

CROCODILE SPECIALIST GROUP NEWSLETTER

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VOLUME 42 Number 2
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IUCN Species Survival Commission

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Cover: Release of captive-bred 1-year-old Orinoco crocodiles (*Crocodylus intermedius*) at the Capanaparo River, near the community of Santa Josefina, Apure State, Venezuela. The event included 58 people, including children (pictured), from Caracas, who were invited to join the release (see pages 6-7). Photographs: Karel Silva.

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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James Hennessy, The National Reptile Zoo, Ireland.
Cathy Shilton, Darwin, Australia.

Editorial

I extend my sincerest gratitude to David, Philippa and Marie Huchzermeyer, who, on the recent winding up of their parents Fritz and Hildegard's estate, kindly assigned the rights of Fritz Huchzermeyer's book (Crocodiles: Biology, Husbandry and Diseases) to the CSG. Those funds will be allocated to the Fritz Huchzermeyer Veterinary Science Student Research Assistance Scheme (FHVS-SRAS), named in Fritz's honour, and which provides funding to postgraduate students carrying out veterinary science research. Fritz was a long-time member of the CSG, and Chaired the CSG Veterinary Science group.

The non-detriment provisions of CITES (Article IV,2a) are once again being reviewed, with 11 separate working groups addressing the many different perspectives of "non-detriment" that have evolved over time in CITES meetings. Dan Natusch (Chair of Snake Specialist Group and CSG member) is chairing the process. The original intent of the text, in the Convention, to encourage Parties to establish and seek advice from their own "scientific management" group, to ensure an export was not contributing to species extinction, has changed dramatically over time. Parties wanting to export are now expected to make a formal non-detriment finding (NDF), and the importing nation, applying stricter domestic measures, can now accept or reject this based on their own domestic values, thus controlling what a Party can export. This was arguably not what any Party signed on to, when they joined the Convention. So it will be interesting to see what this comprehensive working group finally concludes.

Croc School CrocFest was held in May 2023 at St. Augustine Alligator Farm Zoological Park, in conjunction with the AZA Croc School, which celebrated its 20th anniversary. A total of \$US60,000 was raised for Gharial (*Gavialis gangeticus*) research, bringing the total amount raised so far by CrocFest to some \$US860,000. CrocFest has proved to be a profoundly important and successful initiative, due to the selfless work of Colette Adams, Curt Harbsmeier and Flavio Morrissey, and they deserve great credit for it. I also take this opportunity to congratulate Alejandro Larriera and Kent Vliet, who were each presented with the Ralf Sommerlad Crocodile Conservation Award at the event. See page 5 for details.

In May 2023, 169 Orinoco crocodiles (*Crocodylus intermedius*) were released into the Capanaparo River, Venezuela. This is the 16th release since 1991, bringing up the total of 3305 individuals being released to date. See pages 6-7 for details.

Three young Philippine crocodiles (*Crocodylus mindorensis*), produced at Cologne Zoo (Germany), were repatriated to

the Philippines in May 2023. This follows the previous repatriation of two individuals in December 2020. Both events involved collaboration between Cologne Zoo, Philippine Government authorities and Crocodylus Porosus Philippines Inc. See pages 13-16 for details.

Recent surveys in the Punjab Province of Pakistan have confirmed the presence of Gharial (*Gavialis gangeticus*), after an absence of some 30 years in that country. It is considered likely that the animals crossed over from India. The possibility of re-establishing a viable breeding population of Gharial in Pakistan is truly exciting, and would be a giant step for crocodilian conservation generally. The knowledge-base on Gharial biology and conservation in India and Nepal continues to expand, and so if a cooperative agreement with Pakistan can be reached, it may all be possible. See page 13 for details.

A successful Gharial reintroduction program in the Gandak River, Bihar Province, India, has resulted in a collaboration between Los Angeles Zoo, the Bihar Government and Wildlife Trust of India for Gharial conservation. Buoyed by recovery efforts (217 Gharial were observed during a February 2023 survey, compared to 30 in 2014), the three partners have agreed to strengthen conservation efforts and release hatchlings back to the river safely (<https://www.thehindu.com/sci-tech/energy-and-environment/la-zoo-to-ink-pact-with-bihar-govt-wildlife-trust-of-india-for-gharial-conservation/article66957202.ece>).

Indianapolis Zoo is now accepting entries for the "2025 Indianapolis Prize" and "2025 Emerging Conservationist Award". The Indianapolis Prize (\$250,000) recognizes and rewards established conservationists who have achieved major victories in advancing the sustainability of an animal species or a group of species. The Emerging Conservationist Award (\$50,000) recognizes conservationists under 40 years of age with the talent and determination to make a significant impact on saving an animal species or group of species. Nominations/applications for both awards close on 26 February 2024. See www.indianapolisprize.org for details.

Preparations for the next CSG Working Meeting (April 2024) are now well underway, with Sally Isberg leading a local group of CSG members and crocodile enthusiasts. It promises to be another great event, and of course a chance for many CSG members, from a wide range of countries, to catch up in person. See below.

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

27th CSG Working Meeting

The 27th CSG Working Meeting will be held in Darwin, Northern Territory of Australia, on 16-19 April 2024. Preceding the working meeting will be workshops (eg drone, veterinary) on 14 April, and a meeting of the CSG Steering Committee on 15 April. The meeting will be hosted by the Crocodile Research Centre, and the Organising Committee is

busy preparing logistics for the meeting.

The meeting website will be launched soon, with details on venue, registration, accommodation, program, etc. Working Meetings are an excellent opportunity to meet face-to-face with “crocodilian” colleagues working around the world, and we encourage people to consider attending.

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

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 4 students in the April-June 2023 quarter, and 3 applications are currently under review.

1. Ciarán Ó Mórdha (Ireland): Population assessment of *Crocodylus acutus* on Ambergris Caye, Belize.
2. Sonnie Flores (Australia): Developing acoustic communication indices for estuarine crocodiles (*Crocodylus porosus*).
3. José Pérez Galvis (Colombia): Population evaluation of *Caiman crocodilus* and *Crocodylus acutus* in Cispatá Bay, Córdoba, Colombia.
4. Joana Batalha (Portugal): Influence of salinity on habitat preference and spatial distribution in two sympatric crocodile species.

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

In Memoriam

James Aparicio (1967-2023)

James Aparicio was a prominent Bolivian herpetologist, who as a member of the CSG for two decades made important contributions to the group, on three Bolivian species - *Caiman yacare*, *Caiman latirostris* and *Melanosuchus niger*. We count 82 publications, not only on crocodilians, but also lizards (with particular reference to ecology and systematics of *Liolaemus* sp.), amphibians, snakes and turtles. James was an obligatory reference in Bolivian herpetology. His work was developed mainly from the National Museum of Natural History (NMNH) in his native La Paz, of which he was Head of Zoology and Curator of Herpetology of the Bolivian Fauna Collection between 1999 and 2019.



Although not a teacher, James was a prolific trainer of talent in Bolivia. His laboratory was always full of students, to whom James made available all the information to which he

had access. Between 3 and 10 students at any time swarmed around his desk, where James taught them how to handle identification keys, the basics of curatorial work, etc., and supported and advised them on their postgraduate theses.

Field trips with James were a source of commentary among the students for several weeks - or years! Many professionals and colleagues of James had the pleasure of sharing and enjoying field trips with him, where he was always a great companion - hardworking, supportive, jovial, and above all with a great sense of responsibility. James transformed the difficult herpetological work into great adventures, that no-one wanted to miss. It is easy to count among his students more than 20 biology professionals in Bolivia, for whom James will remain forever in the history of herpetology and biology in general in our country.

To top off an impeccable career as a scientist, James was of a very high personal quality. He was always smiling, with a joke always at hand, and willing to support those around him in any way possible. At the same time, James would not hesitate to put his job on the line to defend his professional and institutional ideals. James was part of our lives both professionally and personally and his legacy will give us a light for the future, which we are sure will continue to be marked by James Aparicio, our dear friend, colleague and teacher.

Source: Luis Pacheco and Alfonso Llobet

Luon Nam (1951-2023)

Luon Nam (72 y) passed away tragically on 26 May 2023, in Siem Reap, Cambodia. Nam established Luon Nam Crocodile Farm in 1988, which was registered as a CITES



captive-breeding operation for *Crocodylus siamensis* in 1999. Nam's first interaction with the CSG was in February-March 2005, when the latter undertook a review of crocodile conservation and management in Cambodia. As Chair of the Cambodian Crocodile Farming Development Association, from 2004 until his death, Nam was an integral member of the crocodile industry, aiming to improve husbandry and to contribute to conservation efforts for the wild Siamese crocodile population.

Through the farming association, Nam was involved in: re-establishment of the farming association under new statutes; delivery of the first training course on Farming and Conservation of Crocodiles in Cambodia, held in July 2005, and specifically tailored for industry members; and, organisation of the CSG Regional Meeting held in Siem Reap in May 2015. Nam's leadership role within the industry's ranks will be sorely missed in Cambodia.

Source: Charlie Manolis and Sen Rith

Croc School CrocFest 2023

“Croc School CrocFest 2023” took place on 12 May 2023, at St. Augustine Alligator Farm Zoological Park in St. Augustine, Florida, USA. Donors, sponsors and over 300 attendees raised funds to support a new Gharial Ecology Project initiative focused on documenting the Chambal sand resource, now under a major threat. Sand is in high demand for construction, primarily in urban areas throughout India. This sand mapping project will provide the Indian conservation community, as well as state and central government agencies, with the necessary information to make wise management decisions and take effective conservation actions for gharial survival.

The Gharial Ecology Project (GEP) is a conservation-focused initiative of Madras Crocodile Bank Trust, its parent NGO. Since 2008, GEP has been studying the ecology and natural history of the ~1800+ resident Gharial (*Gavialis gangeticus*) in the 425+ km stretch of the Chambal River and its tributaries in northern India. Gharial of all ages engage in elaborate social behaviours, many of which are unique among living crocodilians. They nest in large colonies, and hundreds of hatchlings are guarded by adults, especially large males. The GEP Indian field team is headed by Jailabdeen A., who is researching acoustic and pheromonal communication, and Pankaj Kumar, who has been the main tracker and behavioural researcher since the project’s beginning. Dr. Jeff Lang continues to advise the project, which is supported by international zoos, individuals and volunteer organizations such as the CrocFest community.

CrocFest fundraisers are family-friendly events geared to increase awareness of and raise money for international crocodilian conservation. Attendees were granted full access to St. Augustine Alligator Farm and were treated to various croc-centric activities, including feedings and behind-the-scenes tours. After an all-you-can-eat BBQ meal, the evening wound up with awards presentations (Fig. 1) and a spirited live auction conducted by Joe Wasilewski and Phil Goss of USARK.

Alejandro Larriera and Kent Vliet were each presented with the Ralf Sommerlad Crocodile Conservation Award during the event (Fig. 1).

Thanks to the generosity of the private sector, zoos, corporate sponsors and academia working together, as of May 2023, CrocFest fundraisers have generated over \$US860,000 for crocodilians in peril! All proceeds raised go directly to crocodilian project beneficiaries, with event expenses covered by event organizers and sponsors.

Event organizers were Curt Harbsmeier (Executive Board Member, ZooTampa), Flavio Morrissiey (Ops Director, You Name It Tours) and Colette Adams (Deputy Director, Gladys Porter Zoo).



Figure 1. Left: Dr. Kent Vliet was presented the Ralf Sommerlad Crocodile Conservation Award by John Brueggen, Director of St. Augustine Alligator Farm Zoological Park. Right: CSG Deputy Chair Alejandro Larriera CSG addresses the CrocFest crowd after being presented the Ralf Sommerlad Crocodile Conservation Award by event organizer, Curt Harbsmeier.



Figure 2. From left: CrocFest participants, Evelyn C. López González (Proyecto Yacaré, Argentina), Robinson Botero-Arias (Colombian graduate research assistant, University of Florida), Karl Guyton (Georgia Aquarium) and Treya Picking (“Croc Doc” member).

Wildlife Conservation Drones & Technologies Summit - 2023

The “Wildlife Conservation Drones & Technologies Summit” will be held on 9-12 October 2023, at Reveille Peak Ranch, Burnet, Texas, USA. Details are outlined on the flyer below. For more information, or to buy tickets, visit [WCDWS.com](https://www.wcdws.com).

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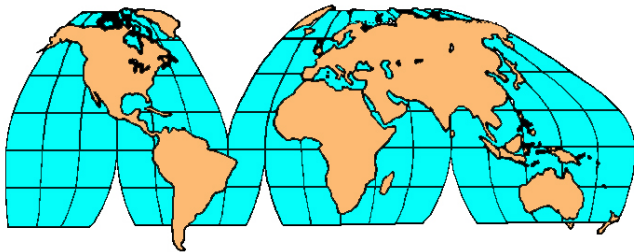
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Lonnie McCaskill, *CSG Drone Working Group.*

Regional Reports



Latin America and the Carribean

Venezuela

ORINOCO CROCODILE RELEASE IN THE CAPANAPARO RIVER, VENEZUELA, 2023. Between 28 April and 1 May 2023, 169 Orinoco crocodile (*Crocodylus intermedius*) were released on the banks of the Capanaparo River, Apure State, near the indigenous Pume community of Santa Josefino. These crocodiles were captive-bred, one-year-old individuals from facilities at Masaguaral Ranch and Leslie Pantin Zoo. In line with the “National Program for the Conservation of the Orinoco Crocodile”, releases of the species into the Capanaparo River began in 1991, and this was the 16th release event, bringing up a total of 3305 individuals released to date. The aim of the program is to reinforce the wild *C. intermedius* population in the Capanaparo River, within Santo Luzardo Capanaparo Cinaruco National Park (Fig. 1).



Figure 1. Release site on the Capanaparo River. Photograph: Alvaro Velasco.

The activity was organized by our social media partner Rio Verde, jointly with Fundación para el Desarrollo de las Ciencias Físicas, Matemáticas y Naturales (FUDECI), Masaguaral Ranch, the Venezuelan Crocodile Specialists Group (GECV), Leslie Pantin Zoo and Fauna Silvestre Productos y Servicios. This was the 4th release held in collaboration with Rio Verde, which offered families from Caracas the opportunity to participate. On this occasion, 58 people, of whom 19 were children under 11 years of age, from the capital, accompanied us (Figs. 2 and 3). Together with members of the Santa Josefino community (Fig. 4), they were shown how to take morphometric data from the crocodiles, learned about their management, and later assisted in the release itself.



Figure 2. Young participants at release. Photograph: Rio Verde.



Figure 3. Participants at release event. Photograph: Rio Verde.



Figure 4. Member of Santa Josefino indigenous community releasing crocodile. Photograph: Rio Verde.

We were also accompanied by doctors from the “Children of the Jungle Project”, who offered medical and dental care to the Pume indigenous community of Santa Josefina (150 children, 70 adults), and made donations of medicines, food and school supplies.

Successes associated with the release program in the Capanaparo River include the recapture in 2020 of a female *C. intermedius* hatched at Dallas World Aquarium in 2007, and sent to Venezuela and released in 2009. This animal had grown from 1460 mm to 3060 mm TL. Also, a male *C. intermedius* hatched at Masaguaral Ranch in 2012, released in 2013, and recaptured in 2019, had grown from 753 mm to 2307 mm TL. Another notable success is the creation of four reproductively active *C. intermedius* populations in Caño Guaritico Wildlife Refuge, Cedral Ranch, Estero de Camaguan Wildlife Refuge and Garza Ranch.

Alvaro Velasco B., *Chair of Venezuelan Crocodile Specialists Group and Associate Researcher FUDECI.*

JOURNEY OF 7 ORINOCO CROCODILES FROM VENEZUELA TO DENMARK. Rene Hedegaard, Director of Krokodille Zoo in Denmark, visited Venezuela for the first time in 2007, and attended the Workshop on the Conservation of the Orinoco Crocodile in Venezuela and Colombia. He later travelled to the Cojedes River, site of one of the most important *Crocodylus intermedius* populations, and spent a few days at Masaguaral Ranch, the first captive breeding centre for the species. Thus began his desire to collaborate and be part of the National Conservation Program of the

Orinoco Crocodile in Venezuela.

In 2013, Krokodille Zoo received 6 female *C. intermedius* that had been produced at Dallas World Aquarium (USA), and began discussions with Fundación para el Desarrollo de las Ciencias Físicas, Matemáticas y Naturales (FUDECI), Hato Masaguaral and the Venezuelan Crocodile Specialists Group (GECV), to obtain some male *C. intermedius* and establish the first breeding center of the species in Europe.

