medicinal use has been documented for at least 284 species. Reptiles are also an important food source, with the heaviest exploitation for this purpose in tropical and subtropical regions. In addition to the consumption of reptile meat for nutritional value, it is often intertwined with cultural beliefs, or consumed for medicinal purposes. The international trade of reptile skins is the largest trade in volume for all uses of reptile species and included 75 species from 2000 to 2017. However, the trade in live reptiles impacts significantly more species, with international trade documented for at least 642 taxa. Available data on the reptile trade may be unreliable due to frequently occurring discrepancies and a general lack of data on the volume and included species. Additionally, the reptile trade increases the risk of disease transmission globally, as well as the introduction of invasive species. All these factors have resulted in population declines across the globe. However, approximately 80%

of the world's population also relies on the use of natural resources for traditional medicine, food, or additional income. In order to effectively reduce the negative impacts of trade on reptiles, it is vital to address the underlying drivers of the trade.

Xia, T., Zhang, L., Sun, G., Yang, X. and Zhang, H. (2021). Genomic evidence of adaptive evolution in the reptilian SOCS gene family. *PeerJ* 9: e11677.

Abstract: The suppressor of the cytokine signaling (SOCS) family of proteins play an essential role in inhibiting cytokine receptor signaling by regulating immune signal pathways. Although SOCS gene functions have been examined extensively, no comprehensive study has been performed on this gene family's molecular evolution in reptiles. In this study, we identified eight canonical SOCS genes using recently-published reptilian genomes. We used phylogenetic analysis to determine that the SOCS genes had highly conserved evolutionary dynamics that we classified into two types. We identified positive SOCS4 selection signals in whole reptile lineages and SOCS2 selection signals in the crocodilian lineage. Selective pressure analyses using the branch model and Z-test revealed that these genes were under different negative selection pressures compared to reptile lineages. We also concluded that the nature of selection pressure varies across different reptile lineages on SOCS3, and the crocodilian lineage has experienced rapid evolution. Our results may provide a theoretical foundation for further analyses of reptilian SOCS genes' functional and molecular mechanisms, as well as their roles in reptile growth and development.

Kuzmin, I.T., Boitsova, E.A., Gombolevskiy, V.A., Mazur, E.V., Morozov, S.P., Sennikov, A.G., Skutschas, P.P. and Sues, H-D. (2021). Braincase anatomy of extant Crocodylia, with new insights into the development and evolution of the neurocranium in crocodylomorphs. *Journal of Anatomy* (doi: [10.1111/joa.13490](https://doi.org/10.1111/joa.13490)).

Abstract: Present-day crocodylians exhibit a remarkably akinetic skull with a highly modified braincase. We present a comprehensive description of the neurocranial osteology of extant crocodylians,

with notes on the development of individual skeletal elements and a discussion of the terminology used for this project. The quadrate is rigidly fixed by multiple contacts with most braincase elements. The parabasisphenoid is sutured to the pterygoids (palate) and the quadrate (suspensorium); as a result, the basiptyergoid joint is completely immobilized. The prootic is reduced and externally concealed by the quadrate. It has a verticalized buttress that participates in the canal for the temporal vasculature. The ventrolateral processes of the otoccipitals completely cover the posteroventral region of the braincase, enclose the occipital nerves and blood vessels in narrow bony canals and also provide additional sutural contacts between the braincase elements and further consolidate the posterior portion of the crocodylian skull. The otic capsule of crocodylians has a characteristic cochlear prominence that corresponds to the lateral route of the perilymphatic sac. Complex internal structures of the otoccipital (extracapsular buttress) additionally arrange the neurovascular structures of the periotic space of the cranium. Most of the braincase elements of crocodylians are excavated by the paratympanic pneumatic sinuses. The braincase in various extant crocodylians has an overall similar structure with some consistent variation between taxa. Several newly observed features of the braincase are present in *Gavialis gangeticus* and extant members of Crocodylidae to the exclusion of alligatorids: the reduced exposure of the prootic buttress on the floor of the temporal canal, the sagittal nuchal crest of the supraoccipital projecting posteriorly beyond the postoccipital processes and the reduced paratympanic pneumaticity. The most distinctive features of the crocodylian braincase (fixed quadrate and basiptyergoid joint, consolidated occiput) evolved relatively rapidly at the base of Crocodylomorpha and accompanied the initial diversification of this clade during the Late Triassic and Early Jurassic. We hypothesize that profound rearrangements in the individual development of the braincases of basal crocodylomorphs underlie these rapid evolutionary modifications. These rearrangements are likely reflected in the embryonic development of extant crocodylians and include the involvement of neomorphic dermal anlagen in different portions of the developing chondrocranium, the extensive ossification of the palatoquadrate cartilage as a single expanded quadrate and the anteromedial inclination of the quadrate.

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