CROCODILE SPECIALIST GROUP NEWSLETTER

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CROCODILE

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GROUP

NEWSLETTER

VOLUME 41 Number 4
OCTOBER 2022 - DECEMBER 2022

IUCN - Species Survival Commission

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COVER PHOTOGRAPH: Partially leucistic wild female Saltwater crocodile (*Crocodylus porosus*) guarding her nest. The nest was built in *Phoenix* sp. habitat and was surrounded by wallows. See pages 13-14. Photograph: Sudhakar Kar.

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

CSG Newsletter

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

The CSG Newsletter provides information on the conservation, status, news and current events concerning 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

The 19th Conference of the Parties to CITES (CoP19) was held in Panama City, Panama, on 14-25 November 2022. The CSG was again well represented, with 25 members in attendance, on national delegations, on the IUCN delegation, or representing other organisations. The outcomes for crocodilians were responsible and realistically matched to the CITES criteria. To some degree this contrasted decisions made on some other species, where the Parties seemed to opt for highly precautionary approaches to trade, in part due to intense lobbying by NGOs ideologically opposed to trade. Great to catch up with so many friends, colleagues and CSG members. A more detailed summary is on pages 4-6.

The IUCN has invited CSG members to review the "Draft - IUCN SSC Position Statement on the Role of Botanic Gardens, Aquariums, and Zoos in Conservation", which was developed by the SSC and a group of experts, to contribute to linking in-situ and ex-situ efforts to save threatened species. The online consultation period runs from 4 January to 28 February 2023. Members can visit the SSC webpage (https://www.iucn.org/our-union/commissions/species-survival-commission/our-work/online-public-consultation) for further information.

It is with sorrow that we report that Wayne King, CSG Chair in 1973-1979 and 1981-1990, passed away in November, after a short illness. Among many other notable achievements, Wayne initiated the founding of the CSG in 1971, and hosted the first working meeting that was held in New York in the same year. A detailed obituary follows this editorial (pages 4-5).

The CSG also lost Paul Weldon, who passed away in December. Paul was well known for his research on the chemistry of compounds contained in the paracloacal and chin (gular) glands of crocodilians, several of which are not found in any other vertebrates.

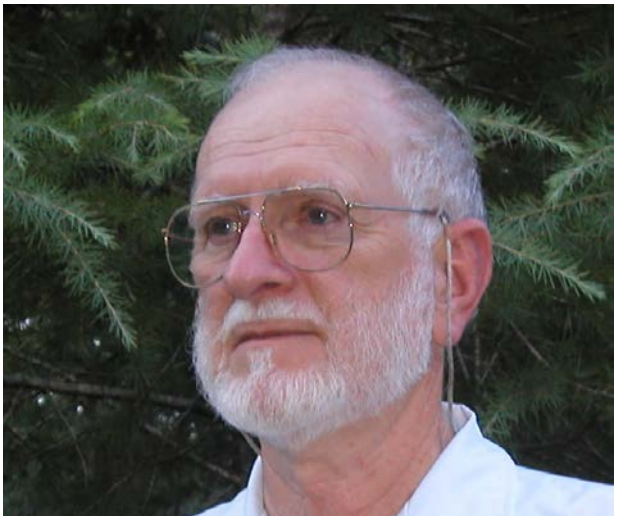
We also closed 2022 with the passing of two influential SSC leaders - Gren Lucas (SSC Chair 1981-89; https://iucn.org/news/202212/appreciation-gren-lucas-iucn) and Mark Stanley-Price (founder Chair, IUCN-SSC Reintroduction Specialist Group, 1988-2000; https://iucn.org/story/202212/mark-stanley-price-1947-2022).

Preparations are well under way for the 27th CSG Working Meeting, to be held in Darwin, Australia, in April 2024. The meeting website will be launched in due course.

Grahame Webb, *CSG Chair.*

Obituary

Frederic Wayne King (1936-2022)



F. Wayne King died on 7 November 2022 in Gainesville, Florida, after a short illness. Wayne spent a long career engaged in research and conservation of reptiles, particularly lizards and crocodylians. He was born in West Palm Beach, Florida, in 1936 and received a BSc (1957) and MSc (1961) from the University of Florida, and his PhD from the University of Miami in 1968 with a thesis on 'Competition between two South Florida Lizards of the Genus *Anolis*'. His early research focused on the systematics and ecology of lizards in the Caribbean region and Southeast Asia. In 1962-63 he spent a year doing fieldwork in Sarawak, sampling reptiles and amphibians. He worked closely with local Iban people, receiving Iban tribal tattoos that he wore proudly on each shoulder. In 1967 he began working with the New York Zoological Society (now Wildlife Conservation Society), where he held the positions of Chair of Education, Curator of Herpetology, Director of Conservation and Environmental Education, and Director of Zoological Conservation, until 1979. He served as Deputy Chair of the IUCN Species Survival Commission in 1978 and Chair of the Crocodile Specialist Group (of which he was one of 11 founding members) from 1973 to 1979 and again from 1981 to 1990. He was the Curator of Reptiles and Director of Florida Museum of Natural History from 1979 to 1997 and occupied positions as Professor of Zoology, Wildlife and Latin American studies at University of Florida until his retirement in 2007.

Significant publications include: Identification of Commercial Crocodile Skins (1971) with Peter Brazaitis; The Audubon Guide to North American Reptiles and Amphibians (1979) with John Behler; and, Crocodilians, Tuataras and Turtle Species of the World (1989) with Russel Burke. In the 1980s and 1990s, Wayne participated in fieldwork and crocodylian surveys in Venezuela, Guyana, Colombia, Nicaragua, Solomon Islands and Palau. However, his major impact was in the field of conservation policy and implementation at the international level. From his institutional bases at NYZS (WCS) and FLMNH and as a member and Chair of the CSG he exerted influence over many colleagues, students,

national agencies, and international wildlife managers. His initial position was that commercial exploitation of crocodylians was responsible for many species decline and should be eliminated. However, later in his career and under the influence of Harry Messel, Grahame Webb, John Hutton and others, he cautiously endorsed well-regulated sustainable use, advising US national agencies, CITES and programs in Colombia, Paraguay and Nicaragua to establish responsible management, trade regulation and monitoring surveys.

Wayne had contacts with the US reptile-leather industry and their representative, Clair Hagen, attended the inaugural CSG meeting in 1971. Through Clair Hagen, the Swiss 'Pfister novelty-leather company' assisted Wayne in arranging a 'Model-book of all novelty leathers' (including toads, sharks, etc.). He initiated the foundation of the CSG in 1971, and hosted the meeting at NYZS. Conservation status of crocodylians discussed there became the basis of the IUCN-SSC Red Data Books and were elaborated and confirmed at the 2nd CSG meeting in South Africa. Wayne was on the official US delegation for the Plenipotentiary Conference in Washington, D. C. which drafted CITES. As CSG Chair for two periods he established the stability and membership of that group, supported expert colleagues in Colombia, South Africa, Thailand, UK, Australia, Venezuela and USA, and was a major influence on IUCN policy. In recognition of his work, he received the Order of the Golden Ark in 1981 from Prince Bernhard of the Netherlands, awarded for major contributions to nature conservation. His influence also extended through many of his students and colleagues including Cecilia and Tomas Blohm, Howard 'Duke' Campbell, Les Garrick, Bob Godshalk, Phillip Hall, Kenny Krysko, Frank Mazzotti, Andy Ross, Andreas Seijas, John Thorbjarnarson and Kent Vliet.

Wayne King's contributions in this field stand as a tribute to his lifetime concern about conservation and crocodylians. He is survived by his wife Sherry and son Jeffrey.

Compiled by Perran Ross, René E. Honegger, Kenneth Krysko and Richard Franz.

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 October-December 2022 quarter.

1. Noah Koflowitch (USA): Comparative analysis of cultural, historical, and folkloric significance of crocodilians and their social behavior.

2. Andre Swanepoel (South Africa): Bio-behavioural stress response in farmed Nile crocodiles, with and without raw *Sceletium tortuosum* plant extract.

3. Muneer Ahmed Blaoch (Pakistan). Distribution, population status, threats and recommendations for the conservation of Marsh Crocodiles (*Crocodylus palustris*) in Balochistan, Pakistan.

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

CITES CoP19

The 19th Conference of the Parties to CITES (CoP19) was held in Panama City, Panama, on 14-25 November 2022. The 75th meeting of the CITES Standing Committee (SC75) took place on 13 November, and the 76th meeting (SC76) on 25 November. The CoP was attended by 3000+ participants, from 170+ countries, and included many NGOs. Of the 25 CSG members who attended, 11 were on national delegations, 5 were on the IUCN delegation, and 9 represented other organisations. Amongst the attendees were 5 CSG "future leaders", partly supported by the CSG.

There were three proposals at CoP19 seeking to transfer national crocodilian populations from Appendix I to Appendix II.

1. Brazil: Transfer of the Brazilian population of *Caiman latirostris* (Broad-snouted caiman) from Appendix I to Appendix II (CoP19 Prop. 11). This proposal was accepted by consensus.

   Caiman latirostris was listed on Appendix I in 1975. In Brazil, some commercial captive-breeding farms were established, but with limited exports. The proposal argued that the wild population, considered to comprise some 400,000 animals, no longer meets the criteria for Appendix 1. No national program of utilisation is planned, but management in Brazil is a State responsibility, and in the future, some States may wish to start a ranching or wild harvest program. The size of the recovered population clearly meets the criteria for Appendix II, which in turn will provide the flexibility needed to optimize management in different areas of the country. The proposal was annotated with a zero export quota for wild harvested animals, so approval from the Parties may be needed if a sustainable use program based on harvesting or ranching the wild population is developed in the future.

2. Philippines: Transfer of the Palawan population of *Crocodylus porosus* (Saltwater crocodile), in the Philippines, from Appendix I to Appendix II (CoP19 Prop. 12). This proposal was accepted by consensus.

   The wild *C. porosus* population in the Philippines was depleted historically by hunting for skins. Around 1990, a major crocodile farming centre, funded by Japan (JICA), was established on Palawan, specifically to breed *C. porosus* for skins. Stock from this facility were used to create sophisticated closed-cycle captive breeding establishments outside of Palawan. There are two areas in which wild *C. porosus* recovery is well documented - Palawan and Mindanao. The proposal concerned only the Palawan population, where local people receive no benefits and serious costs through human-crocodile conflict, from

the recovering population. The proposal is a Government-Private Sector initiative to determine whether a ranching program can be developed, or some other management scheme, where local people can benefit from the recovering population. The proposal was annotated with a zero export quota for wild specimens, pending the development and refinement of the program.

3. Thailand: Transfer of the Thai population of *Crocodylus siamensis* (Siamese crocodile) from Appendix I to Appendix II (CoP19 Prop. 13). This proposal was rejected by the Parties.

   The wild population of *C. siamensis* was considered on the brink of extinction by the late 1960s, and it remains so now. There are perhaps 100 individual wild *C. siamensis* located in small groups in National Parks - fragmented and well separated from each other. Thailand was a true international pioneer in crocodile farming, and the domestic farm population, now 5-6 generations captive-bred, comprises some 1.2+ million animals in 1500 establishments, most of which are small village level breeding farms, but including 29 large CITES-registered farms. Although progeny are traded as Appendix II (the progeny of Appendix I captive breeding), the national population is on Appendix I, and some Parties, with stricter domestic measures, will not import such products. The wild and captive populations are completely separated, and there is strong public and political opposition to reintroducing them to the wild (after 60+ years without them).

   Technically, the wild population still meets the criteria for Appendix I, and under the current interpretation of the Convention, a transfer to Appendix II is not possible. This is clearly a complex issue, and it was agreed to give Thailand guidance on how to proceed. This seems to be to try and rebuild at least 3 of the remnant wild populations as a priority, and present to the next Animals Committee meeting (July 2023) an updated review of the status of the wild population and the regulation of the captive population.

   The Chair of CITES Standing Committee suggested that the Thai case history should be included within further discussions of commercial captive breeding currently being undertaken (CoP19 Doc. 55; Registration of operations that breed Appendix-I animal species in captivity for commercial purposes), because it is a case history where the extent of captive breeding is clearly huge and independent of the wild population. In this regard it seems to parallel parallels chinchilla (*Chinchilla chinchilla*), a rodent whose wild population is on Appendix I, but the domestic form raised for meat is not on the Appendices.

The overall agenda and working documents for CoP19 are on the CITES website (https://cites.org/eng/meetings/cop). The summary records, provides information on all issues dealt with in Committees 1 and 2, and in the final plenary sessions on 24 and 25 November, when all proposals are accepted or rejected by the Parties.

In addition to these formal sessions, the "Daily Schedule" lists a large number of informal side-events, held by various Parties, the Secretariat, IUCN and NGOs as "information sessions". Some seriously good sessions on sustainable use, Indigenous people and communities, the IPBES Sustainable Use report and much more. Some of direct relevance to crocodilians were:

No. 86: Who Really Benefits? IPLCs and Wildlife Use; Sub-title: A review of the impacts of consumptive and non-consumptive wildlife use on local communities and livelihoods. 17 November 2023. Republic of Costa Rica and Fondation Franz Weber.

Questioning economic and other benefits is healthy, but using fallacious economic arguments to undermine the benefits Indigenous People and Local Communities receive is damaging. Claims made about the Northern Territory crocodile program were flawed, deceptive and harmful. Each stage in value-adding from an egg harvested from the wild to an exported Grade 1 skin, requires capital investment, ongoing costs, and increasing risks. Comparing the profit on the raw material to the final price, without considering that investment and risk, is invalid. Like comparing the amount of iron ore purchased (raw material) to the final production of a luxury car. The Indigenous people here receive many benefits from crocodiles, that are increasing not decreasing (http://asrac.org.au/news/new-asrac-crocodile-hatchery).

No. 185: CITES NDF Project 23 November 2023. CITES Secretariat.

A large CITES initiative has been established, in accordance with CITES Decision 18.132 [adopted by the Conference of the Parties to CITES in 2018, subparagraph c) i)], to address "non-detriment" (Article IV, para 2a) and develop new or updated NDF guidance materials. This initiative is just getting started, and an NDF Technical Advisory Group (TAG) will deal with the results from 11 different working groups. Some CSG members (in their private capacities) have been invited as members of some working groups.

"Non-detriment" provisions have proved difficult for Parties to comply with in any standardised way, so hopefully this new initiative will help. One area significant to crocodilians concerns the potential merging of the traceability aspirations of some CITES stakeholders (https://cites.org/eng/prog/Cross-cutting_issues/traceability), with the non-detriment provisions and obligations of the Convention. The text of the Convention refers to exports having to be "not detrimental to the survival of species" - assurance export is not contributing to the biological extinction of species in the wild. Yet it can be argued the benefits trade provides to conservation and livelihoods [Resolution Conf. 8.3 (Rev. CoP13)] could be compromised if consumers cannot satisfy themselves about supply chain intricacies (industrial traceability), which involves many non-biological issues (labour, gender, etc.) beyond the mandate of CITES. The degree to which these two issues can and should be linked, will be interesting to resolve.

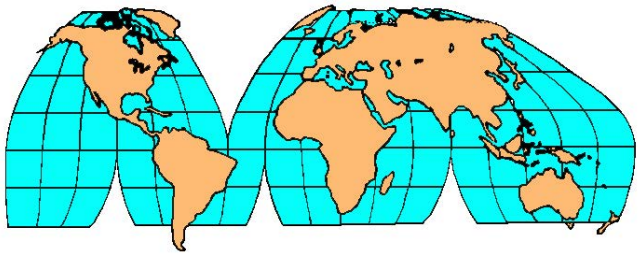
No. 213: Southeast Asia Reptile Conservation Alliance (SARCA 24 November 2023. IUCN-SSC Snake Specialist Group.

SARCA has advanced the science-based management of some reptile species, particularly pythons and water monitors in SE Asia, and has played a major role in linking various companies that use exotic reptile leather to those programs. They released a new proposed certifiable system for "Reptile Farming", which could apply to crocodilians, although CSG itself has formally had no input. International Crocodilian Farmers Association (ICFA) is engaged in a similar certifiable system for farms operated by their members.

Because all species of crocodilians are listed on the Appendices of CITES, CSG members have had a long history of attending CITES CoPs, promoting responsible science-based management when it can, working closely with IUCN. CoP19 was the 12th CoP I have attended in person. It remains a complex biopolitical arena, but one which has and will hopefully continue to have a positively influence on the conservation and management of perhaps half the species of extant crocodilians.

Grahame Webb, *CSG Chair (gwebb@wmi.com.au)*.

Regional Reports



Australia and Oceania

Australia

CUTTLEBONES REGURGIATED BY SALTWATER CROCODILE. A male *Crocodylus porosus* (TL= 3.23 m) was captured in a cage trap baited with a carcass of a feral pig (*Sus scrofa*) in Micket Creek, that feeds into Darwin Harbour of the Northern Territory, on 29 September 2022. We located four damaged cuttlefish bones (*Sepia* sp., approx. 9-13 cm long; Fig. 1) in the trap after removing the crocodile. Given that these cuttlebones were not present in the trap when the bait was set three days earlier, and it was not possible for cuttlefish to enter the trap through the mesh of the cage, we consider the crocodile regurgitated the cuttlebones in the trap.

The crocodile had several barnacles on the nuchal and dorsal scales (Fig. 2), which suggest that the animal had spent a good period of time continuously in sea water. We were unable to find any records indicating that *C. porosus* feed on cuttlefish, and we present this observation as anecdotal support for such predation.

Figure 1. Regurgitated cuttlebones found in trap.

Figure 2. Barnacles on dorsal scales of the crocodile.

Ian Hunt and Yusuke Fukuda, *Northern Territory Department of Environment, Parks and Water Security, Palmerston, NT 0831, Australia (ian.hunt@nt.gov.au)*.

East and Southeast Asia

Lao PDR

RESTORING THE CRITICALLY ENDANGERED SIAMESE CROCODILE TO THE XE CHAMPHONE WETLANDS IN LAO PDR (2019-2022). The Siamese crocodile (*Crocodylus siamensis*) is one of the most critically endangered crocodilians in the world (Platt *et al*. 2019). During the past 50-70 years, wild *C. siamensis* populations throughout mainland Southeast Asia have plummeted in the wake of illegal hunting for skins and meat, government-sponsored extermination programs, habitat loss and over-collecting to stock commercial crocodile farms (Platt *et al*. 2004; Simpson *et al*. 2006; Kanwatanakid-Savini *et al*. 2012;

Guérin 2013; Platt *et al*. 2018a). Fewer than 1000 adult *C. siamensis* now survive in the wild, and most populations are small, fragmented, and of questionable reproductive viability (Platt *et al*. 2019). Furthermore, although hundreds of thousands of *C. siamensis* are now held on commercial crocodile farms in Southeast Asia, the genetic integrity of this burgeoning captive population is compromised by widespread hybridization with Saltwater crocodiles (*C. porosus*) and to a lesser extent Cuban crocodiles (*C. rhombifer*) (FitzSimmons *et al*. 2002; Starr *et al*. 2009; Lepbenjakul *et al*. 2017; Nguyen *et al*. 2018).

The conservation situation is particularly acute in Lao PDR (= Laos) where potentially viable, albeit fragmented populations of wild *C. siamensis* survive in Attapu, Khammouane, Salavan and Savannakhet Provinces (Stuart and Platt 2000; Thorbjarnarson *et al*. 2004; Bezuijen *et al*. 2013; Zeigler *et al*. 2015; Souvannasy *et al*. 2018, 2021). Despite being legally protected as a "Prohibited Category I Species" (hunting and trade is strictly prohibited), Siamese crocodiles are threatened by deliberate killing for food and to protect people and livestock, collection of eggs for domestic consumption, incidental take in fishing gear, and most importantly, habitat loss (Platt 2012; Bezuijen *et al*. 2013; Platt *et al*. 2019). The latter is especially important in Savannakhet Province, which not only harbours some of the largest remaining wild crocodile populations (Bezuijen *et al*. 2013), but is also a major rice producing region and supports the highest rural population density anywhere in Laos (Bezuijen *et al*. 2006; Kosaka *et al*. 2006).

Recognizing that *C. siamensis* faced near-certain extinction in Laos unless immediate action was undertaken, the Wildlife Conservation Society-Lao Program (WCS) working in collaboration with the Government of Lao (GOL) prepared a long-term crocodile recovery plan in 2008 (Hedemark *et al*. 2009). The initial surveys conducted during this process identified a number of small *C. siamensis* populations in Savannakhet Province that would likely benefit from conservation efforts (Bezuijen *et al*. 2006). Encouragingly, most of these populations already received some degree of de facto protection stemming from local religious beliefs that crocodiles embody the spirits of dead ancestors and anyone harassing, harming, or killing a crocodile risks supernatural retribution in the form of misfortune, illness, or even death (Baird 2001; Platt 2012; Bezuijen *et al*. 2013; Platt *et al*. 2018a). Six wetlands in the Champhone and Xangxoy Rivers systems were then selected for inclusion in a community-based conservation project and designated Crocodile Conservation Areas (CCAs). Crude estimates suggested these wetlands might collectively contain 50-70 crocodiles in a metapopulation linked by the Xe Champhone-Xangxoy riverine corridor (Platt *et al*. 2018b).

Village-level discussions were held in communities adjacent to CCAs during 2008-09 to solicit local input for site-specific management plans designed to: 1) enhance crocodile recovery; 2) identify and protect critical wetland habitats; and, 3) establish conservation zones with accompanying regulations (Hedemark *et al*. 2009). In 2010-11, Village Conservation Teams (VCTs) were organized and tasked with monitoring crocodile populations, enforcing community conservation regulations, searching for crocodile nests, and assisting with egg collections, incubating eggs, and head-starting young crocodiles (see below). VCTs consisted of five to 20 locally recruited villagers, each of whom received a modest monthly stipend for participating in the project.

During the same period, WCS together with the Lao Zoo initiated an egg collection and head-starting program in which eggs were collected from the Xe Champhone wetlands and artificially incubated at the Lao Zoo, with the hatchlings then reared to a size [total length (TL) ca. 70-90 cm] considered relatively immune to predation before being released into the CCAs. To further engage local communities and instill a sense of ownership in the resource, from 2012 onwards, artificial incubation and head-starting were conducted in Tan Soum, a village located on the periphery of the wetlands. Augmenting these efforts, a conservation-breeding program using crocodiles genetically confirmed as *C. siamensis* was initiated at the Lao Zoo. Together these programs ultimately provided 65 head-started juveniles for release into the Xe Champhone wetlands during 2013 and 2014 (Platt *et al*. 2018b). Regrettably, and despite our demonstrated success in meeting objectives, donor funding was unexpectedly cancelled in early 2014, forcing us to disband the CCTs and terminate further conservation efforts.

After a hiatus of almost four years, in late 2017 WCS received funding to undertake a rapid assessment of the former CCAs, evaluate past conservation actions, and determine if renewed efforts were warranted. This assessment found evidence of crocodile reproduction (eg eggshells, nests with eggs, and observations of small juveniles) at most CCAs and moreover, increasingly frequent observations of crocodiles reported by villagers suggested the earlier releases had successfully augmented the small wild population. However, water extraction for dry season rice cultivation was identified as a significant and growing threat to wetland integrity and ultimately, the long-term viability of crocodile populations (Platt *et al*. 2018b). Shortly thereafter (2019-20), WCS assumed co-management responsibilities with GOL for the Xe Champhone Ramsar Site (XCRS). VCTs were reassembled and crocodile nest surveys, egg collections, and head-starting resumed during the wet season of 2019 and continue to the present. We herein report on progress made since 2019 towards attaining our ultimate objective of restoring a functional metapopulation (Hanski and Simberloff 1997) of Siamese crocodiles in the Xe Champhone wetland ecosystem.

Xe Champhone Wetlands

The Xe Champhone wetlands are located in the floodplain of the Champhone and Xangxoy Rivers in Savannakhet Province of Central Laos. Much of this area is now administered as the Xe Champhone Ramsar Site (XCRS). Established in 2010, the XCRS encompasses 12,400 ha of seasonally inundated natural and anthropogenic wetlands, agricultural ecosystems, scrublands, and forest, and includes two core areas totaling

2550 ha (IUCN 2011). Siamese crocodiles are considered a focal keystone species within the Ramsar Site and critical crocodile habitat identified during our earlier efforts was taken into consideration when designating the two core areas (IUCN 2011). A proposed boundary expansion will include the Nong Louang Wetland Complex and if approved, increase the area encompassed by the Ramsar site to 45,000 ha (Platt *et al*. 2018b). The XCRS is within the Mekong Plain physiographic province and experiences a tropical monsoonal climate with a wet season extending from mid- to late May through late October; peak rainfall and flooding occurs in September and October (Platt *et al*. 2018b). The physical environment, vegetation, and social setting of XCRS are discussed in greater detail elsewhere (IUCN 2011; Timmins 2013; Platt *et al*. 2018b).

Crocodile Nest Surveys, Egg Collections, and Incubation

Our field observations indicate that *C. siamensis* in central Laos begin nesting in early to mid-May (Fig. 1), shortly before the onset of heavy rains signaling the arrival of the annual monsoon. Given this reproductive phenology, VCTs begin searching for crocodile nests in early May and surveys continue through late July. Teams focus on microsites used by nesting females in previous years, and also search other potential nesting habitat. A significant number of nests are opportunistically found by team members engaged in routine livelihood activities (eg fishing, harvesting snails, cultivating rice fields, etc.). Other villagers who find crocodile nests are asked to inform the local VCT. When a nest is located, VCTs immediately notify the WCS Field Office in Savannakhet and we make arrangements to travel to the site and collect the clutch. During the most recent (2022) nesting season, we successfully employed a drone (DJI Mavic 3 Fly More Combo) to search for crocodile nests in difficult-to-access, heavily vegetated oxbow lakes (Platt *et al*., in prep.). As a result of this preliminary trial, drone surveys will henceforth be incorporated into our annual crocodile nest surveys.

Figure 1. Siamese crocodile nest on a floating peat mat in Xe Champhone Ramsar Site, Lao PDR (June 2022).

Upon being notified of an active crocodile nest by VCTs, we make every effort to recover the clutch as quickly as possible (usually within 24 hours) to reduce the likelihood of losses to poachers, predators, or flooding. Our egg collection protocols are described in detail by Platt (2021). To briefly summarize, we open the nest mound to expose the clutch and carefully remove the eggs. The upward-facing surface of each egg is marked with a pencil to ensure that proper orientation can be maintained during all phases of the collection process. We determine if eggs are viable based on the presence of an opaque band on the eggshell. Each egg is then weighed and measured (length and width) before being placed in a Styrofoam box containing nesting material for transport to our incubation facility in Tan Soum Village. In accordance with local beliefs, VCTs often request that we leave a small number of eggs (1-3) in the nest mound to avoid offending the female crocodile. Depending on where a nest is located, transporting the eggs to our incubation facility can involve lengthy trips over deeply rutted roads. Care is therefore exercised to minimize jarring and vibrations that could damage the developing embryos.

During early years of the project (2011-13) and again in 2019, we incubated each clutch in an artificial nest chamber consisting of a wooden frame (ca. 1 m × 1 m × 1 m) covered with fine-mesh wire netting and fitted with a hinged top. The incubation media consisted of material collected from the nest, dried bamboo leaves, rice straw, and other vegetative detritus, which was kept moist (either by rainfall or supplemental watering) but not wet. We placed the incubation chambers in an exposed location with no overhead tree cover to mimic the natural environment of most nests (Platt *et al*. 2014). In 2020, we adopted a different approach and began incubating eggs in Styrofoam boxes (49 cm × 27 cm wide and 33 cm high). We fill the box with moist sand to a depth of about 10 cm, partially bury each egg in the sand, and then cover the clutch with nest material and dried leaves. Five ventilation holes (ca. 2.5 cm in diameter) in the box and lid allow for airflow (Fig. 2). The incubation media is frequently monitored and moistened if needed. We keep the egg-filled boxes in a vacant room of the village administration building and incubation occurs under ambient air temperatures. At the request of VCTs, we incubate both viable and non-viable eggs.

We found 19 Siamese crocodile nests in XCRS in 2019-22, including one nest from which the clutch had been removed prior to our arrival and another that contained badly decomposed eggs as a result of prolonged submergence by floodwaters (Table 1).

Of these nests, 14 (73.6%) were constructed on floating peat mats and 5 (26.3%) in dense thickets along the shoreline. With a single exception, female crocodiles made no attempt to defend their nests when we collected the clutch. The mean (± 1 SD) clutch size for 18 nests containing eggs was 28.2 ± 10.2 eggs (range= 12 to 55 eggs). The clutch of 55 eggs we found is among the largest reported for wild *C. siamensis* (reviewed by Platt *et al*. 2019). However, given the placement of eggs in distinct clusters within the mound and the wide variation among egg measurements (especially egg width), we cannot rule out the possibility this clutch represents the reproductive efforts of two females that deposited eggs in the same nest mound. Of the 496 eggs we examined (excluding the clutch of 12 badly decomposed eggs), 430 (86.6%) proved viable.

Figure 2. Crocodile eggs are incubated in Styrofoam boxes. Eggs are partially buried in moist sand (top) and then covered with nesting media (middle). Note the opaque bands on viable eggs and ventilation hole in side of box (above the eggs). Eggs are incubated in a vacant room of the village administration office under ambient air temperatures (bottom).

We incubated 420 viable eggs, of which 218 successfully hatched (51.9%). Hatching rates ranged from a low of 43.5% in 2021 to a high of 64.3% in 2020. Based on data from the 2019 cohort (see below), our incubation regime is producing a strongly female-biased sex ratio among the hatchlings.

Head-starting and Translocation

Since the project was resumed in 2019, 47 head-started crocodiles have been released into the wild, and another 149 are currently being head-started for eventual release (Table 2). Given that 218 eggs successfully hatched, this represents a survival rate of 90.0% among our head-started crocodiles.

Table 1. Siamese Crocodile nests found at the Xe Champhone Ramsar Site in Savannakhet Province, Lao PDR (2019-2022). Nests are presented by location in the approximate order of collection. A clutch collected from a nest at Kout Jek (2021) was rotten after being submerged by floodwaters earlier in the year; the viability of these eggs could not be determined. A nest found at Taloung Reservoir (2022) was robbed by egg poachers before our arrival. CS= clutch size. VE (%)= number of viable eggs in clutch. H= hatched. Number of eggs incubated is occasionally less than CS because one or more eggs were left in these nest mounds (see text). Hatching rate was calculated based on the number of viable eggs incubated. In some cases not all viable eggs were incubated. Asterisk denotes a nest that likely contained clutches from two females.

Year/Location	CS	VE (%)	Incubated	H (%)
2019				
Tan Soum Reservoir (1)	24	24 (100)	24	12 (50.0)
Kout Pi Noi	27	27 (100.0)	27	12 (44.4)
Tan Soum Reservoir (2)	40	36 (90.0)	35	22 (62.8)
2020				
Kout Pi Noi	22	21 (95.4)	22	15 (71.4)
Kout Mak Pheo*	55	52 (94.5)	55	32 (61.5)
2021				
Kout Xe Hauk	20	17 (85.0)	20	10 (58.8)
Kout Mak Pheo	38	38 (100.0)	38	4 (10.5)
Kout Kouang	29	28 (96.5)	26	20 (76.9)
Nong Or	24	21 (87.5)	20	10 (50.0)
Kout Jek	12	0 (0.0)	0	0 (0.0)
2022				
Kout Jek	30	2 (6.6)	27	0 (0.0)
Taloung Reservoir	?	?	0	0
Kout Mak Pheo (2)	39	38 (97.4)	37	20 (54.0)
Kout Kouang (1)	13	13 (100.0)	12	9 (75.0)
Kout Kouang (2)	28	28 (100.0)	27	19 (70.3)
Kout Koke	29	29 (100.0)	28	19 (67.8)
Nong Wai	34	34 (100.0)	32	8 (25.0)
Kout Xe Hauk	16	3 (18.7)	14	0 (0.0)
Kout Mak Pheo (2)	28	19 (67.8)	24	6 (31.5)
Totals	**508**	**430**	**468**	**218**

Head-starting is carried out in two batteries of concrete grow-out pens constructed in Tan Soum Village during 2012-13 (Platt *et al*. 2014). Each battery contains four pens (2 m wide × 3 m long × 1.1 m high) with approximately equal areas of land and water (Fig. 3). Cover boards and water hyacinths (*Pontederia crassipes*) are placed in the pens to provide concealment for young crocodiles. VCT members are tasked with feeding crocodiles a variety of locally sourced fresh prey, including fish, eels, frogs, and golden apple snails (*Pomacea canaliculata*). Because young crocodiles lack the jaw strength necessary to crush apple snails, we crack the shells before offering them as food. The water in each grow-out pen is changed at least twice weekly. We collect morphometric data from the cohorts every 1-2 months and segregate similar-sized individuals into different grow-out pens according to total length (TL). This practice is designed

to lessen the competitive impact of dominant individuals on smaller members of the cohort. Crocodiles are head-started for approximately 30 months before being transitioned into the wild.

Table 2. Cohorts of head-started Siamese crocodiles hatched from eggs collected in the Xe Champhone Ramsar Site (2019-2022). The 2019 cohort was released in March-April 2022 (see text).

Cohort	Number	Year of release
2019	47	2022
2020	31	2023
2021	38	2024
2022	80	2025
Total	**196**	**-**

Figure 3. Concrete grow-out pen used to head-start young crocodiles. Water hyacinth provide concealment and woven bamboo matting facilitates movement of hatchlings between water and land. Two batteries, each containing four grow-out pens are available for head-starting crocodiles in Tan Soum Village.