Rene returned to Venezuela in 2015 and 2016, to participate in the reintroduction of captive-bred 1-year-old individuals to their natural habitat, and to formalize his relationship with FUDECI, which manages the Orinoco crocodile project at Masaguaral Ranch.

Several years were spent establishing the necessary steps to be able to send 7 Orinoco crocodiles (one pair of adults and 5 juvenile males), including the signing of a cooperation agreement between Krokodille Zoo and the Venezuelan Ministry of People’s Power for Ecosocialism (MINEC), and provision of support for captive breeding activities, which resulted in the issuance of CITES export permits for the crocodiles. However, due to the COVID-19 pandemic, the entire operation was put on hold.

In 2022, the process was restarted, involving: renewal of CITES permits; hiring of Taurel Customs Agency to support export procedures; Transportes Aereos Portugueses (TAP) being identified as airline to transport the crocodiles to Europe; construction of transport boxes; and, obtaining of Venezuelan Health Certificate and other permits required for transfer of crocodiles from Masaguaral Ranch to Simon Bolivar International Airport, Caracas. In October 2022, TAP advised that it did not have a service in Europe that could take the cargo to Germany, so it was decided that the crocodiles would travel by air to Lisbon (Portugal), by land to Hamburg (Germany), and then a ferry across the Baltic Sea to Denmark.

Two days before commencement of the operation, the team was assembled, comprising Omar Hernandez, Ricardo Babarro, Arnaldo Ferrer, Odilo Enes, Roldan De Sola, Leonel Ovalles, Tomas Blomh and myself. They were accompanied by Mecsys Fuentes, Eneida Marin and Andrea Velasco who, with myself, took charge of taking videos and photographs.

The team travelled to Masaguaral Ranch to collect the crocodiles, each of which was injected with 5% Dextrose solution, micro-chipped and measured, before being placed into transport boxes (5 boxes each contained a single crocodile, one box contained 2 crocodiles) (Fig. 1). The crocodiles had not been fed for a week prior to the trip.

The first sector consisted of approximately 400 km from Masaguaral Ranch to the airport in Caracas, on 9 January. During the transfer we stopped at different checkpoints, where documentation to show the legality of the operation were checked. Once at TAP warehouses, the National Guard, the Anti-drug Command, the Venezuelan Health Institute and the tax regulator (although the cargo was exempt) certified the



Figure 1. Adult crocodile being placed into transport box at Masaguaral Ranch. Photograph: Alvaro Velasco.

documentation. However, Anti-drug Command demanded to see the crocodiles, which was not feasible given that they were unrestrained in their boxes, and without their jaws tied - there was potential risk that they could escape their boxes. So each box was carried out with its crocodile inside, and x-rayed, to confirm that there were no drugs within them. The full load, boxes and crocodiles, weighed around 700 kg.

On 10 January, the boxes were loaded onto a commercial flight (special cargo area for live animals at 27°C) for the trip to Lisbon (Fig. 2). I accompanied the shipment, as a passenger. The trip took more than 8 hours. After I completed migration formalities, Rene picked me up and we made our way to the cargo area of the airport, arriving at around 0600 h (local time; 11 January). Documentation was handed over, and we received the boxes. Cargo staff were excited about this “unusual” shipment, and took photographs as we checked the general condition of the crocodiles through the ventilation holes of the boxes.

The boxes were loaded onto a covered truck, and at 1100 h we began our road trip across Portugal and northern Spain, and crossing the border into France at night. The cabin containing the boxes were ventilated from time to time en route. At the first stop in Portugal, we placed tape over the ventilation holes of the boxes, since the ambient temperature was around 5°C, and we did not want the animals to feel that low temperature when the cabin was being ventilated.

In France, on the first night, Rene contacted Sarah Carpentier,



Figure 2. Transport boxes being loaded onto flight to Portugal. Photograph: Alvaro Velasco.

a friend who works in a zoo/park in French Normandy, to book a hotel with rooms near the parking area, so that we could run an electric lead out the window, to a heater placed in the cabin with the boxes.

At 0800 h the next day (12 January), we continued the journey across France, and at night across Belgium and the Netherlands, and arrived in Hamburg and the port where we took the ferry across the Baltic sea to Denmark - arriving at 0400 h on 13 January. From the ferry terminal, we continued towards Esbjerg, where Krokodille Zoo is located, arriving at around 0600 h. The trip from Lisbon to the zoo took 20 hours, and covered about 3000 km and 7 countries, and crossing the Baltic Sea.

Krokodille Zoo staff, Victor Vest and Alexander List, were waiting for us on arrival at the zoo, and helped unload the boxes into the Tropical Hall, a facility built especially for Orinoco crocodiles. The crocodiles were checked, and they appeared to be in good condition. Later that day, they were released into their new pools (Fig. 3). The adult pair (3.55 m male, 2.5 m female) was placed in one pool (Fig. 4), and the 5 young males (around 2 m TL) in another pool. When the boxes were opened, all crocodiles appeared cautious about entering their new habitats, but over time they adapted and moved throughout the enclosure. The whole process was filmed by Danish television.

The adult crocodiles, Tomas and Cecilia, were named after Tomas and Cecilia Blohm, in recognition of their conservation work with the species at Masaguaral Ranch. The juvenile males were named Omar, Ricardo, John T, Kasper and Alvaro. The females acquired in 2013 were named Rosana, Phoebe, Sarah, Elvira and Jenny.

On 15 January, two days after release into the enclosures, the crocodiles were offered food, which consisted of unborn piglets. Cecilia took one of the piglets but did not eat it immediately, and two of the juvenile males did the same. However, by the next morning there was no food remaining. One week later, all the crocodiles ate without a problem, indicating that the entire process worked perfectly.



Figure 3. Adult Orinoco crocodile being released into enclosure at Krokodille Zoo. Photograph: Alvaro Velasco.



Figure 4. Adult Orinoco crocodiles in Tropical Hall at Krokodille Zoo. Photograph: Alvaro Velasco.

The Tropical Hall consists of 7 pools, each one with caves where crocodiles can hide, and sand areas with infrared lighting to provide heat. The volume of water is 130 kilolitres, which circulates all the time and passes through four purification filters, so the water in the pools is always clear and clean. The Hall was finally opened to the public in April, with all Orinoco crocodiles at Krokodille Zoo on display (Fig. 4).

It is important to highlight the conservation work of zoos, including studies of behavior, feeding, reproduction and environmental education. All the hatchlings produced at Krokodille Zoo will be sent to Venezuela for reintroduction into their natural habitats and to reinforce the wild populations.

The entire operation, from Masaguaral Ranch (Venezuela) to Krokodille Zoo (Denmark), was filmed and photographed, and our social media ally Rio Verde edited a documentary that can be seen on YouTube: <https://www.youtube.com/watch?v=HpkPXpitXHg>.

Alvaro Velasco B., Chair of Venezuelan Crocodile Specialist Group (velascocaiman@gmail.com).

South Asia and Iran

India

STANDARD OPERATING PROCEDURES FOR RESCUE OF STRANDED GHARIAL (*GAVIALIS GANGETICUS*). The Gharial (*Gavialis gangeticus*) is an endemic crocodilian species of the North Indian subcontinent, whose wild populations have been depleted throughout much of their former range. Historically, Gharials were common and abundant throughout the Indus, Ganges, Irrawaddy, Mahanadi and Brahmaputra-Meghna drainages (Lang 2018). The Gharial population was estimated to be between 5000 and 10,000 during the 1940s (Whitaker *et al.* 1974), but by the mid-1970s the species was restricted to around 2% of its historical range and pushed to the verge of extinction due to habitat destruction, depletion in prey biomass and retaliatory killings by fishermen (Lang *et al.* 2019).

The species has been locally extinct from the Indus, Irrawaddy, and most rivers and tributaries of the Ganges and Brahmaputra-Meghna River systems. At present, only five sites in India [Chambal River (National Chambal Sanctuary, Rajasthan, Madhya Pradesh and Uttar Pradesh), Girwa River (Katarniaghat Wildlife Sanctuary, Uttar Pradesh), Ramganga River (Corbett National Park, Uttarakhand), Gandak River (Uttar Pradesh and Bihar), Mahanadi River (Satkosia Gorge Wildlife Sanctuary, Odisha)] are known to contain breeding populations. Further, the estimated global Gharial population is around 650 breeding adults, with 88% confined within National Chambal Sanctuary, India (Lang *et al.* 2019).

These isolated Gharial sub-populations are still facing many anthropogenic threats. For example, sand mining and riverbed cultivation encroach upon basking and nesting sites, disrupting the behaviour of the animals and forcing local populations to leave the area. Disturbance and disruption of basking sites reduce habitat quality for Gharial, and damaged eggs reduce the recruitment rate of the species. Illegal fishing through the use of gill nets for both commercial and subsistence fishing makes animals vulnerable to entanglement. When an animal becomes trapped it drowns or is often killed by fishermen in retaliation for the destruction of their nets. The dams and barrages on the rivers across their range are fragmenting their habitat significantly.

Need for a SOP

During the dry season, irrigation canals sometimes contain more water than adjacent stretches of river downstream of barrages, and Gharial enter these canals in search of deeper water and prey (Yadav and Khan 2016). Since water levels in the canals are governed by gate operations, Gharial may become “stranded” in these sub-optimal canal habitats, and potentially result in mortality. The ability of stranded Gharial to exit canals is severely limited, and human intervention is required.

Despite a few commendable Gharial rescue efforts by the

Uttar Pradesh Forest Department and WWF-India in the Upper Ganga and Chambal Rivers, cases of stranding are not always reported. Hence, it is considered imperative to develop a standard operating procedure (SOP) for rescue and rehabilitation of stranded Gharials and engage the local riparian community for Gharial conservation and monitoring so that strandings can be reported immediately for appropriate actions.

Gharials are easily distinguished from other crocodilians by their long, narrow and slender snout, a morphological uniqueness that makes the capture of Gharial potentially more difficult. This SOP is based on experience gained in 10 rescue operations, and 44 recaptures from the wild for biometrics between 2009 and 2018. It is intended to serve as a ready-to-use guide for teams attempting Gharial rescues. Here, we present some of the key elements of the intended SOP.

1. Preliminary Site Visit

Once information is received regarding a stranded Gharial, it should be circulated to relevant forest officers (Local Divisional Forest Officer and Forest Range Officer) for the record and necessary action. The joint team of the local forest department and trained rescue expert should visit the stranding site and assess the situation. Preliminary observations on habitat conditions, disturbances, health condition and size of the animal, and stress-causing factors (such as noise, people gathering, people throwing stones or other objects on the animals etc.) should be noted, and the urgency of the rescue assessed on the basis of these factors.

2. Strategy for Rescue

Based on the preliminary assessment of the situation, the joint team of trained rescue experts and the local forest/wildlife department should secure formal permission for the rescue from the relevant authority. A multidisciplinary field team, including the species experts, forest officials and fishermen, should also be constituted. Field team members and their roles and responsibilities, and plan of capture, transport and release, should be well discussed and finalised within the team and with all related persons.

The field team should assess the on-site situation and chalk out a plan for the rescue, including assembling of capture gear gears, transport box and vehicle, establishing the best route for transport, etc. Gear that is/may be required for rescue operations includes:

- | | |
|---------------------------------|------------------------|
| 1. first-aid kit | 12. duct tape |
| 2. GPS | 13. wooden planks |
| 3. binoculars | 14. spring balance |
| 4. walkie-talkie | 15. gunny bags |
| 5. camera | 16. towels |
| 6. transportation box | 17. surgical gloves |
| 7. buckets/mugs | 18. vehicle |
| 8. tarpaulin | 19. measur. tape (5 m) |
| 9. silk and jute ropes (10x3 m) | 20. dry bags |

- | | |
|--------------------------------|------------------|
| 10. silk net, 10 and 08 finger | 21. data sheets |
| 11. boat | 22. search light |

3. Release Site Selection

Before capturing the animal, it is important to identify the site for subsequent release. The release site should:

- be the nearest one to the stranding site
- be within the natural geographical range of the species
- comprise suitable habitat for the species
- provide all requirements throughout the year, including enough water in the dry season, protection from turbulent high floods (presence of side creeks and nullahs), suitable sandbanks for basking and nesting, etc.
- not be subjected to undue disturbances such as fishing, sand-mining, hunting, etc.

An important consideration is the potential food resources available, not just immediately, but for the population that is expected to be built up after release (Choudhury and Singh 1982).

4. Capture

The field team should closely monitor the movement patterns of the stranded Gharial, prior to deciding on the capture method. If in open water, fishermen can place a silk drag net at the place where there is the highest probability of capture. If the animal is in a restricted situation, nets, wet gunny bags and/or tarpaulin may be used to capture the animal.

As soon as possible, the snout of the animal should be tied shut using duct tape or heavy-duty rubber bands. As soon as the jaws are secured, the eyes should be covered with a wet sack (hessian sack or gunny bag) to reduce visual stimulation. If it is necessary to restrain the limbs (to prevent struggling), use only wide webbing or tape (5-10 cm wide), tied loosely so as not to restrict blood circulation. And do not keep limbs tied for longer than two hours.

The collective safety of team members and Gharial must be paramount above all other objectives. Unnecessary and undue stress on the animal must be avoided, both from a scientific and animal welfare perspective. Blindfolding captured Gharial is critical to reducing stress from visual stimulation, and generally the animal becomes much easier to handle immediately (Choudhury and Singh 1982).

5. Marking and Morphometrics

Physical examination of the Gharial should be carried out by the trained veterinarian, including an assessment of tail fat, presence of ectoparasites, visible injuries, signs of disease (eg abnormal discharge from eyes, nostrils, mouth, scale-rot), abnormalities (eg metabolic bone disease) etc. If the rescued Gharial is injured or diseased to the extent

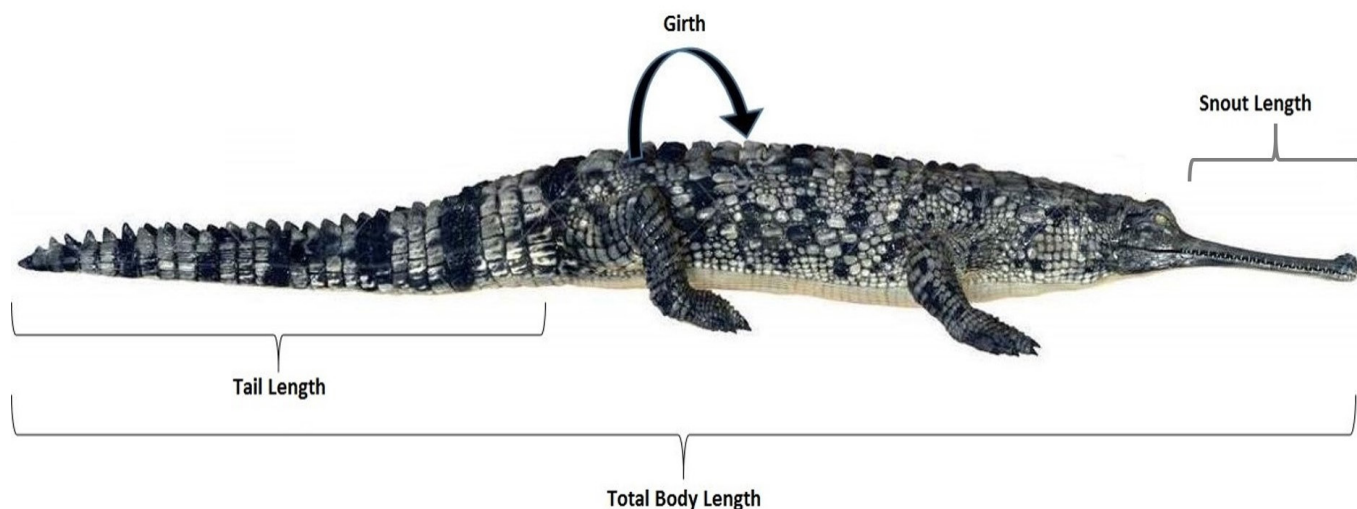


Figure 1. Morphometric measures.

that it requires care and treatment before eventual release, the team should contact the nearest rehabilitation centre and transport the Gharial to that facility for treatment.

The field team should record body weight, snout length, total body length, tail length, girth and sex of the animal (Fig. 1).

The animal should also be checked if it has previously been scute-clipped (Fig. 2). If not previously scute-clipped, the rescued Gharial should be marked with the appropriate scute sequence for later identification. While use of colour tags has proven to be a temporary and easy method for identification, scute-clipping has proven to be more effective in the long-term (Choudhury and Singh 1982). This simple technique involves cutting tail scutes in different combinations (if cut properly, these do not re-grow), thus providing a unique identity number (ID No.) to each animal being released back in the wild (Fig. 2).