We use a "soft-release" strategy to ease the transition of head-started crocodiles from captivity into the wild (Platt *et al*. 2014). Soft-release strategies typically entail the temporary confinement of animals in enclosures at the release site, a practice designed to familiarize animals with local habitats, curtail post-release wandering, and increase the likelihood that stable territories will be established (Letty *et al*. 2007; Knox and Monk 2014). Although crocodilian-specific data appear lacking in the peer-reviewed scientific literature, pre-release confinement has been demonstrated to dramatically increase site fidelity among other translocated reptiles, including chelonians and squamates (Tuberville *et al*. 2005; Knox and Monk 2014; McCoy *et al*. 2014).

We erected a temporary acclimation pen for the release of head-started crocodiles into Phai Cheo (Tan Soum) Reservoir in late February 2022 (Fig. 4). The pen (6 m × 12 m) was constructed in shallow water (ca. 1.5 m deep), encompassed floating and emergent vegetation, and consisted of a light

Figure 4. Temporary acclimation pen constructed for the release of head-started crocodiles at Phai Cheo Reservoir (above) in March-April 2022. The pen encompassed emergent and floating vegetation (below).

bamboo framework covered in plastic poultry netting, and secured to wooden posts driven into the substrate. The base of the poultry netting was buried in the substrate to prevent crocodiles from escaping prematurely by burrowing beneath the fence. Two floating bamboo platforms were placed in the pen to provide sites for basking and feeding. VCT members supplied food (fish, eels, and apple snails) three times weekly throughout the penning period.

We measured and determined the sex of the 2019 cohort (N= 47) before transferring these crocodiles into acclimation pen on 3 March 2022 (Fig. 5). The mean (± 1 SD) and median TL of this cohort were 91.1 ± 10.5 cm and 92.0 cm, respectively (range= 68.0 to 110.0 cm). The cohort consisted of 12 males and 35 females (1 male: 2.9 females). The wariness of the young crocodiles, combined with the water depth and dense aquatic vegetation, made monitoring the cohort after release into the pen extremely difficult. Nonetheless, by 14 March 2022, at least three to five of the larger crocodiles had escaped, apparently by climbing over the fence. These crocodiles remained in the vicinity and approached the pen when VCT members were feeding the other crocodiles. Escapes continued and by 5 May the acclimation pen contained only three crocodiles. Shortly thereafter we removed sections

Figure 5. Larger members of the 2019 cohort shortly before being transferred into the acclimation pen (March 2022).

of the fence and liberated the remaining crocodiles. Our experience mirrors that of 2013-14 when most crocodiles escaped from the acclimation pen within several weeks (Platt *et al*. 2014), and highlights the difficulty of constructing a temporary, escape-proof enclosure. One member of the 2019 cohort drowned after becoming entangled in a fishing net (25 April 2022). Fishermen reportedly captured and released two other members of the 2019 cohort from fish traps during April and May.

Population Monitoring

Given the difficulty of detecting crocodiles during nocturnal spotlight counts in heavily vegetated habitats, and the limitations of camera trapping and track and sign surveys, annual nest counts are the most appropriate method for monitoring long-term population trends of Siamese crocodiles and evaluating conservation outcomes in XCRS (Platt 2021). Nest counts are a valuable tool in crocodilian managements programs worldwide, and have been successfully employed to monitor populations of both hole- and mound-nesting species (eg McNease *et al*. 1994; Rainwater and Platt 2009). Trends in nest count data provide a statistically rigorous means to assess the numerical response of populations over time (Nichols 1987; McNease *et al*. 1994). Furthermore, if the proportional representation of sexually mature females in the population can be determined, nest counts are useful for estimating population size (Chabreck 1966; Nichols 1987; Webb *et al*. 1989). That said, we currently lack sufficient a sufficient number of years of nest count data to statistically detect population trends through linear regression (Zar 1996). However, if we assume breeding females constitute 4-13% of the population (Webb *et al*. 1989), our nest count from 2022 (Table 1) suggests the number of crocodiles inhabiting the Xe Champhone wetlands could range as high as 70 to 225 individuals. As such, this population is of global conservation significance and ranks among the largest known wild *C. siamensis* population anywhere in mainland Southeast Asia.

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Literature Cited

Baird, I.G. (2001). The protected crocodiles, wetlands, and forests at Ban Beung Buoa Thong and Ban Nao Neua, Xaibouli District, Savannakhet Province, southern Lao PDR. Crocodile Specialist Group Newsletter 20(2): 22-24.

Bezuijen, M.R., Cox, J.H. Jr., Thorbjarnarson, J.B., Phothitay, C., Hedermark, M. and Rasphone, A. (2013). Status of Siamese Crocodile (*Crocodylus siamensis*) Schneider, 1801 (Reptilia: Crocodylia) in Laos. Journal of Herpetology 47: 41-65.

Bezuijen, M.R., Phothitay, C., Hedermark, M. and Chanrya, S. (2006). Preliminary status review of the Siamese crocodile (*Crocodylus siamensis* Schneider, 1801) (Reptilia: Crocodylia) in the Lao People's Democratic Republic. Mekong Wetlands Biodiversity Conservation and Sustainable Use Programme: Vientiane, Lao PDR.

Chabreck, R.H. (1966). Methods of determining the size and composition of alligator populations in Louisiana. Proceedings of the Southeastern Association of Game and Fish Agencies 20: 105-122.

FitzSimmons, N.N., Buchan, J.C., Lam, P.V., Polet, G., Hung, T.T., Thang, N.Q. and Gratten, J. (2002). Identification of purebred *Crocodylus siamensis* for reintroduction in Vietnam. Journal of Experimental Zoology 294: 373-381.

Guérin, M. (2013). Getting rid of the crocodile pest in Cambodia. Crocodile Specialist Group Newsletter 32(4): 18-21.

Hanski, I.A. and Simberloff, D. (1997). The metapopulation approach, its history, conceptual domain, and application to conservation. Pp. 5-26 *in* Metapopulation Biology: Ecology, Genetics, and Evolution, ed. by I.A. Hanski and M.E. Gilpin. Academic Press: San Diego.

Hedemark, M., Cox, J.H. Jr. and Somvongsa, C. (2009). Community-based crocodile resource management plan

and project document for Savannakhet Province, Lao PDR. Report to Wildlife Conservation Society-Lao PDR Program: Savannakhet, Laos.

IUCN (2011). Baseline Report: Xe Champhone Wetkand, Champhone and Xonbuly Districts, Savannakhet Province, Lao PDR. Mekong Water Dialogues Project. IUCN Publications: Gland, Switzerland.

Kanwatanakid-Savini, C., Pliosungnoen, M., Pattanavibool, A., Thorbjarnarson, J.B., Limlikhitaksorn, C. and Platt, S.G. (2012). A survey to determine the conservation status of Siamese crocodiles in Kaeng Krachan National Park, Thailand. Herpetological Conservation and Biology 7: 157-168.

Knox, C.D. and Monk, J.M. (2014). Penning prior to release decreases post-translocation dispersal of jeweled geckos. Animal Conservation 17: 18-26.

Kosaka, Y., Takeda, S., Sithrajvongsa, S. and Xaydala, K. (2006). Plant diversity in paddy fields in relation to agricultural practices in Savannakhet Province, Laos. Economic Botany 60: 49-61.

Lepbenjakul, S., Thapana, W., Twilprawat, P., Musangmai, N., Kanchanaketu, T. Temsiripong, Y., Unajak, S., Peyachoknagul, S. and Srikulnathik, K. (2017). High genetic diversity and demographic history of captive Siamese and saltwater crocodiles suggest the first step toward the establishment of a breeding and reintroduction program in Thailand. PLoS ONE 12(9): e0184526.

Letty, J., Marchandeu, S. and Aubineau, J. (2007). Problems encountered by individuals in animal translocations: lessons from field studies. Ecoscience 14: 420-431.

McCoy, E.D., Osman, N., Hauch, B., Emerick, A. and Mushinsky, H.R. (2014). Increasing the chances of successful translocation of a threatened lizard. Animal Conservation 17: 56-64.

McNease, L., Kinler, N. and Joanen, T. (1994). Distribution and relative abundance of alligator nests in Louisiana coastal marshes. Pp. 108-120 *in* Crocodiles. Proceedings of the 12th Working Meeting of the IUCN-SSC Crocodile Specialist Group. IUCN: Gland, Switzerland.

Nichols, J.D. (1987). Population models and crocodile management. Pp. 177-187 *in* Wildlife Management: Crocodiles and Alligators ed. by G.J.W. Webb, S.C. Manolis, and P.J. Whitehead. Surrey Beatty & Sons: Chipping Norton.

Nguyen, T.T., Ziegler, T., Rauhaus, A., Nguyen, T.Q., Tran, D.T.A., Wayakone, S., Luu, V.Q., Vences, M. and Le, M.D. (2018). Genetic screening of Siamese Crocodiles (*Crocodylus siamensis*) in Laos and Vietnam: Identifying purebred individuals for conservation and release programs. Crocodile Specialist Group Newsletter 37(2): 8-14.

Platt, S.G. (2012). Community-based crocodile conservation in Lao PDR. Report to Wildlife Conservation Society: Bronx, New York.

Platt, S.G. (2021). Monitoring the recovery of Siamese crocodiles in wetlands of the Xe Champhone Ramsar Site, Savannakhet Province, Lao PDR. Report to Wildlife Conservation Society: Bronx, New York.

Platt, S.G., Sovannara, H., Kheng, L., Thorbjarnarson, J.B. and Rainwater, T.R. (2004). Population status and conservation of wild Siamese Crocodiles (*Crocodylus siamensis*) in the Tonle Sap Biosphere Reserve, Cambodia. Natural History Bulletin of the Siam Society 52: 133-149.

Platt, S.G., McCaskill, L., Rainwater, T.R., Temsiripong, Y., As-singkily, M., Simpson, B.K. and Bezuijen, M.R. (2019). Siamese Crocodile *Crocodylus siamensis*. *In* Crocodiles: Status Survey and Conservation Action Plan, 4th Edition, ed. by S.C. Manolis and C. Stevenson. Crocodile Specialist Group: Darwin.

Platt, S.G., Thongsavath, O., Outhanekone, P. and Rainwater, T.R. (2018a). Notes on traditional ecological knowledge and ethnoherpetology of Siamese crocodiles in Lao PDR. Crocodile Specialist Group Newsletter 37(4): 6-12.

Platt, S.G., Thongsavath, O., Pothitay, C., Holmes, C., McCaskill, L. and Rainwater, T.R. (2018b). A status assessment and long-term conservation plan for Siamese Crocodiles in the Xe Champhone Ramsar Site, Savannakhet Province, Lao PDR. Pp. 219-237 *in* Crocodiles. Proceedings of the 25th Working Meeting of the IUCN-SSC Crocodile Specialist Group. IUCN: Gland, Switzerland.

Platt, S.G., Thongsavath, O., Sisavath, P., Outhanekone, P., McWilliams, A.C. and Hallam, C.D. (2014). Community-based Siamese crocodile conservation in Lao PDR. Crocodile Specialist Group Newsletter 33(2): 22-27.

Rainwater, T.R., and Platt, S.G. (2009). Possible decline of an American crocodile (*Crocodylus acutus*) population on Turneffe Atoll, Belize. Herpetological Bulletin 107: 3-11.

Simpson, B.K., Chheang, D. and Han, S. (2006). The status of the Siamese Crocodile in Cambodia. Pp. 293-305 *in* Crocodiles. Proceedings of the 18th Working Meeting of the IUCN-SSC Crocodile Specialist Group. IUCN: Gland, Switzerland.

Souvannasy, P. Luu, V.Q., Soudthichak, S., Wayakone, S., Le, M., Nguyen, T.Q. and Ziegler, T. (2018). Evidence of another overlooked Siamese Crocodile (*Crocodylus siamensis*) population in Khammouane Province, central Lao PDR. Crocodile Specialist Group Newsletter 37(3): 6-8.

Souvannasy, P. Luu, V.Q., Wayakone, S., Sounivang, B., Soudthichak, S., Nguyen, Q., Le, M.D. and Ziegler, T. (2021). Camera trap confirmation of another Siamese Crocodile (*Crocodylus siamensis*) population in Khammouane Province, Lao PDR, with notes on conservation planning. Crocodile Specialist Group Newsletter 40(3): 22-24.

Starr, A., Daltry, J. and Ratanapich, N. (2009). DNA study reveals pure Siamese Crocodiles at Phnom Tamao Wildlife Rescue Centre, Cambodia. Crocodile Specialist Group Newsletter 28(2): 5-7.

Stuart, B.L. and Platt, S.G. (2000). Status of Siamese Crocodile in Laos. Pp. 523-530 *in* Crocodiles. Proceedings of the 15th Working Meeting of the IUCN-SSC Crocodile Specialist Group. IUCN: Gland, Switzerland.

Thorbjarnarson, J., Photitay, C. and Hedermark, M. (2004). Conservation of the critically endangered Siamese Crocodile in Lao PDR. Pp. 121-128 *in* Crocodiles. Proceedings of the 17th Working Meeting of the IUCN-SSC Crocodile Specialist Group. IUCN: Gland, Switzerland.

Timmins, R.J. (2013). The significance of the Xe Champhone Ramsar Site (Savannakhet Province, Lao PDR) and its surroundings for biodiversity conservation: Results of bird and mammal surveys and implications for Ramsar site boundary revision. IUCN: Vientiane.

Tuberville, T.D., Clark, E.E., Buhlmann, K.A., and Gibbons, J.W. (2005). Translocation as a conservation tool: site fidelity and movement of repatriated gopher tortoises (*Gopherus polyphemus*). Animal Conservation 8: 349-358.

Webb, G.J.W., Bayliss, P.G. and Manolis, S.C. (1989). Population research on crocodiles in the Northern Territory, 1984-86. Pp. 22-59 *in* Crocodiles. Proceedings of the 8th Working Meeting of the IUCN-SSC Crocodile Specialist Group. IUCN: Gland, Switzerland.

Zar, J.H. Jr. (1996). Biostatistical Analysis. Prentice Hall: Upper Saddle River, New Jersey.

Zeigler, T., Luu, V.Q., Soudthichak, S. and Nguyen, T.Q. (2015). Rediscovery of the Siamese crocodile (*Crocodylus siamensis*) in Khammouane Province, Central Lao PDR. Crocodile Specialist Group Newsletter 34(3): 11-13.

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South Asia and Iran

India

NESTING TREND OF ESTUARINE CROCODILES, *CROCODYLUS POROSUS*, IN THE FOREST BLOCKS OF BHITARKANIKA WILDLIFE SANCTUARY/NATIONAL PARK, ODISHA, INDIA. The population of Estuarine crocodiles (*Crocodylus porosus*) in the river systems of Odisha, as well as in other parts of India, were significantly reduced in the 1970s due to combination of poaching and habitat loss. With initiation of the Government of India/FAO/UNDP Project "Crocodile Breeding and Management", a Crocodile Conservation Project was launched in different states to save *C. porosus*, as well as *Gavialis gangeticus* and *C. palustris*, from extinction. The Estuarine Crocodile Conservation and Research Programme was first implemented by the Odisha Forest Department in Bhitarkanika Wildlife Sanctuary/National Park in mid-1975.

To build up the depleted population of the crocodiles in the wild, priority was given to a "rear and release" program, as well as other conservation activities including preservation of threatened mangrove habitats (Kar 1980). Eggs from crocodile nests located in different forest blocks/habitats of BNP (Fig. 1 and front cover) were collected for incubation at Dangmal Research Centre, from 1975 to 1994. The resulting hatchlings were reared in pools at the research centre (Fig. 2) and were released into the wild in phases after reaching over 1 m total length.

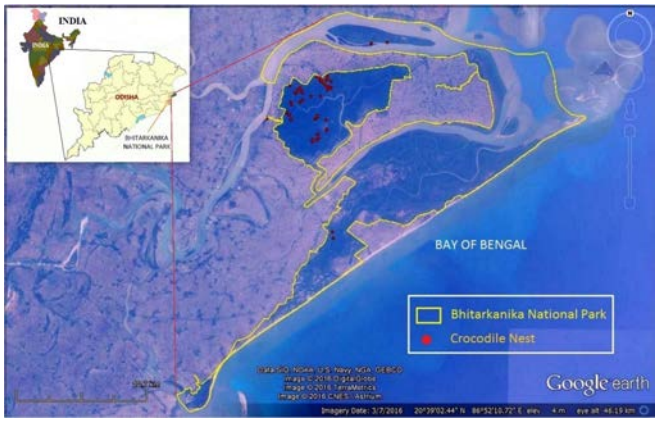

Figure 1. Google Earth Map showing distribution of ?? *C. porosus* nests in the Forest blocks of Bhitarkanika National Park.

The 1976 census indicated a population of 96 crocodiles in different size classes, including 13 females and 16 males, in the entire river systems of BWS/BNP (Kar and Bustard 1989). Of the 13 females, up to six females were laying eggs annually in different forest blocks from 1975 to 1986, depending upon the suitability of the nesting area and availability of nesting materials such as the aquatic fern Kharakari (*Acrostichum aureum*), Hental (*Phoenix paludosa*), etc.

After two decades of studies (1975-1984), it was decided that BNP (145 km^2, 200 km of rivers/creeks), containing core and

Figure 2. Rearing of juvenile *C. porosus* at Dangmal Research Centre before release into the wild. They were conditioned to bucket sound and timing of feeding. Photograph: Sudhakar Kar.

potential crocodile habitats, could not accommodate more released crocodiles. Accordingly, large scale egg collection from wild nests and release of juveniles were stopped, and natural recruitment was allowed to maintain the wild population (Behura and Kar 1981). Since 1995, 1-2 clutches of eggs have been collected for incubation in order to maintain skills in incubation and hatching acquired over the years.

The 2022 census indicated 1784 crocodiles (Kar 2022), of which 300+ were adults. The release program resulted in more than 3000 juvenile crocodiles being released into suitable rivers and creeks in BNP (Kar and Bustard 1990, 1991; Fig. 3). At the beginning of the project in July 1975, only one nest was located. From 1976 to 1984, an average of 5 nests were located annually (range 4 to 6 nests). From 1985 to 1994, an average of 6 nests were laid (range 2 to 8 nests). Since 1995, gradually more females, including released ones (females start laying eggs at 10-12 years of age), nested. Searches for nests were revived in 2003, with 49 nests being recorded in that year. In 2022, a record number of 122 nests was reported, representing a significant increase over historical nesting in the early years of the program.

Figure 3. Released juvenile (1.2 m) and sub-adult (2.1 m) *C. porosus* basking on a muddy river bank on a cool winter morning. Photograph: Nimai-Bhakta.

Most (90.2%) nests have been reported from Kanika Range (main Bhitarkanika River from Khola to Pathasala, Thanapati Creek, Mahinsamada Creek, Suhajore Creek, etc.), since it satisfies all the basic requirements for nesting such as low-lying areas, network of creeks/creeklets, good mangrove cover, preferred nesting materials, no fishing activities, water depth, hypo-salinity condition, etc.). The remainder of nests are scattered in Rajnagar Range (7.4%), Gahirmatha Wildlife Range (2.0%) and Mahakalapada Range (0.8%).

Besides studies on the ecology and biology of Estuarine crocodiles over four and half decades, emphasis have been given to: conducting annual winter census of Estuarine crocodiles in the river systems of Bhitarkanika to assess status and population trends since 1976; and, locating nests in the forest blocks, collection of eggs for incubation and quantifying the nesting trend over time. These are important annual activities which have significance for the future management and conservation of the species as well as the mangrove ecosystems.

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Literature Cited

Behura, B.K. and Kar, S.K. (1981). A note on the egg predators of the Saltwater crocodile, *Crocodylus porosus* Schneider in the Bhitarkanika Wildlife Sanctuary, Orissa. Pranikee 2: 25-28.

Kar, S.K. (1980). The Saltwater crocodile project, Orissa. Makara 2(1) : 7-8.

Kar, S.K. (1990). Results of a pilot Saltwater crocodile, *Crocodylus porosus* Schneider restocking in Bhitarkanika Wildlife Sanctuary, Orissa. Journal of the Bombay Natural History Society 87(2): 195-200.

Kar, S.K. and Bustard, H.R. (1991). Rehabilitation of saltwater crocodiles, *Crocodylus porosus* Schneider in the Bhitarkanika Wildlife Sanctuary, Orissa. Journal of the Bombay Natural History Society 88(3): 395-399.

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

Kar, S.K. and Bustard, H.R. (1989). Status of Saltwater crocodiles (*Crocodylus porosus* Schneider) in Bhitarkanika Wildlife Sanctuary, Orissa, Journal of the Bombay Natural History Society 86(2): 141-150.

Sudhakar Kar, *Subhadra Nibas, Durgamadhab Nagar, Sampur, Bhubaneswar-751003, Odisha, India*.

50 YEARS OF CROCODILE CONSERVATION IN INDIA. In 2022, India celebrated 50 years of enactment of the *Wild Life (Protection) Act, 1972*. A recent publication, "Wildlife India @ 50: Saving the Wild, Securing the Future" (Misra 2022), captures India's 50-year wildlife conservation journey through the eyes and experiences of a diverse set of 31 authors who played a part in it. Crocodilians are represented by Lala Singh in Chapter 11 of the book (Singh 2022).

Crocodile conservation started nationwide in India next only to Project Tiger. It achieved quick success in developing local knowledge and skills by the time international collaboration with UNDP/FAO ended in 1982. The foundation was able to be built and succeed because of research for conservation purposes, as recommended by H. Robert Bustard, who was at that time FAO Chief Technical Advisor.

Lala Singh describes a first-person account about how he stepped out of university and was selected as a crocodile researcher to work on Gharial (*Gavialis gangeticus*), and how Sudhakar Kar and Binod C. Choudhury were inducted into the project for Saltwater crocodiles (*Crocodylus porosus*) and Muggers (*C. palustris*), respectively. Lala narrates his journey through Satkoshia Sanctuary, the field tests we had to undergo for selection, the development of India's first crocodile research base at Tikarpada-Odisha, the central crocodile institute at Hyderabad, and the field camp at Chambal for long-term ecological studies. Among other aspects, Lala narrates experiences of facing dacoits (bandits) in Chambal, capturing wild Gharials for radio-tracking, the Mugger project in Similipal, and the resumption of Gharial breeding in Satkoshia Sanctuary in 2021.

Very fondly, Lala is nostalgic of his participation at the CSG Working Meeting in 1984, in Caracas, Venezuela, with me (Sudhakar) and Binod. There, Professor Harry Messel, then CSG Deputy Chair, gave a call to the assemblage of nearly 300 delegates to give a standing ovation to the success of the Indian crocodile conservation program in the hands of (then) young researchers. Crocodile conservation had emerged from commercial objectives, while Lala and we, his colleagues, have ferried and continued as wildlife researchers over the last 47 years. Thanks Lala.

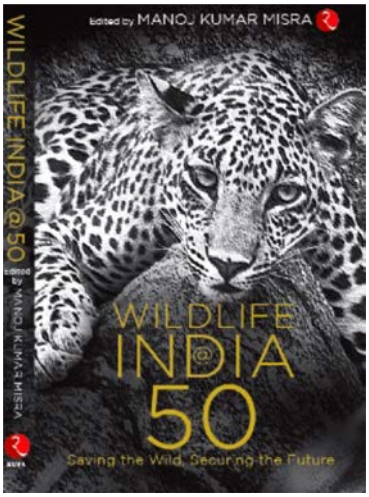

Figure 1. Dr. Lala Singh (right) at launch of "Wildlife India @ 50: Saving the Wild, Securing the Future" on 9 September 2022.

Figure 2. From left: Manoj Kumar Misra (editor), H.S. Panwar (former Director of Wildlife Institute of India), Dr. M. K. Ranjitsinh and Mr. Ravi Singh (Secretary General, WWF-India) at launch of "Wildlife India @ 50: Saving the Wild, Securing the Future".

Literature Cited

Singh, L.A.K. (2022). From commerce to conservation: Saving crocodiles while ferrying as a wildlife researcher. Pp. 164-183 *in* Wildlife India @ 50: Saving the Wild, Securing the Future, ed. by M.K. Misra. Rupa Publications India: New Delhi.

Misra, M.K. (Ed.) (2022). Wildlife India @ 50: Saving the Wild, Securing the Future. Rupa Publications India: New Delhi.

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NEW LOCALITY RECORD FOR *CROCODYLUS PALUSTRIS* (LESSON, 1831) FROM TERAI ARC LANDSCAPE, NORTH INDIA. Of the three species of crocodile found in India, the most common and widely distributed is the Mugger (*Crocodylus palustris*), which inhabits various freshwater habitats such as rivers, lakes, dams, hill streams and village ponds. The Mugger is distributed

across the Indian sub-continent, in India, Nepal, Pakistan, Iran and Sri Lanka, and possibly Bangladesh (Choudhury and de Silva 2013). The species is listed in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), and as 'Vulnerable' in the IUCN Red List of Threatened Species. In order to manage and protect the surviving population in India, the Mugger is listed under 'Schedule I' of the *Wildlife (Protection) Act, 1972*, which enables the country to provide the species with the highest level of legal protection.

In India, the Mugger has been reported in over 10 states. In the hilly northern state of Uttarakhand, the species is distributed across the Corbett Tiger Reserve (Ram-Ganga River and Sonanadi Reservoir) and Baanganga Wetland (near Laxar area in Haridwar District), which is located along the Ganges River. It has also been recorded from the Nanak Sagar, Dhora, Baigul and Sharda Dams, which fall within the Terai Arc landscape (Belal *et al*. 2021). However, since 2010, the species has been reported from quite a few locations in the State for the first time (near Haridwar city and Lansdowne forest) (Joshi *et al*. 2011; Joshi 2013), which indicate that the distribution range of the species is expanding in the upper catchments of the Ganges River.

It is noteworthy to mention that some of the random reports of the presence of the species across Haridwar, Dehradun and Marchula area in Kalagarh forest division were also received in the past. However, confirmed accounts are not available. Though the species is protected in India, little detailed work has been carried out on its distribution, ecology and status in Uttarakhand. Here, we report on the occurrence of *C. palustris* in Haripura Dam, in Terai Arc landscape.

On 4 August 2022 (0530 h), an individual *C. palustris* was sighted near Haripura Dam in Terai Central forest division (29°6'54"N, 79°19'55"E; Fig. 1). After being disturbed by people in the vicinity, the crocodile ran towards an iron railing, adjacent to the dam, but while crossing the hind part of its body became stuck in the railing. After making several vogorous attempts, the crocodile managed to get through of the railing and into the water. The crocodile was estimated to be around 1.2 m in length.

Over the next 20 days, the crocodile was observed basking on the muddy and sandy banks of the reservoir. Muggers were never reported from the area before. Locals said that they had never seen Mugger there previously, and claimed that two pet dogs had been taken. The National Kayaking and Canoeing Championship was being organized in Baur and Haripura Reservoirs, and so this sighting was of some concern to organisers (Ahuja 2022).

A study conducted in the Terai Arc landscape to record the distribution and status of Muggers, including Haripura Dam, did not record the species (Belal *et al*. 2021). Considering that the report of the presence of Muggers in Haripura Dam was previously unconfirmed, our report constitutes the first record of a new locality of the species with photographic evidence. This report also establishes an addition to the herpetofauna of the Terai Central forest division.

Figure 1. Mugger sighted at Haripura Dam. Photographs: Ajay Singh.

Spread across an area of about 3.31 km^2, the 7-km long Haripura Dam (29°8'N, 79°20'E) is built on the Bhakhara River in Udham Singh Nagar District. Landscape mainly consists of hilly terrain, and vegetation is primarily dominated by tropical moist and dry deciduous forest type. The area represents the upper Gangetic plain biogeographic zone. The dam is fed by the Bhakra and Khajia Rivers. The surrounding forest of the reservoir is a natural home to elephant (*Elephas maximus*), tiger (*Panthera tigris*), leopard (*P. pardus*), sloth bear (*Melursus ursinus*), barking deer (*Muntiacus muntjak*), spotted deer (*Axis axis*), sambar (*Rusa unicolor*), wild boar (*Sus scrofa*), Rhesus macaque (*Macaca mulatta*) and small Indian civet (*Viverricula indica*). Further, the dam serves as a refuge for a large number of resident and migratory birds.

Haripura-Baur Reservoir consists of a wide array of aquatic free floating, submerged and semi-submerged plants including swamp morning-glory (*Ipomoea aquatic*), wild sugarcane (*Saccharum spontaneum*), lesser Indian reedmace (*Typha* spp.), knot grass (*Polygonum barbatum*), tape grass (*Vallisnaria* spp.), Indian swampweed (*Hygrophila polysperma*), arrowhead (*Sagittaria sagittifolia*), tall reed grass (*Phragmites karka*), water snowflake (*Nymphoides cristata*) and chickweed (*Stellaria media*) (Ahmed *et al*.

2019). More than 10 villages are located around the reservoir, and cultivate crops for their livelihoods.

Over the last decade, records of Muggers from different locations in the State may be due to unpredictable changes in local climate and availability of adequate habitats across the rivers and their tributaries. Such unusual movements are mostly observed during the monsoon season when the water level of most of the rivers and water bodies rises. As the species is capable of surviving in a wide array of natural and man-made habitats, reports of stray crocodiles across rural areas located adjacent to their habitat occur from time to time.

Although no detailed studies have been carried out, these anecdotal reports suggest that the range of the species is expanding in the State. It also appears that streams and reservoirs, nalas (small water channels) and dams are supporting the surviving population of the species. Efforts by the State Government, such as conducting drone-based crocodile census in the Terai area (Upadhyay 2019) and initiating crocodile trail in Surai forest range (at Kakra canal) in Terai East forest division (Anonymous 2021), are strengthening the conservation actions to protect the species.

Haripura Dam exists across one of the most diverse Terai Arc landscape, which forms an important repository of herpetofauna and is home to several threatened animal species. Further, the riparian vegetation mosaic in the plains of the Bhakra and Khajia Rivers and large muddy and sandy plains of the reservoir, has huge potential to sustain the species. A range of introduced fish in the reservoir, such as Catla (*Catla catla*), rohu (*Labeo rohita*), silver carp (*Hypophthalmichthys molitrix*), nain (*Cirrhinus mrigala*), saur (*Channa marulius*) and lachi (*Wallago attu*) (Ahmed *et al*. 2019), also ensures a healthy aquatic ecosystem. Moreover, the site has the potential to establish populations of Mugger, however this requires comprehensive planning, and consideration of ecological and legal frameworks.

Acknowledgements

We are thankful to Mr. Ajay Singh, Forest Guard (Peepalpadao Range), Terai Central Forest Division, for extending field support.

Literature Cited

Ahmed, T., Bargali, H.S., Bisht, D., Mehra, G.S. and Khan, A. (2019). Status of water birds in Haripura-Baur Reservoir, western Terai-Arc landscape, Uttarakhand, India. Journal of Threatened Taxa 11(9): 14158-14165.

Ahuja, A. (2022). Uttarakhand: Crocodile sightings a concern for national kayaking event organisers. The Times of India, 12 August 2022. (https://timesofindia.indiatimes.com/city/dehradun/uttarakhand-crocodile-sightings-a-concern-for-national-kayaking-event-organisers/articleshow/93512217.cms), accessed 23 December 2022.

Anonymous (2021). Dhami inaugurates U'khand's first crocodile trail in Khatima. The Tribune, 28 December 2021. (https://www.tribuneindia.com/news/schools/dhami-inaugurates-ukhands-first-crocodile-trail-in-khatima-355929), accessed 23 December 2022.

Belal, S.M., Dhakate, P.M. and Ram J. (2021). Status and distribution of marsh crocodile *Crocodylus palustris* in Terai Arc landscape, Uttarakhand, India. Ela Journal of Forestry and Wildlife 10(1): 855-866.

Choudhury, B.C. and de Silva, A. (2013). *Crocodylus palustris*. The IUCN Red List of Threatened Species 2013: e.T5667A3046723.

Da Silva, A. and Lenin, J. (2010). Mugger Crocodile *Crocodylus palustris*. Pp. 94-98 *in* Crocodiles. Status Survey and Conservation Action Plan. Third Edition, ed. by S.C. Manolis and C. Stevenson. Crocodile Specialist Group: Darwin.

Joshi, R., Singh, R. and Negi, M.S. (2011). First record of Mugger Crocodile *Crocodylus palustris* (Lesson, 1831) from the Rajaji National Park, north India. International Journal of Biodiversity & Conservation 3(9): 444-450.

Joshi, R. (2013). Range extension of mugger crocodile *Crocodylus palustris* (Lesson, 1831) in upper Ganges and tributaries, lesser Himalayan zone, north India. Journal of Biology & Earth Sciences 3(1): B100-B109.

Upadhyay, V. (2019). In a first, Uttarakhand using drones for crocodile census. The Times of India, 3 January 2019. (https://timesofindia.indiatimes.com/city/dehradun/in-a-first-uttarakhand-using-drones-for-crocodile-census/articleshow/67371248.cms), accessed 19 December 2022.

Whitaker, R. and Andrews, H. (2003). Crocodile conservation, Western Asia Region: an update. Journal of the Bombay Natural History Society 100(2&3): 432-445.

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Recent Publications

Cuff, A.R., Wiseman, A.L.A., Bishop, P.J., Michel, K.B., Gaignet, R. and Hutchinson, J.R. (2022). Anatomically grounded estimation of hindlimb muscle sizes in Archosauria. Journal of Anatomy (doi: 10.1111/joa.13767).