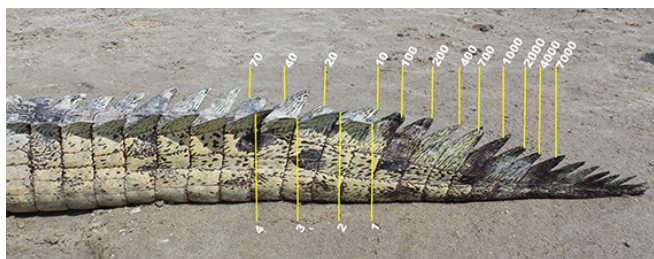


Figure 2. Scute-clip numbering, a formal way of marking an individual Gharial (see Bustard and Choudhury 1981).

Noise and handling should be kept to a minimum during the whole process.

6. Transport

Rescued Gharials over 1.6 m in length should be transported in a ventilated wooden box (see Fig. 3) to the release site. Smooth interiors for containers and padding around the snout of the crocodile can minimize snout damage and are recommended. Suitable cushioning can minimize vibration

and shocks, where these are unavoidable, and there should be no sharp edges or projections on the inner surfaces of the container. Juvenile Gharials of up to 1.5 m length can be transported in moist gunny bags (one animal per bag) - this method is equally effective and cheap. With this method, the snout of the Gharial should be tied with rubber band and mouth of the bag tied with rope (Choudhury and Singh 1982).

For Gharials up to 3 m length, a simple restraining board with webbing straps may also be effective. Animals may also be transported in a vehicle for short distances if adequately restrained. Regardless of mode of transport, care should be taken to ensure that boxes, boards, etc. are well secured on the vehicle, in case of bumpy roads.

Always ensure that the Gharial's head is higher than the body during transport, so that any regurgitated fluids can flow back down the oesophagus rather than the pool at the opening of the glottis.

Due care should be taken during transport to avoid dehydration, overheating, excessive cooling and struggling, and to minimize transport time (Choudhury and Singh 1982). Animals should always be transported singly in a transportation box.

The animal should be observed for any signs of distress at least every four hours, and action taken to alleviate such distress as appropriate (eg keeping animal wet by sprinkling water on it).

The best time to transport crocodiles is the cool dark hours of the early evening and night (Choudhury and Singh 1982). Gharials are more likely to remain calm, and overheating in the heat of the day can be avoided.

Rescued animal/s should not be subjected to large public gatherings and/or displayed during transport, capture or handling operations.

7. Release

The best time to release Gharials is late afternoon (Choudhury and Singh 1982). Early morning and mid-afternoon releases may expose animals to potential disturbance for the rest of the day. In most habitats, there is typically minimal or no disturbance during the night.

After removing ropes from the limbs, and duct tape/ rubber bands from the jaws, animals should be left on the bank, facing the river, and allowed to enter the water by themselves (Fig. 4). Animals should never be released directly into the water.

8. Post-release Monitoring

For the first few days following release, Gharials should be closely monitored (Choudhury 1991). Movement, basking, response to the disturbances, and other observations should be recorded.

Acknowledgements

We express our gratitude to the Uttar Pradesh Forest Department for permitting the joint team of divisional forest departments and WWF-India for rescues and rehabilitation operation of Gharials in the Upper Ganga River. We remain

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Literature Cited

Bustard, H.R. and Choudhury, B.C. (1981). Marking crocodiles for release back into the wild for subsequent identification. *Indian Forester* 107(8): 477-485.

Choudhury, B.C. and Singh L.A.K. (1982). Captive Rearing



Figure 3. Top left: On-site assessment and preparation of strategy for rescue. Top right: Capture of Gharial. Bottom left: Shifting captured Gharial (in ventilated transport box) to vehicle. Bottom right: Releasing rescued Gharial into River Ganga, in Hastinapur Wildlife Sanctuary.

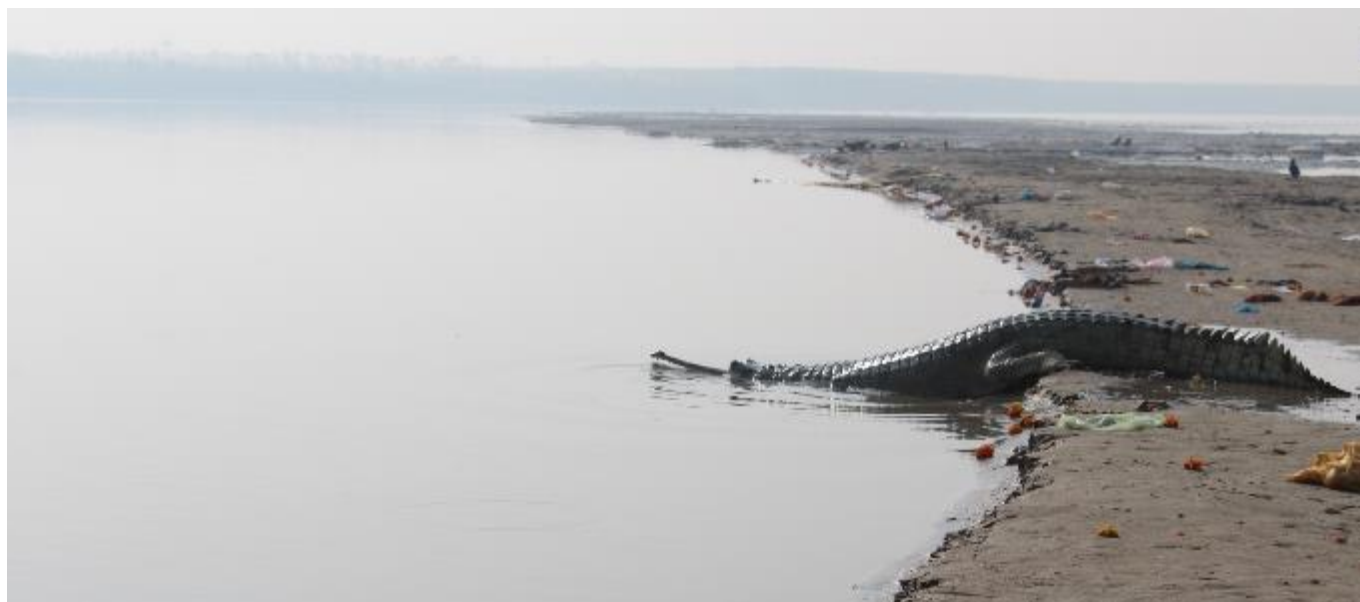


Figure 4. Rescued Gharial entering the River Ganga.

and Management of Crocodiles in India. A Field Guide. Central Crocodile Breeding and Management Training Institute: Hyderabad.

Choudhury, B.C. (1991). Census Operations in Crocodilians. Pp. 1-82 in *Techniques for Wildlife Census in India: A Field Manual*, ed. by W.A. Rodgers. Wildlife Institute of India: Dehradun.

Lang, J.W. (2018). Gharial distributions and abundances: Then and now. Pp. 127 in *Crocodiles. Proceedings of the 25th Working Meeting of the IUCN-SSC Crocodile Specialist Group*. IUCN: Gland, Switzerland.

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

Maskey, T.M. and Percival, H.F. (1994). Status and conservation of Gharial in Nepal. Pp. 77-83 in *Crocodiles. Proceedings of the 12th Working Meeting of the IUCN-SSC Crocodile Specialist Group*. IUCN: Gland, Switzerland.

Whitaker, R., Rajmani, V.C., Basu, D. and Balakrishnan, V. (1974). Preliminary survey of Gharial. Madras Snake Park Trust Report, pp. 1-17.

Yadav, S.K. and Khan, M.S. (2016). Note on Gharial reintroduction and rescue in Upper Ganga River. *Crocodile Specialist Group Newsletter* 35(4): 6-8.

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Pakistan

GHARIALS CONFIRMED IN PAKISTAN. In May 2023, World Wildlife Fund-Pakistan (WWF-Pakistan) confirmed the presence of Gharials (*Gavialis gangeticus*) in the province of Punjab, an area from which the species has not been sighted for some three decades. A survey confirmed the presence of adult and juvenile Gharials, and local fishermen told the WWF-Pakistan team that there had been unconfirmed sightings of Gharials in Okara (near Ravi River) and Head Sulemanki (on the Satluj River, just 2 km from the border with India) nearly a year ago.

It has been suggested that the Gharials may have come into Pakistan from India's Punjab, where 94 Gharials were released into the Beas Conservation Reserve between 2017 and 2021. WWF-Pakistan aims to "step up conservation efforts for the Gharial to ensure that the newly discovered population not only survives but thrives".

Source: Ghai, R. (2023). WWF confirms the presence of gharials in Pakistan's Punjab. Down to Earth, 18 May 2023 (<https://www.downtoearth.org.in/news/wildlife-biodiversity/wwf-confirms-the-presence-of-gharials-in-pakistan-s-punjab-89436>).

Europe

Germany

SECOND REPATRIATION OF CRITICALLY ENDANGERED PHILIPPINE CROCODILES TO PHILIPPINES FOR REINTRODUCTION INTO THE WILD. On 8 May 2023, experts from Cologne Zoo (Germany), in collaboration with the Philippines Government Department of Environment and Natural Resources - Biodiversity

Management Bureau (DENR-BMB) and Crocodylus Porosus Philippines, Inc. (CPPI), succeeded in returning three juvenile Philippine crocodiles (*Crocodylus mindorensis*) produced at the zoo to the Philippines.

The return of Ligaya, Mutya and Mayumi to the Philippines marked the second repatriation of the species from Cologne Zoo. In December 2020, two Philippine crocodiles, Hulky and Dodong, were sent back. Like the first two crocodiles, these three young crocodiles had grown up in Cologne Zoo together with their mother (Figs. 1 and 2).

The names, Ligaya (= happiness), Mutya (= docile) and Mayumi (= jewel), were decided through a naming competition held in September 2021 in cooperation with CPPI, an NGO and member of DENR's "National Committee for Crocodile Conservation - Technical Working Group". CPPI is committed to the sustainable use of commercially-farmed Saltwater crocodiles (*C. porosus*) and research and conservation of the both crocodile species (*C. porosus*, *C. mindorensis*) in the wild.

After their acclimation in a wildlife rescue centre run by DENR-BMB's National Wildlife Research and Rescue Center, Quezon City, Philippines, the three crocodiles will help establish a purebred population that can then be released into the wild to strengthen the highly threatened natural population.

With the support of the Zoological Society for the Conservation of Species and Populations (ZGAP) and the "Zoo Species of the Year 2021" campaign, which was able to raise over €170,000 for crocodile conservation, our cooperation partners from CPPI, supported by Cologne Zoo, are currently building a semi-wild facility and an education centre in the southern Philippines. Due to the COVID-19 pandemic, this project has unfortunately been delayed. There, in Paghungawan Marsh, Siargao Island Protected Landscape and Seascape (SIPLAS), the offspring from the European conservation breeding program will contribute to the establishment of a natural population.

Just like the first repatriation of Hulky and Dodong, the recent arrival of Ligaya, Mutya and Mayumi also caused great excitement in the Philippines. The three crocodiles hatched in late-June/early July in Cologne Zoo Aquarium (Fig. 1). The first breeding of this species in Europe was achieved at Cologne Zoo in July 2013, then the first natural breeding occurred in 2015, and Ligaya, Mutya and Mayumi represent the second natural breeding. Natural breeding involves eggs being left in the enclosure after laying, hatchlings being carried to the water by the mother after hatching, and growing up under the care of their mother, and thus being well socialized and well suited for restocking (Figs. 1 and 2).

The natural breeding event further allowed Cologne Zoo's Philippine crocodile team around section keeper Anna Rauhaus to further observe and document parental care and breeding behaviour (mouth transfer, nest guarding behaviour) of this elusive species. The growth of the young with their



Figure 1. Freshly-hatched crocodiles Ligaya, Mayumi and Mutya, in July 2021 with mother (Mindo) at Cologne Zoo. Photograph: Anna Rauhaus.



Figure 2. Mother (Mindo) with now almost 2-year-old Ligaya, Mayumi and Mutya in April 2023, shortly before repatriation. Photograph: Anna Rauhaus.

mother - no-one knows how long they stay together in nature - was examined this time by Cologne students and this pioneering scientific study is currently being prepared for publication in a conservation journal.

Endemic to the Philippines, the wild *C. mindorensis* population is estimated to comprise about 100 individuals, making it one of the rarest crocodilians in the world. Owing to its fragile status in the wild, the Crocodile Specialist Group supports *ex-situ* management such as conservation breeding in zoos. International captive breeding programs have been executed under Memoranda of Agreement by the Philippine Government (DENR) with zoos in the USA, Australia and Europe. The first Philippine crocodile zoo breeding program in Europe was officially initiated in April 2012, when the European Studbook was established by the European Association of Zoos and Aquaria (EAZA). The European Program is administered by Cologne Zoo and coordinated by Aquarium Curator Prof. Dr. Thomas Ziegler and Terrarium section keeper Anna Rauhaus.

The goal of the European Program was to build up an assurance/reserve colony in European zoos for the species. In 2006, 15 *C. mindorensis* were transferred from DENR - Palawan Wildlife Rescue & Conservation Center (PWRCC)

based on a MoA between the DENR and Danish Krokodille Zoo. In 2009, 10 of the 15 hatchling were transferred to other European zoos based on Wildlife Transfer Certificates issued by Philippine authorities. Crocodiles are a breeding loan from DENR.

Apart from Cologne Zoo, breeding success in Europe has also been achieved in the Czech Republic (Protivin Crocodile Zoo), the UK (ZSL London Zoo) and Denmark (Krokodille Zoo). Mainly due to these recent breeding successes, the number of *C. mindorensis* within the European zoo breeding program has increased from the original 15 individuals, held in 6 institutions, to around 50 individuals distributed among 12 institutions.

This is a striking example of modern zoo work and restocking of threatened natural populations. This is also what the “One Plan Approach” of the IUCN SSC Conservation Planning Specialist Group envisages, namely to combine species protection on-site with species protection through zoos and zoo husbandry in order to be able to carry out species conservation as quickly and optimally as possible in times of dwindling habitats and wild animal populations. The threat status of a species can be minimized by replenishing weakened natural populations from zoo offspring. This showcase example of modern, progressive zoo work in the sense of the One Plan Approach was therefore recently presented as a success story on the “Reverse the Red” homepage (<https://www.reversethered.org/stories/philippine-crocodile>).

“This is a wonderful example of how *ex-situ* measures such as conservation breeding projects, coordinated by modern, scientifically-led zoos, can help to actively support or principally execute the *in-situ* conservation measures in the Range State/s”, says curator of Cologne Zoo’s Aquarium Prof. Dr. Thomas Ziegler, who is also a CSG member. Cologne Zoo’s Director Prof. Theo B. Pagel, summarizes: “This is another successful example of the One Plan Approach, implemented by modern, progressive zoos, which massively support and enable species conservation in nature.”

After agreement between the German Federal Agency for Nature Conservation and the Philippine DENR-BMB, and issuing of respective export and import certificates for this internationally protected species, the second repatriation transfer was organized and facilitated by Cologne Zoo’s animal transfer coordinator Bernd Marcordes, with Sandra Seigfried from the animal travel agency “Gradlyn” at Frankfurt Airport, a company specializing on the transfer of exotic animals. A time-consuming undertaking, because not only does a flight have to be booked, but all kinds of documentation such as health certificates or cooperation agreements have to be collected (Fig. 3).

A cordial welcome for the crocodiles at Manila International Airport was facilitated by the DENR-BMB Wildlife Rescue Center Staff, DENR Wildlife Enforcement Officer Theodore Rodrigo Agir, CPPI biologists Rainier Manalo, Marvin Jay Sarmiento and Jake Wilson Binaday and JK Mercado & Sons (Fig. 4).



Figure 3. Cologne Zoo’s Philippine crocodile team (from left: keepers Dana Schneider, Anna Rauhaus, Christian Niggemann and curator Thomas Ziegler) with Ligaya, Mayumi and Mutya in their transport boxes, immediately before being picked up for the flight. Photograph: Thomas Ziegler.



Figure 4. Cordial welcome with poster prepared by Cologne Zoo’s cooperation partner Crocodylus Porosus Philippines Inc. (CPPI), for Ligaya, Mayumi and Mutya at Manila Airport. Photograph: CPPI.

Assistant Secretary for Climate Change and concurrent Director of BMB, For. Ricardo L. Calderon welcomes the repatriation of the captive-bred Philippine crocodiles with high hopes that these individuals will contribute to the enhancement of the species’ wild population. “We need to step up our efforts to help recover the decimated population of the Philippine crocodile, including the protection of their wetland habitats, not only for the crocodiles but also to secure ecosystems services for the welfare of communities”, Calderon stated.

If all works out as planned, DENR-BMB in collaboration with CPPI has plans for further repatriation of offspring from the European captive-breeding program to the Philippines. Rainier Manalo (CPPI) indicated that there is sufficient space and suitable habitat in the south for restocking Philippine crocodiles. And DENR-BMB and the CPPI Research Team have further plans with Cologne Zoo, supported by ZGAP and donations from the “Zoo Species of the Year 2021”

campaign, namely to create a new area for protection of Philippine crocodiles, including the area from which the species was originally described - the island of Mindoro.

Source: Cologne Zoo Media Release 22/2023 “Second repatriation of the Critically Endangered Philippine crocodile for building up a pure colony in the Philippines for reintroduction into the wild”.

Australia & Oceania

Australia

HUNTING AND FORAGING BEHAVIOUR OF SALTWATER CROCODILES. Crocodilians are generally considered to be specialised predators hunting in the water or at the water’s edge. Observations of hunting and foraging behaviours for many crocodilian species are notoriously difficult to make over long periods of time. Here, I summarise various hunting/foraging behaviours that I have observed with Saltwater crocodiles (*Crocodylus porosus*) on the Daintree River, in north Queensland, Australia. As owner/operator of Solar Whisper Wildlife and Crocodile Cruises, I have spent a good deal of time on the river, which has provided unique opportunities to observe crocodile behaviours directly.

The Daintree River is some 127 km in length, and has a relatively low density of crocodiles (around 1.44 non-hatchlings/km). The downstream start point of the 5-6 km section of the river in which we have operated cruises for 26 years, is about 10 km from the river mouth. This section of the river is tidal, brackish, and bordered by mangroves, sugarcane farms and cattle pastures (Figs. 1 and 2).



Figure 1. Section of the Daintree River in which behavioural observations were recorded.

The section is home to 15 adult *C. porosus* (5 males, 10 females; 2.5<4.7 m) that are known to us, and to which we have assigned names. It is difficult to estimate the small number of juveniles (0.9<2.5 m), which tend to be wary of the



Figure 2. Typical riverbank habitat of the Daintree River where behavioural observations were recorded.

cruise boat, and are rarely sighted. The number of hatchlings (0.25<0.6 m TL) at any given time varies according to the extent of successful nesting, and the high rate of mortality that occurs through the year. Observations are thus limited to hatchlings, yearlings and adults. This small crocodile population has remained somewhat stable over time in terms of size, although we have noted that individual crocodiles are increasing in body size.

I am not trained as a scientist, and am not sure whether the names I have applied to behaviours are correct. I welcome any feedback to correctly identify and name them. Also, this is by no means a complete summary of hunting/foraging behaviours for Saltwater crocodiles, but rather descriptions of the most common behaviours that I have observed. Observations were gathered during the day and at night, and throughout the year.

Food

Food resources in the upstream section of the Daintree River do not appear to be very abundant, and small prey items predominate (eg fish, prawns, crabs, frogs, snakes). Large mammals such as wallabies, kangaroos and possums are not found in the area. Although feral pigs may sometimes be taken at the water’s edge, more often than not crocodiles leave the river and walk into adjacent paddocks to retrieve feral pig carcasses left by recreational hunters. Calf carcasses are also known to have been washed down with floodwaters, and are consumed by large crocodiles. When crocodiles do

find a large “prey” such as calf (infrequent) or feral pig, they do not eat it immediately, but will usually take it away to a small creek, away from other crocodiles, and sometimes remain with the carcass for a number of days.

Over 26 years, I have only seen birds being taken on three occasions, and on two additional occasions the attempts were unsuccessful - but I have seen plenty of opportunities where birds are in close proximity to a crocodile but are seemingly ignored. There has been a steady decline in numbers of wading birds over time, probably due to a number of factors such as loss of mud flats in the river with siltation, mud flats becoming covered with sand, and loss of wetlands due to agriculture and grazing.

The occasional water rat, cane rat and bandicoot come down to the water’s edge at night. Bat colonies are not present every year, nor do they remain for the entire year, but when bats are here it attracts the attention of larger crocodiles, although they appear to be rarely successful in catching the bats. When they are successful, it is usually Little Red Flying Foxes (*Pteropus scapulatus*), that have fallen into the river (see “Response to sounds” later). Spectacled Flying Foxes (*P. conspicillatus*) do not clump onto a single branch as do Little Reds, and in my experience they may be taken when they dip in the river for a drink - I have observed this on two occasions.

A complete list of prey that have been observed to be taken by *C. porosus* in the Daintree River are in the following article in this Newsletter (White 2023).

Images of hunting/foraging behaviours have been extracted from videos, and quality at times is not good. I suggest watching the videos to see the specific behaviours in detail.

Active Hunting

1. Side swish

The “side swish” is the most common hunting method observed. At low tide, the crocodile moves slowly in shallow water along the shoreline, occasionally moving the head sideways under the water, and from side to side, in search of submerged prey. Observed frequently in hatchling and adult *C. porosus*, during the day and night. Has also been reported in caiman (“active search”; Marioni *et al.* 2008), and described by Grigg and Kirshner (2015). See <https://youtu.be/uCF9EpLdhwM>, <https://youtu.be/SOTJz1CIWDU> and https://youtu.be/Tz-1W0AR_mk.

2. Hand out

At low tide (exposed banks), the crocodile moves parallel to the shore, with one foreleg outstretched towards the bank, making a “barrier” between its leg and head, and the shore. As prey are “felt”, the head swings inwards and snaps to grab it. Has been observed frequently in both hatchling and adult (Fig. 3) *C. porosus*, during the day and night.



Figure 3. Adult displaying “hand out” behaviour (see <https://youtu.be/wRIzG0ss1Es> and <https://youtu.be/xlvc65r7qcM>).

3. Cross-posture

This surface fishing behaviour (“cross-posture”) has been observed when there is an abundance of small prawns, and is practiced mostly away from the water’s edge, while the crocodile is swimming, and is not dependent on the tide. Both forelegs are outstretched from the body, with toes pointed upwards. It has been described in caimans (Olmos and Sazima 1999) and sub-adult/adult *C. porosus* in the Northern Territory of Australia (eg East Alligator and Mary Rivers, during fish spawning aggregations; Britton and Britton 2013; Rhind *et al.* 2015; Peberdy and Peberdy 2015). As prey strike the forelegs, the crocodile can quickly turn its head and snap at it. I see it very often, but only with very young hatchlings (Fig. 4). Adults appear to resort to the one arm (“Hand out” - see above), presumably as we do not have large congregations of fish in the Daintree River.

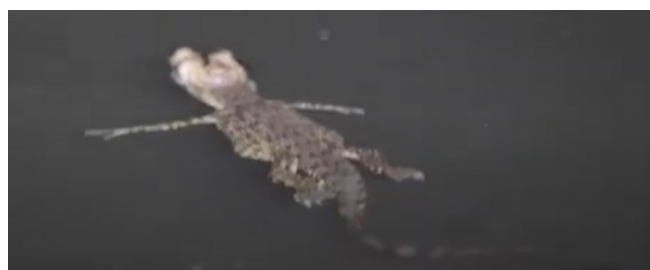


Figure 4. “Cross-posture” in hatchling *C. porosus* (see <https://youtu.be/Z8MeMzRgXmo>).

4. Tail Roundup

This is another active herding technique. Using their bodies and tails, crocodiles position themselves parallel to the shore in shallow water, orienting themselves in a curved position and walking along and trapping fish with the tail bent towards the bank. The tail corrals fish and/or prawns and sweeps them towards the crocodile’s head. Observed occasionally in hatchling (Fig. 5) and adult (Fig. 6) *C. porosus* at low tide, during the day and night. Has also been observed in caiman (Schaller and Crawshaw 1982; Marioni *et al.* 2008; Grigg and Kirshner 2015).

5. Snout burrowing in water

Crocodiles search for crabs in shallow water by totally



Figure 5. Hatchling using “tail roundup” behaviour to catch small prey at water’s edge (see <https://youtu.be/QngC3QXNNCw>).



Figure 6. Adult “Charlotte” using “tail roundup” behaviour to catch small prey at water’s edge (see https://youtu.be/uQuHKy_I1Ow).

submerging their heads and using their snouts to dig under debris in a sweeping motion looking for prey (see <https://youtu.be/n3LdBilyJMU>). They often stop walking and remain in one spot while shovelling their snout back and forth. Observed frequently in adult *C. porosus* during the day and night.

6. Getting muddy

Adult crocodiles have been observed on exposed banks, actively digging in the mud for mud crabs (*Scylla serrata*). Crocodiles appear to visually search along the banks, looking for tell-tale holes made by the crabs. Digging involves the two forelegs to widen the hole, before the snout is used to “feel” for the crab (Fig. 7). Presumably due to the large size of the crabs, only adult *C. porosus* have been observed doing this behaviour. It is not commonly observed, as crocodiles invariably stop when boats approach.



Figure 7. Adult “Scuter” with snout in mud crab hole (see <https://youtu.be/CZZruXfou1o>).

7. Dolphin lunge

Similar to the lunging behaviour observed in caimans (Marioni *et al.* 2008), crocodiles use their hind legs and tail to propel their body forward and partially out of the water, like a dolphin. Primarily used by hatchlings (Fig. 8) and has only been observed once in an adult *C. porosus*.



Figure 8. Following a dolphin lunge (left), a hatchling comes up with a prawn (right) (see <https://youtu.be/8SQdTSfou0Y>).

8. Terrestrial hunting-chasing

Terrestrial hunting (eg chasing prey; Dinets 2010) on land has been observed in hatchlings and yearlings (see <https://youtu.be/SvaEoCRD0Bc>). That it has only been observed during the day may reflect the timing of cruise activities, and perhaps it is more difficult to see at night.

9. Stalking

Similar to a cat stalking a mouse, crocodiles stalk prey with very slow and deliberate controlled movements of their body. Used by adults primarily to hunt Tioman crabs (*Tiomanium indicum*), which only come out in large numbers once a year to breed (Fig. 9). The crabs are easily spooked if they see a predator coming. This behaviour has also been observed in hatchlings hunting small crabs on land and insects up high. Observed during the day and night.



Figure 9. Adult “Lizzie” stalking Tioman crab in mangroves (see <https://youtu.be/T3AMuJy5DQI>).

10. Jumping

Crocodiles of different sizes (hatchlings, yearlings, adults) have been observed to leap vertically out of the water to take prey [eg on overhead branches, flying past (eg bats, see <https://youtu.be/fbQhN13C5qs>)]. Depending on the situation, most of the crocodile’s body can be out of the water during a jump (Fig. 10). This behaviour well-known through boat cruises in the Northern Territory of Australia, where feeding of crocodiles encourages them to “jump”.



Figure 10. Small crocodile with almost entire body out of water, jumping for small crab on branch (see <https://youtu.be/sYTn-YBzk2E>).

11. Flushing

Whilst the crocodile is in front of a prey item, it will splash the water using one foreleg after the other. I have observed this technique used successfully by a hatchling with a spider, which stayed still until the hatchling splashed the water as described, and the spider moved (Fig. 11). In this case it may have been done to make the prey move and make it more “visible” at night. In another case, an adult crocodile appeared to splash the water to distract a frog on the bank, which was taken soon after (Fig. 12).



Figure 11. Hatchling striking water with forelegs before lunging at spider on floating plant in front of it (see <https://youtu.be/Ck68GaanASE>).



Figure 12. Adult “Scuter” striking water with forelegs before lunging at Whitelipped frog on the bank in front of it (see <https://youtu.be/LU56urJfLAU>).

12. Responding to sound

Adult crocodiles have been observed responding to sounds, such as frogs calling (eg in distress). The crocodile will change its direction of swimming or move from basking position, towards the sound. Typically, once the source of the sound has been located, the crocodile makes a rapid launch at the prey. One particular crocodile has been observed responding to such auditory cues over a number of years. Caimans have been observed to wait under trees in which there are frogs (Magnusson *et al.* 1987), presumably in response to their calls. Only adult *C. porosus* have been observed responding to sounds, during the day and night (see <https://youtu.be/I4q48vpScaM>).

Similarly, crocodiles have been observed to respond to the sound of branches breaking due to groups of roosting Little Red Flying Foxes (Fig. 13). Interestingly, when Spectacled Flying Foxes are roosting, they do not appear to break branches. The sound of a branch breaking, in the absence of bats, does not elicit a response from crocodiles. Once a colony of bats is roosting nearby, crocodiles position themselves in the vicinity, waiting for bats to drink as they fly off to forage at dusk/night (see “Jumping”) or for bats to fall to the ground (as indicated by breaking branches or splashes in the water). The response to breaking branches has only been observed in adult *C. porosus* during the day.

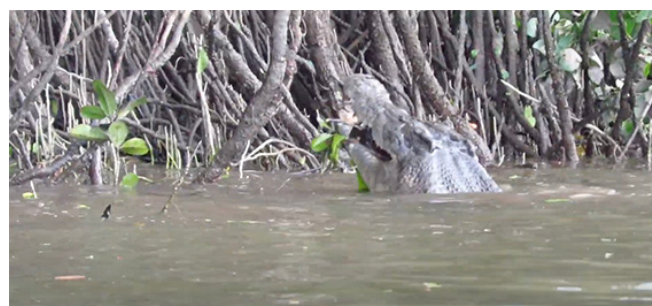


Figure 13. Adult “Dusty-Rose” responding to sound of breaking branch and grabbing a Little Red Flying Fox that had fallen (<https://youtu.be/Hxh2WZS58TA>).

13. I’m picking up good vibrations

Most feeding by hatchlings occurs at the water’s edge. However, hatchlings have been observed in deeper water, feeding at the water’s surface when there is an abundance of prey such as small prawns at night. The crocodiles appear to swim randomly, and successfully capture prey (Fig. 14), which are likely detected by “vibrations” in the water (Soares 2002, 2007).

Even when it is raining, hatchlings appear to be able to discern small prawns from raindrops hitting the water. Grap *et al.* (2020) reported that surface waves generated by prey contain higher frequencies than the surface waves caused by wind, falling leaves, seeds or rain drops. So, from a very young age, crocodiles appear to be able to distinguish between the frequency of waves.



Figure 14. Hatchlings appear to be able to distinguish movement of prey from raindrops (see <https://youtu.be/ZpC9nr29h50>).

Passive hunting

14. Damming

Crocodiles place their bodies, with tail positioned upstream, across small run-off channels created by falling tides or rainfall (Fig. 15). Prey items such as fish and prawns, that are swept out of the channel, must pass by the crocodile's head, where they can be taken. I have only observed this behaviour in adult *C. porosus*. A similar behaviour has been reported in caimans (eg Marioni *et al.* 2008; Schaller and Crawshaw 1982; Thorbjarnarson 1993).



Figure 15. Adult "Scuter" damming run-off channel. Water is flowing to the left in this photograph (see <https://youtu.be/w2TnTDZsoRU>).

A variation of the damming behaviour has been observed when the run-off channel is very narrow. Instead of the body being positioned across the channel, the crocodile places its head directly into the outflowing water of the channel, catching prey as it comes out with the flow (Fig. 16).



Figure 16. Adult "Lizzie" positioning herself in front of a run-off channel (see <https://youtu.be/29omUNzpyWQ>).

15. Open and hope'n

Only observed in hatchlings and yearlings, they lay motionless in the shallows with their head in the water and mouth wide open, with the bottom jaw below the waterline - hoping for food (Fig. 17). Crocodiles snap at anything that passes through their open mouths (eg a wave made by boats may wash small prey directly into their mouth). It has been observed the day and night. In the Northern Territory of Australia, adult *C. porosus* have been observed doing this behaviour (D. Kirshner, pers. comm.).



Figure 17. Hatchlings at water's edge with mouths open, ready to snap at small prey passing by their jaws (see https://youtu.be/zdUBgJ_cxCU).

All ass no class

A case of the right place at the right time, or pure fluke - a hatchling was observed using its tail to flick a prawn into the air and into its mouth. However, the movement of the tail appears to be associated with the hatchling having its head out of the water to catch small prawns that are jumping out of the water (Fig. 18).



Figure 18. Hatchling feeding amongst prawns jumping out of the water (see <https://youtu.be/SSzev2nBvho>).

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Literature Cited

- Britton, A. and Britton, E. (2013). *Crocodylus porosus* (Saltwater crocodile). Fishing behavior. Herpetological Review 44(2): 312.
- Dinets, V. (2010). On terrestrial hunting by crocodilians.