Abstract: In vertebrates, active movement is driven by muscle forces

acting on bones, either directly or through tendinous insertions. There has been much debate over how muscle size and force are reflected by the muscular attachment areas (AAs). Here we investigate the relationship between the physiological cross-sectional area (PCSA), a proxy for the force production of the muscle, and the AA of hindlimb muscles in Nile crocodiles and five bird species. The limbs were held in a fixed position whilst blunt dissection was carried out to isolate the individual muscles. AAs were digitised using a point digitiser, before the muscle was removed from the bone. Muscles were then further dissected and fibre architecture was measured, and PCSA calculated. The raw measures, as well as the ratio of PCSA to AA, were studied and compared for intra-observer error as well as intra- and interspecies differences. We found large variations in the ratio between AAs and PCSA both within and across species, but muscle fascicle lengths are conserved within individual species, whether this was Nile crocodiles or tinamou. Whilst a discriminant analysis was able to separate crocodylian and avian muscle data, the ratios for AA to cross-sectional area for all species and most muscles can be represented by a single equation. The remaining muscles have specific equations to represent their scaling, but equations often have a relatively high success at predicting the ratio of muscle AA to PCSA. We then digitised the muscle AAs of *Coelophysis bauri*, a dinosaur, to estimate the PCSAs and therefore maximal isometric muscle forces. The results are somewhat consistent with other methods for estimating force production, and suggest that, at least for some archosaurian muscles, that it is possible to use muscle AA to estimate muscle sizes. This method is complementary to other methods such as digital volumetric modelling.

Luthada-Raswiswi, R.W. (2022). Crocodile (*Crocodylus niloticus*) Meal Diets as a Potential for Replacement of Fishmeal Protein in Commercial Production of Mozambique Tilapia (*Oreochromis mossambicus*). PhD thesis, University of KwaZulu-Natal, Pietermaritzburg, South Africa.

Abstract: Fishmeal production is mainly sourced from the forage fish species. Fish caught for fishmeal production potentially represents a loss in producing higher trophic level species in the ecosystem. Low stock abundance reduces ecosystem services such as food provisioning to other elements of the ecosystem. Increasing demand, unstable supply, and the high price of the fishmeal with the expansion of aquaculture made it necessary to search for alternative protein sources. Crocodiles are farmed mainly for producing skins used in the production of high-quality fashion accessories. However, the demand for crocodile meat, especially in South Africa, is very low and strict regulations are imposed onto the industry about the use and disposal of crocodile carcasses. This study was conducted to assess the nutritional value of crocodile meals and their suitability as a fishmeal replacement in animal feeds, especially fish. Systematic review and meta-analysis results showed the gap that some animal by-products, including crocodile meat, had not been assessed as protein sources in aquaculture or animal feeds. Different size groups of fish are not considered in studies when testing different alternatives for fishmeals. The nutritional values of *Crocodylus niloticus* derived meal obtained in the current study is of comparable quality for use in aquaculture feeds, compared to by-products meal quality reported for meal derived from bovine bones and meat, feathers, blood and other poultry by-products. There were similarities in the gross feed conversion ratio for fry and the specific growth rate for fingerlings of *Oreochromis mossambicus* among all the experimental diets fed. That means the *C. niloticus* meal is a suitable animal protein source for replacing fishmeal in *O. mossambicus* diets. Some haematological parameters such as red blood cells count, and haemoglobin concentrations were significantly different among *O. mossambicus* fed crocodile-based and commercial diets. However, platelets count, haematocrit value, mean cell volume, mean cell haemoglobin, and mean cell haemoglobin concentrations were not significantly different among all diets fed. More future studies are recommended for different levels of *C. niloticus* meal in other fish species, different size groups, and haematological parameters. This study provides new information to the aquaculture industry regarding reducing supply constraints imposed by high cost and competitive uses for fishmeal and waste management on crocodile farms.

Buitrago, F., Rivera, L. and Espinosa, A. (2022).Estimación de la distribución y abundancia de los cocodrilos en la Reserva Natura (San Rafael del Sur, Nicaragua) durante el primer semestre del 2022. Revista Nicaraguense de Biodiversidad 80.

Resumen: Entre los meses de noviembre del 2021 y junio del 2022 se llevaron a cabo conteos de cocodrilos en los embalses de la Reserva Natura, con el propósito de conocer el tamaño de las poblaciones de esta especie en los embalses El Lagarto y Las Cercetas, así mismo para poder contar con información que permita hacer un análisis comparativo de tendencias en años posteriores. En el embalse el Lagarto se recorrieron 1.85 km cada vez, y se observaron un total estimado de 20 individuos, siendo el individuo de mayor tamaño un cocodrilo de 2.5 m de longitud total estimada. La abundancia estimada de individuos en el embalse El Lagarto fue en promedio de cuatro cocodrilos por recorrido y de 2.16 individuos por kilómetro. En el embalse Las Cercetas, se recorrieron 1.33 km cada vez, y se observaron un total estimado de 13 individuos, siendo 2.5 m la mayor talla registrada. La abundancia de individuos estimada para el embalse Las Cercetas fue de 3.5 individuos por recorrido y de 2.63 individuos por kilómetro.

Abstract: During 8 months (November 2021-June 2022) crocodile surveys were carried out in Reserva Natura's artificial lakes, with the objective of estimating the population sizes of this species in Las Cercetas and El Lagarto artificial lakes, and at the same time to set a baseline that will allow a comparative trend analysis in the years to come. 1.85 km of survey were covered in El Lagarto artificial lake every time, and a total of 20 crocodiles were registered, being 2.5 m the largest size observed. The relative abundance of crocodiles in this lake was four crocodiles per survey and 2.16 crocodilesper km covered. In Las Cercetas artificial lake surveys were 1.33 km in length, and 13 was the total estimated number of crocodiles observed during all transects. The largest crocodile had an estimated length of 2.5 m. The relative abundance of crocodiles in Las Cercetas was 3.5 crocodiles per survey and 2.63 crocodiles per km covered.

Wang, T., Joyce, W. and Hick, J.W. (2019). Similitude in the cardiorespiratory responses to exercise across vertebrates. Current Opinion in Physiology 10:137-145.

Abstract: The anatomy of the heart and the respiratory organs differs enormously amongst vertebrates, and the absolute rates of oxygen uptake - both at rest and exercise - are several-fold higher in the endothermic birds and mammals when compared to fish, amphibians and reptiles (all ectothermic). Despite these large differences, all vertebrates can elevate the rate of oxygen consumption by 5-10 times when engaging in physical exercise. The increased oxygen delivery is attained by increasing the convective flows (ie increased ventilation and cardiac output) as well as increased extraction of oxygen from the blood leading that widens the arterial-venous oxygen concentration difference with an extraction of approximately 90%. All members of all vertebrate classes appear to exhibit some diffusive limitation for oxygen in the gills or lungs, whereas arterial PCO_2 tends to decrease due to hyperventilation.

Baker, C.J., Frère, C.H., Franklin, C.E., Campbell, H.A., Irwin, T.R. and Dwyer, R.G. (2022). Crocodile social environments dictated by male philopatry. Behavioral Ecology 33(1): 156-166.

Abstract: Examining the social behaviors of solitary species can be challenging due to the rarity in which interactions occur and the large and often inaccessible areas which these animals inhabit. As shared space-use is a prerequisite for the expression of social behaviors, we can gain insights into the social environments of solitary species by

examining the degree of spatial overlap between individuals. Over a 10-year period, we examined how spatial overlap amongst 105 estuarine crocodiles *Crocodylus porosus* was influenced by season, sex, and movement tactic. We discovered that crocodiles displayed highly consistent spatial overlaps with conspecifics between months and across years. Furthermore, male crocodiles that exhibited a greater degree of site fidelity displayed more stable social environments, while females and males that were less site-attached had more dynamic social environments with spatial overlaps between conspecifics peaking during the mating season. Our results demonstrate how long-term tracking of multiple individuals within the same population can be used to quantify the spatial structure and social environment of cryptic and solitary species.

Groh, S.S., Upchurch, P., Barrett, P.M. and Day, J.J. (2022). How to date a crocodile: estimation of neosuchian clade ages and a comparison of four time-scaling methods. Paleontology (https://doi.org/10.1111/pala.12589).

Abstract: Clade ages within the crocodylomorph clade Neosuchia have long been debated. Molecular and morphological studies have yielded remarkably divergent results. Despite recent advances, there has been no comprehensive relative comparison of the major time calibration methods available to estimate clade ages based on morphological data. We used four methods (cal3, extended Hedman, smoothed ghost lineage analysis (sGLA) and the fossilized birth-death model (FBD)) to date clade ages derived from a published crocodylomorph supertree and a new neosuchian phylogeny. All time-scaling methods applied here agree on the origination of Neosuchia during the Late Triassic or Early Jurassic, and the presence of the major extant eusuchian groups (Crocodyloidea, Gavialoidea, Alligatoroidea and Caimaininae) by the end of the Late Cretaceous. The number of distinct lineages present before the K/Pg boundary is less certain, with support for two competing scenarios in which Crocodylinae, Tomistominae and Diplocynodontinae either: (1) diverged from other eusuchian lineages before the K/Pg boundary; or (2) evolved during a 'burst' of diversification after the K/Pg event. Cal3 and FBD proved to be the most suitable methods for time-scaling phylogenetic trees dominated by fossil taxa. Extended Hedman estimates are substantially older than the others, with larger standard deviations and a strong sensitivity to taxon sampling and topological changes; sGLA has similar problems. We conclude that a detailed understanding of phylogenetic relationships, tree reconstruction methods, and good taxonomic coverage (in particular the inclusion of the oldest taxon in each clade) is essential when evaluating the results of such dating analyses.

Vanrenen, B. (2022). A bite force of three thousand pounds. Tampa Review 63: 94-97.

Pashchenko, D. (2022). The crocodilian forearm and wrist: biomechanics and functional morphology. Biomechanics Communication 67(3): 168-179.

Abstract: An attempt has been made to explain the features of the wrist structure of crocodiles, which sharply distinguish them from other reptiles. Biomechanical model of a crocodilian forearm and manus is created with using of the vector contours method from the theory of mechanisms and machines. The key role of the V finger in the manus stability during the stance phase is shown. On the basis of this data, it is concluded that there is no bipedal stage in evolutionary history of crocodiles and their high specialization for quadrupedal parasagittal running with the emergence of a gallop as a result. The special way of parasagittal forelimb posture of the crocodiles offered to name instant parasagittality.

Parra, S. and Sellés, A. (2022). New cranial remains of the broad-nosed crocodile *Elosuchus* (Pholidosauridae; Mesoeucocodrylia) and its palaeoecological implications. Historical Biology (https://doi.org/10.1080/08912963.2022.2130791).

Abstract: Sometimes Natural History Museums unknowingly treasure singular specimens in their collections for decades. The re-discovery of such elements allows the description of previously unknown features of well-known taxa. Here, we describe a nearly complete left premaxilla attributed to the pholidosaurid *Elosuchus*. Specimen IPS3303 shows some remarkable differences with previously known premaxillae of *Elosuchus*, especially concerning the relative position of the fifth premaxillary tooth and the premaxilla-maxilla sutural surface morphology. Because of the scarcity of current data, it is difficult to evaluate the significance of such differences. The described element is about 40% larger than the largest premaxilla of *Elosuchus* known so far, suggesting that this taxon could achieve remarkable body size proportions. The preliminary analyses of the dentition and the neurovascular system of the premaxilla provide new insight into the palaeoecology of this riverine crocodylomorph from the Cretaceous of Africa.

Isberg, S.R. (2022). How many fathers? Study design implications when inferring multiple paternity in crocodilians. Ecology and Evolution Journal 12(10): e9379 (doi: 10.1002/ece3.9379).

Abstract: Up to 10 males were reported to sire clutches of crocodilian eggs but review of the underlying study designs raised questions of potential upward bias of inferred sire numbers. To test this premise, different scenarios were explored using a published dataset of 16 known single-sire saltwater crocodile pairs and their offspring which were originally confirmed using a 11 loci microsatellite panel in CERVUS. Varying the number of microsatellites, omitting one or both parental genotypes and using different parentage analysis techniques revealed that total allele number, rather than number of loci, determined inferred sire accuracy in two opposing ways. Using the single-locus minimum method and GERUD, which both require prior knowledge of family groupings (ie nests), fewer alleles (and loci) accurately inferred only one father. In contrast, CERVUS and COLONY required all 11 loci (65 alleles) and both parental genotypes to (a) assign correct family groups and (b) infer the correct sire number, except in one family where two sires were equally assigned based on their number of homozygous loci. When less genotype information was provided, CERVUS and COLONY inferred up to six and seven sires, respectively. Given this data is from confirmed single-sire matings, and yet up to seven sires could be inferred, the significance of inappropriate study design is clearly demonstrated. Consideration should be carefully given to genotype data, particularly those collected specifically for population diversity studies, which are also used to infer multiple paternity because the underlying data collection assumptions are not equivalent between the two outcomes.

Achatz, T.J., Martens, J.R., Kudlai, O., Junker, K., Boe, N.W. and Tkach, V.V. (2022). A new genus of Diplostomids (Digenea: Diplostomoidea) from the Nile crocodile in South Africa with a key to Diplostomid genera. Journal of Parasitology 108(5): 453-466.

Abstract: The Diplostomidae Poirier, 1886 is a large family of digeneans within the superfamily Diplostomoidea Poirier, 1886. Members of the family are distributed worldwide and parasitize a diversity of tetrapod definitive hosts. Notably, only 2 mature diplostomids are known from crocodilians and both are suggested to be accidental infections. In this study, we use morphological and molecular data to describe *Neofibricola* n. gen. from a Nile crocodile *Crocodylus niloticus* collected in South Africa. We provide a description of adults and metacercariae of the type species, *Neofibricola smiti* n. sp., and metacercariae of a likely congeneric species. We generated partial 28S and internal transcribed spacer region ribosomal deoxyribonucleic acid (DNA) and cytochrome c oxidase 1 subunit mitochondrial DNA for both species and utilized the newly generated 28S sequences to examine phylogenetic

affinities of these new taxa. In addition, we provide a new key to diplostomid genera, considering the substantial systematic changes and newly erected genera since the previously published key to diplostomid genera.

Parunyakul, K., Srisuksai, K., Santativongchai, P., Charoenlappanit, S., Phaonakrop, N., Roytrakul, S., Tulayakul, P. and Fungfuang, W. (2022). Serum proteomic analysis reveals the differential dose effects of crocodile oil from *Crocodylus siamensis* on energy metabolism in rats. Open Veterinary Journal 12(5): 697-708.

Abstract: Dietary fat composition is a potential major factor affecting energy metabolism. Crocodile oil (CO) is rich in mono- and poly-unsaturated fatty acids exhibiting anti-inflammatory and healing properties. This study investigated different levels of CO consumption on alterations and expression of proteins involved in energy metabolism in rats. Twenty-one male Sprague-Dawley rats were divided into three groups and administered sterile water (N) or different doses of CO [1% or 3% (v/w) CO] orally once daily for 8 weeks. Body weight gain, food intake, energy intake, blood lipid profiles, and serum energy-related metabolites were determined. The serum proteome was analyzed using shotgun proteomics, and the functions of several candidate proteins were classified using PANTHER software. There were no significant differences in body weight or energy intake were observed between groups. However, both CO-treated groups showed significantly decreased serum triglyceride (TG) levels ($p<0.05$). Moreover, post-treatment serum TG levels in the 1%CO group were significantly lower than pre-treatment compared with other groups. The serum oxaloacetate level was also significantly higher in both CO groups than in the N group. The proteomic analysis classified 4525 serum proteins and revealed more unique proteins involved in cellular metabolic activity in both CO-treated groups than in the N group. Self-organizing tree algorithm clustering of 295 shared differentially expressed proteins in both CO-treatment groups showed that upregulated hyper-expressed protein clusters in both CO groups were associated with catalytic activity and molecular activity on the same levels.CO simultaneously enhances energy metabolism and improves lipid profiles.

Liu, Y., Meng, G., Wu, S., Zhang, X., Zhao, C. and Yang, H. (2022). Influencing factors and measurement of "willingness to accept" living with alligators in a nature reserve: A case study in National Chinese Alligator Nature Reserve, China. Land 11: 1768.

Abstract: The establishment of nature reserves is an important measure to protect the wild population of Chinese alligators. Due to the overlap of nature reserves and human living areas, there is a certain conflict between economic development and ecological protection. How to formulate a feasible eco-compensation scheme and accurately analyze the influencing factors of eco-compensation willingnessis of great significance to alleviate the contradiction between local residents and Chinese alligators. In this study, the contingent valuation method (CVM) was used to measure and analyze the residents'willingness to accept (WTA) at National Chinese Alligator Nature Reserve (NCANR) located in Anhui province, China. Furthermore, decision tree modeling and logistic regression were used to analyzethe influencing factors of residents' WTA in NCANR, which provides a new insight to the influencing factors of eco-compensation. The results indicate that: (1) 93% of the residents living in NCANR havea WTA compensation, and the amount of WTA is CNY 25,542 (USD 3659.36) per household per year; and (2) individual characteristics, ecological protection cognition and external impact affect the WTA, and external impact on local residents is the most important factor affecting WTA. Therefore, it is necessary to make differential compensation to ensure the fairness of eco-compensation. In addition, the propaganda of eco-compensation should be strengthened, and the boundary of NCANR needs to be further clarified. The sources of funds for eco-compensation are supposed to be broadened, and poverty alleviation can be combined with eco-compensation policies.

Hu, M.Y., Yu, Q.Z., Lin, J.Q. and Fang, S.G. (2022). Sexual dimorphism of the gut microbiota in the Chinese alligator and its convergence in the wild environment. International Journal of Molecular Science 23(20): 12140.

Abstract: The gut microbiota forms a complex microecosystem in vertebrates and is affected by various factors. As a key intrinsic factor, sex has a persistent impact on the formation and development of gut microbiota. Few studies have analyzed sexual dimorphism of gut microbiota, particularly in wild animals. We used 16S rRNA gene sequencing to analyze the gut microbiota of juvenile and adult Chinese alligators, and untargeted metabolomics to study serum metabolomes of adult alligators. We observed significant sexual differences in the community diversity in juvenile, but not adult, alligators. In terms of taxonomic composition, the phylum Fusobacteriota and genus *Cetobacterium* were highly abundant in adult alligators, similar to those present in carnivorous fishes, whereas the gut microbiota composition in juvenile alligators resembled that in terrestrial reptiles, indicating that adults are affected by their wild aquatic environment and lack sex dimorphism in gut microbiota. The correlation analysis revealed that the gut microbiota of adults was also affected by cyanobacteria in the external environment, and this effect was sex-biased and mediated by sex hormones. Overall, this study reveals sexual differences in the gut microbiota of crocodilians and their convergence in the external environment, while also providing insights into host-microbiota interactions in wildlife.

Balaguera-Reina, S.A. and Mazzotti, F.J. (2022). Belly up or belly down: Effect of body position on snout vent length and total length measurements in American crocodiles (*Crocodylus acutus*). Amphibia-Reptilia (doi:10.1163/15685381-bja10110).

Abstract: The interpretation of morphometric data is relevant to understanding biological phenomena. Currently, little is known about the effect of body position on morphometric measurements in crocodylians as well as the extent to which these data are interchangeable. We investigated the effect of body position on snout-vent-length (SVL) and total-length (TL) measured ventrally (belly up) and dorsally (belly down) on 725 *Crocodylus acutus* (mean TL ventral and dorsal 68.49 cm and 69.82 cm, range = 33.1-185.4 cm and 33.8-185.4 cm) across South Florida, United States. We found evidence that body posture significantly influences SVL and TL measurements. However, regardless of body position, the variation found in SVL was less than 1 mm, and for TL was on average only 3 mm. We concluded that even though there is a difference when measuring American crocodiles belly up and belly down, there is a minimal effect on the outcome (less than half centimeter), which falls within the normal measurement instrument error (ie measurement tape) even more so under field conditions. If researchers concur that this is an acceptable error, then SVL and TL measurements taken belly up or belly down can be used interchangeably.

Honegger, R.E. and Blackburn, D.G. (2022). The arrival of the dragons of our forefathers, or some remarks on early [non-English] European encounters with exotic reptiles. Bibliotheca Herpetologica 16(9): 94-117.

Tokita, M. and Sato, H. (2022). Creating morphological diversity in reptilian temporal skull region: A review of potential developmental mechanisms. Evolution and Development (https://doi.org/10.1111/ede.12419).

Abstract: Reptilian skull morphology is highly diverse and broadly categorized into three categories based on the number and position

of the temporal fenestrations: anapsid, synapsid, and diapsid. According to recent phylogenetic analysis, temporal fenestrations evolved twice independently in amniotes, once in Synapsida and once in Diapsida. Although functional aspects underlying the evolution of tetrapod temporal fenestrations have been well investigated, few studies have investigated the developmental mechanisms responsible for differences in the pattern of temporal skull region. To determine what these mechanisms might be, we first examined how the five temporal bones develop by comparing embryonic cranial osteogenesis between representative extant reptilian species. The pattern of temporal skull region may depend on differences in temporal bone growth rate and growth direction during ontogeny. Next, we compared the histogenesis patterns and the expression of two key osteogenic genes, *Runx2* and *Msx2*, in the temporal region of the representative reptilian embryos. Our comparative analyses suggest that the embryonic histological condition of the domain where temporal fenestrations would form predicts temporal skull morphology in adults and regulatory modifications of *Runx2* and *Msx2* expression in osteogenic mesenchymal precursor cells are likely involved in generating morphological diversity in the temporal skull region of reptiles.

King, G.E. (2022). Baboon perspectives on the ecology and behavior of early human ancestors. Proceedings of the National Academy of Science USA 119(45): e2116182119.

Abstract: For more than 70 y researchers have looked to baboons (monkeys of the genus *Papio*) as a source of hypotheses about the ecology and behavior of early hominins (early human ancestors and their close relatives). This approach has undergone a resurgence in the last decade as a result of rapidly increasing knowledge from experimental and field studies of baboons and from archeological and paleontological studies of hominins. The result is a rich array of analogies, scenarios, and other stimuli to thought about the ecology and behavior of early hominins. The main intent here is to illustrate baboon perspectives on early hominins, with emphasis on recent developments. This begins with a discussion of baboons and hominins as we know them currently and explains the reasons for drawing comparisons between them. These include occupation of diverse environments, combination of arboreal and terrestrial capabilities, relatively large body size, and sexual dimorphism. The remainder of the paper illustrates the main points with a small number of examples drawn from diverse areas of interest: diet (grasses and fish), danger (leopards and crocodiles), social organization (troops and multilevel societies), social relationships (male-male, male-female, female-female), communication (possible foundations of language), cognition (use of social information, comparison of self to others), and bipedalism (a speculative developmental hypothesis about the neurological basis). The conclusion is optimistic about the future of baboon perspectives on early hominins.

Yadav, R.K., Lamichhane, S., Thanet, D.R., Rayamajhi, T., Bhattarai, S., Bashyal, A. and Lamichhane, B.R. (2022). Gharial (*Gavialis gangeticus*, Gmelin, 1789) abundance in the Rapti River, Chitwan National Park, Nepal. Ecology and Evolution Journal 12(10): e9425.

Abstract: Gharial (*Gavialis gangeticus*) is a Critically Endangered crocodilian species whose abundance in Nepalese rivers is low due to the threat they face. We estimated gharial abundance in the Rapti River, one of the major rivers in Chitwan National Park (CNP) holding the largest numbers of gharials in Nepal. The Rapti River, running across the CNP, was divided into 18 segments, each measuring ~4 km, and gharials were counted directly with three replicates. Gharial count data were analyzed using an N-mixture model (negative binomial) and the overall occupancy of gharials was estimated using a single season occupancy model. Covariate effects were also investigated on gharial abundance. Our findings revealed that the Rapti River is home to 150 gharials (119-181), with a mean abundance of 8.3 (SD= 3.45) across each segment. The presence of humans and square of Rapti River depth were the significant covariates that had a negative and positive impact on gharial abundance, respectively. Similarly, the number of sandbank present influenced the detection probability of gharials. Our study shows that gharial population estimation can be improved using the N-mixture model. The overall gharial occupancy estimated using single season occupancy model was 0.84 (SD= 0.08), with a detection probability of 0.37 (SD= 0.02). The management authority should concentrate on segments to minimize human disturbance (eg fishing, washing clothes, extraction of riverbed materials). If the gharial population in this river declines, their population in central Nepal will be threatened. Hence, we suggest designating the Rapti River section that passes across the CNP as a "no extraction zone."

Desai, B., Patel, A., Shah, S., Raval, M.S. and Ghosal, R. (2022). Identification of free-ranging mugger crocodiles by applying deep learning methods on UAV imagery. Ecological Informatics (https://doi.org/10.1016/j.ecoinf.2022.101874).

Abstract: Individual identification contributes significantly towards investigating behavioral mechanisms of animals and understanding underlying ecological principles. Most studies employ invasive procedures for individually identifying organisms. In recent times, computer-vision techniques have served as an alternative to invasive methods. However, these studies primarily rely on user input data collected from captivity or from individuals under partially restrained conditions. Challenges in collecting data from free-ranging individuals are higher when compared to captive populations. However, the former is a far more important priority for real-world applications. In this paper, we used UAV to collect data from free-ranging mugger crocodiles, *Crocodylus palustris*. We applied convolutional neural networks (CNNs) to individually identify muggers based on their dorsal scute patterns. The CNN model was trained on a data set of 88,000 images focusing on the mugger's dorsal body. The data was collected from 143 individuals across 19 different locations along the western part of India. We trained two CNN models, one with an annotated bounding box approach, the YOLO-v5l, and another without annotations, the Inception-v3. We used two parameters, True Positive Rate (TPR) and True Negative Rate (TNR), to validate the efficiency of the trained models. Using YOLO-v5l, TPR (re-identification of trained muggers) and TNR (differentiating untrained muggers as 'unknown') values at the 0.84 threshold were 88.8% and 89.6%, respectively. The trained model showed 100% TNR for the non-mugger species, the Gharial, *Gavialis gangeticus*, and the Saltwater crocodile, *Crocodylus porosus*. The performance of the CNN model was reliable and accurate while using only 125 images per individual for training purposes. Inception-v3 underperformed for both the parameters, thus, showing that a bounding box approach (YOLO-v5l model) with background elimination is a promising method to individually identify free-ranging mugger crocodiles. Our manuscript demonstrates that UAV imagery appears to be a promising tool for non-invasive collection of data from free-ranging populations. It can be used to train open-source algorithms for individual identification. Further, the identification method is entirely based upon dorsal scute patterns, which can be applied to different crocodilian species, as well.

Sandoval-Hernández, I., Bolaños-Montero, J.R., Sasa-Marín, M. and Monrós-González, J.S. (2022). Landscape analysis for the American crocodile *Crocodylus acutus* (Reptilia: Crocodilidae) in northwestern Costa Rica. Revista Mexicana de Biodiversidad 93 (2022): e934087.

Abstract: Northwest Costa Rica has the largest crocodile population in the country, but it is also an important area of the human population growth, tourism, crops, and aquaculture, that have generated great changes in the region. For these reasons, a landscape analysis for the American crocodile, *Crocodylus acutus*, was conducted to determine which landscape variables may benefit the reptile. The analysis included the Tempisque Great Wetlands (TGW) and the

Central Pacific (CP). The TGW had a higher linear density of rivers and roads, and more extensive wetlands and flood zones, whereas the CP had a higher number of towns. Forest coverage was recovering in both regions, although the rate of recovery was different. The values of the fractal dimension (FD), the shape index (SI), the Shannon diversity index, and the equity index increased slightly in both zones, indicating that fragmentation is increasing in the study area. The average density of crocodiles was correlated with change in coverage per year (rs= 0.74) and with FD and SI (rs= 0.65 for both). In the CP, the density of crocodiles was also correlated with change in coverage per year (rs= 0.48) and with FD and SI (rs= 0.93 and 0.74, respectively).

Choudhury, N. and Rathod, A. (2022). Wildlife conservation - a challenge under present scenario. Pp. 15-29 (Chapter 2) *in* Latest Trends in Zoology and Entomological Sciences, Volume 13, ed. by B. Deka. AkiNik Publications: New Delhi.

Abstract: Under current scenario of world, Wildlife is a point of our attention. Wildlife conservation is a platform of markedawareness, actionand lossof biodiversity is a reflection about issues that affect the biodiversity of our planet. We have seen how the desire of humans to dominate, manipulate and control nature and has caused irreparable harm to nature. We have seen numerous animals and plant species being driven to extinction by us in the last couple of decades alone. Hence, it is very important to make people aware of protecting their environment and the biodiversity at their niche, whether it is animal of plant species. The current study highlights the steps taken by Indian Government to protect some endangered species like rhinoceros, tiger, elephant, crocodile, some migratory species of birds and medicinal plants. The present review throws light on the steps that might be taken to protect wildlife by us.

Balaguera-Reina, S.A., Angulo-Bedoya, M., Moncada-Jimenez, J.F., Webster, M., Roberto, I.J. and Mazzotti, F.J. (2022). Update: Assessing the evolutionary trajectory of the Apaporis caiman (*Caiman crocodilus apaporiensis*, Medem 1955) via mitochondrial molecular markers. Biological Journal of the Linnean Society (https://doi.org/10.1093/biolinnean/blac115).

Abstract: The spectacled caiman (*Caiman crocodilus*) is currently considered to be a species complex due to the relatively high morphological and molecular diversity expressed across its range. One of the populations of interest, inhabiting the Apaporis River (Colombia), was described based on skull features as an incipient species (*C. c. apaporiensis*) and has been treated by some authors as a full species. Recent molecular work challenged this hypothesis, because relatively low mitochondrial molecular differentiation was found between the morphologically described Apaporis caiman and *C. crocodilus* (s.s.) Amazonian populations. Here, we present an update on the topic based on a larger molecular sample size and on analysis of expanded geometric morphometric data that include six newly collected skulls. Morphometric data support the existence of previously recognized morphotypes within the complex in Colombia and demonstrate that the newly collected material can be assigned to the classic Apaporis caiman morphotype. However, our expanded genetic analysis fails to find appreciable mitochondrial molecular divergence of the Apaporis caiman population from the *C. c. crocodilus* population (*COI-CytB*: Amazon Peru 0.17 ± 0.06%, *CytB*-only: Caquetá River Colombia 0.08 ± 0.07%). The Apaporis caiman is interpreted to be a phenotypically distinct member of the *cis*-Andean *C. crocodilus* metapopulation that has not yet achieved (or may not be undergoing at all) appreciable genetic differentiation. Thus, it should not be considered a fully independent evolutionary lineage, nor given full species rank.

Guillette, T.C., Jackson, T.W., Guillette, M., McCord, J. and Belcher, S.M. (2022). Blood concentrations of per- and polyfluoroalkyl substances are associated with autoimmune-like effects in American alligators from Wilmington, North Carolina. Frontiers in Toxicology 4: 1010185 (doi: 10.3389/ftox.2022.1010185).

Abstract: Surface and groundwater of the Cape Fear River basin in central and coastal North Carolina is contaminated with high levels of per- and polyfluoroalkyl substances (PFAS). Elevated levels of PFAS have also been found in blood of fish and wildlife from the Cape Fear River, and in the blood of human populations reliant on contaminated well or surface water from the Cape Fear River basin as a source of drinking water. While the public and environmental health impacts of long-term PFAS exposures are poorly understood, elevated blood concentrations of some PFAS are linked with immunotoxicity and increased incidence of some chronic autoimmune diseases in human populations. The goal of this One Environmental Health study was to evaluate PFAS exposure and biomarkers related to immune health in populations of American alligators (*Alligator mississippiensis*), a protected and predictive sentinel species of adverse effects caused by persistent toxic pollutants. We found that serum PFAS concentrations in alligator populations from the Cape Fear River were increased compared to a reference population of alligators from the adjoining Lumber River basin. The elevated serum PFAS concentrations in the Cape Fear River alligators were associated with increased innate immune activities, and autoimmune-like phenotypes in this population. In addition to evidence of significantly higher double stranded-DNA binding autoantibodies in adult Cape Fear River alligators, our qRT-PCR analysis found remarkably high induction of Interferon-α signature genes implicated in the pathology of human autoimmune disease. We interpret the association of increased PFAS exposure with disrupted immune functions to suggest that PFAS broadly alters immune activities resulting in autoimmune-like pathology in American alligators. This work substantiates and extends evidence from experimental models and human epidemiology studies showing that some PFAS are immune toxicants.

Moleón, M.S., Cuervo, P.F., Parachú Marcó, M.V., Pietrobon, E.O., Jahn, G.A. and Siroski, P.A. (2023). Effects of physical restraint and endogenous adrenocorticotropin challenges on corticosterone levels and immunological indexes in the Broad-snouted Caiman (*Caiman latirostris*). Canadian Journal of Zoology 101 (dx.doi.org/10.1139/cjz-2022-0053).

Abstract: In the wild, vertebrates face numerous unpredictable and harmful stressors such as storms, fires, earthquakes, tsunamis, and others. A typical physiological response to a perceived stressor is the increased secretion of glucocorticoids. Such a response is adaptive in the short-term and could modulate the cellular immune response. Our purpose in this study was to examine the effect of stimulation with adrenocorticotropin (ACTH) injection and physical restraint (PR) on plasma corticosterone (CORT) levels, and total and differential white blood cell counts in the Broad-snouted caiman (*Caiman latirostris* (Daudin, 1802)). Individuals under PR increased CORT levels over time. Otherwise, no differences were observed in the CORT concentration between individuals injected with ACTH and those injected with saline solution. High CORT concentrations in the PR caimans produced a biphasic profile on total white blood cell counts, as well as the lymphocyte and heterophil counts. This response to PR may represent a stress response with an increase in immune surveillance in organs.

Holliday, C.M., Schachner, E.R. and Laitman, J.T. (Eds.) (2022). Special Issue: The Age of Crocodilians and their kin: Their anatomy, physiology and evolution. The Anatomical Record 305(10): 2331-3108.

Meemark, T., Daduang, S., Maraming, P., Tippayawat, P. and Daduang, J. (2022). Byproduct of crocodile liver extract: Potential *in vitro* viral inhibition in a flu model. Asia-Pacific Journal of Science and Technology 27(6) (https://www.tci-thaijo.org/index.php/APST/

index).

Abstract: Crocodile organs have been used in traditional medicines for the purpose of disease reduction. However, these claims have not been rigorously studied. This study aimed to explore the potential of crude extract from the liver of *Crocodylus siamensis* (CLE) against influenza virus. The toxicity concentration (CC50) of CLE was assayed by a colorimetric assay for cellular metabolic activity (MTT) and was found to be 32.0 mg/mL, and the concentration reducing replication (EC50) of influenza A (H3N2/Vic) evaluated by a viral titration technique for A549 cells was 0.039 mg/mL. The selectivity index (SI), which is the ratio between cytotoxicity and antiviral activity, was 818. A time-of-addition assay was used to identify which step(s) of the viral propagation chain was blocked by CLE. The expression of immune-related genes was tested by RT-PCR to observe the possible mechanisms of antiviral activity. The antiviral activity of CLE on multiple cycles of viral replication was assessed by the viral titration technique. CLE pretreatment of cells resulted in higher viral inhibition. The mRNA expression levels of the immune-related genes MxA, IL-2, CCL5/RANTES, and CXCL10/IP-10 were significantly different in the CLE-treated group. We found that CLE inhibited the propagation of influenza A (H3N2/Vic). This study is a starting point to investigate the scientific analysis of crocodile byproducts.

Eustace, A., Gunda, D.M., Mremi, R., Sanya, J. Kamili, E., Munuo, W.A., Saigilu, M.M., Martin, E.H., Kisingo, A.W. and Kahana, L. (2022). Patterns pertaining to crocodile attacks on humans in Tanzania: Baseline data to support mitigation measures. Human Ecology (https://doi.org/10.1007/s10745-022-00355-z&).

Abstract: Studies of animal attacks on humans in Tanzania have been biased towards large mammals, such as elephants, lions, and hyenas, overlooking attacks from other taxa, including reptiles. Here, we used data from government institutions to explore patterns of attacks on humans by crocodiles in Tanzania between 2010 and 2019. We obtained a total of 575 crocodile attacks, with most of the attacks occurring within or adjacent to the Nile crocodile range. Crocodile attacks varied significantly by victim gender, with 81% of attacks involving males. Furthermore, 58% of the attacks were fatal, with the proportion being more significant to children than adult victims. To reduce the frequency of attacks and fatalities, we recommend the construction of crocodile exclusion enclosures in crocodile attack hotspots and raising awareness in riparian communities, especially for children in schools, regarding crocodile range, attacks, and how to avoid them.

Schoeman, R.P., Erbe, C., Pavan, G., Righini, R. and Thomas, J.A. (2022). Analysis of soundscapes as an ecological tool. Pp. 217-267 *in* Exploring Animal Behavior Through Sound: Volume 1. Springer: Cham.

Abstract: Soundscapes have been likened to acoustic landscapes, encompassing all the acoustic features of an area. The sounds that make up a soundscape can be grouped according to their source into biophony (sounds from animals), geophony (sounds from atmospheric and geophysical events), and anthropophony (sounds from human activities). Natural soundscapes have changed over time because of human activities that generate sound, alter land-use patterns, remove animals from natural settings, and result in climate change. These human activities have direct and indirect effects on animal distribution patterns and (acoustic) behavior. Consequently, current soundscapes may be very different from those a few hundred years ago. This is of concern as natural soundscapes have ecological value. Losing natural soundscapes may, therefore, result in a loss of biodiversity and ecosystem functioning. The study of soundscapes can identify ecosystems undergoing change and potentially document causes (such as noise from human activities). Methods for studying soundscapes range from listening and creating visual (spectrographic) displays to the computation of acoustic indices and advanced statistical modeling. Passive acoustic recording has become an ecological tool for research, monitoring, and ultimately conservation management. This chapter introduces terrestrial and aquatic soundscapes, soundscape analysis tools, and soundscape management.

Price, C., Ezat, M.A., Hanzena, C. and Downs, C.T. (2022). Never smile at a crocodile: Gaping behaviour in the Nile crocodile at Ndumo Game Reserve, South Africa. Behavioural Processes 203 (https://doi.org/10.1016/j.beproc.2022.104772).

Abstract: Gaping is a regularly observed behaviour in crocodilians globally but is still poorly understood in relation to external variables which could trigger this behaviour. The occurrence of gaping behaviour was investigated in a large wild population of Nile crocodiles (*Crocodylus niloticus*) during the dry and wet seasons at Nyamithi Pan, Ndumo Game Reserve, South Africa. This is one of the longest crocodile gaping behaviour studies conducted in the wild, with 300 h of observations conducted over two seasons resulting in 1120 gaping behaviours recorded. The most common size class observed was between 1.5 and 2.5 m (n= 697), which accounted for 62.2% of the gaping observations. A significant decrease in gaping duration was observed as ambient temperatures increased, and the gape duration was longer at a higher degree angle. In addition, an increase in gape duration was observed as the number of neighbouring crocodiles increased. These results suggest gaping behaviour occurs when there are other crocodiles nearby and when temperatures do not necessitate thermoregulation. The study suggests that gaping could be used as a form of thermoregulation and intra-species communication.

Campos, Z., Magnusson, W.E. and Soriano, B. (2022). Temperature variation in nests of *Paleosuchus palpebrosus* (Crocodylia: Alligatoridae) near the southern edge of the species' range, Brazil. Brazilian Journal of Biology 82 (https://doi.org/10.1590/1519-6984.266315).

Abstract: We monitored the temperature of seven *Paleosuchus palpebrosus* nests found on the banks of streams surrounding the Brazilian Pantanal, near the southern limit of the species' distribution, between 2008 and 2013. The mean temperature of the nests between 45 and 68 days incubation, the presumed period of sex determination, varied between 26.1 and 31.5ºC. Nest temperatures were 2 to 5°C higher than air temperatures, presumably due to metabolic heat of decay of material within the nests, but air temperature explained 10-50% of the variance in egg-chamber temperatures. The estimated incubation periods for nests from which eggs hatched were 80, 84, 86, 90 and 104 days with a mean of 89 (SD= 9.23) days, though these are probably slight overestimates because eggs may have hatched in the period between inspections. For these nests, there was no significant relationship between mean temperature and incubation period (r^2= 0.23, p= 0.411).

Zeiträg, C. (2022). The Evolution of Social Cognition in Archosauria. Gaze following and play as windows to social cognition in dinosaurs. PhD thesis, Lund University, Sweden.

Abstract: Social cognition entails all cognitive processes involved in social interactions. To study the evolution of social cognition, it is crucial to investigate several distantly related lineages. Studies in comparative cognition have traditionally been biased towards primates and a few social mammalian species, limiting evolutionary interpretations to few and closely related lineages. To obtain a better understanding of the evolution of social cognition in the avian lineage, this thesis investigates species phylogenetically bracketing the lineage of dinosaurs from which the birds derived. Crocodylians and modern birds form the clade Archosauria that also comprises the extinct dinosaurs. Through studying socio-cognitive capacities in extant archosaurs, it is possible to draw

inferences on the social cognition of non-avian dinosaurs. In this light, two topics are covered in this thesis: gaze following and play. We found shared low-level gaze following skills in birds and alligators, while only birds demonstrated visual perspective taking. The more sophisticated gaze following repertoire of birds is likely caused by their dramatic increase of neurons in the cerebellum. This structure has been proposed to be involved in the formation of so-called internal forward models that allow for the formation of social predictions. We moreover studied the development of gaze following skills in ravens and found an extraordinarily early ontogenetic onset of such predictive capacities. Furthermore, we regarded socio-cognitive skills and their development through the lense of play. We studied play behaviours of greater rheas and found a pronounced aspect of sociality in their play repertoire early in their ontogeny. Finally, we used our findings to hypothesize about social cognition in extinct dinosaurs. Our findings are indicative of an earlier evolution of visual perspective taking in dinosaurs than in mammals. This is probably linked to the evolution of refined visual senses in this lineage. Non-avian paravian dinosaurs likely followed each other's gazes and might have been capable of generating social predictions based on observed gaze. Moreover, they most likely played, and their play probably contained a pronounced aspect of sociality. Taken together, the findings of this thesis suggest that nonavian paravians possessed a variety of socio-cognitive skills surpassing those of mammals living at the same time.

Jangpromma, N., Konkchaiyaphum, M., Punpad, A., Sosiangdi, S., Daduang, S., Klaynongsruang, S. and Tankrathok, A. (2022). Rational design of RN15m4 cathelin domain-based peptides from Siamese crocodile cathelicidin improves antimicrobial activity. Applied Biochemistry and Biotechnology (doi: 10.1007/s12010-022-04210-1).

Abstract: Antimicrobial peptides are becoming a new generation of antibiotics due to their therapeutic potential and ability to decrease drug-resistant bacteria development. Cathelicidins are known as effective peptides of vertebrate immunity that play crucial roles in the defensive strategy against pathogens. To improve its potency, the RN15 antibacterial peptide derived from the cathelin domain of *Crocodylus siamensis* cathelicidin has been modified and its antimicrobial properties investigated. Peptides were derived by template-based and physicochemical designation. The RN15 derivative peptides were predicted through their structure modeling, antimicrobial potency, and peptide-membrane calculation. The antimicrobial and cytotoxic activities of candidate peptides were investigated. Simultaneous consideration of physicochemical characteristics, secondary structure modeling, and the result of antimicrobial peptide tools prediction indicated that RN15m4 peptide was a candidate derivative antimicrobial peptide. The RN15m4 peptide expresses antimicrobial activity against most Gram-positive and Gram-negative bacteria and fungi with a lower minimum inhibition concentration (MIC) than the parent peptide. Besides, the time-killing assay shows that the designed peptide performed its ability to quickly kill bacteria better than the original peptide. Scanning electron microscopy (SEM) displayed the destruction of the bacterial cell membrane caused by the RN15m4 peptide. In addition, the RN15m4 peptide exhibits low hemolytic activity and low cytotoxic activity as good as the template peptide. The RN15m4 peptide performs a range of antimicrobial activities with low cell toxicity. Our study has illustrated the combination approach to peptide design for potent antibiotic peptide discovery.

Yu, Q.Z., Hu, M.Y., Wang, L., Lin, J.Q. and Fang, S.G. (2022). Incubation determines favorable microbial communities in Chinese alligator nests. Frontiers of Microbiology (doi: 10.3389/fmicb.2022.983808).

Abstract: Nest materials are a major heat source due to rotting promoted by microbial activity. Additionally, they are a potential microbial source given their direct contact with eggshells. Microbial dynamics during incubation have been studied in wild birds; however, similar studies in reptiles remain elusive. Here, the study characterized microbial communities in the nest materials of Chinese alligator (*Alligator sinensis*) using high-throughput sequencing of bacterial 16S rRNA genes and fungal internal transcribed spacer (ITS) region sequences. The results showed that significant changes in the diversity and structure of microbial communities according to different incubation periods. The diversity and richness of bacterial species increased significantly over time, but the relative abundance of the most dominant bacteria in pre-incubation period, including some pathogenic bacteria, declined after incubation. In contrast, fungal species diversity and richness decreased significantly with time. Additionally, nest material composition significantly influenced microbial community structure rather than species diversity and richness. Notably, the fungal community structure showed a stronger response than bacteria to nest material composition, which varied due to differences in plant litter composition. Our results demonstrate the significant response of microbial community diversity and structure to differences in incubation periods and nest material composition in reptiles. It is further emphasized that the importance of incubation period in the conservation of the Chinese alligator and could inform similar studies in other reptiles and birds.

Kunchala, S.R., Van Dijk, A., Veldhuizen, E.J.A., Donnellan, S.C., Haagsman, H.P. and Orgeig, S. (2022). Avian surfactant protein (SP)-A2 first arose in an early tetrapod before the divergence of amphibians and gradually lost the collagen domain. Developmental & Comparative Immunology (doi: 10.1016/j.dci.2022.104582).

Abstract: The air-liquid interface of the mammalian lung is lined with pulmonary surfactants, a mixture of specific proteins and lipids that serve a dual purpose-enabling air-breathing and protection against pathogens. In mammals, surfactant proteins A (SP-A) and D (SP -D) are involved in innate defence of the lung. Birds seem to lack the SP-D gene, but possess SP-A2, an additional SP-A-like gene. Here we investigated the evolution of the SP-A and SP-D genes using computational gene prediction, homology, simulation modelling and phylogeny with published avian and other vertebrate genomes. PCR was used to confirm the identity and expression of SP-A analogues in various tissue homogenates of zebra finch and turkey. In silico analysis confirmed the absence of SP-D-like genes in all 47 published avian genomes. Zebra finch and turkey SP-A1 and SP-A2 sequences, confirmed by PCR of lung homogenates, were compared with sequenced and in silico predicted vertebrate homologs to construct a phylogenetic tree. The collagen domain of avian SP-A1, especially that of zebra finch, was dramatically shorter than that of mammalian SP-A. Amphibian and reptilian genomes also contain avian-like SP-A2 protein sequences with a collagen domain. NCBI Gnomon-predicted avian and alligator SP-A2 proteins all lacked the collagen domain completely. Both avian SP-A1 and SP-A2 sequences form separate clades, which are most closely related to their closest relatives, the alligators. The C-terminal carbohydrate recognition domain (CRD) of zebra finch SP-A1 was structurally almost identical to that of rat SP-A. In fact, the CRD of SP-A is highly conserved among all the vertebrates. Birds retained a truncated version of mammalian type SP-A1 as well as a non-collagenous C-type lectin, designated SP-A2, while losing the large collagenous SP-D lectin, reflecting their evolutionary trajectory towards a unidirectional respiratory system. In the context of zoonotic infections, how these evolutionary changes affect avian pulmonary surface protection is not clear.

Spain, M., Pearson, C. and Rosenblatt, A.E. (2022). Social structure and habitat design affect the impact of a novel feeding enrichment for alligators. Zoo Biology (doi: 10.1002/zoo.21744).

Abstract: Providing enrichment that expands the range of behavioral opportunities associated with food acquisition and environmental exploration is an important contributing factor to the well-being of zoo animals. These behaviors can be difficult to promote in

carnivores, given their foraging strategies and the logistical, ethical, and financial challenges of providing live prey. In this study, we introduced a novel feeding enrichment to Jacksonville Zoo and Gardens' five adult American alligators (*Alligator mississippiensis*) in an attempt to simulate a live prey organism within the exhibit and promote natural hunting behaviors like chasing and lunging, as well as increase daily activity levels. The enrichment promoted some behavioral goals for two of the alligators, but it did not promote behavioral goals for the other three alligators. This could have been due to a variety of factors including an existing dominance hierarchy amongst the group's females and the resulting spatial distribution of individuals across a habitat with only one water feature. Our results suggest that female alligators may carve out territories and avoid overlapping space usage with other females during the warmest months of the year. Given the outcomes and limitations of this enrichment strategy, we provide recommendations for this group specifically as well as future enrichment efforts in the general captive crocodilian population.

Montaña-Lozano, P., Balaguera-Reina, S.A. and Prada Quiroga, C.F. (2022). Comparative analysis of codon usage of mitochondrial genomes provides evolutionary insights into reptiles. Gene (doi: 10.1016/j.gene.2022.146999).

Abstract: Current available information on reptile genomes provides great potential for the study of unique adaptations from a genomic perspective. We compared differences in base composition and codon usage patterns across 400 reptile mitochondrial genomes assessing AT and GC skew, GC frequency, codon usage, effective number of codons , and codon adaptation index. We identified poor GC content in reptile mitochondrial genomes, with a predominant bias toward Adenine. We determined a compositional asymmetry between different taxonomic groups, which are inversely correlated to the rates of rearrangements in the mitogenome. We found that the most common codons in reptile mitochondrion are CTA (L), ATA (M) and ACA (T), which relates with have been found in birds, meaning that these patterns are shared across sauropsid mitogenomes. Codon usage bias clustering and effective codon number analyses revelated compositional asymmetry based on RSCU as well as that reptile mitogenomes are translationally efficient and are under selection pressure. Codon adaptation index revealed highest values in turtles indicating higher translational efficiency of mitochondrial genes among all reptiles, which could be related to metabolic adaptations (ie tolerance to anoxic conditions). This was also seen in other groups such as crocodiles (ie acclimation to cold) and snakes (phylogenetic origin of toxin-secreting oral glands and the evolutionary redesign of cytochrome c oxidase complex genes). We discuss our findings in the context of potential adaptations and evolutionary implications that these genomic differences provide to reptiles.

Hocutt, C.H. (2022). Seasonal variation in thermoregulation of wild free-ranging Nile crocodiles: Recovery of a 36-year old data set. International Journal of Current Microbiology and Applied Science 11(10): 101-11.

Abstract: Thermoregulation data for four'problem' Nile crocodiles (*Crocodylus niloticus*) introduced to Lake Ngezi, Zimbabwe were collected from winter through early summer 1986-87 using abdominally implanted radio-transmitters with calibrated thermistors. These remain after 36 years the largest (1.94-3.48 m) wild free-ranging Nile crocodiles thus far evaluated re: body temperatures and thermoregulation. Both cooling and heating rates were highest in the smallest subjects, progressively lower in larger individuals. Body temperatures (T_b's) cooled at night, but remained above or equal to water temperatures (T_w). All T_{bmax}'s exceeded maximum air temperatures (T_a) by 10ºC during daytime with the highest recorded T_b being 36.4ºC. Daily T_b amplitudes of >10ºC were routinely exhibited in all specimens, regardless of size or sex. Both T_{bmax} and T_{bmin} generally lagged T_{amax}'s and T_{amin}'s by about two hours, respectively. The mean T_b's increased ~2ºC monthly from June through October 1986 for each individual regardless of size or sex with supplemental data inferring T_b's increased through January-February 1987.

Galli, G.L.J., Lock, M.C., Smith, K.L.M., Giussani, D.A. and Crossley II, D.A. (2022). Effects of developmental hypoxia on the vertebrate cardiovascular system. Physiology (https://doi.org/10.1152/physiol.00022.2022).

Abstract: Developmental hypoxia has profound and persistent effects on the vertebrate cardiovascular system, but the nature, magnitude and long-term outcome of the hypoxic consequences are species-specific. Here we aim to identify common and novel cardiovascular responses among vertebrates that encounter developmental hypoxia, and we discuss the possible medical and ecological implications.

Nie, H., Zhang, Y., Duan, S., Zhang, Y., Xu, Y., Zhan, J., Wen, Y. and Wu, X. (2022). RNA-sequencing analysis of gene-expression profiles in the dorsal gland of *Alligator sinensis* at different time points of embryonic and neonatal development. Life 12: 1787.

Simple Summary: Skin derivatives, such as integumentary glands, keratin, and bony structures deriving from the epidermis or dermis, are commonly found in various vertebrates species and are suggested to possess a variety of functions that are closely related to the lifestyle of the species. However, most reptile glandular skin derivatives have undergone obvious degeneration due to environmental adaptation to dry land, with the exception of a few skin glands with specific functions. An oval organ/tissue called the dorsal gland spreading from the mid-cervical region to the anterior caudal region in the axial musculature on the dorsal mid-line has been reported in crocodilians, including *Alligator sinensis*, which is a critically endangered species of the 23 existing crocodilian species. Here, we present the first investigation to focus on particular states of cell proliferation and cell apoptosis, we provide direct molecular evidence which supports the speculation that it might serve as a holocrine secretory, as observed in the other known multicellular exocrine glands. Furthermore, the high-throughput analysis of gene-expression profiles at different timepoints of embryonic and neonatal *A. sinensis* suggested that it might function through the transport and deposition of pigment and lipids via lysosomal exocytosis, these function might relate to an adaptive function in the transition from an amniotic fluid environment to the terrestrial environment around hatching. The corresponding results have considerable importance in enriching our understanding of the intrinsic relationship between the skin derivatives and lifestyles of crocodilians. Furthermore, they have provided a theoretical basis for the rearing and management of newborn *A. sinensis*.

Abstract: Significant advances have been made in the morphological observations of the dorsal gland (DG), an oval organ/tissue which lies on both sides of the dorsal midline of the crocodilian. In the current study, RNA sequencing (RNA-seq) was used to identify the changing patterns of *Alligator sinesis* DGs at different timepoints from the 31st embryonic day (E31) to the newly hatched 1st day (NH1). A comprehensive transcriptional changes of differentially expression gene (DEGs) involved in the melanogenesis, cholesterol metabolism, and cell apoptosis pathways suggested that the DG might serves as a functional secretory gland in formation, transport and deposition of pigment, and lipids secretion via lysosomal exocytosis. Furthermore, the remarkable immunohistochemical staining of proliferating cell nuclear antigen (PCNA) and B-cell lymphoma 2 (Bcl-2)-positive signals in the basilar cells, in parallel with the immuno-reactive TdT-mediated dUTP nick-End labeling(TUNEL) within suprabasal cells, provided direct molecular evidence supporting for the speculation that DG serves as a holocrine secretion mode. Finally, subsequent phylogenetic and immunohistochemical analysis for the PITX2, the identified DEGs in the RNA-seq, was helpful to further elucidate the transcriptional regulatory mechanism of candidate genes. In conclusion, the current results are of considerable importance in

enriching our understanding of the intrinsic relationship between the skin derivatives and lifestyles of newborn *A. sinesis*.

Nkama, C.L., Okoro, K.N. and Egbule, E. (2022). Eco-preservation through the lens of Igbo beliefs and practices: A re-imagination. Religions 13: 1066.

Abstract: This research was carried out to investigate the various cultural practices of the Igbo people of Eastern Nigeria that were/are useful in saving the ecosystem from capricious human activities in traditional society. This is with the aim of finding how they could be adopted to checkmate the modern practices that degrade and violate the environment. The researchers adopted a qualitative approach for data collection. This is because the research is a social survey and addresses social issues. As such, data were collected using surveys and oral/personal communication. The study discovered that there is a nexus between indigenous cultural/cosmological knowledge and ecosystem preservation/sustainability and as such notes that the current earth devastation within modern Igbo society is a result of neglect of the indigenous knowledge system. The work observes that, if this knowledge system is incorporated into current ethics of eco-preservation, the present eco-risk would diminish. The work therefore recommends that cultural/indigenous environmental education, advocacy and ecosystem activism and locally managed ecotourism be incorporated into both formal and informal education of the modern Igbo knowledge system.

Lee, G., Son, J., Kim, D., Ko, H.J., Lee, S.G. and Cho, K. (2022). Crocodile-skin-inspired omnidirectionally stretchable pressure sensor. Small (https://doi.org/10.1002/smll.202205643).

Abstract: Stretchable pressure sensors are important components of multimodal electronic skin needed for potentializing numerous Internet of Things applications. In particular, to use pressure sensors in various wearable/skin-attachable electronics, both high deformability and strain-independent sensitivity must be realized. However, previously reported stretchable pressure sensors cannot meet these standards because they exhibit limited stretchability and nonuniform sensitivity under deformation. Herein, inspired by the unique sensory organ of a crocodile, an omnidirectionally stretchable piezoresistive pressure sensor made of polydimethylsiloxane (PDMS)/silver nanowires (AgNWs) composites with microdomes and wrinkled surfaces is developed. The stretchable pressure sensor exhibits high sensitivity that changes negligibly even under uniaxial and biaxial tensile strains of 100% and 50%, respectively. This behavior is attributed to the microdomes responsible for detecting applied pressures being weakly affected by tensile strains, while the isotropic wrinkles between the microdomes deform to effectively reduce the external stress. In addition, because the device comprises all PDMS-based structures, it exhibits outstanding robustness under repeated mechanical stimuli. The device shows strong potential as a wearable pressure sensor and an artificial crocodile sensing organ, successfully detecting applied pressures in various scenarios. Therefore, the pressure sensor is expected to find applications in electronic skin for prosthetics and human-machine interface systems.

Whitaker, Z. (2022). Bringing reptiles into the conservation sphere - a personal account. *In* Conservation through Sustainable Use. Lessons from India. Lessons from India, ed. by A. Varghese, M.A. Oommen, M.M. Paul and S. Nath. Routledge India: London.

Abstract: Beginning in the 1970s with the work of a core team of 'wildlifers', a chain of organisations and projects was established with the focal themes of research, education, and conservation. This included the Madras Snake Park, Irula Snake Catchers Industrial Cooperative Society, Madras Crocodile Bank, Irula Women's Society, and three field stations in the Western Ghats, Andaman Islands and the Chambal River. This ponderous heap has been a self-sustaining, dynamic entity with unique features that need to be looked at as models of responsible tourism, biodiversity conservation, and sustainability. This hands-on conservationist's account recounts the journey, the mistakes, and the successes.

Aung, Y.H. (2022). Is It Possible to Escape from a Crocodile Attack? Review of Human and Saltwater Crocodile Conflict in Asia and Australia. MSc thesis, NTNU.

Abstract: Human and saltwater crocodile conflict has been increasing yearly in crocodile-inhabited countries in Asia and Australia. This study was conducted to foster the safety of humans and the wellbeing of saltwater crocodiles, with the aim of a final coexistence. This study complied with database attack reports (www.croco-attack.info) from 2013 to 2021. The results showed that a developed country has fewer human-crocodile conflicts than developing countries. Among others, crocodile attacks were mostly reported from Indonesia (63.1%). Fatal and nonfatal attacks by crocodiles mainly depended on the type of activity that victims were performing and the age of the victims, the incidences did not depend on victim sex. Fishing was the riskiest practice to be involved in a fatal attack (55.7%), especially for male victims, as they were involved in more fishing practices (92.7%) than female victims (7.3%). Younger victims were more likely involved in fatal attacks compared to older victims. Swimming was the most common practice for younger victims, especially females. Fishing was the most common practice for young adults and old adult victims, especially males which performed more fishing practices compared to females. The study recommends the promotion of the cultural belief of local people in the saltwater crocodile, as this is common in developing countries, as well as the creation of alternative livelihoods for local people living near crocodile habitats, as risky livelihoods and close proximity with wild animals generate more conflicts between humans and animals.

Sey, M. (2022). Probing the mechanical properties of soft and hard biomaterials: polydimethylsiloxane (PDMS) micropillars and alligator teeth. MME Undergraduate Research Symposium (https://digitalcommons.fiu.edu/mme-urs/2022/11-2022/10/).

Abstract: Mechanical properties are essential to quantitatively characterize materials' intrinsic properties ranging from soft to rigid scales. It can effectively facilitate optimal material selection corresponding to their practical applications. Unlike mesoscale, microscale mechanical properties measure localized structural and fundamental components, which is especially superior for assessing materials with hierarchical or ultrastructural properties. This study aims to characterize localized mechanical properties of soft and hard materials: engineering polydimethylsiloxane (PDMS) micropillars and alligator teeth. The stiffness of PDMS pillar arrays is designed by the solvent-casting method, a raw input parameter to calculate the twitch force of cardiac microtissues. The microstructure-associated mechanical properties of alligator teeth will provide crucial information on designing abrasion-resistant toughening materials. Nanoindentation tests were conducted using 50 μm conospherical and 100 nm Berkovich probes. An endoscope camera was used to detect probe-surface contact and capture the indentation process. Hertz and Oliver-Pharr models were applied to analyze stiffness and elastic modulus. The results demonstrated the stiffness of micropillars was 3.4-5.45 N/m. It also indicated a high structural-mechanical relationship for alligator teeth samples. This study reveals the fundamental role of the nanoindentation technique in reviewing micromechanical properties and localized deformation behavior.

Johnson, J.M., Bock, S.L., Smaga, C.R., Lambert, M.R., Rainwater, T.R., Wilkinson, P.M. and Parrott, B.B. (2022). Investigating the relationships between maternally-transferred mercury and hatchling development, behavior, and survival in the American alligator

(*Alligator mississippiensis*). Available at SSRN: https://ssrn.com/abstract=4265611 or http://dx.doi.org/10.2139/ssrn.4265611.

Abstract: Mercury is a highly toxic and pervasive environmental contaminant that can be transferred from mother to offspring during development. Numerous consequences of maternally-transferred mercury have been observed, including reduced clutch viability, reduced offspring size, and behavioral alterations. These sublethal effects are often assumed to decrease survivorship, though this is seldom assessed. Here, we examined how maternally-transferred mercury interacts with incubation temperature to influence reproductive success, offspring behavior, and subsequent survival in the American alligator (*Alligator mississippiensis*). We collected nine clutches of eggs from a mercury contaminated reservoir on the Savannah River Site, South Carolina, and incubated them at female- and male-promoting temperatures. Clutch-averaged mercury in egg yolk ranged from 0.248-0.554 ppm compared to 0.018-0.052 ppm at a site with low levels of mercury contamination; mercury levels in hatchling blood ranged from 0.090-0.490 ppm (mean= 0.240 ppm, n= 158). We found few, mostly negligible correlations between life history traits and mercury, although we noted a positive relationship with egg mass, which may be mediated by other maternal effects such as resource provisioning. Incubation temperature exerted strong effects on hatchling phenotypes, with warmer, male-promoting temperatures producing larger and bolder hatchlings. Presumptive females, produced from cooler incubation temperatures, spent more time in warm areas during behavior trials. Hatchlings were released 10-15 days post-hatch and surveyed over 8 months to assess survival. Survivorship was positively correlated with hatchling size and negatively correlated with proportional time spent in warm areas. Presumptive females had much lower survivorship, suggesting a possible linkage between both hatchling size and behavior with survival. Overall survivorship for the 8-month period was 0.185-0.208, depending on the modelling approach. In general, our study suggests that incubation temperature has a stronger effect on offspring behavior and survival than maternally-transferred mercury pollution in a top aquatic predator.

Hu, M.Y., Chen, Y.W., Chai, Z.F., Wang, Y.Z., Lin, J.Q. and Fang, S.G. (2022). Antibacterial properties and potential mechanism of serum from Chinese alligator. Microorganisms 10: 2210.

Abstract: The Chinese alligator (*Alligator sinensis*) is an ancient reptile with strong immunity that lives in wetland environments. This study tested the antibacterial ability of Chinese alligator serum (CAS) against *Klebsiella pneumoniae*, *Escherichia coli*, *Staphylococcus aureus* and *Pseudomonas aeruginosa* and analyzed the potential underlying mechanisms. Results showed that the CAS had a marked antibacterial effect on *K. pneumoniae*, *E. coli* and *P. aeruginosa*, while *S. aureus* was only mildly affected. However, these effects disappeared when Protease K was added to the serum. The serum proteome analysis revealed that the antibacterial ability of CAS was produced by interactions among various proteins and that the complement proteins played a major antibacterial role. Therefore, we made relevant predictions about the structure and function of complement component 3. In addition, sequence alignment and phylogenetic analysis of complement component 3d (C3d) in four mammalian species and two alligator species showed that the amino acids that make up the acid pocket on the concave surface of alligator C3d are not identical to those in mammals. This study provided evidence that CAS elicits significant antibacterial effects against some pathogens and provides the basis for further development of novel antibacterial drugs.

Faria, C. (2023). Animal Ethics in the Wild: Wild Animal Suffering and Intervention in Nature. Cambridge University Press: Cambridge, UK.

Romanenko, S.A., Prokopov, D.Y., Proskuryakova, A.A., Davletshina, G.I., Tupikin, A.E., Kasai, F., Ferguson-Smith, M.A. and Vladimir A Trifonov, V.A. (2022). The cytogenetic map of the Nile crocodile (*Crocodylus niloticus*, Crocodylidae, Reptilia) with fluorescence *in situ* localization of major repetitive DNAs. International Journal of Molecular Science 23(21): 13063 (doi: 10.3390/ijms232113063).

Abstract: Tandemly arranged and dispersed repetitive DNA sequences are important structural and functional elements that make up a significant portion of vertebrate genomes. Using high throughput, low coverage whole genome sequencing followed by bioinformatics analysis, we have identified seven major tandem repetitive DNAs and two fragments of LTR retrotransposons in the genome of the Nile crocodile (*Crocodylus niloticus*, 2n= 32). The repeats showed great variability in structure, genomic organization, and chromosomal distribution as revealed by fluorescence *in situ* hybridization (FISH). We found that centromeric and pericentromeric heterochromatin of *C. niloticus* is composed of previously described in *Crocodylus siamensis* CSI-HindIII and CSI-DraI repetitive sequence families, a satellite revealed in *Crocodylus porosus*, and additionally contains at least three previously unannotated tandem repeats. Both LTR sequences identified here belong to the ERV1 family of endogenous retroviruses. Each pericentromeric region was characterized by a diverse set of repeats, with the exception of chromosome pair 4, in which we found only one type of satellite. Only a few repeats showed non-centromeric signals in addition to their centromeric localization. Mapping of 18S-28S ribosomal RNA genes and telomeric sequences (TTAGGG)n did not demonstrate any co-localization of these sequences with revealed centromeric and pericentromeric heterochromatic blocks.

Cuff, A.R., Wiseman, A.L.A., Bishop, P.J., Michel, K.B., Gaignet, R. and Hutchinson, J.R. (2022). Anatomically grounded estimation of hindlimb muscle sizes in Archosauria. Journal of Anatomy (doi: 10.1111/joa.13767).

Abstract: In vertebrates, active movement is driven by muscle forces acting on bones, either directly or through tendinous insertions. There has been much debate over how muscle size and force are reflected by the muscular attachment areas (AAs). Here we investigate the relationship between the physiological cross-sectional area (PCSA), a proxy for the force production of the muscle, and the AA of hindlimb muscles in Nile crocodiles and five bird species. The limbs were held in a fixed position whilst blunt dissection was carried out to isolate the individual muscles. AAs were digitised using a point digitiser, before the muscle was removed from the bone. Muscles were then further dissected and fibre architecture was measured, and PCSA calculated. The raw measures, as well as the ratio of PCSA to AA, were studied and compared for intra-observer error as well as intra- and interspecies differences. We found large variations in the ratio between AAs and PCSA both within and across species, but muscle fascicle lengths are conserved within individual species, whether this was Nile crocodiles or tinamou. Whilst a discriminant analysis was able to separate crocodylian and avian muscle data, the ratios for AA to cross-sectional area for all species and most muscles can be represented by a single equation. The remaining muscles have specific equations to represent their scaling, but equations often have a relatively high success at predicting the ratio of muscle AA to PCSA. We then digitised the muscle AAs of *Coelophysis bauri*, a dinosaur, to estimate the PCSAs and therefore maximal isometric muscle forces. The results are somewhat consistent with other methods for estimating force production, and suggest that, at least for some archosaurian muscles, that it is possible to use muscle AA to estimate muscle sizes. This method is complementary to other methods such as digital volumetric modelling.