- Grap, N.J., Machts, T., Essert H, S. and Bleckmann, H. (2020). Stimulus discrimination and surface wave source localization in crocodilians. *Zoology (Jena)* 139 (doi: 10.1016/j.zool.2020.125743).
- Grigg, G. and Kirshner, D. (2015). *Biology and Evolution of Crocodylians*. CSIRO Publishing: Australia.
- Magnusson, W.E., Vieira da Silva, E. and Lima, A.P. (1987). Diets of Amazonian crocodilians. *Journal of Herpetology* 21(2): 85-95.
- Olmos, F. and Sazima, I. (1999). A fishing tactic in floating Paraguayan caiman: The cross-posture. *Copeia* 1999: 875-877.
- Peberdy, C. and Peberdy, C. (2015). Saltwater crocodiles fishing for mullet. *Crocodile Specialist Group Newsletter* 34(3): 27.
- Rhind, D., Ricketts, A., Calvert, G. and Lyons, K. (2015). *Crocodylus porosus* (Estuarine Crocodile). Fishing behavior. *Herpetological Review* 46(2): 248-249.
- Schaller, G.B. and Crawshaw Jr., P.G. (1982). Fishing behavior of Paraguayan caiman (*Caiman crocodilus*). *Copeia* 1982(1): 66-72.
- Soares, D. (2002). An ancient sensory organ in crocodilians. *Nature* 417: 241-242.
- Soares, D. (2007). The evolution of dome pressure receptors on crocodiles. Pp. 157-162 in *Evolution of Nervous Systems*, ed. by J.H. Kaas and T.H. Bullock. Elsevier: Amsterdam.
- Thorbjarnarson, J.B. (1993). Fishing behavior of Spectacled caiman in the Venezuelan Llanos. *Copeia* 1993(4): 1166-1171.
- White, D. (2023). Diet of Saltwater crocodiles in the Daintree River, Australia. *Crocodile Specialist Group Newsletter* 42(2): 21-22.
- David White, 1585 Mossman Daintree Road, Wonga Beach, Queensland 4873, Australia.

DIET OF SALTWATER CROCODILES IN THE DAINTREE RIVER, AUSTRALIA. Over the course of 26 years of operating a boat cruise in the Daintree River, Queensland, Australia, I have made numerous observations of prey being taken by Saltwater crocodiles (*Crocodylus porosus*). These observations were made in a 5-6 km section of the Daintree River, starting some 10 km upstream of the river mouth. This part of the river is tidal, brackish, and bordered by mangroves, sugarcane farms and cattle pastures (see Figs. 1 and 2 in White 2023). A summary of associated hunting/foraging behaviours is also provided by White (2023).

The small population of *C. porosus* in this area is comprised mainly of adults (N= 15; 2.5<4.7 m TL). Hatchlings (0.25<0.6 m TL) and yearlings (0.6<0.9 m TL) are also commonly sighted, although numbers vary depending on the extent of successful nesting and mortality in the first year of life. Juveniles (0.9<2.5 m TL) tend to be very wary, and are not sighted commonly.

Prey observed to be taken by different size classes of crocodile are in Table 1. Although feral pigs may be taken at the water's edge, adult crocodiles mostly leave the river and walk into adjacent paddocks to scavenge feral pig carcasses that have been left by recreational hunters. Likewise, the occasional calf carcass washed down by floodwaters, is consumed by large crocodiles (White 2023).

Table 1. Prey items observed to be taken by hatchling (H), yearling (Y), juvenile (J) and adult (A) *C. porosus*.

Mammals		
Domestic dog	<i>Canis familiaris</i>	A
Feral pig (scavenged)	<i>Sus scrofa</i>	A
Cow (scavenged)	<i>Bos taurus</i>	A
Canefield rat	<i>Rattus sordidus</i>	J
Brown bandicoot	<i>Isodon macrourus</i>	A
Spectacled flying fox	<i>Pteropus conspicillatus</i>	A
Little red flying fox	<i>Pteropus scapulatus</i>	A
Birds		
Radjah shell duck	<i>Tadorna radjah</i>	A
Black butcherbird	<i>Cracticus quoyi</i>	A
Australian White Ibis	<i>Threskiornis molucca</i>	J
Reptiles		
Saltwater crocodile	<i>Crocodylus porosus</i>	A
Scrub python	<i>Simalia kinghorni</i>	A
Little file snake	<i>Acrochordus granulatus</i>	A
Common tree snake	<i>Dendrelaphis punctulatus</i>	A
Water python	<i>Liasis fuscus</i>	A
Amphibians		
White lipped tree frog	<i>Nyctimystes infrafrenatus</i>	J, A
Cane toad	<i>Rhinella marina</i>	H, Y, J, A
Fish		
Bull shark	<i>Carcharhinus leucas</i>	A
Barramundi	<i>Lates calcarifer</i>	A
Catfish	-	A
Fish	-	Y, J, A
Mudskipper	Family Oxudercidae	H, Y
Eel	<i>Anguilla reinhardtii</i> (?)	J
Crustaceans		
Mud crab	<i>Scylla serrata</i>	A
Tioman crab	<i>Tiomanium indicum</i>	A
Shore crab	<i>Metopograpsus frontalis</i>	Y, J, A
Mangrove crabs	various species	Y, J, A
Fiddler crabs	various species	Y, J
Prawns	various species	H, Y, A
Insects		
Katydid	-	H, Y
Spiders	-	H, Y
Cockroaches	-	H

I have never seen an adult *C. porosus* eat a hatchling, and yet I have seen plenty of opportunities to do so. This supports Webb and Manolis (1992), who indicated that *C. porosus* hatchling survival appears to be independent of the number of larger crocodiles in the population. I have seen two hatchlings eaten by 2-year-old juveniles, a 12-year-old adult female eat a 3-year-old juvenile, and an adult female eat a 4-year-old juvenile.

The observations here contribute to our knowledge of the diet of *C. porosus* in tidal habitats (Figs. 1-3), particularly adults. Previous published accounts have dealt primarily with the diet of juveniles and sub-adults (Taylor 1979; Webb *et al.* 1991).

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I thank Charlie Manolis for assistance with drafting of this article.

Literature Cited

- Taylor, J.A. (1979). The foods and feeding habits of subadult *Crocodylus porosus* Schneider in northern Australia. *Australian Wildlife Research* 6: 347-359.
- Webb, G.J.W., Hollis, G.J. and Manolis, S.C. (1991). Feeding, growth and food conversion rates of wild juvenile saltwater

crocodiles (*Crocodylus porosus*). *Journal of Herpetology* 25: 462-473.

Webb, G.J.W. and Manolis, S.C. (1992). Monitoring saltwater crocodiles (*Crocodylus porosus*) in the Northern Territory of Australia. Pp. 404-418 in *Wildlife 2001: Populations*, ed. by D.R. McCullough and R.H. Barrett. Elsevier Applied Science: New York.

White, D. (2023). Hunting and foraging behaviour of Saltwater crocodiles. *Crocodile Specialist Group Newsletter* 42(2): 16-21.

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EVOLUTIONARY HISTORY OF CROCODYLIFORMES IN AUSTRALASIA. A recent publication, authored by Ristevski *et al.* (2023), summarises our current understanding on the taxonomic diversity and phylogenetic relationships of Australasian crocodyliforms, based on first-hand knowledge of fossil material and a detailed review of the published literature (see page 31 for Abstract). I congratulate the authors, who have done an excellent job of pulling together our knowledge on this topic, and I thoroughly recommend the publication to anyone interested in the 113 million year history of crocodyliformes in this region.



Figure 1. Saltwater crocodile with (from left): Scrub python, Mud crab and Australian white ibis.



Figure 2. Saltwater crocodile with (from left): Little file snake, crab and eel.



Figure 3. Saltwater crocodile with (from left): mudskipper, eel and crab.

Ristevski, J., Willis, P.M.A., Yates, A.M., White, M.A., Hart, L.J., Stein, M.D., Price, G.J. and Salisbury, S.W. (2023). Migrations, diversifications and extinctions: the evolutionary history of crocodyliforms in Australasia. *Alcheringa: An Australasian Journal of Palaeontology* (<https://doi.org/10.1080/03115518.2023.2201319>).

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Recent Publications

Martin, A.J. (2023). *Life Sculpted. Tales of the Animals, Plants, and Fungi That Drill, Break, and Scrape to Shape the Earth*. University of Chicago Press: Chicago.

Overview: Did you know elephants dig ballroom-sized caves alongside volcanoes? Or that parrotfish chew coral reefs and poop sandy beaches? Or that our planet once hosted a 5-ton dinosaur-crunching alligator cousin? In fact, almost since its fascinating start, life was boring. Billions of years ago bacteria, algae, and fungi began breaking down rocks in oceans, a role they still perform today. About a half-billion years ago, animal ancestors began drilling, scraping, gnawing, or breaking rocky seascapes. In turn, their descendants crunched through the materials of life itself - shells, wood, and bones. Today, such “bioeroders” continue to shape our planet - from the bacteria that devour our teeth to the mighty moon snail, always hunting for food, as evidenced by tiny snail-made boreholes in clams and other moon snails. There is no better guide to these lifeforms than Anthony J. Martin, a popular science author, paleontologist, and co-discoverer of the first known burrowing dinosaur. Following the crumbs of lichens, sponges, worms, clams, snails, octopi, barnacles, sea urchins, termites, beetles, fishes, dinosaurs, crocodilians, birds, elephants, and (of course) humans, *Life Sculpted* reveals how bioerosion expanded with the tree of life, becoming an essential part of how ecosystems function while reshaping the face of our planet. With vast knowledge and no small amount of whimsy, Martin uses paleontology, biology, and geology to reveal the awesome power of life’s chewing force. He provokes us to think deeply about the past and present of bioerosion, while also considering how knowledge of this history might aid us in mitigating and adapting to climate change in the future. Yes, Martin concedes, sometimes life can be hard - but life also makes everything less hard every day.

Pereira Filho, G.A., Barreto Guedes, T., Candido de França, R., de Freitas, M.A., Lourenço-de-Moraes, R., Oliveira Mesquita, D., Sales Nunes, P.M., Ribeiro Delfim, F., Dubeux, M.J.M. and Rodrigues França, F.G. (2023). Composition, species richness, and conservation of the reptiles of the highly threatened northern Brazilian Atlantic forest. Pp. 169-183 in *Animal Biodiversity and Conservation in Brazil’s Northern Atlantic Forest*. Springer: Cham.

Abstract: The northern Brazilian Atlantic Forest comprising the states of Alagoas, Pernambuco, Paraíba, and Rio Grande do Norte is considered a distinct biogeographic unity, also known as Pernambuco Endemism Center (PEC). This unique area harbors a high biodiversity with threatened, rare, and endemic species and is considered of high relevance for the preservation of the whole biome. In this chapter, we present for the first time a complete list of all reptile species found in PEC, composed by 6 species of amphisbaenians, 38 lizards (3 endemics), 88 snakes (7 endemics), 5 chelonians, and 2 crocodilians. The numbers can be considered high but can increase once many areas remain unexplored. We also

present beta diversity analyses showing that the south of Pernambuco and Alagoas state are the richest regions; on the other hand, the north of Rio Grande do Norte presents low numbers of species and can be considered the poorest area. A possible explanation for these differences in richness and species composition possibly relies on floristic distinctiveness and differences in the moisture along the area. We also detected the insufficient number of conservation units in PEC denoting a worrying panorama for the most threatened sector of the entire Atlantic Forest. Conservation measures combined with scientific research are urgent to protect such unique and important forests.

Sánchez Álvarez, B., Pérez Garduza, F., Monroy Ojeda, A., Santiago Plata, V.M., López Mondragón, S. and Charrau, P. (2023). Bird-herpetofauna interactions in the Usumacinta River basin, Mexico. *Revista Latinoamericana de Herpetología* 6(1): 131-139.

Abstract: Interspecific interactions between vertebrates of different groups are common but also complex and of great importance for community structure. In particular, predation, considered a trophic interaction, plays a significant role in food webs structure and selective effects on prey in natural ecosystems. In this paper we provide new information on the trophic relationship between birds and herpetofauna (reptiles and amphibians) in the complex and biodiverse Usumacinta River basin, through 10 observations recorded between 2012 and 2021. The observations show interactions for feeding purposes of 8 bird species, including herons (*Tigrisoma mexicanum*), jays (*Psilorhinus morio*), raptors (*Caracara cheriway*, *Pseudastur albicollis*, *Harpagus bidentatus*, *Buteo plagiatus*), puffbirds (*Malacoptila panamensis*), and ducks (*Dendrocygna autumnalis*), with snakes (*Coniophanes quinquevittatus*), turtles (*Chelydra rossignonii*, *Trachemys venusta*), lizards (*Iguana iguana*, *Sceloporus serrifer*), crocodiles (*Crocodylus moreletii*), and frogs (*Smilisca baudinii*).

Numbere, A.O. and Otufu, P.P. (2023). Exploration of local beliefs and cultural heritages as tools for species Conservation in selected sites in Africa. Pp. 177-202 in *Sustainable Utilization and Conservation of Africa’s Biological Resources and Environment*, ed. by S.C. Izah and M.C. Ogwu. Springer: Singapore.

Abstract: The most effective means of conserving species is incorporating the human factor in the conservation plan, a “win-win” ecology situation. In Africa, cultural and traditional heritages are highly respected because they are conservation tools and play a vital role in people’s daily lives. There is a strong acceptance of local cosmology, which believes in the potency of ancestral spirits and powers. Therefore, traditional laws can be used to protect sites with endangered species and would prevent the overexploitation and extinction of many species in the Niger Delta area. Sacred places can be established in localities that have endangered species across the region, such as the crocodile (*Osteolaemus tetraspis*) holy site in the Biseni and Osiana Kingdoms, which resulted over the years in the protection of thousands of this species from human hunting. If adequately documented, the protected areas can serve as conservation sites that become a tourist’s attraction to generate revenue for the local community. Therefore, this chapter uniquely provides examples of how local belief has been used to preserve forests and rivers in some Niger Delta communities.

Gunnin, D., Schubert, B.W. and Woodward, H.N. (2023). Testing paleohistological assumptions using a large-scale study of *Alligator mississippiensis* with application to a fossil alligator from the southern Appalachians. Oral presentation, Appalachian Student Research Forum, East Tennessee University (<https://dc.etsu.edu/asrf/2023/schedule/11/>).

Abstract: Histological analysis of long bone thin sections has in recent decades been broadly applied to infer growth rates and ecology

in extinct vertebrates, particularly within non-analogous clades. Meaningful interpretation of bone histology and extrapolation to an extinct organism's life history requires a robust understanding of the factors influencing bone growth and histological presentation. Archosaurs are commonly the subject of osteohistological studies and, as such, much of our knowledge of their paleohistology is derived from the two extant lineages: avian dinosaurs and crocodylians. The American alligator (*A. mississippiensis*) is widely available for study in the United States and several osteohistological analyses have been published. These studies focused on intraskeletal variation, histovariability, and skeletochronology in one or a few specimens, and in one study a larger sample of pen-raised captive born specimens. However, no published studies test paleohistological assumptions using large-scale geographic and climatic variation in bone histology among extant wild crocodylians. To fill this gap in our knowledge of archosaurian osteohistology, we prepared a collection of humeral and femoral thin sections of 45 *Alligator* from North Carolina, Arkansas, Georgia, and South Carolina. Previously prepared thin sections from pen-raised Louisiana *Alligator* were also included. For this study we began by comparing growth rates inferred from counts and measurements of arrested growth (LAGs), which represent annual cycles, and femoral dimensions which correlate strongly to body length. Comparison of these data revealed that, on average, *Alligator* specimens subject to shorter growing seasons (ie those in cooler climates) tend to show more LAGs when compared to more southerly *Alligator* specimens of similar size. Bone tissue also varies between specimens, suggesting a variable tempo of bone growth in response to differing climatic and environmental regimes. Finally, histological thin sections of early Pliocene *Alligator* fossils from the Gray Fossil Site (GFS), Washington Co., Tennessee were prepared to explore the paleobiology of this biogeographically unique Appalachian alligator. Assessing variation in this fossil taxon's closest living relative (*A. mississippiensis*) provides insight into the paleoecology and growth rates of the GFS *Alligator*, as well as the climate of the southern Appalachians during the past. Results suggest that the fossil species may have grown more slowly than extant relatives along the southeastern United States coastal plain, and that some parts of the skeleton reached asymptotic growth at a smaller size.

Enchev, M. (2022). Small, small metacrocodyliad. Pp. 189-208 in *Si Sapis, Sis Apis, Anniversary Collection, Dedicated to the 65th Anniversary of Prof. PhD Denka Krasteva*. University Publishing House "Bishop Konstantin Preslavski": Shumen. (In Russian)

Abstract: The article addresses the presence of the image of the crocodile in children's literature, concerned with its semantic features and functional variations, while based on a fictional material without any historical, genre, or national peculiarities. It explores the aesthetic uses of the crocodile in a didactic, psychotherapeutic, and game context, and observes its hidden usage in political semantics.

Andrade, R.C.L.P., Sena, M.V.A., Brum, A.S., Campos, D.A., Kellner, A.W.A., Bantim, R.A.M.B. and Sayão, J.M. (2023). Osteohistology of the big-sized cretaceous crocodylomorph *Stratiosuchus maxhechti* (Notosuchia, Baurusuchidae) indicates fast growth and niche partitioning with medium-sized theropods. *Journal of South American Earth Sciences* (<https://doi.org/10.1016/j.jsames.2023.104363>).

Abstract: Among the wide diversity of notosuchian crocodyliforms, Baurusuchidae is remarkable by their morphology, indicating a terrestrial hypercarnivory habit during the Late Cretaceous of Gondwana. Commonly, amongst baurusuchids, the anatomy of the large-sized *Stratiosuchus maxhechti* shows theropod mimic features in its skull and limb bones. Such similarities supported the hypothesis of competitive exclusion of medium to large-sized theropods by baurusuchids. However, a recent taphonomical approach claims that other lines of evidence should be considered (eg biomechanics); the fossil record is biased in Bauru Group; and

supported a niche partitioning between theropods and baurusuchids. Here we performed a paleohistological analysis on a baurusuchid (*S. maxhechti*) to evaluate if the terrestrial ecology implies fast growth and if microstructure is similar to that found in theropods, with insights into a niche competition hypothesis. Two different specimens were samples for this study, two femora (DGM 1477-R) and a left ulna and tibia (MCT 1714-R). All four samples show the presence of a fibrolamellar complex arranged in a cyclical growth. The growth zones are composed of woven matrix that gradually turns into a lamellar zone, and is followed by LAGs. There is also the presence of simple and anastomosed vascular canals. Compared to living crocodylians the growth shows a higher depositional rate and a more complex organization pattern. In this respect, the growth dynamics are like medium-to-large theropods. *Stratiosuchus* lacks an external fundamental system, which means that the material studied here represents individuals that died before reaching maximum size, suggesting that they could take more than twelve years to reach full size. Comparing the body mass estimates by femoral circumference (~178-180 kg) and the bone microstructure with theropods, they share a fast growth pattern of fibrolamellar bone. However, for the diversity in body sizes, favor the niche partitioning hypothesis over the suggestion of competitive exclusion between baurusuchids and theropods as previously advocated.

Moleón, M.S., Santiago, G., Hilevski, S. and Siroski, P.A. (2023). Blood biochemistry parameters of Broad snouted caiman, *Caiman latirostris* subjected to stress conditions, applying micro-volume techniques. *Journal of Experimental Zoology A, Ecology and Integrative Physiology* (doi: [10.1002/jez.2705](https://doi.org/10.1002/jez.2705)).

Abstract: Plasma biochemistry values represent a crucial and minimally invasive tool for evaluating nutritional and physiological condition of the animal. Biochemical data provides valuable information in those species exposed to environmental stressors. In this study, we aimed to apply for the first time micro-volume plasma tests to measured total plasma protein, albumin, and glucose in juvenile *Caiman latirostris* and to compare our results with other studies reporting crocodylian biochemistry values. We found that caimans from heat treatment were heavier, longer and had higher levels of glucose than those from the control group. Conversely, food restricted caimans had less growth, body condition and had 32.1% lower albumin concentrations than those from the control group. While no significant differences were observed in any parameters measured from water restricted caimans compared with control group. The values obtained for each of the biochemical determinations were lower than those previously reported for adult of *C. latirostris*, but similar finding for protein concentration compared with *Alligator mississippiensis*. Micro technique offers the advantage of increasing information and at the same time a greater physiological understanding of the crocodylian species.

Sales-Oliveira, V.C., dos Santos, R., Gomes Goes, C.A., Milan Calegari, R., Garrido-Ramos, M.A., Altmanová, M., Ezaz, T., Liehr, T., Porto-Foresti, F., Utsunomia, R. and de Bello Cioffi, M. (2023). Evolution of ancient satellite DNAs in extant alligators and caimans (Crocodylia, Reptilia). *bioRxiv* (<https://doi.org/10.1101/2023.04.18.537305>).

Abstract: Crocodylians are one of the oldest extant vertebrate lineages, which exhibits a combination of evolutionary success and morphological resilience that have persisted throughout the history of life on Earth. Such an ability to endure over such a long geological time span is of great evolutionary importance. Here, we performed a comprehensive analysis of the satellite DNA diversity of the extant alligators and caimans, making significant progress in our understanding of the evolution of repetitive regions present in ancient genomes. The alligators and caimans displayed a small number of satDNA families (varying between 3 and 13 satDNAs, in *A. sinensis* and *C. latirostris*, respectively) as well as little variation both within and between species, highlighting an exceptional

long-term conservation of satDNA elements throughout evolution. We also tracked the origin of the ancestral forms of all satDNAs belonging to the common ancestor of Caimaninae and Alligatoridae. Fluorescence *in situ* experiments showed distinct hybridization patterns for the identical ortholog satDNAs, indicating their inner dynamic evolution. Why, in addition to their previously known low genetic, karyotype, and morphological diversity, have crocodilians altered so little over such a long period of time with such a highly variable genome fraction? We argued that such an “evolutionary package” was likely the outcome of severe demographic declines or founder events and that it represents evolutionary responses to a long-lasting bottleneck history.

Zhang, N., Zhang, H., Fan, G., Sun, K., Jiang, Q., Lv, Z., Han, B., Nie, Z., Shao, Y., Zhou, Y., Zhang, B., Wu, X. and Pan, T. (2023). Effects of eggshell thickness, calcium content, and number of pores in erosion craters on hatching rate of Chinese alligator eggs. *Animals* 13: 1405.

Abstract: The Chinese alligator (*Alligator sinensis*), found only in a small region in southeastern Anhui Province, is listed as critically endangered (CR) by the International Union for Conservation of Nature (IUCN) due to its current declining population trend. Any abnormalities in the physical properties of an egg can decrease the hatching rate. In particular, eggshells play an essential role in embryo development, motivating us to analyze the microstructures of the eggshells of Chinese alligators. In this study, we categorized the eggshells into two groups, based on the hatching rates, and analyzed the relationship between the eggshell parameters (eggshell thickness, calcium content, and number of pores in erosion craters) and the hatching rate, as well as the relationships between the eggshell parameters. We found that the shells of the eggs with high hatching rates were thicker than those of the eggs with low hatching rates. There were also fewer erosion-crater pores on the surfaces of the eggs with high hatching rates than on the surfaces of the eggs with low hatching rates. Moreover, the shell Ca content was significantly higher in the eggs with high hatching rates than in the eggs with low hatching rates. Cluster modeling indicated that the highest hatching rate occurred when the eggshell thickness was 200-380 μm and there were 1-12 pores. These results suggest that eggs with adequate Ca contents, thicker shells, and less air permeability are more likely to hatch. Furthermore, our findings can inform future studies, which will be vital for the survival of the critically endangered Chinese alligator species.

Kline, C. (2023). Centering animals within rural tourism. Pp. 344-358 in *Handbook on Tourism and Rural Community Development*, ed. by H. Mair. Edward Elgar Publishing: Northampton, Massachusetts USA.

Abstract: This chapter opens with a brief synopsis of how tourism literature has addressed: animals in rural tourism to date and outlines various elements of context where animal-based tourism can be found, paying particular attention to the context of rural community development. Applying the tenets of Critical Theory to animal tourism, it becomes evident where gaps exist in the current efforts of both the academy and industry. To move forward, a transmodern paradigm on animals in rural tourism is suggested - particularly by employing partners to make co-creating efforts robust and bring to bear the advantages of varying perspectives and knowledges. The chapter closes with two cases of activities that embody rural lifestyles and heritage and how we might find a solution to animal welfare violations through a new form of tourism and rural community development.

Guo, K., Wang, C-F., Du, Y., Qu, Y-F., Braña, F. and Ji, X. (2023). The functional significance of residual yolk in lizards. *Current Zoology* 69(2): 192-199.

Abstract: Residual yolk is assumed to be an important source of energy and nutrients during early life in nonmammalian amniotes. Available data show that the mean size of residual yolk is far smaller in lizards than in turtles, snakes, crocodiles, and birds, raising a question of whether residual yolk is of functional significance in lizards. Here, we compared data from 26 lizard species with those from other nonmammalian amniotes to test the hypothesis that residual yolk is functionally less significant in species producing more fully developed offspring. In our sample, species mean offspring water contents ranged from 73% to 84% of body wet mass; species mean proportions of carcass dry mass, fat-body dry mass, and residual yolk dry mass to offspring dry mass ranged from 84% to 99%, 0% to 5.0%, and 0% to 14.4%, respectively. Lizards are, on average, more fully developed at hatching or birth than snakes, as revealed by the fact that the mean proportion of carcass dry mass to body dry mass and offspring water contents were both higher in lizards than in snakes. We conclude that the functional significance of residual yolk during early life is generally less evident in lizards. Even in the lizards where residual yolk is of potential functional significance, this portion of yolk contributes little, if any, to postembryonic growth. Future work could usefully collect data across a wider spectrum of reptile taxa to establish a precocial-altricial continuum and test the hypothesis that species with a smaller amount of residual yolk are closer to the precocial end of the continuum.

Bona, P., Pol, D., Perez, L.M., Tineo, D.E., Brandoni, D. and Noriega, J.I. (2023). The first record of *Purussaurus* (Crocodylia, Alligatoridae) in the Late Miocene of Argentina. *Revista del Museo Argentino de Ciencias Naturales nueva serie* 25(1): 71-84.

Abstract: Herein we report the first record of *Purussaurus* Barbosa-Rodrigues, 1892 for the Neogene of Argentina. This genus is recorded in Miocene beds of different localities in Colombia, Venezuela, Brazil, and Perú, and includes at least three different species with total body lengths ranging from 8 to 13 m. The material reported here is a partially preserved tooth (MAS-PV 386) found at the locality Toma Vieja (Paraná, Entre Ríos Province, Argentina), in strata informally known as “Conglomerado osífero” or “Mesopotamiense” (Late Miocene) and traditionally regarded as the basal levels of the Ituzaingó Formation. The material corresponds to the apical portion of a conical crown, slightly compressed, lingually curved, and with a subrounded apex. The enamel is ornamented with thin apicobasal ridges that are anastomosed and separated by shallow grooves. These ridges are transversely crossed by shallow lines that give the enamel surface a crackled aspect. The crown has a continuous carina formed by the enamel that runs along the mesial and distal surface of the tooth, which divides the vestibular (or labial side of the tooth) and lingual faces of the crown that are subequal in size. The carina is ornamented with fine enamel wrinkles that are parallel to each other and perpendicular to the mesiodistal carina. This condition, known as pseudozipodonty, together with the enamel structure and overall shape of the crown, allow referring the specimen MAS-PV 386 to *Purussaurus* sp. This finding represents the southernmost record of one of the largest predatorial neosuchian crocodylians which inhabited the wetlands that developed during the Late Miocene in South America.

Johnson, E., Arias, E., Daniels, T. and Greene, N. (2023). Temporal patterns in tooth morphology in secondarily aquatic tetrapods. In 27th Annual Symposium of Student Scholars, Kennesaw State University (<https://digitalcommons.kennesaw.edu/undergradsymposiumksu/spring2023/presentations/179/>).

Abstract: We investigated how dental morphology has changed over time in secondarily aquatic tetrapods: vertebrate clades with terrestrial ancestors who evolved into fully aquatic or marine forms. Such clades include crocodilians, ichthyosaurs, mosasaurs, and cetaceans. Secondarily aquatic tetrapods are characterized by a myriad of morphological changes such as limb reduction, body

streamlining, and sensory organ alteration. The teeth and skulls of extant and fossil cetaceans and crocodilians were examined using museum specimens and image repositories. We used ImageJ to measure the dimensions of the skulls and teeth. The results suggest that dental morphology was influenced by the body size and feeding method (observed or inferred) of each species. Crocodilian tooth shape was more affected by body size than by temporal patterns. Cetacean dental morphology diverged over time into two lineages, each characterized by the retention of teeth or replacement of teeth by baleen. Within the extant toothed whales, dental morphology exhibits variation in size but convergence of shape. The results of this investigation will shed light on patterns of convergent evolution in the secondarily aquatic vertebrates.

Mograbi, P.J., Archer, E., Fabricius, C., Wynberg, R. and Donaldson, J. (2023). The sustainable use of wild species benefits biodiversity and human wellbeing in South Africa. *South African Journal of Science* 119(3/4) (<https://doi.org/10.17159/sajs.2023/15739>).

Abstract: A recent report from the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) assessed how the sustainable use of wild species benefits people and nature, and which policies work best to prevent unsustainable exploitation. In the context of an accelerating and alarming biodiversity crisis, the assessment findings have important implications for South Africa, a megadiverse country with a population that relies extensively on the use of wild species for food, energy, medicine, and income, amongst many other purposes. This Commentary reflects on implications of the IPBES assessment for South Africa, drawing on insights from local contributing authors.

Moss, R.A., Murphy, K.M., Gardner, S.T., Watkins, M.M., Finger, J.W., Kelley, M.D., Elsey, R.M., Warner, D.A. and Mendonça, M.T. (2023). Exposure to ecologically relevant estrogen levels do not influence morphology or immune parameters in hatchling American alligators (*Alligator mississippiensis*). Available at SSRN: <https://ssrn.com/abstract=4420990> or <http://dx.doi.org/10.2139/ssrn.4420990>.

Abstract: Human activity (eg agriculture, waste management) has increased the concentrations of endocrine-disrupting contaminants (EDCs) in many ecological systems. Many EDCs are xenoestrogens, which imitate naturally derived estrogen like estradiol 17- β (E2). These pollutants can critically affect a broad range of biological functions, particularly in organisms inhabiting aquatic environments. E2 and associated receptors are involved in regulating innate immune responses, thus documenting the influence of exogenous E2 on immune parameters is important for understanding health consequences. In this study, we document the impact of environmentally-relevant concentrations of E2 on circulating glucocorticoid levels and several innate immune parameters in hatchling American alligators (*Alligator mississippiensis*). Twenty-three hatchling alligators were randomly placed in one of three groups: control (no E2 exposure), low E2 (0.5 μ g/kg E2), or high E2 (1 μ g/kg E2). Several biomarkers were quantified to monitor the impact of E2: growth, change in body condition, white blood cell (WBC) counts, glucocorticoid levels, and general antibody response. Blood E2 concentrations were greater in individuals exposed to E2 compared to controls, but plasma corticosterone levels were reduced among the experimental groups. Morphology, growth, and immune parameters of E2 exposed animals did not differ from controls. These results suggest that acute exposure to increased environmental estrogen concentrations may alter plasma hormone concentrations but have little to no impact on morphology or immune responses. Future studies may expand on this by monitoring biomarkers in wild populations across time, which will provide insight into how different species are impacted by environmental contaminants.

Booth, S., Taplin, L., Brien, M., Campbell, H. and Christian,

K. (2023). Aversive conditioning of larger estuarine crocodiles (*Crocodylus porosus*) and the remote deployment of transmitters. *Herpetological Conservation and Biology* 18(1): 168-181.

Abstract: Aversive conditioning has been used with terrestrial predators to reduce conflict with humans by changing predator behavior or moving them away. Proving the effectiveness of this management tool for cryptic animals, however, can be challenging. In this study, we assessed the interaction between presence and sightability in Estuarine Crocodiles (*Crocodylus porosus*) after a period of aversive conditioning. Crocodiles >2 m in length were subjected to aversive conditioning using two non-lethal beanbags fired from a 12-gauge shotgun. Traditional night-time surveys were conducted prior to and after aversive conditioning to determine any changes in crocodile sightability. To detect crocodiles underwater and their movement, we attached acoustic transmitters with a hand-held pole harpoon, which were monitored with an acoustic receiver array. This technique allowed for transmitter attachment without the need for capture. Immediately after aversive conditioning, there was a significant reduction in the sightability of larger Estuarine Crocodiles (>2 m) using traditional spotlight survey, and a detectable change in the movement patterns of two of the three tagged individuals. The two tagged crocodiles resumed normal movement patterns soon after (42 h, 15 d) and no crocodiles left the area in response to the treatment. Aversive conditioning has limited use in moving crocodiles away from a discrete area; however, it did have a short-term impact on crocodile behavior and crocodiles became more challenging to detect by traditional spotlight survey. The reduced sightability may indicate an increased wariness of people, which in some circumstances may be an acceptable outcome for management.