Pessoa-Lima, C., Tostes-Figueiredo, J., Macedo-Ribeiro, N., Schmaltz Hsiou, A., Pereira Muniz, F., Maulin, J.A., Franceschini-Santos, V.H., Barbosa de Sousa, F., Barbosa Jr, F., Peres Line, S.R., Gerlach, R.F. and Cardoso Langer, M. (2022). Structure and

chemical composition of ca. 10-million-year-old (Late Miocene of Western Amazon) and present-day teeth of related species. Biology (Basel) 11(11): 1636 (doi: 10.3390/biology11111636).

Abstract: Molecular information has been gathered from fossilized dental enamel, the best-preserved tissue of vertebrates. However, the association of morphological features with the possible mineral and organic information of this tissue is still poorly understood in the context of the emerging area of paleoproteomics. This study aims to compare the morphological features and chemical composition of dental enamel of extinct and extant terrestrial vertebrates of Crocodylia: *Purussaurus* sp. (extinct) and *Melanosuchus niger* (extant), and Rodentia: *Neoepiblema* sp. (extinct) and *Hydrochoerus hydrochaeris* (extant). To obtain structural and chemical data, superficial and internal enamel were analyzed by Scanning Electron Microscopy (SEM) and Energy Dispersive Spectroscopy (SEM-EDS). Organic, mineral, and water content were obtained using polarizing microscopy and microradiography on ground sections of four teeth, resulting in a higher organic volume than previously expected (up to 49%). It is observed that both modern and fossil tooth enamel exhibit the same major constituents: 36.7% Ca, 17.2% P, and 41% O, characteristic of hydroxyapatite. Additionally, 27 other elements were measured from superficial enamel by inductively coupled mass spectrometry (ICP-MS). Zinc was the most abundant microelement detected, followed by Pb, Fe, Mg, and Al. Morphological features observed include enamel rods in the rodent teeth, while incremental lines and semiprismatic enamel were observed in the alligator species. The fossil enamel was in an excellent state for microscopic analyses. Results show that all major dental enamel's physical, chemical, and morphological features are present both in extant and extinct fossil tooth enamel (>8.5 Ma) in both taxa.

Khan, M., Ahmed, S., Zamir, A. and Saeed, S. (2022). First record of Mugger crocodile (*Crocodylus palustris* Lesson, 1831) from Haji Shahr, District Kachhi, Balochistan, Pakistan. International Journal of Biology and Biotechnology 19(4): 549-552.

Abstract: Marsh crocodile (*Crocodylus palustris* Lesson, 1831) is considered one of the oldest creatures on the planet. It is a critically endangered species of freshwater crocodile that was once abundant in the tropics. A high level of exploitation of this animal is in the leather industry. This study aims to develop a method to (a) estimate its current population in the study area, (b) identify habitat destruction, and (c) suggest conservation strategies and public awareness. A questionnaire was developed to estimate the population size of this species during summer in 2022 using a direct day and night count method. The study area is subject to frequent drought conditions, biotic stress as a result of sprawling urbanization, and frequent fishing practices by the local population. All these factors were found to have a negative impact on their population size.

Santana, F.L., Estrada, K., Alford, M.A., Wu, B.C., Dostert, M., Pedraz, L., Akhoundsadegh, N., Kalsi, P., Haney, E.F., Straus, S.K., Corzo, G. and Hancock, R.E.W. (2022). Novel alligator Cathelicidin As-CATH8 demonstrates anti-infective activity against clinically relevant and crocodylian bacterial pathogens. Antibiotics 11(11): 1603.

Abstract: Host defense peptides (HDPs) represent an alternative way to address the emergence of antibiotic resistance. Crocodylians are interesting species for the study of these molecules because of their potent immune system, which confers high resistance to infection. Profile hidden Markov models were used to screen the genomes of four crocodylian species for encoded cathelicidins and eighteen novel sequences were identified. Synthetic cathelicidins showed broad spectrum antimicrobial and antibiofilm activity against several clinically important antibiotic-resistant bacteria. In particular, the As-CATH8 cathelicidin showed potent in vitro activity profiles similar to the last-resort antibiotics vancomycin and polymyxin B. In addition, As-CATH8 demonstrated rapid killing of planktonic and biofilm cells, which correlated with its ability to cause cytoplasmic membrane depolarization and permeabilization as well as binding to DNA. As-CATH8 displayed greater antibiofilm activity than the human cathelicidin LL-37 against methicillin-resistant *Staphylococcus aureus* in a human organoid model of biofilm skin infection. Furthermore, As-CATH8 demonstrated strong antibacterial effects in a murine abscess model of high-density bacterial infections against clinical isolates of *S. aureus* and *Acinetobacter baumannii*, two of the most common bacterial species causing skin infections globally. Overall, this work expands the repertoire of cathelicidin peptides known in crocodylians, including one with considerable therapeutic promise for treating common skin infections.

Vasconcelos, B.D. and Brandao, R.A. (2022). Predation on *Tamandua tetradactyla* (Pilosa: Myrmecophagidae) by *Caiman latirostris* (Crocodylia: Alligatoridae) in a highly seasonal habitat in Central Brazil. North-Western Journal of Zoology 18(2): e222502 (http://biozoojournals.ro/nwjz/index.html).

Abstract: *Caiman latirostris* is an opportunistic predator found in rivers, mangroves, and wetlands throughout eastern South America. We report here the predation of *Tamandua tetradactyla* by *Caiman latirostris* in an old cattle dam in the Serra da Bodoquena National Park, Brazil. The adult caiman was accompanied by its hatchlings that fed on the lacerated parts of the Lesser anteater and possibly the insects attracted by the carcass. Although *C. latirostris* acts as a fundamental organism for the balance of ecosystems, most of the species' diet records are anecdotal, making this record relevant for understanding the ecology of the species.

Bellanthudawa, B.K.A., Nawalage, N.M.S.K., Panagoda, P.A.B.G., Karunarathne, H.K.A.D., Weerasinghe, H.W.G.A.S., Tharaka, L.K.D.N., Dissanayake, D.M.S.N., De Silva, P.K.S.K., Pathmanathan, K., Suvendran, S., Mahawaththa, M.W.I.C., Bandara, A.G.G.C., Neththipola, M.M.T.D. and Perera, I.J.J.U.N. (2022). Human-crocodile co-occurrence of saltwater crocodile (*Crocodylus porosus*) in an urban wetland; Rapid assessment of Bellanwila-Attidiya Sanctuary (Bas), Sri Lanka. Available at SSRN: https://ssrn.com/abstract=4276415 or http://dx.doi.org/10.2139/ssrn.4276415.

Abstract: The potential threat from Saltwater crocodiles (*Crocodylus porosus*) to humans and from humans to crocodiles may increase in urban areas due to habitat destruction. The present study attempted to assess the abundance of *C. porosus* and the human crocodile co-occurrence along an urban wetland of Bellanwila-Attidiya Sanctuary, Nedimala Canal (Unit 1= 1.11 km) and Bolgoda-Kawdana Lake (Unit 2= 0.77 km) in Colombo, Sri Lanka. Eyeshine surveys were conducted to assess the abundance of *C. porosus* in selected microhabitats. In addition, a questionnaire survey was carried out to understand the human perception of human-crocodile co-occurrence, knowledge of crocodile behavior, and their ecological importance. Twenty-eight individuals in the adjacent vicinity were interviewed. A total of 10 individual *C. porosus* (2 hatchlings and 6 adults from Unit 1, 1 hatchling and 1 adult in Unit 2) were sighted. Further, 6 individuals were found among vegetation and 2 individuals were found among vegetation near the bank. In terms of water quality, the measured water quality values were below the limits of the standards. Respondents were aware of crocodile conservation (55%), and the value of crocodiles (41%). The population of *C. porosus* has declined compared to a previous study. Further, more than half of respondents living close to the area were aware of food, habitat, and conservation. For conservation and management, (54%) of the respondents proposed to capture and translocation, the establishment of fences, and raising awareness as sustainable management strategies for the human crocodile co-occurrence.

La'Toya, V.L. (2023). Pain recognition in reptiles. Veterinary Clinics of North America: Exotic Animal Practice 26(1): 27-41.

Sladky, K.K. (2023). Treatment of pain in reptiles. Veterinary Clinics of North America: Exotic Animal Practice 26(1): 43-64.

Fabbri, M. and Bhullar, B-A.S. (2022). The endocast of *Euparkeria* sheds light on the ancestral archosaur nervous system. Palaeontology 2022: e12630.

Abstract: Understanding the evolution of the tetrapod brain is essential to trace the history of ecomorphological diversification of modern clades. While previous studies focused on the morphological transformation of the nervous system along the dinosaur-bird transition, little is known about the brain anatomy of archosauriformes and early archosaurs. Here, we describe the endocast of *Euparkeria capensis*, a small bodied, terrestrial archosauriform closely related to Archosauria, with the goal of resolving the current uncertainties surrounding the ancestral condition of the archosaurian nervous system. The endocast of *Euparkeria* is sigmoidal, with large olfactory bulbs, an expanded cerebral hemisphere and an elongated flocculus. We suggest that this pivotal taxon was an active predator with a remarkable olfactory acuity. Overall, the endocast of *Euparkeria* resembles the ones observed in phytosaurs, crocodilians and early dinosaurs, implying that modern crocodilians retain an archosaurian plesiomorphic brain morphology.

Heo, N. and Jo, S. (2022). Philosophy of eating and being eaten from a planetary perspective - focusing on Val Plumwood and Haewol Choi Sihyeong. Journal of the Korean Academy of New Religions 47: 141-167.

Abstract: Australian philosopher Val Plumwood found that humans can also be prey through his experience of being prey for crocodiles. And she realized that the natural world was maintained by the cycle of eating and being fed. Thus, she calls the system that maintains one's own survival through the sacrifice of others as the 'Earth Community Model,' and suggested that western culture has taken the humanistic view of 'human exceptionalism' that separates humans from the natural world, and this has led to today's ecological crisis. Based on these reflections, he criticized the attitude of treating animals only as meat, and insisted on considering ethical meanings in meals. This point of view tells us that Plumwood was not a simple ecology philosopher, but a 'geologist' who approached ecological issues from the point of view of the earth community. On the other hand, Plumwood's philosophy provides a room for conversation with 19th century Korean Donghak thinker Haewol Choi Sihyeong. If Plumwood paid attention to the experience of being eaten, he focused on the phenomenon of eating. Based on the ontology that "All things are heaven" and a viewpoint of human that "We have Heaven in ours," Choi Sihyeong described an act of eating as "Heaven eats Heaven." According to Haewol, from the point of view of the whole Earth, the act of eating something is nothing but nature nurtures nature, and daily meals are nothing but a ritual in which Heaven inside us serves Heaven outside us. As such, Haewol's Donghak philosophy has a lot of room for dialogue with the ecological philosophy from the geological perspective, which is emerging in the West recently.

Neves, J. and Giger, J.C. (2022). On crocodiles and turtles. Stereotypes, emotional tendencies and implications for conservation. Human Dimensions of Wildlife (https://doi.org/10.1080/10871209.2022.2146815).

Abstract: Even with the increasing global threat, reptiles have not been a preferential group for animal conservation due to a set of factors affecting attitudes and emotions. This research extends the current knowledge of crocodiles and turtles to stereotypes and emotional dispositions people have. Through the Stereotype Content Model, crocodiles were found to belong to the threatening-awe stereotype, generating feelings of respect and fear but also holding our attention and admiration. This stereotype is also associated with passive facilitation and active harm. Even though participants showed mild positive attitudes toward crocodile conservation and expressed intent to help a crocodile conservation trust, crocodiles ranked last in the donation preference. Turtles, on the other hand, were found to fit the protective stereotype, represented as affectionate and competent and were viewed as belonging to the in-group. These emotions reflected the participants' predisposition for active and passive facilitation with regard to conservation attitudes and intentions.

Lesmana, L.F. and Jura, D. (2022). The existence of crocodile bread at the Betawi Community wedding's offerings in christian education perspective. International Journal of Science and Society 4(4) (doi: https://doi.org/10.54783/ijsoc.v4i4.576).

Abstract: The use of crocodile bread is very important as part of the offerings at the Betawi traditional wedding ceremony. The 'Seserahan' event is a series that must exist at the wedding where the groom is the giver of material to the bride with a symbolic meaning. In general, the Betawi people believe that the crocodile is an animal with a symbol of loyalty. This article attempts to describe the existence of crocodile bread in a series of 'Seserahan' at Betawi weddings. Crocodile bread is seen as a symbol of the loyalty of the two parties who agreed to build a household and this principle is believed to this day. The study of the existence of crocodile bread in the Betawi people's wedding ceremony, which is viewed from the perspective of Christian education, is expected to provide enlightenment for those who want to observe this local wisdom so that they can add cultural insight. By using a descriptive approach, it is hoped that this study will provide the information needed when discussing the existence of this crocodile bread. Christian education conveys educative information so that people can understand the existence of crocodile bread responsibly based on Christian values.

Díaz Molano, A.L. (2022). Identificación de los impactos generados por la actividad turística sobre la fauna silvestre y la comunidad local del área de Puerto Nariño, Amazonas. BSc thesis, Universidad Externado de Colombia, Bogota, Colombia.

Abstract: The work focuses on analyzing the current and potential impacts that occur on the fauna when the tourist activity is carried out in the area of Puerto Nariño, Amazonas; specifically in fish, primates (monkeys), birds, mammals (river dolphins, manatees, sloths, tapirs, jaguars, and otters), and reptiles (alligators). This is carried out according to the opinions of experts who have worked and investigated the subject, resulting in the fact that tourism cannot be seen as the main and direct activity that has affected the fauna, although it can be shown that tourism has caused both structural and functional transformations in the landscape. Now, two possible scenarios are possible in the potential impacts; On the one hand, if tourism continues to be carried out irregularly, there could be impacts on the fauna such as displacement, extinction and even less genetic recombination; Otherwise, if tourism is carried out in a sustainable way, protocols of good practices for fauna sighting could be created for other species for their preservation and conservation. Finally, the creation of a sectoral technical standard for wildlife sighting is recommended, as well as better government articulation in institutions focused on tourism and compliance with the protocols and guides of good practices for wildlife sighting.

Hart, L.J., Campione, N.E. and McCurry, M.R. (2022). On the estimation of body mass in temnospondyls: a case study using the large-bodied *Eryops* and *Paracyclotosaurus*. Palaeontology 2022: e12629.

Abstract: Temnospondyli are a morphologically varied and ecologically diverse clade of tetrapods that survived for over 200 million years. The body mass of temnospondyls is a key variable in inferring their ecological, physiological and biomechanical attributes. However, estimating the body mass of these extinct creatures has proven difficult because the group has no extant descendants. Here we apply a wide range of body mass estimation techniques developed for tetrapods to the iconic temnospondyls *Paracyclotosaurus davidi* and *Eryops megacephalus*. These same methods are also applied to a collection of extant organisms that serve as ecological and morphological analogues. These include the giant salamanders *Andrias japonicus* and *Andrias davidianus*, the tiger salamander *Ambystoma tigrinum*, the California newt *Taricha torosa* and the saltwater crocodile, *Crocodylus porosus*. We find that several methods can provide accurate mass estimations across this range of living taxa, suggesting their suitability for estimating the body masses of temnospondyls. Based on this, we estimate the mass of *Paracyclotosaurus* to have been between 159 and 365 kg, and that of *Eryops* between 102 and 222 kg. These findings provide a basis for examining body size evolution in this clade across their entire temporal span.

Von Baczko, M.B., Desojo, J.B., Trotteyn, M.J. and Stocker, M.R. (2023). Paleoneurology of the early diversification of Triassic archosauriforms and pseudosuchians. Pp. 179-211 *in* Paleoneurology of Amniotes, ed. by M.T. Dozo, A. Paulina-Carabajal, T.E. Macrini and S. Walsh. Springer, Cham.

Abstract: Archosauriformes is a very diverse group of reptiles, that includes the clade Archosauria - the ruling reptiles - represented by Pseudosuchia (crocodylians) and Avemetatarsalia (birds). During the Triassic Period, pseudosuchians, in particular, are represented by an enormous diversity of body forms, sizes, and life habits that mainly dominated the continental environments. The skulls of early Triassic archosauriforms have been extensively modified in each group, allowing the filling of continental niches available after the Permian-Triassic mass extinction (~252 Ma). The internal anatomy of those skulls reflects the soft tissues that they contained and protected (i.e. central nervous system, vascular tissues, sensorial organs), and the study of these bony correlates, better known as paleoneurology, has been applied to archosauriforms and pseudosuchians since the late 1800s. Although not enough information is known about the paleoneurology of these groups, it is a flourishing area that has seen remarkable advances in the last decades and still needs to be explored in more detail. Here we present an updated review of reptilian paleoneurology particularly focused on early archosauriforms and pseudosuchians from the Triassic, including the descriptions of known endocranial casts and novel information of the major clades as well as the paleobiological interpretations that can be inferred from them.

Sobral, G. (2023). The paleoneurology of early reptiles. Pp. 9-27 *in* Paleoneurology of Amniotes, ed. by M.T. Dozo, A. Paulina-Carabajal, T.E. Macrini and S. Walsh. Springer, Cham.

Abstract: Reptiles represent the most speciose group of living tetrapods. They occupy a variety of niches and display a wide range of locomotory modes, both related to a high diversity of sensory and neurological mechanisms. However, little is known about the early evolution of these systems, as few studies on the brain of early reptiles exist. Old accounts consider parts of the brain based on the anatomical analysis of the braincase, but they do not include several brain regions and rarely consider it in a broader evolutionary scenario. Likewise, recent approaches remain rare and superficial, focusing in comparative analysis of other, late-diverging groups. Computed tomography scanning has been widely used to assess the paleoneurology of fossils, but such studies are still largely missing for early reptiles. Here, the morphological diversity of the encephalon and sensory systems of early reptiles is revised, and areas of potential interest are indicated for future research. The scarce data seems to corroborate a stepwise adaptation to terrestrial habitats, but subsequent back-to-water transitions remain poorly understood. Without proper information on early reptiles, our understanding of the paleobiology of these groups is weak, hampering our comprehension on the flourishing of reptile diversity.

Barrios, F., Bona, P., Paulina-Carabajal, A., Leardi, J.M., Holliday, C.M., Lessner, E.J. (2023). An overview on the crocodylomorpha cranial neuroanatomy: Variability, morphological patterns and paleobiological implications. Pp. 213-266 *in* Paleoneurology of Amniotes, ed. by M.T. Dozo, A. Paulina-Carabajal, T.E. Macrini and S. Walsh. Springer: Cham.

Abstract: An overview of the neuroanatomy and the principal anatomical transformations of the cranial endocast of the main lineages of Crocodylomorpha are presented. One of the main transformations of the cranial endocast within pseudosuchians seems to be the lateral extension of the cerebral hemispheres, occurred near the node Crocodyliformes and interpreted as a reversal in thalattosuchians and dyrosaurids to cranial endocast with narrow cerebral hemispheres. Relatively larger cerebral hemispheres indicate greater processing of environmental information and more complex responses. Prominent olfactory bulbs and expanded optic lobes of several terrestrial notosuchians are linked to greater olfactory acuity and visual capacity. Inner ear morphology is mostly conservative in Crocodylomorpha; however, the vestibulum and lagena are dorsoventrally short in *Almadasuchus* and aquatic crocodyliforms. Relative sizes of the trigeminal fossa and maxillomandibular foramen showed an increase in size along the line to amphibious crown crocodylians, contrasting with putatively terrestrial crocodyliforms as protosuchids and several notosuchians, further suggesting that somatosensation evolved later in the group than previously proposed (but depending on the phylogenetic position of thalattosuchians). Neuroanatomical information at the base of Crocodylomorpha-Crocodyliformes and within Mesoeucrocodylia is relatively scarce, but crucial to understanding the neurological novelties developed by the group in terrestrial and aquatic environments.

Young, B.A. and Cramberg, M. (2022). The influence of movement on the cerebrospinal fluid pressure of the American alligator (*Alligator mississippiensis*). Biology 11: 1702.

Abstract: This study was undertaken to document how the cerebrospinal fluid (CSF) pressure varied during movements and physiological activities. Using surgically implanted pressure catheters; the CSF pressure was recorded from sub-adult American alligators (*Alligator mississippiensis*) under anesthesia and post-recovery. Pressures were recorded during physiological activities (the cardiac cycle; passive and active ventilation); manual manipulation of the anesthetized animals (foot sweeps; tail oscillations; and body bends); as well as voluntary movements post-recovery (changes in body tone; defensive strikes; and locomotion). The CSF pulsations associated with the cardiac cycle had the lowest mean amplitude (3.7 mm Hg); during active ventilation and defensive strikes; the alligators routinely generated CSF pressure spikes in excess of 100 mm Hg. The recorded CSF pressures appear to be caused by a variety of mechanisms including vascular pressure; fluid inertia; and possible physical displacement of the spinal cord. The results of the study suggest that any model of CSF dynamics or perfusion should incorporate the episodic high-pressure CSF pulsations associated with movement.

Chavan, U.M. and Borkar, M.R. (2022). Population trends of Mugger Crocodile and human-crocodile interactions along the Savitri River at Mahad, Maharashtra, India. Journal of Threatened Taxa 14(11): 22118-22132.

Abstract: In this paper, we report monitoring of a resident population of Mugger Crocodile *Crocodylus palustris* (Lesson, 1831) along a

stretch of 3.5 km of the river Savitri on the outskirts of Mahad town of Raigad District in Maharashtra, on monthly basis from 2014 to 2021. This river is increasingly becoming a sink of anthropogenic wastes emerging from adjacent settlements impacting its habitat value, and puts the reptile side by side with humans and human-wastes that could be a cause of rising incidents of crocodile mortality in the recent times here, as also reported from elsewhere. Savitri River has been a fishing ground for local indigenous communities, who also use the river bank for washing clothes and utensils, and for swimming. Such proximity between people and crocodiles creates a potential for negative interaction. This long-term study monitored the Mugger population trends for the last 8 years at four transect stretches along the river. Counts are suggestive of a healthy viable population of Mugger in this river currently, but a future conflict situation cannot be ruled out. Being generalist feeders, Muggers can sustain themselves on fish, and scavenge on dumped carrion and other anthropogenic organic wastes. With the exception of a few sporadic incidents of aggression by the Muggers at this location, no human casualties have been reported thus far, however, this does not rule out fatal reciprocal interactions in future and hence a few practical mitigation measures have been suggested.

Hixon, S.W., Domic, A.I., Douglass, K.G., Roberts, P., Eccles, L., Buckley, M., Ivory, S., Noe, S. and Kennett, D.J. (2022). Cutmarked bone of drought-tolerant extinct megafauna deposited with traces of fire, human foraging, and introduced animals in SW Madagascar. Scientific Reports 12(1): 18504 (doi: 10.1038/s41598-022-22980-w).

Abstract: People could have hunted Madagascar's megafauna to extinction, particularly when introduced taxa and drought exacerbated the effects of predation. However, such explanations are difficult to test due to the scarcity of individual sites with unambiguous traces of humans, introduced taxa, and endemic megaherbivores. We excavated three coastal ponds in arid SW Madagascar and present a unique combination of traces of human activity (modified pygmy hippo bone, processed estuarine shell and fish bone, and charcoal), along with bones of extinct megafauna (giant tortoises, pygmy hippos, and elephant birds), extirpated fauna (eg crocodiles), and introduced vertebrates (eg zebu cattle). The disappearance of megafauna from the study sites at ~1000 years ago followed a relatively arid interval and closely coincides with increasingly frequent traces of human foraging, fire, and pastoralism. Our analyses fail to document drought-associated extirpation or multiple millennia of megafauna hunting and suggest that a late combination of hunting, forest clearance, and pastoralism drove extirpations.

Pritz, M.B. (2022). Nuclei and tracts in the pretectum and associated tegmentum of crocodiles. Journal of Comparative Neurology (doi: 10.1002/cne.25433).

Abstract: In all vertebrates, the pretectum and associated tegmentum arise from prosomere 1, but the adult derivatives of these embryonic regions are not well defined in reptiles-especially in crocodiles, the reptilian group most closely related to birds. Despite its importance in vision and visuomotor behavior, descriptions of the pretectum in crocodiles are brief and photographs are lacking. To fill this gap in knowledge, the pretectum and associated tegmentum were examined in two crocodilians, *Caiman crocodilus* and *Alligator mississippiensis*, using a variety of histological stains in all three traditional planes of section. These observations were compared with similar studies in other reptiles and birds. These comparisons were hampered by differences in nomenclature and limited data. Nevertheless, pretectal nuclei in receipt of retinal input in crocodiles, other reptiles, and birds were the most easily identified when compared with the present analysis. Despite identifying the traditional nuclei comprising the pretectum of crocodiles, other areas remain to be characterized. Nevertheless, knowledge gained from this description will aid further investigations of this brain region in crocodiles and other reptiles as well as provide a reference for developmental studies in crocodiles.

Viveros-Peredo, S., Ahuja-Aguirre, C., López-deBuen, L. and Domínguez-Mancera, B. (2022). Growth pattern of farmed Morelet's crocodiles (*Crocodylus moreletii*) from hatchlings to juveniles. South American Journal of Herpetology 25(1): 76-87.

Abstract: The objective of this study was to determine the growth pattern of farmed *Crocodylus moreletii* individuals from hatchling to juvenile. A total of 3743 crocodiles (3098 males and 645 females) were included. Crocodiles hatched from artificially incubated eggs. Individuals were classified into three age categories: (1) neonate (0-4 months), (2) developing (4-12 months), and (3) juvenile (12-27 months). Seven biometric evaluations were conducted. The first one was at 4 d after hatching, and the following evaluations were at 4, 8, 12, 17, 22, and 27 months of age. In each evaluation, the total length, weight, and sex of each individual were registered. Crocodiles were subsequently classified into three growth groups: (1) fast: length and weight greater than 1 SD from the mean, (2) average: length and weight within 1 SD from the mean, and (3) slow: length and weight lower than 1 SD from the mean. Linear polynomial (LPN), quadratic polynomial (QPN), and three-parameter sigmoidal (SIG3) models were used to evaluate length and weight as a function of age to describe growth. For length and weight, SIG3 and QPN, respectively, produced the highest R^2 in all growth groups and the general population. LPN did not fit the weight data. The models that best fitted length and weight in relation to age were SIG3 and QPN, so both could be used to evaluate the growth pattern in other populations of farmed young *Crocodylus moreletii*.

Sandoval Hernández, I., Sasa Marín, M., Monrós González, J.S., Bolaños Montero, J.R. and Sánchez Ramírez, J. (2022). Potential habitat of the American crocodile (*Crocodylus acutus*: Reptilia: Crocodilidae) and identification of areas of interaction with humans in Costa Rica. South American Journal of Herpetology 25(1): 66-75.

Abstract: Crocodilians are known to interact substantially with humans. Conflicts are observed when both species share a habitat and are documented worldwide. In Costa Rica, this conflict has been detected along with increases in human activities. For this reason, we undertook a study to identify potential crocodile habitats and the areas of interaction with humans on the Pacific and Caribbean coasts and the Northern Zone of Costa Rica. This work was performed during 2019 and 2020 in both regions, and determination of the potential habitat of crocodiles was made through analysis of the elevation, topography, drainage net, flooding areas, mangrove areas, and rivers and their outlets. To identify areas of human-crocodile interactions, a map of the potential habitat was used and changes to those habitats were analyzed (eg road density, population density, and the density of the populated core). The relationship between species was established to predict interaction hotspots between humans and crocodiles. The habitats with high potential for crocodiles on the Pacific slope correspond to 18% of the study area, and the medium potential habitat to 54%. Within the Central Pacific, there are few areas at higher elevations or with a large index of urbanism; these low potential habitats represent 27% of the study area. In the Central Pacific, the high and medium potential habitats together represent 72% of the study area. On the Caribbean slope, the high potential habitat was identified in areas closer to the coast mainly in the North and Central Caribbean (corresponding to 29% of the study area), while 66% of the study area was labeled as medium potential habitat. In the Northern area, most of the habitat was identified as medium potential, there being only small fragments recognized as high potential habitat. In the Northern Zone and Caribbean Zone, the areas at higher elevation with some land development were identified as low potential habitat (4%). Importantly, 96% of the area of the Caribbean slope and the Northern Zone were identified as high or medium potential habitat.

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

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

Sawan, S., Mondal, T., Williams, A.C., Yadav, S.P. and Krishnamurthy, R. (2023). Hybrid drone-based survey of riverine habitat and crocodiles in complex landscapes. International Journal of Environmental Science and Technology (https://doi.org/10.1007/s13762-022-04739-y).

Abstract: Technological integration in conservation and management dramatically increases the range and quality of data collection in a short time and with high accuracy. Unmanned aerial vehicles (UAVs) are effective in surveillance, mapping, and monitoring and, combined with conventional remote-sensing techniques, offer enhanced scope and overcome several technological and operational challenges in wildlife research and management. Especially in places like India, where the terrain complexity is high and has a low workforce for routine patrolling, UAV technology offers an alternate support system to manage the natural areas and key species. Pioneer effort was made in India for surveying critically endangered aquatic species using UAV in Ken River, Madhya Pradesh. A fixed wing V-TOL UAV was used for survey approximately 24.5 km of river stretch flowing through Ken Gharial Sanctuary and Panna Tiger Reserve to count population of a critically endangered aquatic species, ie crocodiles. Flight time of almost 4.5 h maintaining 100 m altitude with five pre-planned missions the UAV acquired 5193 images covering 1858.564 hectares area. 61 crocodile and 1 gharial was found in the search effort. Body length measurement was calculated for every single individual. Our pioneering efforts received wider attention and facilitated increased use of the technology. Other than population count, we also recorded and processed data for crocodile habitat, landscape terrain, 3D models and NDVI. There is a need for concerted efforts to upscale the use of this technology with enhanced capacity of the researchers and managers to leverage its optimal capacity while supporting ground-based conservation with improved vigor and success.

Prado, R.O.F., Carrillo, D.M.I., Hernández, R.J.A., Ruíz, R.J.A. and García, C.A.C. (2022). Biochemical reference intervals for captive bred *Crocodylus moreletii* and *Crocodylus acutus* in the Alcuzahue Lagoon, Colima, Mexico. Arquivo Brasileiro de Medicina Veterinaria e Zootecnia 74(6): 1049-1058.

Abstract: *Crocodylus moreletii* and *Crocodylus acutus* are two endangered crocodile species endemic to Mexico. In this descriptive cross-sectional study, a total of 58 crocodiles (30 females and 28 males) were examined to determine and evaluate 24 blood biochemical indicators associated with energy, lipid, protein, mineral and enzymatic metabolic processes. Most of the serum biochemistry parameters were similar among sexes by species. However, male crocodiles showed higher triacylglycerol concentration and alkaline phosphatase activity, and lower globulin concentration than females. There were some significant differences between species. Total bilirubin, triacylglycerol, carbon dioxide, and hydrogen carbonate were higher in *C. moreletii*, and urea nitrogen, creatinine, alanine aminotransferase, and aspartate aminotransferase were higher in *C. acutus*. These reference values are very important for the protection of crocodiles. The calculated confidence intervals could be used to detect alert situations when at least 5% of the sampled crocodiles would fall outside of the calculated reference interval for a given parameter.

Yoshida, J., Kobayashi, Y. and Fiorillo, A.R. (2022). Evolutionary insights from an anatomical network analysis of the hyolaryngeal apparatus in extant archosaurs (birds and crocodilians). The Anatomical Record (https://doi.org/10.1002/ar.25153).

Abstract: Adaptive radiation of archosaurs, represented by crocodilians, non-avian dinosaurs, and birds, since the Mesozoic has been studied mainly based on their major skeletal elements (skull, vertebrae, and limbs). However, little is known about the evolution of their hyolaryngeal apparatus, which is involved with feeding, respiration, and vocalization, because of poor fossil preservation and the difficulty in determining the musculoskeletal homology of the apparatus. Network analysis is a framework to quantitatively characterize the topological organization of anatomical structures for comparing structural integration and modularity regardless of ambiguous homology. Herein, we modeled the musculoskeletal system of hyolarynx in six species of extant archosaurs and its sister-taxon turtle, and conducted a network analysis using network parameters, modular partition, and bone centrality in a phylogenetic framework. The network parameters reveal that ancestral archosaurs have reduced the numbers of elements and links and acquired complex networks as a whole domain with strong modularity in the hyolarynx. Furthermore, the modular partition and centrality reveal that the hyoids are highly evolvable, while the larynx is constrained and less evolvable. The archosaur hyolarynx exhibits different evolutionary trends: crocodilians with the system integration, basihyal simplification, and ceratobranchial centralization; and birds with the simplicity, weak integration, and modularity of the hyolarynx, laryngeal integration with cricoid centrality, and tongue-module expansion with the acquisition of paraglossal. Four hyolaryngeal bones (ceratobranchial, basihyal, paraglossal, and cricoid) have played important roles in archosaur evolution, and their fossil records are keys to understanding the two major archosaur lineages toward crocodilians and birds.

Venczel, M., Codrea, V.A. and Trif, N. (2022). Eocene gavialoid teeth from southern Transylvania with notes on the diversity of Paleogene crocodilians from Romania. North-Western Journal of Zoology 19(1): e231901.