Howell, H.J. and Searcy, C.A. (2023). The role of invasive species and charismatic megafauna in everglades herpetofaunal research. *Herpetological Conservation and Biology* 18(1): 128-139.

Abstract: The Everglades of south Florida, USA, is a unique natural wildlife area, which is home to a diverse array of native herpetofaunal species. The Everglades have undergone transformations fueled by ongoing habitat loss and fragmentation, hydrological modification, a deluge of introduced exotic and invasive species, and the implementation of various ecosystem-wide restoration projects. Here, we analyzed trends in the herpetofaunal research over a 20-y period between 2001 and 2021 by conducting a review of the published scientific literature. We conducted a separate review of unpublished abstracts from the Greater Everglades Ecosystem Restoration Conference (GEER) to compare localized research trends and to include research that may not have been published in a peer-reviewed journal. We included 235 papers in our literature review of published articles and 150 poster and paper presentations from the GEER meetings from 2001-2021. We found a significant positive trend in the number of studies on Everglades herpetofauna over this period, driven primarily by an increase in research focused on invasive species. In addition, there are taxonomic biases in the literature, with crocodilians being significantly over-represented relative to their taxon diversity and Caudates completely absent. Studies on a single invasive species, the Burmese Python (*Python bivittatus*), account for 22% of all published literature during this period and 30% of all GEER presentations. This review highlights both broad trends and large gaps in the Everglades herpetofaunal research and offers direction for future studies seeking to provide a more complete assessment of Everglades reptiles and amphibians.

Halaçlar, K., Rummy, P., Liu, J., Hunt, A., Van Do, T., Trung Minh, N. and Deng, T. (2023). Exceptionally well-preserved crocodilian coprolites from the Late Eocene of northern Vietnam (Na Duong Formation): Ichnology and paleoecological significance. Available at SSRN: <https://ssrn.com/abstract=4429570> or <http://dx.doi.org/10.2139/ssrn.4429570>.

Abstract: This study aims to reconstruct the paleoenvironment of the Na Duong Basin by examining 55 coprolites and coprolite fragments from the fossil site. The use of coproecology is essential for understanding the intensive prey-predator relationships, the trophic relationship, and the ecosystem evolution within the paleo-locality. Through quantitative and multi-disciplinary analyses, a crocodilian producer was identified for the putative coprolites, and a new ichnogenus and species, *Crococopros naduongensis* ichnogen. et ichnosp. nov., were erected based on derived characters and comparisons. The study provides evidence of an ancient river or lake-like environment dominated by crocodilian fauna, suggesting that the Na Duong food chain was ideal and healthy for the survival of crocodilian species during that period of time. The findings also demonstrate the richness of ichnofauna, fauna, flora, and the suitable climate, indicating that Na Duong Basin was a fossil Lagerstätte of Southeast Asia. Overall, the study offers a unique snapshot of the past and sheds light on the ecosystem of the region, contributing to our understanding of paleoenvironmental conditions and biotic interactions in the area.

Singh, S.K. (2023). Assessment of Green Sectors of Chitwan with Special Reference to Carbon Sequestration and Biodiversity Conservation (A Case Study of Chitwan National Park). Bachelor of Environmental Science thesis, Tribhuvan University, Ghantaghar, Kathmandu.

Abstract: This report summarizes over the studies done over Green and Brown sector of Chitwan and Hetauda during the field visit. The effectiveness of *ex situ* conservation in Nepal was studied from the case study of Elephant breeding center and Crocodile breeding center. The objective of the study was to study the status and role of crocodile and elephant breeding center. Direct observation and survey was carried out for the study. The elephant center has been successful in breeding elephant in captivity and releasing them in the wild. The Gharial breeding center serves as sanctuary for endangered species of crocodile in Nepal. The assessment of carbon stock was carried out in Kumroj Buffer zone community forest (KBZCF) and found to be 1593.6012 Mg c/hectare. The carbon stock of KBZCF was calculated by concentric circular sampling method. The study of indigenous knowledge and environment friendliness of Tharu community was studied by direct observation and key informant interview method. The Tharu communities, tradition, knowledge and practices have contributed to the conservation and sustainability of their environment. The avifaunal diversity in Sauraha area was carried out to study bird diversity in Sauraha, Chitwan. The study was carried out by direct observation method and 53 bird species were found where Black Drongo and Alexandrine parakeet were found to be dominant species. The inventory of floral and faunal diversity in Beeshazar Taal area was studied by Strip transect method. 17 faunal species were found among which Deer was found to be dominant having 17 in number. 10 species of flora were found among which Eichhornia was dominant. The ecotourism potential of Chitwan National Park was analyzed by questionnaire method and found that the ecotourism potential of CNP is significantly high. The agriculture pattern in Sauraha was studied by direct questionnaire method and found that paddy, mustard and wheat were dominant in production. It is found that farmers were dissatisfied with the economic return from the farming due to low productivity and intervention of wild animals.

Young, M.T., Bowman, C.I.W., Erb, A., Schwab, J.A., Witmer, L.M., Herrera, Y. and Brusatte, S.L. (2023). Evidence for a novel cranial thermoregulatory pathway in thalattosuchian crocodylomorphs. *PeerJ* 11: e15353.

Abstract: Thalattosuchian crocodylomorphs were a diverse clade that lived from the Early Jurassic to the Early Cretaceous. The subclade Metriorhynchoidea underwent a remarkable transition, evolving from semi-aquatic ambush predators into fully aquatic forms living in the open oceans. Thalattosuchians share a peculiar

palatal morphology with semi-aquatic and aquatic fossil cetaceans: paired anteroposteriorly aligned grooves along the palatal surface of the bony secondary palate. In extant cetaceans, these grooves are continuous with the greater palatine artery foramina, arteries that supply their oral thermoregulatory structures. Herein, we investigate the origins of thalattosuchian palatal grooves by examining CT scans of 6 thalattosuchian species (1 teleosauroid, 2 early-diverging metriorhynchoids and 3 metriorhynchids), and CT scans of 11 extant crocodylian species. All thalattosuchians had paired osseous canals, enclosed by the palatines, that connect the nasal cavity to the oral cavity. These osseous canals open into the oral cavity via foramina at the posterior terminus of the palatal grooves. Extant crocodylians lack both the external grooves and the internal canals. We posit that in thalattosuchians these novel palatal canals transmitted hypertrophied medial nasal vessels (artery and vein), creating a novel heat exchange pathway connecting the palatal vascular plexus to the endocranial region. Given the general hypertrophy of thalattosuchian cephalic vasculature, and their increased blood flow and volume, thalattosuchians would have required a more extensive suite of thermoregulatory pathways to maintain stable temperatures for their neurosensory tissues.

Raselli, I., Foth, C. and Anquetin, J. (2023). From the past to the future: Unraveling the complexity of the crocodylian skull morphology. *Proceedings of 20th Swiss Geoscience Meeting, Lausanne 2022.*

Abstract: In this study, we capture a comprehensive part of the clade's morphological disparity and taxonomic diversity based on over 170 three-dimensional, high-quality surface scans of skulls and mandibles from 26 extant crocodylian species. With the tools of Geometric Morphometrics and multivariate statistics we dissect the aspects of modularity and integration, morphological disparity, evolutionary allometry, phylogenetic inertia and the influence of functionality and abiotic factors, in order to understand the driving forces in the morphological evolution of the crocodylian skull. Our results show amongst other that the crocodylian mandible consists of two modules, while the morphologically more complex cranium is a constellation of three general morphological units which split into a total of five sub-modules. These sub-modules form family-specific clusters. The combined cranial and mandibular modularity pattern of each family reflects a different ratio of phylogenetic constraint and ecological factor. With these and other new insights into the driving forces and constraints of the morphological evolution of Crocodylia, we discuss the evolutionary conditioning and long-term survival chances of extant crocodylian species in the light of the increasingly rapid environmental changes. Furthermore our study provides a breadth of new aspects of the crocodylian skull morphology, which will serve as a solid base for future studies elucidating the fossil record of Crocodylia.

Platt, S.G., Boutxakittilath, S., Thongsavath, O., Leslie, S.C., Ounboundisane, S. and Rainwater, T.R. (2023). *Crocodylus siamensis* (Siamese Crocodile). Pufferfish consumption and mortality. *Herpetological Review* 54(1): 64-65.

Valli, F.E., Leiva, P.M.L., Lavandera, J., Contini, M.C., Gerstner, C., Piña, C.I., Simoncini, M.S. and González, M.A. (2023). Caiman's fat enriched with n-3 fatty acids: potential food supplement. *Tropical Animal Health and Production* 55: 194 (<https://doi.org/10.1007/s11250-023-03602-7>).

Abstract: Broad-snouted caiman (*Caiman latirostris*) products (meat, fat and oil) are currently beginning to be valued as a food of special interest due to its high content of n-3 fatty acids. Thus, the objective of this study was to characterize the fats of caiman fed with diets enriched with flaxseeds (*Linus usitatissimum*) rich in n-3 fatty acids, lignans and antioxidants. Caimans were fed six days a week with: a control diet (C), and a diet enriched with ground

flaxseed=90% C+10% flaxseed ground (FS), during 30 (FS30) and 60 (FS60) days. Animals fed the flaxseed-enriched diets increased linolenic acid content and reduced the n-6/n-3 ratio of fats relative to controls, and this improvement increased over time. The proportion of eicosapentaenoic acid also increased, but there was no difference at the time the enriched diets were offered. Caiman fat of the FS30 and FS60, showed a decrease in lipoperoxidation (24% and 40%) and reactive oxygen species (44% and 76%) accompanied by an increase in antioxidant systems. Consumption of a flax-enriched diet by caimans increases the content of essential fatty acids and improves the lipoperoxidative status of fat. This provides an enriched fat with potential for the development products for human consumption.

Wu, H.-J., Tseng, Y.-C.; Tsao, S.-H., Chiang, P.-L., Tai, W.-Y., Hsieh, H.-I., Yu, H.-T. and Juang, J.-Y. (2023). A comparative study on the microstructures, mineral content, and mechanical properties of non-avian reptilian eggshells. *Biology* 12: 688.

Abstract: We analyze 214 freshly laid eggs belonging to 16 species across three orders of Class Reptilia. Using mechanical compression tests, we measure each egg's absolute stiffness (K, unit: N m⁻¹) and relative stiffness (C number). The effective Young's modulus, E, was obtained by combining experimental and numerical methods. The mineral (CaCO₃) content was measured by acid-base titration, the microstructures by scanning electron microscopy (SEM), and the crystallography by electron backscatter diffraction (EBSD). We find that the C number of reptilian eggs is, on average, higher than that of bird eggs, indicating that reptilian eggs are stiffer with respect to the egg mass than birds. However, Young's moduli of the reptilian eggshells (32.85 ± 3.48 GPa) are similar to those of avian eggshells (32.07 ± 5.95 GPa), even though those eggshells have different crystal forms, microstructures, and crystallography. Titration measurement shows that the reptilian eggshells are highly mineralized (>89% for 9 Testudines species and 96% for *Caiman crocodilus*). Comparing the species with aragonite and calcite crystals, we find that calcite shells, including those of the Kwangsi gecko (inner part) and spectacled caiman (outer part), generally have larger grains than the aragonite ones. However, the grain size is not correlated to the effective Young's modulus. Also, as measured by the C number, the aragonite shells are, on average, stiffer than the calcite ones (except for the Kwangsi gecko), primarily due to their thicker shells.

Padmakumar, V. and Shanthakumar, M. (2023). The ecological and evolutionary significance of the crocodile-plover symbiosis - A review. *International Journal of Forest, Animal and Fisheries Research* 7(3).

Abstract: The present study investigates the epibiotic relationship between the Nile crocodile (*Crocodylus niloticus*) and the Egyptian plover (*Pluvianus aegyptius*), also known as the crocodile bird. Epibiosis is a form of symbiosis where one organism resides on the surface of another. To understand this relationship, the present study examines the ecological and evolutionary context of it, as well as the behavioral and physiological mechanisms that facilitate it. Furthermore, the present study evaluates the implications and challenges for conservation of this relationship. To achieve these objectives, a literature review on this topic summarizes the main findings, which indicate that the crocodile offers a safe habitat for the plover to roost and nest, while the plover cleans the crocodile's teeth and removes parasites. However, the present study also identifies the limitations and gaps in the current knowledge and proposes directions for future research. This study argues that this relationship between living organisms is a remarkable case of cooperation and confidence in nature, and that it deserves more interest from researchers and decision-makers.

Sabu, U. (2023). Religion in ancient Egypt. In Premchand on

Literature and Life. Routledge: UK.

Abstract: The ancient Egyptians were very religious and beliefs formed an integral part of their daily lives. Some cities worshipped female deities rather than male ones. After the primacy given to the gods of the heavens, Egyptians worshipped gods and goddesses who presided over foodgrains and fields, and made the soil fertile. Many Egyptian cities claimed that parts of Osiris's body lay buried under their temples. Traders in the city of Thebes had once even managed to make a crocodile wear earrings and bangles of gold. The inhabitants of the city of Mandas are believed to have worshipped a goat. The ancient city of Memphis worshipped a black bull that had a bright triangular mark on its forehead and thick hair on its tail. Egyptian burial grounds are full of such corpses and Europeans have carried them away by the thousands.

Kampouridis, P., Hartung, J. and Augustin, F.J. (2023). The Eocene-Oligocene vertebrate assemblages of the Fayum Depression, Egypt. Pp. 373-405 in *The Phanerozoic Geology and Natural Resources of Egypt*. Advances in Science, Technology & Innovation. Springer: Cham.

Abstract: The Fayum has yielded one of the oldest and richest records of fossil mammals from Africa. Today, the Fayum Depression represents an oasis in the Western Desert of Egypt, south of Cairo, and contains several localities that are world renowned for their diverse Eocene to Oligocene vertebrate assemblages. The fossil sites of the Fayum area have provided numerous extraordinarily well-preserved vertebrate remains including complete skulls and partial skeletons of turtles, crocodiles, birds, and mammals. Thus, the Fayum Depression has shed light onto the evolution and biogeography of vertebrates during the Paleogene leading to the establishment of two new orders, several new families and subfamilies, and numerous new species of mammals. In recent years, these fossils have provided clues about ecological aspects of some groups using new methods such as stable isotope analysis and μ CT scanning. Despite the fact that the Fayum Depression represents a historical excavation site that has been excavated and studied by numerous famous palaeontologists since the nineteenth century, the area continues to provide new insights into the evolution of mammals during the Eocene to Oligocene, greatly improving our understanding of early Cenozoic vertebrate evolution. This chapter presents a historical review of the excavations in the Fayum Depression and a taxonomic overview of its fossil fauna. Special focus was placed on the taxonomy and, where applicable, ecology of terrestrial mammals from the historical Paleogene Fayum localities.

Schilliger, L., Najjar, C., Paillusseau, C., François, C., Gandar, F., Boughdiri, H. and Gansuana, M. (2023). Pancuronium Bromide for chemical immobilization of adult Nile crocodiles (*Crocodylus niloticus*): A field study. *Animals* 13: 1578.

Abstract: Pancuronium bromide is a neuromuscular blocker used for immobilizing crocodiles that can be reversed with neostigmine. A recommended drug dose has only been established for saltwater crocodiles (*Crocodylus porosus*), mostly based on trials in juveniles and subadults. After trialing a dose recommendation in a small cohort of 9 Nile crocodiles (*Crocodylus niloticus*), we developed and applied a new dose recommendation for large adult Nile crocodiles. We trialed and adapted a pancuronium bromide (Pavulon 4 mg/2 mL) dose in Nile crocodiles originally established for saltwater crocodiles and applied the new dose for the immobilization of 32 Nile crocodiles destined for transport. Reversal was achieved with neostigmine (Stigmine 0.5 mg/mL). Nine crocodiles were included in the trial phase; the induction time was highly variable (average: 70 min; range: 20-143 min), and the recovery time was prolonged (average: 22 h; range: 50 min-5 days), especially in large animals after reversal with neostigmine. Based on these results, we established a dose-independent recommendation (3 mg pancuronium bromide and 2.5 mg neostigmine) for animals weighing ≥270 kg (TL ≥ ~3.8

m). When applied to 32 adult male crocodiles (BW range: 270-460 kg; TL range: 3.76-4.48 m), the shortest induction time was ~20 min and the longest ~45 min. Pancuronium bromide and its antidote, neostigmine, are effective for the immobilization and reversal of adult male Nile crocodiles (TL $\geq$ 3.8 m or BW $\geq$ 270 kg) when given in a weight-independent fashion.