Abstract: Herein, we report a small collection of isolated crocodilian teeth recovered from shallow marine Eocene deposits of Turnu Roșu (Porcești), Romania. The teeth probably represent an attritional assemblage that could have belonged to several individuals of various sizes and ages, provided with heterodont dentition of at least five morphotypes (slender caniniform, triangular-lanceolate shaped, enlarged conical, slender conical, and low crowned). We assigned the isolated teeth to Gavialoidea based on a number of morphological characters shared with representatives of early gavialoids, known from the early-middle Eocene of western Europe or North Africa. The gavialoids from Turnu Roșu represent a new group for the Paleogene of Romania that probably reached the territory of southern Transylvania in the Middle Eocene. Possible scenarios

for the origin of southern Transylvanian gavialoids imagine an existence of a western-eastern European route or a migration route direct from North Africa and an ancestor close to the morphology of *Maroccosuchus* from the region of western Tethys.

Lawson, A.J., Jodice, P.G.R., Rainwater, T.R., Dunham, K.D., Hart, M., Butfiloski, J.W., Wilkinson, P.M., McFadden, K.W. and Moore, C.T. (2022). Hidden in plain sight: Integrated population models to resolve partially observable latent population structure. Ecosphere 13: e4321.

Abstract: Population models often require detailed information on sex, age, or size-specific abundances, but population monitoring programs cannot always acquire data at the desired resolution. Thus, state uncertainty in monitoring data can potentially limit the demographic resolution of management decisions, which may be particularly problematic for stage- or size-structured species subject to consumptive use. American alligators (*Alligator mississippiensis*; hereafter alligator) have a complex life history characterized by delayed maturity and slow somatic growth, which makes the species particularly sensitive to overharvest. Though alligator populations are subject to recreational harvest throughout their range, the most widely used monitoring method (nightlight surveys) is often unable to obtain size class-specific counts, which limits the ability of managers to evaluate the effects of harvest policies. We constructed a Bayesian integrated population model (IPM) for alligators in Georgetown County, SC, USA, using records of mark-recapture-recovery, clutch size, harvest, and nightlight survey counts collected locally, and auxiliary information on fecundity, sex ratio, and somatic growth from other studies. We created a multistate mark-recapture-recovery model with six size classes to estimate survival probability, and we linked it to a state-space count model to derive estimates of size class-specific detection probability and abundance. Because we worked from a count dataset in which 60% of the original observations were of unknown size, we treated size class as a latent property of detections and developed a novel observation model to make use of information where size could be partly observed. Detection probability was positively associated with alligator size and water temperature, and negatively influenced by water level. Survival probability was lowest in the smallest size class but was relatively similar among the other five size classes (>0.90 for each). While the two nightlight survey count sites exhibited relatively stable population trends, we detected substantially different patterns in size class-specific abundance and trends between each site, including 30%-50% declines in the largest size classes at the site with greater harvest pressure. Here, we illustrate the use of IPMs to produce high-resolution output of latent population structure that is partially observed during the monitoring process.

Heida, B. and Márquez-Ramos, L. (2023). International environmental agreements and imperfect enforcement: Evidence from CITES. Journal of Environmental Economics and Management 118 (https://doi.org/10.1016/j.jeem.2023.102784).

Abstract: International environmental agreements address global environmental problems such as the decline in biodiversity. The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) regulates international trade in wildlife to prevent its decline. Discussions about CITES' effectiveness abound, but evidence is lacking. We combine the largest available panel database on wildlife populations with the history of countries' membership and species' protection under CITES. We find that after more than 20 years of a species' inclusion into CITES, wildlife populations increase by about 66% in countries with thorough enforcement, irrespective of whether trade in the species is only restricted or completely banned under CITES. Our results suggest re-focusing discussions away from whether CITES should partially restrict trade or impose a complete trade ban, and towards better enforcement. More generally, we find that enforcement is crucial for effective international environmental agreements.

Rodriguez-Cordero, A.L., Balaguera-Reina, S.A., Morales-Franco, J.C., Munn, M. and Densmore III, L.D. (2022). Predicting habitat suitability of *Caiman yacare* and assessing the role of protected areas under current and future climate and deforestation models. Climate Risk Management 35 (https://doi.org/10.1016/j.crm.2022.100407).

Abstract: Climate change and habitat degradation are recognized as serious threats for wildlife and an important aspects to be considered in conservation biology. However, little is known about how such environmental changes might impact crocodylians inhabiting the Neotropics and the effectiveness of Protected Areas (PAs) for long-term species conservation. To fill this gap, we used the Yacare Caiman (*Caiman yacare*) as a model to explore how climate change and habitat degradation might affect its distribution by 2050 and the effectiveness of current PAs for species conservation in response to future environmental changes. To this end, we estimated *C. yacare* suitable habitat using an ensemble modeling and consensus approach and assessed the species distribution variation inside and outside PAs as a consequence of two greenhouse emission scenarios (Representative Concentration Pathways [RCPs] 4.5 and 8.5), and three General Circulation Models (GCMs; ACCESS1-0, CANESM2, and MRI-CGCM3) for 2050. We estimated the current suitable habitat for *C. yacare* to be 854,494 km^2 divided across five countries: Brazil (396,476 km^2), Bolivia (377,853 km^2), Paraguay (38,288 km^2), Argentina (35,423 km^2), and Peru (6451 km^2). Of these countries, Peru is the only one that can be considered "potential" because the species has not been registered there yet. We found that currently only 26.8% (228,835 km^2) of *C. yacare* suitable habitat is under any type of protection of the IUCN Protected Area Categories System, which is currently well preserved from habitat degradation with only 1.9% reduced due to deforestation. We predicted that on average 56.2% of the current species range might be lost because of climate change and habitat degradation and only 14.7% of its suitable range could be preserved based on the current PAs system. Based on our assessment, we showed that future climate change scenarios and habitat degradation processes will require the establishment of additional PAs as well as the implementation of sustainable management strategies emphasizing corridors and suitable habitat linkages. These integrative approaches can be implemented in several ecoregions including the Pantanal flooded savannas, Cerrado woodlands and savannas, Beni savanna, Chiquitano dry forests, and Amazon moist forests, which we predict will be relatively well-preserved under most of the future climate change scenarios and constituting as priority regions for the long-term conservation of the species and tropical biodiversity.

Wang, Y.Y., Claessens, L.P.A.M. and Sullivan, C. (2023). Deep reptilian evolutionary roots of a major avian respiratory adaptation. Communications Biology 6: 3.

Abstract: Vertebral ribs of the anterior thorax in extant birds bear bony prongs called uncinate processes, which improve the mechanical advantage of mm. appendicocostales to move air through the immobile lung and pneumatic air sacs. Among non-avian archosaurs, broad, cartilaginous uncinate processes are present in extant crocodylians, and likely have a ventilatory function. Preserved ossified or calcified uncinate processes are known in several non-avian dinosaurs. However, whether other fossil archosaurs possessed cartilaginous uncinate processes has been unclear. Here, we establish osteological correlates for uncinate attachment to vertebral ribs in extant archosaurs, with which we inferred the presence of uncinate processes in at least 19 fossil archosaur taxa. An ancestral state reconstruction based on the infer distribution suggests that cartilaginous uncinate processes were plesiomorphically present in Dinosauria and arguably in Archosauria, indicating that uncinate processes, and presumably their ventilatory function, have a deep evolutionary history extending back well beyond the origin of birds.

Wu, X.C., Wang, Y.C., You, H.L., Zhang, Y.Q. and Yi, L.P. (2023). New brevirostrines (Crocodylia, Brevirostres) from the

Upper Cretaceous of China. Cretaceous Research 144 (https://doi.org/10.1016/j.cretres.2022.105450).

Abstract: A new alligatoroid, *Eurycephalosuchus gannanensis* gen. et sp. nov. and an undetermined brevirostrine, *Brevirostres* gen. et sp. indet. are described. They are preserved together in the Upper Cretaceous of Jiangxi Province, China. *Eurycephalosuchus gannanensis* is established based on a well-preserved skull with the mandible and some postcranial elements, and *Brevirostres* gen. et sp. indet. is represented by the right scapula and coracoid. *Eurycephalosuchus gannanensis* is assigned to Alligatoroidea and phylogenetically nested within a sub-group of Orientalosuchina with other four genera from China and Vietnam. *Eurycephalosuchus gannanensis* differs from all other orientalosuchines primarily in the short and broad appearance of its skull, the abnormally short (anteroposteriorly narrow) skull table, the exclusion of the parietal from the occipital ridge posteriorly, the postdentary part of the mandible much deeper than the anterior part dorsoventrally, the splenial excluded from the mandibular symphysis, and the external mandibular fenestra small and nearly vertical in orientation. It is different from *Brevirostres* gen. et sp. indet. in that the distal end of the scapular blade is relatively broader, and the anterior margin of the coracoid is more concave in addition to the smaller size. The discovery of the two new forms not only enriches the diversity of the local fauna but also confirms the monophyly of Orientalosuchina and the Asian dispersal event of the clade after diverging from the mainline rather than a sub-lineage of Alligatoroidea in the Late Cretaceous.

Alelign, D., Tena, T., Tessema, M. and Kidanewold, A. (2022). Drug-resistant aerobic bacterial pathogens in patients with crocodile bite wounds attending at Arba Minch General Hospital, southern Ethiopia. International Journal of General Medicine 2022: 8669-8676.

Abstract: A polymicrobial infection containing a diverse range of drug-resistant bacteria worsens the success of treatment for crocodile bite wound infection. However, there is a dearth of data in Ethiopia, where crocodile bite injuries are relatively common, particularly in the area around Lake Abaya and Lake Chamo in southern Ethiopia. A hospital-based cross-sectional study was conducted from 1 May 2021 to 30 April 2022, at Arba Minch General Hospital. Eleven consenting patients with crocodile bite wounds were enrolled in this study. Wound swabs were collected aseptically following microbiological procedures. The diversity and type of aerobic bacterial pathogens, and drug-resistant patterns were used to determine and characterize the nature of crocodile bite wound infections. Among 11 patients with crocodile bite wounds, 72.7% (8/11) of wound samples were found to be culture-positive, with a total of 21 aerobic bacterial isolates. Gram-negative bacterial isolates were found in 57.1% (12/21). Triple-bacterial isolates were found in 62.5% (5/8) of wound samples, followed by 37.5% (3/8) of double bacterial isolates. *Pseudomonas aeruginosa* (n= 5), followed by *Citrobacter* spp. (n= 4), and coagulase-negative *Staphylococci* (CoNS) (n= 4) were frequently isolated bacteria. Methicillin resistance (MR-CoNS) was found in 75% of isolated CoNS. 6.7% of the isolated *Enterococcus faecalis* was vancomycin-resistant (VRE), while 60% of the isolated *P. aeruginosa* were piperacillin-resistant. Overall, 85.7% (18/21) of the isolates were found to be multidrug-resistant (MDR), with 55.6% (10/18) of them being Gram-negative MDR bacterial isolates. Numerous aerobic bacteria that are resistant to the majority of common antibiotics have been associated with infections in crocodile bite wounds. Thus, the key to providing empirical therapy for such wounds is detecting the drug-resistant pattern of bacterial isolates.

Kojima, L.V., Tuberville, T.D. and Parrott, B.B. (2023). Integrating mercury concentrations in American alligators (*Alligator mississippiensis*) with hunter consumption surveys to estimate exposure risk. Environmental Toxicology and Chemistry (doi: 10.1002/etc.5524).

Abstract: Mercury is a naturally occurring element but is also considered a widespread contaminant due to global anthropogenic activity. Even in moderate amounts, mercury (Hg) is an established neurotoxin and is associated with a range of adverse outcomes both in humans and wildlife. Humans in the United States are most commonly exposed to Hg through contaminated food or drinking water, and the consumption of game species, particularly those occupying higher trophic levels, has the potential to expose hunters to high concentrations of Hg. In the present study, we determined Hg concentrations in tail muscle and blood from American alligators (*Alligator mississippiensis*) inhabiting a region (Savannah River Site, SC, USA) with known Hg contamination. We then integrated these data with alligator harvest records and previously published surveys of alligator meat consumption patterns to estimate potential exposure risk. We found that the average Hg concentrations in tail muscle (1.34 mg/kg, wet wt) from sampled alligators exceeded the recommended threshold for Hg exposure based on the World Health Organization's guidelines (0.5 mg/kg, wet wt). In addition, based on regional consumption pattern reported for both adults and children, we estimated Hg exposures (mean adult= 0.419 μg/kg/day, mean child= 2.24 μg/kg/day) occurring well above the US Environmental Protection Agency methylmercury reference dose of 0.1 µg/kg/day. Although the two reservoirs sampled in the present study are not currently open to alligator hunting, they are connected to waters that are publicly accessible, and the extent of alligator mobility across these sites is not known. Together, the findings reported in the present study further demonstrate the need for active monitoring of Hg concentrations in game species, which can convey substantial exposure risks to the public.

Wehrle, B.A. and German, D.P. (2023). Reptilian digestive efficiency: Past, present, and future. Comparative Biochemistry and Physiology Part A: Molecular & Integrative Physiology 277 (https://doi.org/10.1016/j.cbpa.2023.111369).

Abstract: Digestion and assimilation of nutrients and energy is central to survival. At its most basic level, investigations of digestion in animals must examine digestive efficiency, or how much of a given meal (i.e., energy) or a specific nutrient an organism can acquire from its food. There are many studies examining this in reptiles, but there is large variation in methodology, and thus, in the conclusions drawn from the gathered data. The majority rely on ratio-based analyses that can jeopardize the reliability of their findings. Therefore, we reviewed the literature to identify common themes in the digestive efficiency data on reptiles. Due to the sheer number of available studies, we largely focused on lizards, but included data on all reptilian groups. As an example of what the current data can reveal, we performed a meta-analysis of digestive efficiency in lizards as a function of temperature using regression analyses. We detected a weak positive trend of soluble carbohydrate digestibility as a function of temperature, but no similar trend in broad-scale digestive efficiency, and propose that these patterns be reevaluated with non-ratio data. We conclude with calls to end conducting analyses on ratios and instead employ covariate methods, for more studies of reptilian digestive efficiency and related processes using consistent methodology, more representation of each population (e.g., many studies focus on males only), and more detailed studies examining the effects of temperature on digestion (since the current data are inconclusive).

Warwick, C., Pilny, A., Steedman, C., Howell, T., Martínez-Silvestre, A., Cadenas, V. and Grant, R. (2023). Mobile zoos and other itinerant animal handling events: Current status and recommendations for future policies. Animals (https://doi.org/10.3390/ani13020214).

Abstract: Mobile zoos are events in which non-domesticated (exotic) and domesticated species are transported to venues such as schools, hospitals, parties, and community centres, for the

purposes of education, entertainment, or social and therapeutic assistance. We conducted literature searches and surveyed related government agencies regarding existing provisions within laws and policies, number of mobile zoos, and formal guidance issued concerning operation of such events in 74 countries or regions. We also examined governmental and non-governmental guidance standards for mobile zoos, as well as websites for mobile zoo operations, assessed promotional or educational materials for scientific accuracy, and recorded the diversity of species in use. We used the EMODE (Easy, Moderate, Difficult, or Extreme) algorithm, to evaluate identified species associated with mobile zoos for their suitability for keeping. We recorded 14 areas of concern regarding animal biology and public health and safety, and 8 areas of false and misleading content in promotional or educational materials. We identified at least 341 species used for mobile zoos. Mobile zoos are largely unregulated, unmonitored, and uncontrolled, and appear to be increasing. Issues regarding poor animal welfare, public health and safety, and education raise several serious concerns. Using the precautionary principle when empirical evidence was not available, we advise that exotic species should not be used for mobile zoos and similar itinerant events.

Guedes, J.J.M., Moura, M.R. and Diniz-Filho, J.A.F. (2023). Species out of sight: elucidating the determinants of research effort in global reptiles. Ecography 2023: e06491.

Abstract: More than two million species have been described so far, but our knowledge on most taxa remains scarce or inexistent, and the available biodiversity data is often taxonomically, phylogenetically and spatially biased. Unevenness in research effort across species or regions can interact with data biases and compromise our ability to properly study and conserve biodiversity. Herein, we assess the influence of biological, conservation, geographic and socioeconomic correlates of reptile research effort globally and across six biogeographic realms. We combine bibliometric data from the Scopus database with trait-based approaches and provide research effort information for 10 531 reptile species, modelling it as a function of 10 putative correlates of species-level variation in research effort through negative binomial generalised mixed effect models. We show that reptile research effort is highly skewed toward certain taxa and regions, such as turtles, crocodiles, tuatara, viperids, pythons and some anguimorph lizards, as well as for temperate compared to tropical regions. Our findings indicate that greater research attention is directed towards large-sized and early described reptile species, particularly those whose geographic range overlap with biodiversity institutions. Although we demonstrate that biological and socioeconomic factors more strongly affect reptile research effort variation, geography and conservation-related factors also matter. Global patterns are mostly consistent, but variation across realms were observed and likely reflects differences in socioeconomic attributes as well as in the amount of species to be studied in each realm. Directing researchers and citizen scientists' attention toward understudied taxa will contribute to alleviate this biased biodiversity knowledge, although the sheer amount of species in tropical regions inevitably makes it a long-term solution. Performing comparative studies across species with similar levels of research attention could represent a more immediate and feasible alternative.

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

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

Guo, Y.Z., Zhang, Y., Wang, Q., Yu, J., Wan, Q.H., Huang, J. and Fang, S.G. (2023). Alternative telomere maintenance mechanism in *Alligator sinensis* provides insights into aging evolution. iScience 26: 105850.

Abstract: Lifespan is a life-history trait that undergoes natural selection. Telomeres are hallmarks of aging, and shortening rate predicts species lifespan, making telomere maintenance mechanisms throughout different lifespans a worthy topic for study. Alligators are suitable for the exploration of anti-aging molecular mechanisms, because they exhibit low or even negligible mortality in adults and no significant telomere shortening. Telomerase reverse transcriptase (TERT) expression is absent in the adult *Alligator sinensis*, as in humans. Selection analyses on telomere maintenance genes indicated that ATM, FANCE, SAMHD1, HMBOX1, NAT10, and MAP3K4 experienced positive selection on *A. sinensis*. Repressed pleiotropic ATM kinase in *A. sinensis* suggests their fitness optimum shift. In ATM downstream, Alternative Lengthening of Telomeres (ALT)-related genes were clustered in a higher expression pattern in *A. sinensis*, which covers 10-15% of human cancers showing no telomerase activities. In summary, we demonstrated how telomere shortening, telomerase activities, and ALT contributed to anti-aging strategies.

Campos, Z., Muniz, F., Magnusson, W.E., Rodrigues, D., Rossi, R., Júnior, N.S. and Silva, R.L. (2022). A growth model for *Paleosuchus trigonatus* (Crocodylia: Alligatoridae) from the Rio Negro predicts growth of individuals from the Xingu River, Brazil. Phyllomedusa 21(2): 117-123.

Abstract: Patterns of growth of crocodilians vary geographically within the same species, so models developed in one area may not predict size-age relationships in others. We used recapture data for three females and six males of *Paleosuchus trigonatus* from the Belo Monte hydroelectric dam area on the Xingu River to validate a growth model developed on a tributary of the Rio Negro. Individuals were recaptured between two and 10 years after marking (2012-2022). The data indicate that the monomolecular (von Bertalanfy by length) model is adequate to model growth of intermediate size animals. Recapture of one female after 8 years indicates that the Rio Negro model can be used to model growth with accuracy for individuals from the Xingu River.

Cerio, D.G. and Witmer, L.M. (2022). Orbital soft tissues, bones,

and allometry: Implications for the size and position of crocodylian eyes. The Anatomical Record (https://doi.org/10.1002/ar.25133).

Abstract: Although the visual system of crocodylians has attracted interest regarding optical parameters and retinal anatomy, fundamental questions remain about the allometry of the eyeball and whether such scaling is the same across all crown groups of crocodylians. In addition, anatomy and identities of adnexal soft tissues that interact with the visual system are not well understood in many cases. We used contrast-enhancing iodine stain and high-resolution micro-computed tomography to assess the anatomy of orbital soft tissues, including extraocular muscles and glands, in crocodylians. We also used regression analysis to estimate the allometric relationship between the bony orbit and eyeball across *Alligator mississippiensis* and *Crocodylus niloticus* for the first time. Results revealed tight, negatively allometric relationships between the bony orbit and eyeball. Notably, the eyes of *C. niloticus* were larger for a given orbit size than the eyes of *A. mississippiensis*, although the slope of the relationship was no different between these two crown crocodylian groups. Among the findings from our anatomical study, new details were uncovered about the homologies of muscles of the abducens complex. In particular, M. rectus lateralis of crocodylians is revealed to have a more complex form than previously appreciated, being adhered to the tendon of the nictitating membrane, which may be apomorphic for Crocodylia. Our calculation of the orbit-eyeball allometric relationship and study of the adnexal soft tissues of the crocodylian visual system, in combination with previous work by other teams in other crown saurian clades, is a critical, formerly missing, piece in the Extant Phylogenetic Bracket for restoring the visual apparatus of extinct crocodyliforms and other archosauriform groups.

Pierini, S.E., Imhof, A., Larriera, A., Simoncini, M.S., Príncipe, G. and Piña, C.I. (2023). Nest-sharing behavior of captive Broad-snouted caimans (*Caiman latirostris*): cooperation or exploitation? Amphibia-Reptilia.

Abstract: Communal egg-laying is not frequently observed in crocodilians that exhibit nest attendance. However, it has been reported for both wild and captive *Caiman latirostris*. To understand the proximate causes of communal nesting, we aim to describe the nesting behavior of caimans during communal egg-laying in a captive population. Video cameras were placed at nests and the behavior of females was monitored throughout three incubation periods. We documented and analyzed social behavioral data. Nest-sharing behavior consisted of several females congregating and performing nest construction, nest vigilance and nest maintenance. It was observed in all nests previous to egg-laying. After the first laying, one female prevented others from approaching. The second egg-laying female negatively affected the previous clutch. Working together at the same nest would appear to be an exploitative rather than a cooperative activity, and communal nesting could be a competitive interaction, due to limited suitable nesting sites or overcrowding due to captivity.

Turner, M.L. and Gatesy, S.M. (2022). Inner workings of the alligator ankle reveal the mechanistic origins of archosaur locomotor diversity. Journal of Anatomy (doi: 10.1111/joa.13801).

Abstract: Major transformations in the locomotor system of archosaurs (a major clade of reptiles including birds, crocodiles, dinosaurs, and pterosaurs) were accompanied by significant modifications to ankle anatomy. How the evolution of such a complex multijoint structure is related to shifts in ankle function and locomotor diversity across this clade remains unclear and weakly grounded in extant experimental data. Here, we used X-ray Reconstruction of Moving Morphology to reconstruct skeletal motion and quantify the sources of three-dimensional ankle mobility in the American alligator, a species that retains the ancestral archosaur ankle structure. We then applied the observed relationships between joint excursion and locomotor behaviors to predict ankle function in extinct archosaurs. High-resolution reconstructions of *Alligator* skeletal movement revealed previously unseen regionalized coordination among joints responsible for overall ankle rotation. Differences in joint contributions between maneuvers and steady walking parallel transitions in mobility inferred from the ankle structure of fossil taxa in lineages with more erect hind limb postures. Key ankle structures related to ankle mobility were identified in the alligator, which permitted the characterization of ancestral archosaur ankle function. Modifications of these structures provide morphological evidence for functional convergence among sublineages of bird-line and crocodylian-line archosaurs. Using the dynamic insight into the internal sources of *Alligator* ankle mobility and trends among locomotor modes, we trace anatomical shifts and propose a mechanistic hypothesis for the evolution of ankle structure and function across Archosauria.

Carfagno, A., Lin, S-C., Chafran, L., Akhrymuk, I., Callahan, V., Po, M., Zhu, Y., Altalhi, A., Durkin, D.P., Russo, P., Vliet, K.A., Webb-Robertson, B-J., Kehn-Hall, K., Bishop, B. (2022). Bioprospecting the American Alligator Peptidome for antiviral peptides against Venezuelan equine encephalitis virus. Proteomics (https://doi.org/10.1002/pmic.202200237).

Abstract: The innate immune protection provided by cationic antimicrobial peptides (CAMPs) has been shown to extend to antiviral activity, with putative mechanisms of action including direct interaction with host cells or pathogen membranes. The lack of therapeutics available for the treatment of viruses such as Venezuelan equine encephalitis virus (VEEV) underscores the urgency of novel strategies for antiviral discovery. American alligator plasma has been shown to exhibit strong *in vitro* antibacterial activity, and functionalized hydrogel particles have been successfully employed for the identification of specific CAMPs from alligator plasma. Here, a novel bait strategy in which particles were encapsulated in membranes from either healthy or VEEV-infected cells was implemented to identify peptides preferentially targeting infected cells for subsequent evaluation of antiviral activity. Statistical analysis of peptide identification results was used to select five candidate peptides for testing, of which one exhibited a dose-dependent inhibition of VEEV and also significantly inhibited infectious titers. Results suggest our bioprospecting strategy provides a versatile platform that may be adapted for antiviral peptide identification from complex biological samples.

Odetti, L.M., Simoniello, M.F. and Poletta, G.L. (2022). Alterations in the expression of antioxidant enzyme genes in response to pesticide exposure during embryonic development in the native reptile species *Caiman latirostris*. Bulletin of Environmental Contamination and Toxicology 110 (https://doi.org/10.1007/s00128-022-03652-x).

Abstract: The aim of this study was to quantify the expression levels of Catalase (cat) and copper, zinc Superoxide dismutase (Cu, Zn-sod) genes involved in the antioxidant response in *Caiman latirostris* (broad-snouted caiman) blood, after embryonic exposure to the formulations cypermethrin (CYP), chlorpyrifos (CPF), glyphosate (GLY), and their binary and ternary mixtures. Experimental groups were: negative control (NC-distilled water), vehicle control (VC-ethanol), GLY-2%, CYP-0.12%, CPF-0.8%, a ternary mixture of them (TM), and three binary mixtures. The applications were made on the nest material in contact with the eggs at the beginning of the incubation period. After hatching, RNA was isolated from blood and expression levels analyzed through qPCR. The results showed downregulation in the expression of sod and cat genes in the three binary mixtures studied, compared to the controls. In addition, we found a possible antagonistic effect between different pesticides in the TM on the expression of both genes.

Gutiérrez-Ibáñez, C., Kettler, L., Pilon, M.C., Carr, C.E. and Wylie,

D.R. (2023). Cerebellar inputs in the American alligator (*Alligator mississippiensis*). Brain, Behavior and Evolution 98: 44-59.

Abstract: Crocodilians (alligators, crocodiles, and gharials) are the closet living relatives to birds and, as such, represent a key clade to understand the evolution of the avian brain. However, many aspects of crocodilian neurobiology remain unknown. In this paper, we address an important knowledge gap as there are no published studies of cerebellar connections in any crocodilian species. We used injections of retrograde tracers into the cerebellum of the American alligator (*Alligator mississippiensis*) to describe for the first time the origin of climbing and mossy fiber inputs. We found that inputs to the cerebellum in the American alligator are similar to those of other nonavian reptiles and birds. Retrograde labeled cells were found in the spinal cord, inferior olive, reticular formation, vestibular and cerebellar nuclei, as well as in nucleus ruber and surrounding tegmentum. Additionally, we found no retrogradely labeled cells in the anterior rhombencephalon which suggest that, like other nonavian reptiles, crocodilians may lack pontine nuclei. Similar to birds and other nonavian reptiles, we found inputs to the cerebellum from the pretectal nucleus lentiformis mesencephali. Additionally, we found retrogradely labeled neurons in two nuclei in the pretectum: the nucleus circularis and the interstitial nucleus of the posterior commissure. These pretectal projections have not been described in any other nonavian reptile to date, but they do resemble projections from the nucleus spiriformis medialis of birds. Our results show that many inputs to the cerebellum are highly conserved among sauropsids and that extensive pretectal inputs to the cerebellum are not exclusive to the avian brain. Finally, we suggest that the pontine nuclei of birds are an evolutionary novelty that may have evolved after the last common ancestor between birds and crocodilians, and may represent an intriguing case of convergent evolution with mammals.

Oluwatoyin, J.O. (2022). Prevalence of *Salmonella* and *Shigella* sp. in Ready-to-Eat Game Meat Sold in Different Cities in Southwestern Nigeria. BSc (Hons) thesis, Mountain Top University, Ogun State, Nigeria.

Abstract: Different meat products have been implicated in outbreaks of *Salmonella* and *Shigella* sp. worldwide. Game meat refers to any animal gotten from wildlife. A variety of game meat such as Grasscutters and Antelopes are predominantly consumed. However, hunting and consumption of game meat increases the risk of zoonotic infections. Also the process of hunting and processing wild animals is usually done under unsanitary situations in which they come into touch with humans and domesticated animals considerably increasing the chances of disease transmission and infection. This research was carried out to investigate the presence of *Salmonella* and *Shigella* species in different game meat sold in various cities within southwestern Nigeria. Isolation and identification of these two pathogens was performed using culture techniques and molecular techniques respectively, the isolates were then subjected to biochemical testing. The *Salmonella* isolates were confirmed by the presence of *Salmonella enterica* subsp. I (SSI) gene and the *Shigella* isolates were confirmed by the presence of 16s rRNA gene using simplex PCR. A total of 55 samples were analyzed for the presence of *Salmonella* and *Shigella* sp., 41.8% of the game meat samples investigated were positive for *Salmonella enterica* subspecies I and 45.5% were positive for *Shigella* sp. This high prevalence is of public health concern due to the low infective dose of these pathogens.

Odetti, L.M., Lopez Gonzalez, E.C., Siroski, P.A., Simoniello, M.F. and Poletta, G.L. (2023). How the exposure to environmentally relevant pesticide formulations affects the expression of stress response genes and its relation to oxidative damage and genotoxicity in *Caiman latirostris*. Environmental Toxicology and Pharmacology 97.

Abstract: This study aimed to analyze the molecular stress responses thought the expression levels of catalase (cat), superoxide dismutase (sod) and heat shock protein 70 (hsp70) genes, and how these relate with cellular stress response considering oxidative damage to lipids, DNA and genotoxicity in blood of *Caiman latirostris* hatchlings exposed to pesticide formulations under *ex situ* conditions. Treatments were: negative control (NC-tap water), glyphosate 2% (GLY), cypermethrin 0.12% (CYP), chlorpyrifos 0.8% (CPF), and their ternary mixture (Mx3). The concentrations and schedule of application were those recommended in soybean crops. Soil and water showed pesticides residues in all exposed groups. Results showed a statistically significant increase in the micronucleus frequency and DNA damage, with an important oxidation in all exposed groups. The expression level of cat gene was significantly higher in CYP while the expression of hsp70 was significantly lower in GLY, CYP and Mx3, compared to NC. Pesticides tested showed alterations in expression levels, growth parameters, DNA damage and base oxidation under realistic exposure conditions, and can threaten, in the long term, the health status of wild populations.

Avila-Cervantes, J. and Larsson, H.C.E. (2022). Ice Age effects on genetic divergence of the American crocodile (*Crocodylus acutus*) in Panama: reconstructing limits of gene flow and environmental ranges: a reply to O'Dea *et al*. (2022). Evolution 77(1): 329-334.

Abstract: O'Dea *et al*. (2022) (Pleistocene sea level changes and crocodile population histories on the isthmus of panama: a comment on Avila-Cervantes *et al*. (2020). Evolution, 76(11), 2778-2783. https://doi.org/10.1111/evo.14610) question our hypothesis that sea-level changes during the past glaciation played a role in restricting gene flow between Pacific and Caribbean *Crocodylus acutus* in Panama. They argue that an error in sea-level high-stand reconstruction during the last interglacial period (118-130 ka) does not support our hypothesis. Although they are correct in our high-stand reconstruction error, overlooked the point in that we were presenting a model of restricted gene flow across the Panamanian Isthmus during low sea levels. We review the assumptions of gene demographic methods, emphasizing that we were focusing on times of genetic divergence. We expand here why gene flow between these coastal populations could have been restricted during the last glacial maximum (19-26.5 ka) and the 50,000 years preceding it when sea levels were lower than today. O'Dea et al. suggest local climates may have played larger roles than sea levels. We demonstrate that paleoclimate estimates for the past 3.3 Ma in Panama are within the bounds of extant *C. acutus*. The importance of Ice Age Sea-level dynamics on Neotropical species was likely profound and should be incorporated into evolutionary studies of these taxa.

Checklist of parasites associated with 'reptiles' in Northeast Brazil
Lacerda, G.M.C., Santana, J. de A., de Araujo Filho, J.A. and Ribeiro, S.C. (2022). Journal of Helminthology 97 (doi: 10.1017/S0022149X22000785).

Abstract: Reptiles, as well as other vertebrate groups, harbour a significant diversity of parasitic organisms, from nematodes and other helminths to viruses and bacteria. The Northeast is one of the richest regions in Brazil in terms of the reptile diversity, number of species and endemism. Parasites are diverse organisms and knowledge about the parasitic fauna of vertebrates is an important factor in understanding the ecological relationships between hosts and the environment. Studies on the parasitic fauna of reptiles in South America have increased in the past few years. The present review is a compilation of 122 studies published from 1924 to 2021. We present information on 101 species of reptiles from five groups (amphisbaenians, crocodile, testudines, snakes and lizards) and 183 parasitic taxa belonging to four phyla: Nematoda; Arthropoda; Platyhelminthes; and Acanthocephala. Nematodes were the most frequently recorded species. Lizards and snakes had more records of parasitism and higher levels of parasite richness and diversity. Ceará was the state with most studies and recorded cases of parasite-

host association. The Caatinga and Atlantic Forest were the most investigated environments. The objective of this review was to contribute knowledge on the parasitic biodiversity in reptiles from Northeast Brazil, which may help identify gaps in our knowledge and guide future studies.

De Cupere, B., Van Neer, W., Barba Colmenero, V. and Jiménez Serrano, A. (2022). Newly discovered crocodile mummies of variable quality from an undisturbed tomb at Qubbat al-Hawā (Aswan, Egypt). PLoS One 18(1): e0279137.

Abstract: A description is provided of the crocodile remains that were found during an excavation carried out in 2019 at Qubbat al-Hawā (Aswan, Egypt). The material consists of five more or less complete bodies and five heads that were in varying states of preservation and completeness. The absence of resin, which was apparently not used during the preparation of the mummies, and the almost complete loss of linen bandages, due to insect damage, allowed a detailed morphological and osteometric description of the remains. Attention was focused on the general state of preservation of the crocodiles, the completeness of their skeletons and skulls, the presence of cut or other marks that could indicate the cause of death, and the processing of the carcasses. Moreover, the possible provenance of the crocodiles, the methods of capture and killing of the animals and their possible chronological attribution are discussed. It is concluded that the manner in which these specimens were prepared, as well as the variation observed in the type of 'final product', are unlike any other crocodile material described so far. The preparation method suggests a pre-Ptolemaic date for the deposit. The morphological and metrical features indicate that both *Crocodylus niloticus* and the recently resurrected species *Crocodylus suchu*s are present among these individuals that range from 1.8 to 3.5 m in length.

Natarajan, C., Signore, A.V., Bautista, N.M., Hoffmann, F.G., Tame, J.R.H., Fago, A. and Storz, J.F. (2022). Evolution and molecular basis of a novel allosteric property of crocodilian hemoglobin. Current Biology 33(1): 98-108.

Abstract: The extraordinary breath-hold diving capacity of crocodilians has been ascribed to a unique mode of allosterically regulating hemoglobin (Hb)-oxygenation in circulating red blood cells. We investigated the origin and mechanistic basis of this novel biochemical phenomenon by performing directed mutagenesis experiments on resurrected ancestral Hbs. Comparisons of Hb function between the common ancestor of archosaurs (the group that includes crocodilians and birds) and the last common ancestor of modern crocodilians revealed that regulation of Hb-O2 affinity via allosteric binding of bicarbonate ions represents a croc-specific innovation that evolved in combination with the loss of allosteric regulation by ATP binding. Mutagenesis experiments revealed that evolution of the novel allosteric function in crocodilians and the concomitant loss of ancestral function were not mechanistically coupled and were caused by different sets of substitutions. The gain of bicarbonate sensitivity in crocodilian Hb involved the direct effect of few amino acid substitutions at key sites in combination with indirect effects of numerous other substitutions at structurally disparate sites. Such indirect interaction effects suggest that evolution of the novel protein function was conditional on neutral mutations that produced no adaptive benefit when they first arose but that contributed to a permissive background for subsequent function-altering mutations at other sites. Due to the context dependence of causative substitutions, the unique allosteric properties of crocodilian Hb cannot be easily transplanted into divergent homologs of other species.

Pochat-Cottilloux, Y., Martin, J.E., Amiot, R., Cubo, J. and de Buffrénil, V. (2023). A survey of osteoderm histology and ornamentation among Crocodylomorpha: A new proxy to infer lifestyle? Journal of Morphology 284(1): e21542.

Abstract: Osteoderms of 8 extant and extinct species of crocodylomorphs are studied histologically and morphologically. Most osteoderms display the typical "crocodilian" structure with a woven-fibered matrix surrounded by an upper and a lower parallel fibered matrix. The dorsal ornamentation of those specimens consists of a pit-and-ridge structure, with corresponding remodeling mechanisms. However, an osteoderm of *Iberosuchus*, studied here for the first time, differs in being nearly devoid of ornamentation; moreover, it shows strong bundles of straight Sharpey's fibers perpendicular to the surface in its lateral and dorsal walls, along with a rough plywood-like structure in its basal plate. This suggests that this osteoderm was more deeply anchored within the dermis than the other osteoderms studied hitherto. This peculiar structure might have been linked to a terrestrial ecology and a specific thermoregulation strategy. Some other notosuchians in our sample do not exhibit ornamentation on their osteoderms, as opposed to neosuchians. Considering current interpretations of osteoderm function(s) in crocodilians, our observations are discussed in reference to possible ecophysiological peculiarities of Notosuchia in general, and *Iberosuchus* in particular.

Hart, A.G. (2023). The Deadly Balance: Predators and People in a Crowded World. Bloomsbury Publishing: London.

Abstract: The predators that can hunt, kill and eat us occupy a unique place in the human psyche. In this book, Adam Hart looks at our relationship with these animals from a conservation perspective. Whether it's lions in Africa, tigers in India or sharks in the world's oceans, we are fascinated by - and often terrified of - predators. Animals that can hunt, kill, and eat us occupy a unique place in the human psyche, and for good reason. Predation forms a big part of our evolutionary history, but in the modern world there are many people who live alongside animals that can, and sometimes do, make them prey. In The Deadly Balance, biologist Adam Hart explores the complex relationships we have with predators, and investigates what happens when humans become prey. From big cats to army ants, via snakes, bears, wolves, crocodiles, piranhas and more, Hart busts some myths and explores the science behind such encounters. Despite their fearsome and often wildly exaggerated reputations, these animals have far more to fear from us than we do from them. By probing the latest conservation science, Hart explores how we might both conserve the world's predators and live safely alongside them.

Cubas-Rodriguez, A.M., Cupul-Magaña, F.G., Peraza, R.A. and Chamé-Vázquez, D. (2023). New locality record of the American Crocodile, *Crocodylus acutus* (Cuvier, 1807), from Honduras. Herpetology Notes 16: 55-57.

Okello, P. (2023). Assessment of Human-Wildlife Co-existence Strategies Adopted by Communities Living in and around Queen Elizabeth National Park. MSc thesis, Makerere University, Kampala, Uganda.

Abstract: Human-wildlife co-existence is a prerequisite for protected area conservation. Many studies have been carried out on human-wildlife conflict and local communities' exploitation of protected areas resources besides a long established practice of community-based conservation by Uganda Wildlife Authority. However, there has been limited information to deepen the understanding and broaden knowledge on human-wildlife co-existence so as to bolster the strategies used by local communities and UWA. To fill this gap, a study was carried out in Queen Elizabeth National Park to generate information that can enhance the co-existence between wildlife and local communities. Specifically, the study examined the benefits obtained by the adjacent communities from the park and how the people co-existed with wild animals. A cross sectional research design with qualitative and quantitative approaches of data collection was adopted. A structured questionnaire was administered

to collect data from 309 respondents randomly sampled from Kyambura, Katwe, Kazinga and Muhokya parishes surrounding the park. Questionnaire responses were edited, coded and entered in the STATA 15 to create data file and later used to generate statistical summary. Qualitative information from key informant interviews was summarized and presented as a narrative. Results show that the local communities benefited from the park in a number of ways. They caught different fish types especially tilapia from Lake Edward and Lake George, harvested wild food plants and obtained bush meat from hippopotamus and Uganda kob that were top listed. It was also noted that different tribes preferred different types of bush meat. For example, the Basongora liked rabbit meat; the Congolese chose monkey meat while the Bakonjo preferred meat of hippopotamus. Local people also harvested herbal medicines mainly the leaves, roots and bark of a number of plants especially Kigelia africana, Aloe vera and Mondia whitei. Body parts of elephants, lions and hippopotamus were reportedly used for treatment of a number of ailments including wounds, mental illness, cancer, epilepsy, tuberculosis, skin rush, cough and many others. The local people also collected water from the park for washing, cooking, watering home garden vegetables and livestock. Furthermore, local people exploited non-timber forest products and were employed in the park as well as in tourism related enterprises. Human-wildlife coexistence strategies adopted included digging deep and wide trenches to bar non-jumping animals from crossing from the park onto the farmlands and settlements, establishment of apiaries particularly to deter elephants from leaving the park, sprinkling of red pepper powder on the park's boundary and construction of crocodile cages to protect human when collecting water. Based on the results, an integrated and community-based approach to manage the park's resources is recommended and future studies should quantify the benefits of human-wildlife coexistence in the park.

Mao, L., Zhou, M., Yao, L., Yu, H., Yan, X., Shen, Y., Chen, W., Ma, P., Ma, Y., Zhang, S. and Tan, S.C. (2023). Crocodile skin-inspired protective composite textiles with pattern-controllable soft-rigid unified structures. Advanced Functional Materials (https://doi.org/10.1002/adfm.202213419).

Abstract: Functional textiles with desirable protective properties (ie high cut-, stab-, and abrasion resistance) and wearability (ie excellent flexibility and permeability) remain unmet goals for personal protective equipment. Herein, inspired by crocodile skin, a unique and soft-rigid unified structure (SRUS) is reported by integrating rigid protective blocks onto a soft textile substrate while obtaining a high cut-, stab-, and abrasion-resistant composite textile that is flexible, waterproof, and breathable. Rigid blocks, consisting of epoxy resin reinforced by inorganic powders, strongly adhere to the soft textile surface with small intervals between each other via a pattern-controllable integrated molding (PCIM) approach. Consequently, the SRUS design guarantees superior protective performance through rigid protective blocks and satisfactory flexibility and permeability via soft textiles and intervals. The SRUS textile achieves excellent cut-resistance (58 N), the highest grades of stab- (38 N) and abrasion-resistance (600 r mg^{-1}), and good flexibility (65 mN cm) and permeability (60 mm s^{-1}) values, indicating a distinct combination of desirable protective and wearable performance. The proposed SRUS protective textiles, incorporating the PCIM approach, offer a novel strategy for manufacturing functional soft composite textiles that combine high protective performance and good wearability, opening up a new avenue for the development of personal protective equipment.

Adewale, R., Olabiyi, E., Akinsorotan, O., Salami, W. and Banjo, O. (2022). Heavy metals accumulation in faeces of wildlife around Ogun River in Old Oyo National Park, Nigeria. Journal of Agricultural Faculty of Gaziosmanpaşa University 39(3): 199-204.

Abstract: Knowledge of bioaccumulation of heavy metals (HMs) in wildlife of our national parks is poor. With the use of standard procedures, this study evaluated wildlife dungs in Old Oyo National Park for bioaccumulation of nickel (Ni), arsenic (As), zinc (Zn), cadmium (Cd), lead (Pb), cupper (Cu), chromium (Cr) and cobalt (Co). Composite dung samples of kob (K), cane rat (CR), crocodile (C), pattas monkey (PM), olive baboon (OB), civet cat (CC) and western hartebeest (WH) were collected along River Ogun. Concentrations were significantly different ($\alpha<0.05$) among the dungs, ranging from 3.99 ± 0.56 (CR) to 27.09 ± 0.20 mg kg^{-1} (C) for Cu, 176.60 ± 8.30 (K) to 347.83 ± 3.35 mg kg^{-1} (PM) for Zn, 7.29 ± 0.04 (CC) to 43.07 ± 0.19 mg kg^{-1} (C) for Pb, 37.64 ± 1.39 (CC) to 157.57 ± 0.19 mg kg^{-1} (C) for Mn, 24.75 ± 0.48 (WH) to 65.00 ± 68 mg kg^{-1} (C) for Cd and 2.63 ± 0.05 (PM) to 5.76 ± 0.07 mg kg^{-1} (C) for Cr. There were no traces of Ni and Co detection in the dungs, but concentrations of Pb, Mn, Cd and Cr were significant and positively correlated. It is likely that the river is a major source of HM contaminants. There is need for all wildlife dietary sources to be investigated.

Myburgh, A., Botha, H., Combrink, X., Myburgh, J., Guillette, Jr., L.J., Hall, G., Chimimba, C. and Woodborne, S. (2022). Terrestrial diet dependence in an unprotected Nile crocodile (*Crocodylus niloticus*) population. Journal of Herpetology 56(4): 507-513.

Abstract: Nile Crocodile (*Crocodylus niloticus*) populations that exist outside of protected areas are under threat in South Africa. They are believed to predominantly feed on fish, but they also take prey from the terrestrial system, which brings them into conflict with humans and hampers their management. Here, we use stable light isotope analysis to explore the diet of an unprotected Nile Crocodile population in the Olifants River, Mpumalanga and Limpopo Provinces. Nitrogen stable isotope ratios were obtained from fish and crocodile populations along the length (± 430 km) of the river. The catchment is severely polluted with elevated $\delta^{15}N$ values at nutrient hotspots, which provides a basis for tracking the trophic response of crocodiles to the longitudinal profile of fish $\delta^{15}N$ values. Crocodiles did not respond to changes in the δ15N values of fish populations and dietary predictions based on size-specific diet to tissue discrimination factors suggests a nonaquatic food base. These results suggest terrestrial diet dependence in one of the few viable Nile Crocodile populations from outside protected areas, posing unique challenges to their conservation.

Chaudhari, D.B., Chaudhari, A., Vaidh, I. and Patel, H.J. (2022). First confirmed record of the Mugger crocodile (*Crocodylus palustris*) from the Purna River, Tapi District, Gujarat. Reptiles & Amphibians 29: 436-438.

Nadarajan, R., Hassan, R., Izwan Zulaini, M. Gani, A., Azuwan Hassan, M., Ahmad, R. and Ketol, B. (2022). Genetic analysis of Saltwater crocodile (*Crocodylus porosus*) from Sarawak River basin, Sarawak using Cytochrome Oxidase I and Cytochrome b Gene Analysis. Survey in Fisheries Sciences 10(1): 80-88.

Abstract: *Crocodylus porosus* or known as saltwater crocodile is the common crocodilian species in Sarawak. *C. porosus* is currently placed under Appendix II of Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES) in Sarawak, thus trade is allowed with Permits from the authority. Sarawak River Basin (SRB) supports a large *C. porosus* wild population and will be involved in regulated crocodile harvesting exercise. However, there is limited information on the genetics of crocodiles in the area. Thus, this study is designed to determine the genetic diversity and molecular phylogeny of *C. porosus* using combine gene of Cytochrome Oxidase I (COI) and Cytochrome b (Cyt b) mtDNA gene analysis. Scutes and tissues samples were collected from wild crocodiles in SRB, later subjected to standard molecular biology techniques and DNA sequencing. Approximately 499 bp of COI gene and 418 bp of Cyt b genes from 9 individuals had been successfully sequenced. Nucleotide composition analysis showed

that Cytosine is the highest while the lowest was Guanine and higher proportion of A+T bases was observed compared to G+C bases for both genes. The average nucleotide frequencies combine genes are as follow: Adenine= 28.5%, Thymine= 26.8%, Cytosine= 28.7% and Guanine= 16.0%, respectively. In this study, intraspecific genetic divergence values of *C. porosus* ranged between 0 to 1.7% for both genes whereas interspecific genetic divergence values range between 8.5 to 10%. Based on both COI and Cyt b gene information, phylogenetics trees constructed using Neighbour-joining, Maximum Parsimony and Maximum Likelihood methods show that *C. porosus* is monophyletic, with *Tomistoma schlegelii* as the outgroup. This is an ongoing project as more samples are needed to produce a large database for future metagenomics study of Sarawak crocodiles.

Ouedraogo, I., Oueda, A., Hema, M.E., Shirley, M.H. and Kabre, B.G. (2022). Impact of anthropogenic activities on the abundance of *Crocodylus suchus* (Saint-Hilaire 1807) within the Nazinga Game Ranch, Burkina Faso. Open Journal of Ecology 12(12) (doi: 10.4236/oje.2022.1212046).

Abstract: In Burkina Faso, human activities are practiced in Nazinga Game Ranch (NGR) which is colonized by West African crocodiles *Crocodylus suchus* (Geoffroy Saint-Hilaire 1807) decades ago. This study which aims to estimate impact of anthropogenic activities on abundance of *C. suchus* has been conducted in NGR reservoirs. For data collection, *C. suchus* populations were counted morning, afternoon and night from October 2015 to May 2017 in 11 reservoirs. Binoculars were used for remote observations and spotlight was used by night. According to the size of the sites and its accessibility, direct observations were carried out on foot or by canoe. Every time we observed crocodiles, they were numbered and added information such as their size, their behavior, geographical coordinates and the type of habitat were collected. Human activities were noted after direct observations. The R software version 3.5.3 was used for data analysis. A total of 1849 crocodiles including hatchlings, juveniles, subadults and adults were counted in these 11 reservoirs of the NGR. They were more abundant in reservoirs than rivers with highest abundances in Akalon, Akwazena, Kalieboulou and Barka. Crocodile showed very high visibility at night their abundances showed important correlation with human activities and environmental factors such as roads, fishing, tourism, moon phases and "died crocodiles" and in NGR.

Brittain, K.P. (202x). Genetic and Genomic Diversity of Crocodylians: Applications in Evolution and Immunogenetic. PhD thesis, University of Sydney, Sydney, Australia.

Abstract: There are ~27 recognised extant species of crocodylians (Crocodylia), which inhabit a large range of tropical, fresh- or saltwater ecosystems around the world. Crocodylians appear to have an effective immune system that allows them to cope with a variety of pathogenic challenges. Crocodylians have been shown to live with a range of opportunistic infections, and yet wild animals seldom display disease symptoms. Also, reptile immune systems are less well studied than their mammalian and avian counterparts, and yet reptiles hold a unique evolutionary position as cold-blooded amniotes. Studying the evolutionary rates and diversity of immune system components in crocodylians could contribute to our overall understanding of the development of the immune system. Genetic and peptidome studies of the crocodylian immune system have improved our understanding of the organisation, evolution and diversity of some components of the adaptive immune system, however, there is much yet undiscovered when it comes to components that modulate the functions of the adaptive and innate immune systems in crocodylians. The availability of genomic resources would be beneficial to further investigations into disease susceptibility and resistance in industry and endangered wild populations. At present, only four crocodylian draft genomes have been sequenced and are publicly available. The projects undertaken in this thesis were initiated due to the limited genomic and immunogenetic resources available for crocodylian species. This research was to provide foundations in a key immune modulatory system in crocodylians, as well as to investigate applications of crocodylian genomic data in answering current evolutionary and immunogenetic questions.

Giger, J-C., Alves, V. and Almeida, J. (2022). The social representations of zoo goers toward crocodiles and turtles: Structural analysis and Implications for conservation. Social Sciences 11: 571i

Abstract: Zoos have changed dramatically over the last century and today attract millions of people worldwide, being places where visitors can closely watch wildlife and learn about the species on display. Although present at most zoos, reptiles are challenging animals in terms of visitor interest and engagement, as some species do not fit aesthetic standards from the human standpoint, have culturally negative perceptions or generate aversive emotions. By studying zoo visitors' social representations of crocodiles and turtles, we aimed to detail their structures, as well as identifying their prototypical elements that help to understand their emotional and cognitive framing. The findings show the crocodile's prototypical image as a big, fearsome predator with teeth as its main physical attribute. Male visitors showed a more emotional perception of this animal. The turtle's prototypical image is a slow, hard-shelled ancestral sea animal with a neutral-to-positive set of traits, with no particular differences between genders. Our results shed a more detailed light on some of the social constructs that make up the mental images of these animals, which can help the zoological community direct communication toward a more fluent conversation between stakeholders toward conservation.

Conradie, W., Keates, C., Verburgt, L., Baptista, N.L., Harvey, J., Júlio, T. and Neef, G. (2022). Contributions to the herpetofauna of the Angolan OkavangoCuando-Zambezi River drainages. Part 2: Lizards (Sauria), chelonians, and crocodiles. Amphibian & Reptile Conservation 16(2): 181-214.

Abstract: This work is the second report of the results obtained from a series of rapid biodiversity surveys of the upper Cuito, Cubango, Cuando, Zambezi, and Kwanza River basins in Angola, which were conducted between 2015 and 2019 in conjunction with the National Geographic Okavango Wilderness Project. The herpetofauna of this region are poorly documented and the results of these surveys help to address the knowledge gap regarding the conservation importance of this region. Here, an updated checklist is provided for the current and historical records of lizards, chelonians, and crocodiles from the southeastern region of Angola. A total of 369 new records were documented comprising 40 species, bringing the total number of recognized lizard, chelonian, and crocodile species in this region to 58. These surveys documented four new country records (ie *Lygodactylus chobiensis*, *Agama armata*, *Pachydactylus wahlbergii*, and *Ichnotropis* cf. *grandiceps*) and increased the total number of reptile species known to occur in Angola (excluding snakes) from approximately 157 to 161. Finally, updated distribution maps for the whole country are provided for all of the species encountered in this study.

Kidd-Weaver, A. (2022). Behavioral Ecology of the American Alligator (*Alligator mississippiensis*) in Human-Dominated Landscapes of Coastal South Carolina. PhD thesis, Clemson University, South Carolina, USA.

Abstract: When wildlife habitat is developed to accommodate growing human populations, wildlife are forced to move to undisturbed landscapes or to acclimate to a novel, anthropogenic environment. In this dissertation, we investigated the behavior and ecology of the American alligator (*Alligator mississippiensis*) in coastal, residential resort communities with an overarching goal of identifying behavioral patterns of alligators that can inform risk management strategies. In Chapter One, we compared the space use

of male and female alligators in primarily wetland versus residential landscapes across three seasons to determine if and how space use behaviors of alligators differ. We found that alligator home ranges in residential landscapes were constrained around discrete freshwater features and included greater access to saline aquatic resources, and sex and seasonal differences in resource selection were muted compared to that of wetland alligators. Establishing that residential alligators use space differently, we estimated alligator abundance in seven golf courses to understand how many alligators humans encounter in residential landscapes and the factors influencing humans' abilities to detect alligators that are present in Chapter Two. We found that alligator abundance was greater in areas with more freshwater alligator habitat potentially reaching similar densities to alligator populations in relatively undisturbed environments, and humans' ability to detect alligators was related to the configuration of alligator habitat in the landscape and physiological and behavioral limits of an alligators' risk-taking behaviors. In Chapter Three, we investigated how human-alligator interactions impact alligators' tolerance of closely approaching humans in residential landscapes. We found that alligators exposed to aversive treatment by humans over 10 years were 2.57-11.11 times more likely to flee from approaching humans, depending on alligator size, than alligators with primarily benign experiences with humans. In Chapter Four, we built on evidence of alligator sensitization from Chapter Three using a before-after-control-impact experimental design to investigate if short-term capture-mark-release efforts produce similar sensitization effects on alligator behavior. We found that alligators exposed to one week of capture-markrelease were 1.65 times more likely to flee from humans after captures occurred than before captures. Collectively, our findings suggest that chronic exposure to humans can alter alligator space use behaviors in a way that can support similar population sizes to those in relatively undisturbed environments, but that acute experiences with humans can alter alligators' perceptions of humans to promote alligator behaviors that correspond to tolerance or avoidance of humans. Risk management strategies can use this information to proactively manipulate alligators' experiences with humans in a way that both increases alligators' probability of flight and humans' ability to detect alligators, and to improve residents' education of when and where alligator interactions are most likely to occur.

Lessner, E.J., Dollman, K.N., Clark, J.M., Xu, X. and Holliday, C.M. (2023). Ecomorphological patterns in trigeminal canal branching among sauropsids reveal sensory shift in suchians. Journal of Anatomy (https://doi.org/10.1111/joa.13826).

Abstract: The vertebrate trigeminal nerve is the primary mediator of somatosensory information from nerve endings across the face, extending nerve branches through bony canals in the face and mandibles, terminating in sensory receptors. Reptiles evolved several extreme forms of cranial somatosensation in which enhanced trigeminal tissues are present in species engaging in unique mechanosensory behaviors. However, morphology varies by clade and ecology among reptiles. Few lineages approach the extreme degree of tactile somatosensation possessed by crocodylians, the only remaining members of a clade that underwent an ecological transition from the terrestrial to semiaquatic habitat, also evolving a specialized trigeminal system. It remains to be understood how trigeminal osteological correlates inform how adaptations for enhanced cranial sensation evolved in crocodylians. Here we identify an increase in sensory abilities in Early Jurassic crocodylomorphs, preceding the transitions to a semiaquatic habitat. Through quantification of trigeminal neurovascular canal branching patterns in an extant phylogenetic bracket we quantify and identify morphologies associated with sensory behaviors in representative fossil taxa, we find stepwise progression of increasing neurovascular canal density, complexity, and distribution from the primitive archosaurian to the derived crocodilian condition. Model-based inferences of sensory ecologies tested on quantified morphologies of extant taxa with known sensory behaviors indicate a parallel increase in sensory abilities among pseudosuchians. These findings establish patterns of reptile trigeminal ecomorphology, revealing evolutionary patterns of somatosensory ecology.

Font, E., Burghardt, G.M. and Leal, M. (2023). Brains, behaviour, and cognition: Multiple misconceptions. Pp. 211-238 *in* Health and Welfare of Captive Reptiles, ed. by C. Warwick, P.C. Arena and G.M. Burghardt. Springer: Cham.

Abstract: Despite abundant evidence to the contrary, non-avian reptiles are widely considered as behavioural and cognitive underachievers. The persistent myth of the sluggish, primitive, stupid reptile can be traced, at least in part, to long-standing misconceptions about reptilian brain size and organisation. Historically, reptile brains have been considered small and lacking the neural structures that support complex cognition in other vertebrates. In particular, the notion that reptiles lack a cerebral cortex has led to expectations that their behaviour and cognition should be simple and unsophisticated in comparison with birds and mammals. However, it was shown several decades ago that reptiles possess a large pallium comprising three–four distinct cortical areas and a dorsal ventricular ridge that may be functionally equivalent to parts of mammalian neocortex. In fact, forebrain organisation conforms to a common plan in birds and reptiles, which may seem surprising given the recent trend to put the cognitive achievements of birds above those of reptiles yet on a par with mammals. Moreover, the view that reptiles do not exhibit complex cognition faces a growing list of exceptions. Reptiles are capable of spatial, social, reversal, problem-solving, and many other types of learning and cognitively demanding behaviours provided that experimental designs account for some peculiarities of their biology involving their morphology, physiology, and ecology. Unlike frequent caricatures that depict reptiles as clumsy, inflexible, and instinct-driven, much reptile behaviour is precisely performed, delicate in appearance, readily modified, and contextually determined. Recent work has shown that reptiles can show elaborate communication and social systems, parental care, social learning, and play. Although such research is sparse compared to endothermic vertebrates, and the diversity among them immense, captive reptiles also benefit from enrichment, recognise their caretakers individually and form bonds with them, and are affected by early social isolation in ways similar to birds and mammals. Still, the gap between what we know and what we would like to know about reptilian behaviour and cognition is enormous.

Alvarez, G., Miranda-Chumacero, G., Mollericona, J.L., Nallar, R. and Wallace, R.B. (2022). Nutritional properties of spectacled caiman (*Caiman yacare*) meat marketed as part of a wildlife management strategy in the Beni river basin. Neotropical Hydrobiology and Aquatic Conservation 3(2): 53-65.

Abstract; We determined the nutritional quality of yacare meat (*Caiman yacare*) in the Beni River basin. Commercial cut samples were obtained from the tails of four males harvested as part of a management plan implemented in the Tacana Indigenous Territory. This plan guarantees long-term sustainability of caiman hunting. pH analysis, the Eber test, and the ammoniacal nitrogen test suggest that the meat was of good quality, processed properly, and free of contamination. Nutritional analyses suggest that yacare meat is a healthy alternative for human consumption, as it has a high protein value (23.02 g/100 g) and low fat concentration (0.67 g/100 g). Yacare meat has a high concentration of minerals such as phosphorus (227.53 g) and calcium (11.84 g), both beneficial for memory and cardiovascular health. Caiman meat can be considered as a valuable nutritional supplement in human diets both in urban and rural areas.

Perrichon, G., Hautier, L., Pochat-Cottilloux, Y., Raselli, I., Salaviale, C., Dailh, B., Rinder, N., Fernandez, V., Adrien, J., Lachambre, J. and Martin, J.E. (2023). Ontogenetic variability of the intertympanic sinus distinguishes lineages within Crocodylia. Journal of Anatomy (doi: 10.1111/joa.13830).

Abstract: The phylogenetic relationships within crown Crocodylia remain contentious due to conflicts between molecular and morphological hypotheses. However, morphology-based datasets are mostly constructed on external characters, overlooking internal structures. Here, we use 3D geometric morphometrics to study the shape of the in-tertympanic sinus system in crown crocodylians during ontogeny, in order to assess its significance in a taxonomic context. Intertympanic sinus shape was found to be highly correlated with size and modulated by cranial shape during development. Still, adult sinus morphology distinguishes specimens at the family, genus and species level. We observe a clear distinction between Alligatoridae and Longirostres, a separation of different *Crocodylus* species and the subfossil Malagasy genus *Voay*, and a distinction between the *Tomistoma* and *Gavialis* lineages. Our approach is independent of molecular methods but concurs with the molecular topologies. Therefore, sinus characters could add significantly to morphological datasets, offering an alternative viewpoint to resolve problems in crocodylian relationships.

Nama, K.S., Meena, H.M. and Choudhary, K. (2023). Impact of temperature on sex ration of Gharial population in National Chambal Sanctuary, Rajasthan. Emerging Trends in Climate Change 1(3): 1-8.

Abstract: Temperature dependent sex determination (TSD) is a type of environmental sex determination. It is a natural process, but due to changing climate, this process is getting disturbed. A vivid example of this is the disturbing sex ratio of alligators in the Chambal River of Rajasthan. The annual census shows that although there has been a steady increase in the overall number of gharials in the NCS, but there have been clear and noticeable changes in their sex ratio in relation to the annual temperature. In 2016, the difference in male: female ratio was 1:8.32, which reached 1:13.4 in 2020. Thus, after 2016, where there has been a relative decrease in the mean temperature, its effect is visible in gharials in the form of an increased number of females, while the number of males has increased much less than that of gharials in the NCS, Rajasthan part. The sex ratio shows the deviation from the perspective of climate.

Crowe-Riddell, J.M. and Lillywhite, H.B. (2023). Sensory systems. Pp. 45-91 ***in*** Health and Welfare of Captive Reptiles, ed. by C. Warwick, P.C. Arena and G.M. Burghardt. Springer: Cham.

Abstract: Behaviour is shaped by the perception of the surrounding world, which is created by the senses. Reptilian sensory systems are shaped by the varied ecologies and complex evolutionary histories of reptiles. In this chapter, we outline the major senses of reptiles: photoreception (vision, parietal eyes, cutaneous), mechanoreception (hearing, balance, and touch), chemoreception (gustation, olfaction, vomeronasal), thermoreception (cutaneous, heat-pit), and magnetoreception. We give general descriptions of the sensory anatomy, including relevant examples of how senses relate to the behaviour and sensory evolution of these animals. We also focus on how major senses mediate intraspecific communication in reptiles, focusing on visual communication via colouration and other visual displays, acoustic communication through calls and songs, and chemical communication using specialised scent glands. Among the diverse sensory specialisations of reptiles, we also outline some of the rare senses for select taxa including magnetoreception navigation in archosaurs, and heat-pit foraging in snakes. Although these unusual senses can be directly related to important behaviours, reptiles do not rely solely on one sensory system for any behaviour, and almost all stimuli are integrated in the brain to inform immediate decision-making. Thus, all sensory capabilities should be considered when attempting to understand the relative importance of sensory systems to reptilian behaviour. We aim to impart an appreciation for how different stimuli may be perceived by reptiles in captivity. Further, signals salient to various reptiles may be invisible to humans (eg UV colouration, pheromones), and different reptiles may have heightened or impoverished sensory abilities. Thus, an understanding of reptilian sensory systems is vital for ensuring animal health and welfare in captivity.

Amavet, P.S., Pacheco-Sierra, G., Uhart, M.M., Prado, W.S. and Siroski, P.A. (2023). Phylogeographical analysis and phylogenetic inference based on the cytochrome b gene in the genus *Caiman* (Crocodylia: Alligatoridae) in Central and South America. Biological Journal of the Linnean Society XX: 1-15.

Abstract: The genus *Caiman* is one of the most taxonomically conflicted among crocodilians. *Caiman crocodilus* has four subspecies: *Caiman crocodilus crocodilus*, *Caiman crocodilus fuscus, Caiman crocodilus chiapasius* and *Caiman crocodilus apaporiensis*, but some studies recognize *Caiman yacare* as a subspecies of *C. crocodilus* or as a *C. crocodilus-C. yacare* complex. In Argentina, *Caiman latirostris* and *C. yacare* are present and included in sustainable use programmes, although they have hardly been studied at the genetic level. The present study had two main objectives: (1) to study the genetic diversity, structure and phylogeny of *C. yacare* and *C. latirostris* in Argentina; and (2) to perform a phylogenetic analysis of the genus *Caiman* throughout its entire distribution. The results show high haplotype diversity for both species but low nucleotide diversity for *C. latirostris*. Phylogenetic analysis shows a clear separation between both species but, surprisingly, a well-differentiated clade belonging to the Chaco region was observed. The phylogenetic analysis exhibited clades made up of the sequences of each *Caiman* species, with some inconsistencies: in the clade of *C. crocodilus*, one sequence of *C. yacare* is included, and one clade is observed including sequences from *C. c. fuscus* and *C. c. chiapasius*. These data indicate the need to undertake interdisciplinary studies to clarify the taxonomic status of these crocodilian species.

Lensink, A.V., Swan, G.E. and Myburg, J.G. (2023). The structure of the eggshell and eggshell membranes of *Crocodylus niloticus*. Journal of Microscopy (doi: 10.1111/jmi.13173).

Abstract: The macro- and microstructure, elemental composition, and crystallographic characteristics of the eggshell and eggshell membranes of the *Crocodylus niloticus* egg was investigated using optical and electron microscopy, energy-dispersive X-ray spectroscopy (EDS), electron back scatter diffraction (EBSD) and computerized tomography. The translucent ellipsoid egg is composed of two basic layers, the outer calcified layer referred to as the shell and an inner organic fiber layer, referred to as the shell membrane. The outer inorganic calcite shell is further divided into an external, palisade and mammillary layers with pore channels traversing the shell. The external layer is a thin layer of amorphous calcium and phosphorus, the underlying palisade layer consist of irregular wedge-shaped crystals composed calcite with traces of magnesium, sodium, sulphur, and phosphorus. The crystals are mostly elongated, orientated perpendicular to the shell surface ending in cone shaped knobs which forms the inner mammillary layer. The elemental composition of the mammillae is like that of the palisade layer, but the crystal structure is much smaller and orientated randomly. The highest number of mammillae and shell pores are found at the equator of the egg, becoming fewer towards the egg poles. The shell thickness follows the same pattern, with the thickest area located at the equator. The eggshell membrane located right beneath and embedded in the mammillary layer of the shell; it is made up of unorganized fiber sheets roughly orientated at right angles to one another. Individual fibers consist of numerous smaller fibrils forming open channels that runs longitudinally through the fiber. The basic measurements, and microscopic and chemical structure of the Nile crocodile egg was studied using several microscopy and analytical techniques. It was found that the translucent white egg has two basic layers; the outer shell and inner membrane. The outer shell is further divided into three layers and has openings, called pores extending between the inside and outside of the shell. The highest number of the pores is found around the middle circumference of the egg. The outermost layer is a thin characterless layer made up of calcium and

phosphorus, and the middle layer consists of interlocking wedge-shaped calcite crystals with traces of magnesium, sodium, sulphur, and phosphorus. These crystals end in cone shaped knobs on the inner aspect of the shell and then also forms the third inner layer of the shell. The amount of these knobs, called mammillae, are highest at the equator of the egg and becomes fewer towards the egg poles. The shell thickness follows the same pattern, with the thickest area located at the equator. The second layer of the egg, the membrane is found right beneath the shell and is embedded in the mammillae. The membrane is composed of numerous fibers roughly arranged in parallel sheets of varying directions. Each individual fiber is made up of smaller fibrils clustered together, and forming open channels that runs lengthwise through the fiber.

Wu, L., Wu, X.C., You, H.L., Zhang, Y., Zhao, J., Yuan, Y., Zhang, H. and Li, S. (2023). A new specimen of *Hsisosuchus* (Mesoeucrocodylia, Crocodyliformes) from the Upper Jurassic of Yunnan, China with implications for the diversity of the ventral trunk shield of osteoderms in the genus. Historical Biology (https://doi.org/10.1080/08912963.2023.2170796).

Abstract: *Hsisosuchus*, with three known species, was the most common genus of crocodyliforms in the Sichuan Basin during the Jurassic. However, the overall shape of the ventral trunk shield of osteoderms has not been clarified due to the lack of complete specimens. A new specimen of *Hsisosuchus* recently recovered from the Upper Jurassic of Yunnan has the nearly complete ventral trunk shield preserved. This specimen provides an example for the first time for us to understand the shape and the way of the arrangement of the osteoderms in the ventral trunk shield in the genus. Compared with the articulated part of the ventral trunk shield preserved in two of the three species of the genus, the osteoderms of the ventral trunk shield of the new specimen are different in both shape and way of arrangement, indicating that the pattern of the ventral trunk shield is not constant within *Hsisosuchus*. With no skull and much of the postcranial skeleton poorly preserved as well as no corresponding element that can be used to compare with all the three species, the new specimen was considered as an indeterminate species of *Hsisosuchus*, awaiting more materials to clarify the problem.

Platt, S.G., Lin, N., Soe, M.M., Wint, K.T.Z., Elsey, R.M. and Rainwater, T.R. (2022). Notes on two large estuarine crocodile (*Crocodylus porosus*) skulls from the Ayeyarwady Delta of Myanmar. Herpetological Review 53(4): 573-578.

Sebastian, A., Pragna, R., Aswin, R. and Geetha, K.S. (2023). Design of shark detection and decoy buoys. Pp. 662-669 *in* Proceedings of the International Conference on Intelligent Data Communication Technologies and Internet of Things (IDCIoT 2023). Available at SSRN: https://ssrn.com/abstract=4326417 or http://dx.doi.org/10.2139/ssrn.4326417.

Abstract: Humans and wildlife negatively interact when there is a loss of property, livelihood, or even life; this interaction is referred to as a human-wildlife conflict. Defensive and retaliatory killing may lead to the eventual extinction of these species. One such conflict occasionally occurs near coastal areas between cold-blooded saline water creatures like sharks and people. This work presents a proof of concept for developing a buoy that can detect cold-blooded predators and serve as a decoy system to deter human attacks. The decoy system is based on numerous biological facts and information about shark species. The model can detect up to 14 species of sharks and saline crocodiles using pattern recognition with a collective accuracy of 92%. The designed buoy is a novel approach to prevent human attacks near the coast with its decoy system based on the factual behavior of the predatory shark species and crocodiles.

Pierre, M.A., Jacobsen, K.S., Hallett, M.T., Harris, A.M., Melville, A., Barnabus, H. and Sillero-Zubiri, C. (2023). Drivers of human-black caiman (*Melanosuchus niger*) conflict in Indigenous communities in the North Rupununi wetlands, southwestern Guyana. Conservation Science and Practice 5(1): e12848.

Abstract: Recovering populations of large carnivores impact the people that live alongside them, sometimes leading to conflict and lethal retaliation. One such carnivore, the black caiman (Melanosuchus niger) has been implicated in the destruction of fishing equipment, depredation of livestock and pets, and attacks on humans. In order to understand how various stakeholder groups are affected by the negative impacts of living alongside caiman, and their resulting attitudes and behaviors towards caiman, we conducted semistructured interviews in seven Indigenous communities in southwestern Guyana from November 2017 to October 2019. We used logistic and ordinal regression to identify demographic indicators of fishing behavior and factors that are associated with negative attitudes and antagonistic behavior. Loss of pets in addition to an effect of gender, rather than competition overfishing resources (as hypothesized) may drive conflict between Indigenous communities and black caiman. We propose site differences, such as ecotourism may affect attitudes about and behavior towards caiman. The presence of impacts on communities and retaliatory behavior indicates that human-wildlife and wildlife-human impacts involving black caiman may be a concern for the recovery of the species' populations, and the communities that coexist with them.

Gray, K.L. and Brereton, J.E. (2022). Investigating the behaviour and enclosure use of zoo-housed Cuvier's dwarf caiman *Paleosuchus palpebrosus*. The Herpetological Bulletin 162: 5-10.

Abstract: The welfare needs of reptiles in zoological collections are generally less well understood than those of other taxa. Crocodilians represent an excellent opportunity to study a commonly-housed, conservation-dependant zoo animal. We studied the behaviour and enclosure use of five dwarf caimans *Paleosuchus palpebrosus* through day and night, at two British zoological collections; the enclosures had either six or seven identifiable zones. Time of day, mean temperature and collection were used as predictors of behaviour and enclosure usage. Camera traps recorded the position and behaviour of caimans at 30-second intervals. At each zoo, 80 hours of data were collected from which we constructed activity budgets and calculate a relativised Electivity Index of enclosure usage. The results identified that water-based perching, floating, swimming, immobile water behaviour and underwater behaviour were significantly affected by time of day, and that collection and temperature were good predictors of some behaviours. As for enclosure use, zone 3 (shallow water) was slightly overutilised in both collections, while all other zones were underutilised. Time was a significant predictor of the use of zones 3, 5, 6 and 7. There is considerable scope for future research on crocodilians in zoos.

Gardin, A., Garcia, G., Boisserie, J-R., Schuster, M. and Otero, O. (2022). From paleoecology of crocodilians to paleoenvironments in the Shungura Formation (Plio-Pleistocene, Ethiopia), an interdisciplinary ballad using the oxygen stable isotopes. Colloque du GDR Grand Rift Africain, November 2022, Lyon, France.

Abstract: The evolution of the Turkana Depression is geologically constrained by the East African Rift, but it is characterized by complex environmental, and more particularly hydrological, changes recently questioned by new sedimentological data. In the context of the Shungura Formation (Plio-Pleistocene, Ethiopia), these hydrographic changes are only documented by sedimentological studies and freshwater invertebrate assemblages, while terrestrial environments are by far more widely studied. However, aquatic environments retain information about water, an essential resource, and its interactions with climate, geodynamics and aquatic communities. The characterization of these humid areas, using freshwater organisms, is therefore essential to more accurately

infer paleoenvironmental characteristics in this context. With an application in the Shungura Formation, we explore a new approach using the oxygen isotopic composition (δ18O) of fossil crocodilian teeth to describe environmental changes between 3 and 1 million years ago. This powerful geochemical tool is at the interface between the biology and geology, since it offers paleoecological information on crocodilians in their paleoenvironmental context. When most studies using δ18O to characterize paleoenvironments obscure paleoecological information (and vice versa), the integration of the two allows to go further and gain precision in paleoenvironmental interpretations. This contribution will present the results obtained on the crocodilians of the Shungura Formation from the article Gardin *et al*. (in prep) and will open the discussion on the interdisciplinary approach to the use of the δ18O to describe paleoenvironments. Gardin A., Pucéat E., Garcia G., Boisserie J.-R., Schuster M., Nutz A., Otero O. δ18O in crocodilian teeth apatite documents the diversity of aquatic environments and suggests their relative stability in the Turkana Depression between 3.0 and 2.6 Ma (Shungura Formation, Plio-Pleistocene, Ethiopia). In prep.

Baker, C.J. (2023). Using Spatial Ecology to Reveal Sociality: The Movement Ecology, Behaviour, and Social Structure of the Estuarine Crocodile, *Crocodylus porosus*. PhD thesis, University of Queensland, St. Lucia, Queensland, Australia.

Abstract: All species are inherently social. Regardless of a species level of gregariousness, individuals must make social decisions to balance the costs and benefits of sharing their environment with conspecifics, and for most to reproduce. Our understanding of animal sociality has primarily been based around the study of group-living species and the evolution of complex social behaviours (eg cooperation) that are frequently observed within animal groups. Far less attention has been given to understanding sociality in non-group living species, which are often assumed to lack the social complexity and competence of group-living species. This is largely due the difficulty of observing and examining the social behaviours of non-group living species because of the rarity in which interactions occur and the large and often inaccessible areas which these animals inhabit. The overall objective of my thesis was to investigate how techniques and approaches from spatial ecology and socioecology could be integrated to gain novel insights into the social behaviours and systems of a non-group living species, the estuarine crocodile *Crocodylus porosus*. To achieve this, I utilized an ongoing 13-year longitudinal dataset that monitored the occurrence and movements of a wild population of estuarine crocodiles in the Wenlock River, Cape York, Australia. As shared space-use is a prerequisite for the expression of social behaviours, in Chapter 2 I investigated the social environment of estuarine crocodiles by determining the spatial overlap and structure of the population. I found that crocodiles displayed non-random spatial structuring, with individuals actively forming and maintaining spatial overlaps with conspecifics for up to five years. Furthermore, male crocodiles that exhibited a greater degree of site attachment displayed more stable social environments, while females and males that were less site-attached had more dynamic social environments, with spatial overlaps between conspecifics peaking during the mating season. In Chapter 3, I used co-occurrences of animals at fixed acoustic receivers (rather than spatial home range overlaps) to characterize the fine-scale association patterns and social structure of this wild crocodile population. I found that estuarine crocodiles displayed a highly structured social system, with their social structure being split into spatially distinct communities. Furthermore, I found that this social structure was highly dynamic, with the association rates and connectedness of the population peaking during the dry season, before then disintegrating at the onset of the wet season. At a finer scale, the formation of communities was found to coincide with an increase in the association rate between mature and mature-immature dyads prior to the onset of the mating season. In Chapter 4, I examined whether crocodiles displayed individual differences in their behavioural phenotypes (between individual variation) and how consistently (within individual variation) they adopt these phenotypes through time in their degree of sociability, activity, and site fidelity. I found that for each of the behaviours measured, individual crocodiles varied not only how the behavioural phenotypes they adopt, but also in how consistently they adopt these phenotypes over time. Individuals which on average displayed greater sociability and site fidelity were also more consistent in their expression of these behaviours through time. In contrast, female crocodiles that were on average more active were also less consistent in their degree of activity through time, while no correlation was present in males. Further, I found the presence of a behavioural syndrome between sociability and activity, with individuals that on average were more active being less willing to associate with conspecifics. Taken together, my thesis reveals that rather than simply being 'asocial' and intolerant of conspecifics, estuarine crocodiles instead possess a highly dynamic social system where individuals control how they associate with conspecifics depending on maturity status, movement strategy, and the proximity to the crocodile mating season. Furthermore, I demonstrate how the integration of approaches and techniques from both spatial and socioecology can be used to gain novel insights into the social behaviours and systems of non-group living species across varying spatial and temporal scales (ie spatial structure, social structure, between and within individual variation). In doing so, my work encourages further investigation into the social systems of other non-group living species, providing a more holistic understanding of animal sociality and evolution.

Tomcho, A., Dickens, M., Mead, A.J., Mead, H.F., Seminack, C. and Patterson, D.B. (2023). Late Pleistocene ecosystem evolution in southeastern North America: A transdisciplinary approach using fossil American alligator enamel isotopes. Georgia Journal of Science 81(1): Article 83.

Abstract: Existing research points to utilizing ancient ecosystem functionality as a means of understanding contemporary biological responses to climate change and human population expansion. In this study, we use enamel isotope values (δ13C, δ18O) from modern and fossil American alligators (*Alligator mississippiensis*) from the Clark Quarry Site Complex (CQSC; Brunswick, GA) dating to ~60,000 years ago to better understand the aquatic ecosystems and climatic conditions of coastal landscapes in southeastern North America during the late Pleistocene. In particular, we use these data as a proxy for the position of the CQSC relative to the paleoshoreline during this period, which has been variably hypothesized in the existing literature. Serially sampled δ13C values from modern alligator enamel (N= 13; Jekyll Island, GA and Aiken, SC), after correcting for contemporary atmospheric CO_2 levels, averaged -10.8‰ (± 6.2), while δ18O values averaged 1.0‰ (± 1.7). δ13C values from serially sampled fossil alligator enamel (N= 14; CQSC) averaged 8.3‰ (±1.4), while δ18O values averaged -2.9‰ (± 2.2). These data indicate that CQSC alligator δ13C values are intermediate between modern alligator samples characteristic of strictly marine (Jekyll Island, GA) or strictly freshwater (Aiken, SC) environments, and CQSC alligator δ18O values are depleted relative to those from all modern aquatic systems sampled here (freshwater, brackish and marine). These data suggest that 1) the CQSC was part of a brackish system during the late Pleistocene, and 2) southeastern North America was dominated by cooler ambient temperatures during this period. This pattern in temperature is also supported by δ18O values from CQSC megaherbivores (*Mammuthus columbi*, *Bison latifrons*). These enamel data indicate that the CQSC ecosystem was markedly different from those characteristic of the region today. Our findings can be used as an ecological framework for testing hypotheses related to the extinction of species due to climatic changes and the expansion of human populations during the late Pleistocene.

Wang, J., Su, B., Xing, D., Bruce, T.J., Li, S., Bern, L., Shang, M., Johnson, A., Simora, R.M.C., Coogan, M., Hettiarachchi, D.U., Wang, W., Hasin, T., Al-Armanazi, J., Lu, C. and Dunham, R.A. (2023). Generation of eco-friendly channel catfish, *Ictalurus punctatus*, harboring alligator cathelicidin gene with robust disease

resistance by harnessing different CRISPR/Cas9-mediated systems. bioRxiv (doi: https://doi.org/10.1101/2023.01.05.522889).

Abstract: The CRISPR/Cas9 platform holds promise for modifying fish traits of interest as a precise and versatile tool for genome manipulation. To reduce introgression of transgene and control reproduction, catfish species have been studied for upscaled disease resistance and intervening of reproduction to lower the potential environmental risks of introgression of escapees' as transgenic animals. Taking advantage of the CRISPR/Cas9-mediated system, we succeeded in integrating the cathelicidin gene from an alligator (*Alligator sinensis*; As-Cath) into the target luteinizing hormone (LH) locus of channel catfish (*Ictalurus punctatus*) using two delivery systems assisted by double-stranded DNA (dsDNA) and single-stranded oligodeoxynucleotides (ssODNs), respectively. In this study, high knock-in (KI) efficiency (22.38%, 64/286) but low on-target was achieved using the ssODN strategy, whereas adopting a dsDNA as the donor template led to an efficient on-target KI (10.80%, 23/213). On-target KI of As-Cath was instrumental in establishing the LH knockout (LH−_As-Cath+) catfish line, which displayed heightened disease resistance and reduced fecundity compared to the wild-type sibling fish. Furthermore, implanting with HCG and LHRHa can restore the fecundity, spawnability and hatchability of the new transgenic fish line. Overall, we replaced the LH gene with an alligator cathelicidin transgene and then administered hormone therapy to gain complete reproductive control of disease-resistant transgenic catfish in an environmentally sound manner. This strategy not only effectively improves the consumer-valued traits, but also guards against genetic contamination. This is a breakthrough in aquaculture genetics to confine fish reproduction and prevent the establishment of transgenic or domestic genotypes in the natural environment.

Taques, A.S., Neto, J.V., Chitarra, G.S. and Ribeiro, R.V. (2022). Physico-chemical and sensory characteristics of nuggets with mechanically separated meat of alligator of the Pantanal. Brazilian Journal of Development 8(12): 76824-76841.

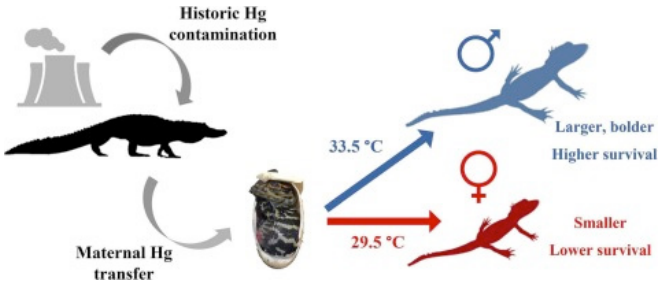
Abstract: Objetivando-se avaliar nuggets elaborados a partir de aparas de jacaré do pantanal com adição de carne mecanicamente separada (CMS), cinco tratamentos (0, 15, 30, 45 e 60%) com adição de CMS de jacaré do pantanal foram elaborados e avaliados quanto à composição centesimal, pH, Aw, força de cisalhamento, índice de peróxido, bases voláteis totais, cor objetiva CIE L*, a* e b*. Observou-se diferença significativa para as análises de composição centesimal apresentando teores de umidade entre 39.54% a 48.03%. A proteína e cinzas aumentaram de acordo com o índice de CMS adicionada. Os nugetts com adição de CMS de jacaré do pantanal apresentaram valores superiores de luminosidade, croma a* e b* em relação ao sem CMS. A força de cisalhamento variou entre 0.27 a 0.35. Houve diferença significativa para Aw entre os tratamentos. O resultado microbiológico dos tratamentos de nuggets foi evidenciado em acordo com o estabelecido por legislação. As formulações com adição de 45 e 60% CMS de jacaré do pantanal em nuggets de jacaré demonstraram melhores características físico-quimicas e todos os níveis de adição de CMS não interferiram na percepção sensorial de cor, textura, sabor e aparência global.

Sy, E.Y. and Lorenzo II, A.N. (2022). Online trade of live crocodilians in the Philippines. Journal of Nature Studies 21(2): 1-14.

Abstract: The ongoing utilization of online platforms to trade wildlife in the Philippines appears to be increasing in the last two decades. An online survey on 20 Facebook groups specializing in the trade of live reptiles was conducted from July 2016 to December 2018 to elucidate the dynamics of live crocodilian trade in the Philippines. A total of 71 unique posts representing three crocodilian species and a minimum of 164 individuals were posted by 50 traders in Facebook groups during the study period. The Spectacled Caiman *Caiman crocodilus* was the most traded species with 126 individuals or 77% of the total quantity. The Saltwater Crocodile *Crocodylus porosus* and the critically endangered Philippine Crocodile *Crocodylus mindorensis* were also documented. While all *C. crocodilus* individuals offered for sale were most likely imported legally or captive-bred in the Philippines, some *C. porosus* and *C. mindorensis* offered for sale may be sourced illegally from the wild.

Johnson, J.M., Bock, S.L., Smaga, C.R., Lamberet, M.R., Rainwater, T.R., Wilkinson, P.M. and Parrott, B.B. (2023). Relationships between maternally-transferred mercury and hatchling development, behavior, and survival in the American alligator (*Alligator mississippiensis*) Science of the Total Environment 870 (https://doi.org/10.1016/j.scitotenv.2023.162010).

Abstract: Mercury is a toxic and pervasive environmental contaminant that can be transferred from mother to offspring during development. Consequences of maternally-transferred mercury have been observed in vertebrate taxa, including reduced clutch viability, reduced offspring size, and behavioral alterations. These sublethal effects have been assumed to decrease survivorship, though this is seldom assessed. Here, we examined how maternally-transferred mercury interacts with incubation temperature to influence reproductive success, offspring behavior, and subsequent survival in the American alligator (*Alligator mississippiensis*). We collected nine clutches of eggs from a mercury contaminated reservoir on the Savannah River Site, South Carolina, and incubated eggs at either female- or male-promoting temperatures. Clutch-averaged mercury in egg yolk was high relative to other studies in crocodilians and ranged from 0.248 to 0.554 ppm compared to 0.018-0.052 ppm at a site with low levels of mercury contamination; mercury levels in hatchling blood ranged from 0.090 to 0.490 ppm (mean= 0.240 ppm, n= 158). We found few, mostly negligible correlations between life history traits and mercury but noted a positive relationship with egg mass, possibly mediated by correlated maternal effects such as resource provisioning. Incubation temperature exerted strong effects on hatchling phenotypes, with warmer, male-promoting temperatures producing larger and bolder hatchlings. Presumptive females, produced from cooler incubation temperatures, spent more time in warm areas during behavior trials. Hatchlings were released 10-15 days post-hatch and surveyed over 8 months to assess survival. Survivorship was positively correlated with hatchling size and negatively correlated with proportional time spent in warm areas. Presumptive females had much lower survival, and overall survivorship for the 8-month period was 0.185-0.208, depending on the modelling approach. Our study suggests that, within the range of concentrations we observed, incubation temperature has a stronger effect on offspring behavior and survival than maternally-transferred mercury pollution in American alligators.



Das, D., Banerjee, A., Pathak, S. and Paul, S. (2023). Importance of animal models in the field of cancer research. Pp. 3-26 *in* Handbook of Animal Models and its Uses in Cancer Research, ed. by S. Pathak, A. Banerjee and A. Bisgin. Springer Nature: Singapore.

Sennikov, A.G. (2023). A New pseudosuchian from the Early Triassic of eastern Europe. Paleontological Journal 56: 1391-1418.

Abstract: A new genus and species of Pseudosuchia (Rauisuchidae), *Scolotosuchus basileus* Sennikov, gen. et sp. nov., from the Early Triassic Donskaya Luka locality is described. *Scolotosuchus* is characterized by a peculiar morphology of the cervical and anterior thoracic vertebrae with short spinous processes and an unusual crocodiloid joint in the hind limb, which cannot be attributed to either the normal or reversed type.

Zuhadmono, A. (2023). Green or Blue? Am I being 'washed'? The Way Sustainable Luxury Fashion Brands Communicate Sustainability Practices in their Websites. The Case of Stella McCartney and Gucci. MSc thesis, Jönköping University, Jönköping, Sweden.

Abstract: This case study examines how luxury fashion brands communicate their sustainability practices on the brands' sustainability page on the company's website and whether selected luxury fashion brands are greenwashing and bluewashing. The luxury brands selected for this study are Stella McCartney and Gucci, on the grounds that both brands have different types of businesses and approaches. To understand the context, this study uses the triple bottom line sustainability concept by Elkinton (1998), sustainable luxury fashion brands (Godart & Seong 2017; Wiedmann *et al*. 2009; Joey *et al*. 2012; Franco *et al*. 2019), greenwashing concept by Delmas & Burbano (2011) and bluewashing concept (Sailer *et al*. 2022). To conduct the analysis, this study uses textual, eco-lexicon categorization developed by Thomas (2008) and the categorization from Milanesi *et al*. (2022) is adapted for visual analysis and the sins of greenwashing by Terra Choice (2010) to see the potential of greenwashing. The results shows that Stella McCartney and Gucci sustainable communication serves as their marketing strategy which encourage purchase and therefore it is problematic. Both brands use vague, ambiguous words, terms, and certifications and lack of transparency. While the images are not yet seen as a potential tool to communicate sustainability initiatives. Even though the brands are known as sustainable fashion brands, the result demonstrates brands show irrelevancies and paradoxes between what the brands communicate and their actual practices; therefore show potential greenwashing and bluewashing.

Field, E.K. (2022). Investigating the Reptilian Innate Immune System: A Review and Examination of the Relationship between Immunity, Stress, and Reproduction. MSc thesis, Arkansas State University, Arkansas, Jonesboro, USA.

Nishan, K.C., Neupane, B., Belbabse, B., Dhami, B., Bist, B.S., Basyal, C.R. and Bhattarai, S. (2023). Factors influencing the habitat selection of Mugger crocodile (*Crocodylus palustris*) and its conservation threats in the Rapti River of Chitwan National Park, Nepal. Global Ecology and Conservation (https://doi.org/10.1016/j.gecco.2023.e02406).

Abstract: Mugger crocodiles (hereafter called muggers) are the apex predator and keystone species in slow flowing freshwater ecosystem. They play an important role in its functioning by distributing nutrients and increasing primary productivity. Muggers have a sympatric distribution with gharials in the Rapti and Narayani River of Chitwan National Park, but more research and conservation attention has been focused on gharials in Nepal. The inadequate availability of information on the occupied habitats of muggers restrict their evidence-based conservation and management. Therefore, we investigated the ecological factors affecting the habitat selection of muggers and its conservation threats in the Rapti River. We conducted a preliminary survey, followed by a detailed habitat survey, conducted in February and March 2022. During the detailed habitat survey, the pre-defined habitat characteristics were recorded at each station spaced at 500 m intervals along the river as well as the locations where muggers were sighted. We used a generalized linear model (glm) under the binomial family with a logit link function to analyze the factors influencing the habitat selection of muggers. The dependent variable was the presence or absence of muggers at sampling points and the independent variables included: river bank aspect, river width, mid-river depth, river bank substrate type, river bank slope, water current, invasive alien plant species, and anthropogenic disturbances. In addition, a relative whole-site ranking method was employed to determine the most prevalent threats to the mugger. During the survey period, we recorded a total of 46 mugger individuals, 71.8% were observed basking and 28.2% were observed submerged in the river. The highest percentage of muggers (39.1%) was observed on the sandy river bank, followed by the grass and forest bank (19.5%), and clay and sandy bank (15%), respectively. Only the river banks with moderate (15-25°) and moderately steep (25-35°) slopes were found to be the significant factors influencing the occurrence of muggers. Fishing and extraction of river materials, and disposal of garbage and solid waste were ranked as the most prevalent conservation threats. For the long-term conservation of muggers in the Rapti River, effective habitat management plans and strategies are required to control illegal anthropogenic activities such as fishing, sand mining, and boulder quarrying. Research on spatio-temporal partitioning between mugger and gharials is recommended to understand how resources are shared by the species.

Vyas, R. (2023). The mysterious deaths of Mugger crocodiles (*Crocodylus palustris*) near Vadodara, Gujarat, India. Reptiles & Amphibians 30: e18141 (https://doi.org/10.17161/randa.v29i1.18141).

Bertone, S., Godahewa, A., Balaguera-Reina, S.A., Briggs-Gonzalez, V. and Mazzotti, F.J. (2023). First successful nest for the Vulnerable American crocodile *Crocodylus acutus* population on the west coast of Florida, USA.

Abstract: The American crocodile *Crocodylus acutus* occurs across the Americas, with its northernmost distribution being in South Florida, USA. This species has undergone severe declines across its range and is categorized globally as Vulnerable on the IUCN Red List and as Threatened on the U.S. Federal Endangered Species List. Long-term monitoring studies in the USA have documented a shift in American crocodile nesting activity and an expansion of its range throughout the southern and eastern coasts of South Florida. However, no successful American crocodile nests have been recorded until now on the west coast of South Florida. Here we document the American crocodile nest monitoring conducted during 1997-2021 at Rookery Bay National Estuarine Research Reserve and the first successful nest from the west coast of South Florida for *C. acutus*. Marco Airport and McIlvane Marsh are the two main American crocodile nesting areas identified at the Reserve, with 92 nests and 3586 eggs recorded during 1997-2021. We found most nests at Marco Airport (95.7%) and only four nests (4.3%) at McIlvane Marsh. To date, none of the nests found at Marco Airport have produced successful hatchlings. In contrast, hatchlings have been produced at McIlvane Marsh since nests were first documented there in 2020. We discuss the implications of our findings in terms of the future conservation of the species.

Prusty, S. and Sharma, A. (2023). Occupational hazards faced by inland fishers of Odisha State, India. Journal of Agromedicine (doi: 10.1080/1059924X.2023.2178572).

Abstract: Objective: To identify occupational hazards and hazard control strategies adopted by inland fishers of Odisha state in India. Methods: Information on occupational hazards faced by fishers was collected by personal interviews with 90 riverine and reservoir fishers of Odisha. Through qualitative discussions with key informants and review of literature, a list of occupational hazards was prepared and classified into physical, ergonomics, psychosocial, and natural. Responses were quantified, and descriptive statistics were used for

data analysis. Results: Occupational hazards faced by fishers were physical (94%), ergonomic (75%), psychosocial (50%), and natural (34%) in nature. Physical hazards included sharp fishing instruments, uneven surfaces, high temperatures, and wet/slippery areas on the vessel along with the presence of snake/leech/crocodile/fish fin rays. About 97% of reservoir and 90% of riverine fishers reported physical hazards leading to cuts, fractures, dehydration, headache, sunburn, snake bite, leech bite, crocodile bite, and injuries due to fish fin rays. Heavy nature of work and force exerting activities caused pain in the upper back (50%), shoulders (45%), and lower back (41%). Regarding psychosocial hazard, stress (31%) and anxiety (23%) was reported. Common reasons for this were uncertainty in fish catch and extended working hours, causing tiredness, headache, dizziness, and fatigue. Natural hazards like cyclones, floods, and excessive rain caused financial loss and damage to fishing nets and boats. Regarding personal protective equipment (PPE), floating buoys were used by 26% of riverine and 43% of reservoir fishers to avoid drowning. Conclusion: Occupational hazards in the inland fishing sector were identified as physical, ergonomic, psychosocial, and natural. No particular hazard control strategy was reported to be used. Integrating the occupational safety measures in the fisheries policies is thus needed.

Lourenço-de-Moraes, R., Campos, F.S., Cabral, P., Silva-Soares, T., Nobrega, Y.C., Covre, A.C. and França, F.G.R. (2023). Global conservation prioritization areas in three dimensions of crocodilian diversity. Scientific Reports 13: 2568.

Abstract: Crocodilians are a taxonomic group of large predators with important ecological and evolutionary benefits for ecosystem functioning in the face of global change. Anthropogenic actions affect negatively crocodilians' survival and more than half of the species are threatened with extinction worldwide. Here, we map and explore three dimensions of crocodilian diversity on a global scale. To highlight the ecological importance of crocodilians, we correlate the spatial distribution of species with the ecosystem services of nutrient retention in the world. We calculate the effectiveness of global protected networks in safeguarding crocodilian species and provide three prioritization models for conservation planning. Our results show the main hotspots of ecological and evolutionary values are in southern North, Central and South America, west-central Africa, northeastern India, and southeastern Asia. African species have the highest correlation to nutrient retention patterns. Twenty-five percent of the world's crocodilian species are not significantly represented in the existing protected area networks. The most alarming cases are reported in northeastern India, eastern China, and west-central Africa, which include threatened species with low or non-significant representation in the protected area networks. Our highest conservation prioritization model targets southern North America, east-central Central America, northern South America, west-central Africa, northeastern India, eastern China, southern Laos, Cambodia, and some points in southeastern Asia. Our research provides a global prioritization scheme to protect multiple dimensions of crocodilian diversity for achieving effective conservation outcomes.

Srisuksai, K., Parunyakul, K., Santativongchai, P., Phaonakrop, N., Roytrakul, S., Tulayakul, P. and Fungfuang, W. (2023). Antioxidant activity of crocodile oil (*Crocodylus siamensis*) on cognitive function in rats. Foods 12: 791.

Abstract: Crocodile oil (CO) is rich in monounsaturated fatty acids and polyunsaturated fatty acids. The antioxidant activity and cognitive effect of monounsaturated fatty acids and polyunsaturated fatty acids have been largely reported. This work aimed to investigate the effect of CO on antioxidant activity and cognitive function in rats. Twenty-one rats were divided into three treatment groups: (1) sterile water (NS), (2) 1 mL/kg of CO (NC1), and (3) 3 mL/kg of CO (NC3). Rats underwent oral gavage once daily for 8 weeks. CO treatment decreased the triglycerides level significantly compared with that in the NS group. CO had a free radical scavenging ability greater than that of olive oil but had no effect on levels of antioxidant markers in the brain. Expression of unique proteins in the CO-treatment group were correlated with the detoxification of hydrogen peroxide. Rats in the NC1 group had better memory function than rats in the NC3 group. Expression of unique proteins in the NC1 group was correlated with memory function. However, CO did not cause a decline in cognitive function in rats. CO can be an alternative dietary oil because it has a hypolipidemia effect and antioxidant activity. In addition, CO did not cause a negative effect on cognitive function.

Keddy, P.A. (2023). Natural disturbance. Pp. 63-72 *in* Causal Factors for Wetland Management and Restoration: A Concise Guide. Wetlands: Ecology, Conservation and Management, Volume 8. Springer: Cham.

Abstract: Natural disturbances remove biomass from wetlands. In extreme cases, they also remove the substrate. Natural disturbances tend to increase biological diversity in wetlands. Fire is a common natural disturbance. Along rivers, bank erosion and sedimentation produce a diversity of habitat types. Animals may also create natural disturbance: hippopotamus and alligators are two examples. Wetland plants have many means of recovering from natural disturbances. Humans often reduce natural disturbances, and this leads to many undesirable changes, including invasion by woody plants.

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