Vyas, R., Mistry, V., Vaghasiya, P. and Chauhan, D. (2023). Review of mugger *Crocodylus palustris* Lesson, 1831 mortality by vehicle collisions in Gujarat state, India. *Journal of Animal Diversity* 5(1) (<http://dx.doi.org/10.52547/JAD.2023.5.1.5>).

Abstract: Railway lines, roadways, canals, and electricity cable networks pose serious problems to wildlife, fragmenting habitats worldwide. These infrastructures are well-recognized as linear intrusions. Today they represent a threat to wildlife, including to the mugger or marsh crocodile (*Crocodylus palustris* Lesson, 1831). The current study documents 15 crocodile-vehicle collisions (CVCs) recorded in 2 years (2021 and 2022); 11 were on roads, and 4 were on railway tracks. Sex was determined for 11 individuals (5 males, 6 females) and 4 were of undeterminable sex due to crushing. A total of 13 individuals were found dead at the various sites of collision, and two juvenile individuals were found injured and one of them was treated successfully and returned to the wild. The highest number of CVCs (9) occurred in Central Gujarat, followed by 3 CVCs in Saurashtra, 2 in the Kutch region, and 1 in North Gujarat. Mitigation measures required for the collision situations in Gujarat are discussed. A literature survey showed that a total of 75 CVCs were recorded within the last 18 years due to the state's road (n= 51, 68%) and railway (n= 24, 32%) networks, with the highest number of CVCs (56) observed in Central Gujarat and the lowest numbers of CVCs noted in North Gujarat (2) and South Gujarat (no CVCs). There was a high number of subadult and juvenile mugger CVC victims. The CVC site location in the different regions of Gujarat state positively corresponds to crocodile populations. However, the mugger crocodile (*C. palustris*) is nationally protected under the Indian Wildlife Act as a Schedule I species, and the IUCN criteria is 'Vulnerable' and it is an Appendix 1 (CITES) species; therefore, conservation measures are required. CVC incidences were recorded widely in the entire species distribution range, from Iran, India, and Sri Lanka, and can be considered as an emerging threat to mugger crocodiles.

Saito, K. and Hamaya, Y. (2023). On the asymptotic stability of discrete crocodilians model. *Advances in Pure Mathematics* 13(5): 211-225.

Abstract: The sex ratio of crocodiles is strongly biased towards females, often as high as 10 females to 1 male. In crocodilians, the temperature of egg incubation is the environmental factor determining sex. If the temperature is low, around 30°C, the hatchlings are all females. Higher temperature, around 34°C, hatch all males. This study was made to consider the asymptotic stability of a positive equilibrium point in a nonlinear discrete model of the basic nesting population model, which is described in three-region depending on the temperature of egg incubation. This model is based on key life-historical data and Murray's research. To study above, we have applied the classical linearization method and P. Cull's method and moreover, we employ non-standard discretization methods for later our Equations (6)-(8) and (15).

Hughes, A., Auliya, M., Altherr, S., Scheffers, B., Janssen, J., Nijman, V., Shepherd, C.R., D'Cruze, N., Sy, E. and Edwards, D.P. (2023). Determining the sustainability of legal wildlife trade. *Journal of Environmental Management* 341 (<https://doi.org/10.1016/j.jenvman.2023.117987>).

Abstract: Exploitation of wildlife represents one of the greatest threats to species survival according to the Intergovernmental

Science-Policy Platform on Biodiversity and Ecosystem Services. Whilst detrimental impacts of illegal trade are well recognised, legal trade is often equated to being sustainable despite the lack of evidence or data in the majority of cases. We review the sustainability of wildlife trade, the adequacy of tools, safeguards, and frameworks to understand and regulate trade, and identify gaps in data that undermine our ability to truly understand the sustainability of trade. We provide 183 examples showing unsustainable trade in a broad range of taxonomic groups. In most cases, neither illegal nor legal trade are supported by rigorous evidence of sustainability, with the lack of data on export levels and population monitoring data precluding true assessments of species or population-level impacts. We propose a more precautionary approach to wildlife trade and monitoring that requires those who profit from trade to provide proof of sustainability. We then identify four core areas that must be strengthened to achieve this goal: (1) rigorous data collection and analyses of populations; (2) linking trade quotas to IUCN and international accords; (3) improved databases and compliance of trade; and (4) enhanced understanding of trade bans, market forces, and species substitutions. Enacting these core areas in regulatory frameworks, including CITES, is essential to the continued survival of many threatened species. There are no winners from unsustainable collection and trade: without sustainable management not only will species or populations become extinct, but communities dependent upon these species will lose livelihoods.

Siddiqui, R., Akbar, N., Cruz Soares, N., Al-Hroub, H.M., Semreen, M.H., Maciver, S.K. and Khan, N.A. (2023). Mass spectrometric analysis of bioactive conditioned media of bacteria isolated from reptilian gut. *Future Science OA* 9(5): FSO861 ([doi: 10.2144/fsoa-2023-0030](https://doi.org/10.2144/fsoa-2023-0030)).

Abstract: Aim: To determine whether selected gut bacteria of crocodile exhibit antibacterial properties. Materials & methods: Two bacteria isolated from *Crocodylus porosus* gut were used, namely: *Pseudomonas aeruginosa* and *Aeromonas dhakensis*. Conditioned media were tested against pathogenic bacteria and metabolites were analyzed using liquid chromatography-mass spectrometry. Results & conclusion: Antibacterial assays revealed that conditioned media showed potent effects against pathogenic Gram-positive and Gram-negative bacteria. LC-MS revealed identity of 210 metabolites. The abundant metabolites were, N-Acetyl-L-tyrosine, Acetaminophen, Trans-Ferulic acid, N, N-Dimethylformamide, Pyrocatechol, Cyclohexanone, Diphenhydramine, Melatonin, Gamma-terpinene, Cysteamine, 3-phenoxypropionic acid, Indole-3-carbinol, Benzaldehyde, Benzocaine, 2-Aminobenzoic acid, 3-Methylindole. These findings suggest that crocodile gut bacteria are potential source of novel bioactive molecules that can be utilized as pre/post-antibiotics for the benefit of human health.

Smith, B., Crossley, J.L., Conner, J., Elsey, R.M., Wang, T. and Crossley II, D.A. (2023). Exposure to hypoxia during embryonic development affects blood flow patterns and heart rate in juvenile American alligators during digestion. *Comparative Biochemistry & Physiology A Molecular & Integrative Physiology* ([doi: 10.1016/j.cbpa.2023.111440](https://doi.org/10.1016/j.cbpa.2023.111440)).

Abstract: The developmental environment can alter an organism's phenotype through epigenetic mechanisms. We incubated eggs from American alligators in 10% O₂ (hypoxia) to investigate the functional plasticity of blood flow patterns in response to feeding later in life. Digestion is associated with marked elevations of metabolism, and we therefore used the feeding-induced stimulation of tissue O₂ demand to determine whether there are lasting effects of developmental hypoxia on the cardiovascular response to digestion later in life. In all animals studied, digestion elicited tachycardia and an elevation of blood flow in the right aorta, left aorta, and the pulmonary artery, whereas flows in the carotid and subclavian artery did not change. We found that heart rate and systemic blood flow remained elevated for a longer time period in juvenile alligators that

had been incubated in hypoxia; we also found that the pulmonary blood flow was elevated at 24, 36, and 48 h. Collectively, our findings demonstrate that exposure to hypoxia during incubation has lasting effects on the hemodynamics of juvenile alligators 4 years after hatching.

Ashepet, M-G., Dahdouh-Guebas, F., Redpath, S., Pooley, S. and Hume, J. (2023). The state and perceptions of human-crocodile interactions around Murchison Falls Conservation Area, Uganda. *Human Dimensions of Wildlife* (<https://doi.org/10.1080/10871209.2023.2212692>).

Abstract: Wildlife conflicts between people and large herbivores or mammalian carnivores are widely researched in Africa, but there is limited work on human-crocodile conflicts (HCC). In Uganda, conservation efforts have enabled the recovery of the Nile Crocodile (*Crocodylus niloticus*) population, yet the expanding human population and activities increasingly overlap with crocodile habitats resulting in negative interactions. This study used a combination of literature review, surveys, and the Nominal Group Technique to investigate the factors underpinning HCC around Murchison Falls Conservation Area. Results indicate that 115 attacks on humans occurred during 2012-2017, 84.3% of these being fatal. Also, 93.1% of the attacks occurred as victims were either fishing or collecting water. Construction of crocodile exclusion enclosures and translocation of problem crocodiles to protected areas were the most preferred mitigation measure. To reduce the prevalence of human injuries and offset local hostility toward crocodiles, conservation actors need to actively engage the affected communities.

Chukwuka, A.V. (2023). First report of fishkill incidence in Bonny-Andoni coastal area, Nigeria: Inferences from probable causes from remotely sensed data. *Croatian Journal of Fisheries* 81(2): 83-91.

Abstract: A fish kill is characterised by the death of a large number of fish in a given area within a short period of time. This is an indicator that water quality and ecosystem conditions in general have deteriorated. Remote sensing data from the MODIS instrument on the Aqua and Terra-2 satellites were accessed from 18 to 22 March 2020, a period that spans before and after the fish kill was reported. Analysis of the remote sensing data shows that the fish kill was preceded by strong winds, ie major and sustained wind events. The maps of sea surface temperatures prior to the fish kill show that high-temperature water masses flowed from the equator toward the Bonny-Andoni coast. The dates of occurrence of the high-temperature surface water masses and high wind events around the Bonny-Andoni coastal area were consistent with the location and timing of the fish kill, as indicated by community reports. We hypothesise that the low-oxygen, high-temperature surface water masses passing from the equator on the windward side of the coast may have encountered migrating crocodiles and trapped an entire school of this benthopelagic fish species, causing acute respiratory distress. The results and hypothesis confirm local reports of gasping fish about 2 nautical miles off the Bonny-Andoni coast. This report confirms the relationship between wind patterns, temperature, and fish kills, providing the first empirical account of probable causes. Because fish kills occur episodically and often leave no trace, this report and future analyses of remote sensing data may be the best way to elucidate this event.

Mascarenhas-Junior, P.B., Sousa Correia, J.M. and Simões, P.I. (2023). Tracking crocodylia: a review of telemetry studies on movements and spatial use. *Animal Biotelemetry* 11: 21

Abstract: Crocodylians are top predators that play key ecological roles in aquatic ecosystems. As in other groups of large predators, crocodylian populations are often impacted by habitat loss, habitat degradation or direct exploitation for commercial purposes or subsistence. Hence, understanding their spatiotemporal ecology

can provide valuable information for conservation planning. We reviewed the published scientific literature on telemetry-tracking in crocodylians, combining the terms “telemetry”, “track” or “tag” and variations; “VHF”, “UHF”, “satellite”, “GPS”, “radio”, “acoustic” or “transmitters”; and “caiman”, “alligator”, “crocodile”, “gharial” or “Crocodylia”. Publications retrieved by our search were carefully reviewed for information on study length, geographic location, sample size, taxonomy, and telemetry technology used. We identified 72 research articles in indexed journals and 110 reports available from the IUCN’s Crocodile Specialist Group, published between 1970 and 2022. Publications included 23 of the 27-living described crocodylian species. We identified strong geographic and taxonomic biases, with most articles proceeding from the USA (21.2%) and Australia (14%), with *Alligator mississippiensis* and *Crocodylus porosus* as the main target species in studies conducted in these countries, respectively. Despite representing 22% of IUCN’s reports, *Gavialis gangeticus* was referred in a single indexed research article. VHF telemetry was the prevalent tracking method, followed by GPS and acoustic transmitters. Studies using VHF devices had generally shorter in length when compared to alternative technologies. Transmitter weight represented less than 2% of the body mass of the carrying individual in all studies. Although attachment site of transmitters was notified in all research papers, few described anaesthetic or clinical procedures during attachment (33%). Our review highlights the need to encourage publication of crocodylian telemetry studies in non-English speaking countries in Asia, Africa, and Latin America, where many endemic species are threatened. We also highlight the need of detailed information on methods and results to facilitate the choice and implementation of appropriate protocols in future telemetry-tracking studies.

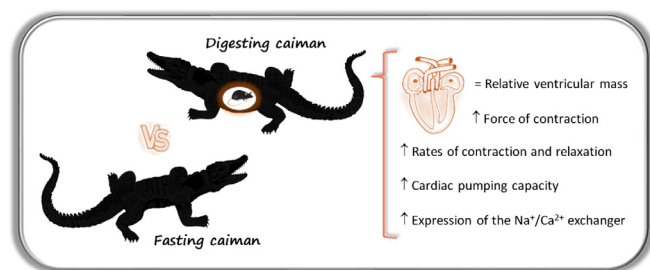
Zeiträg, C., Reber, S.A. and Osvath, M. (2023). Gaze following in Archosauria-Alligators and palaeognath birds suggest dinosaur origin of visual perspective taking. *Science Advances* 9(20): eadf040.

Abstract: Taking someone else’s visual perspective marks an evolutionary shift in the formation of advanced social cognition. It enables using others’ attention to discover otherwise hidden aspects of the surroundings and is foundational for human communication and understanding of others. Visual perspective taking has also been found in some other primates, a few songbirds, and some canids. However, despite its essential role for social cognition, visual perspective taking has only been fragmentedly studied in animals, leaving its evolution and origins uncharted. To begin to narrow this knowledge gap, we investigated extant archosaurs by comparing the neurocognitively least derived extant birds-palaeognaths-with the closest living relatives of birds, the crocodylians. In a gaze following paradigm, we showed that palaeognaths engage in visual perspective taking and grasp the referentiality of gazes, while crocodylians do not. This suggests that visual perspective taking originated in early birds or nonavian dinosaurs-likely earlier than in mammals.

Guelli Lopes, A., Amaral Monteiro, D., da Silva Vasconcelos, E. and Kalinin, A.L. (2023). Contractile function of fasting and digesting broad-snouted caiman (*Caiman latirostris*). *Canadian Journal of Zoology* (<https://doi.org/10.1139/cjz-2022-0180>).

Abstract: Feeding regimes are a critical process to ensure survival and reproduction, which modulate several behavioral and physiological patterns of ectotherms, especially cardiovascular adjustments. However, crocodylian myocardial contractile function after food intake remains understudied. We investigated the importance of ventricular myocardial contractility during digestion in the broad-snouted caiman, *Caiman latirostris* Daudin, 1801. Isometric ventricle preparations and Ca^{2+} -handling protein expression were used to investigate the effects of prolonged fasting (30 days) and feeding (48 h after feeding on meals at 15% of body mass) on cardiac function. Upon feeding, there was no significant difference in relative ventricular mass. The cardiac response of

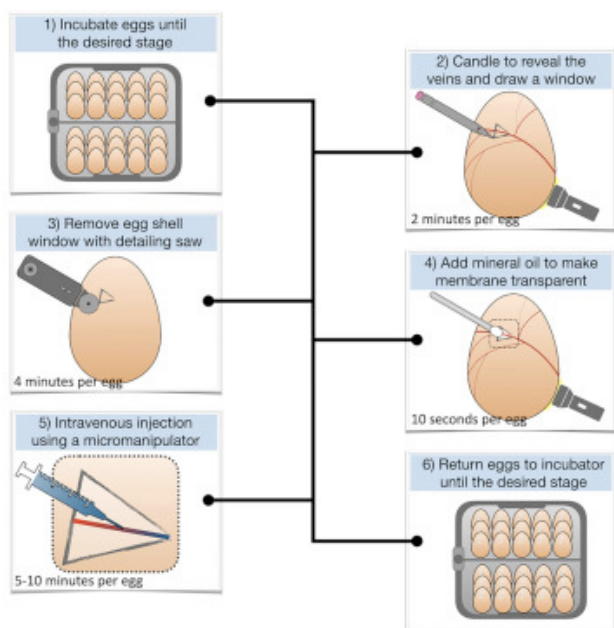
the caiman to digestion was characterized by upregulation of the $\text{Na}^+/\text{Ca}^{2+}$ exchanger expression and an increase in myocardial contractility (positive inotropism and lusitropism) within the physiological range of heart rate. The digesting caiman's ventricular myocardium was able to maintain faster kinetics of contraction and relaxation, allowing for significantly increased cardiac pumping capacity at higher pacing frequencies. Our results demonstrated that the myocardium of broad-snouted caimans exhibits specializations in excitation-contraction coupling, which can provide a means to support high cardiovascular performance during digestion.



Cooper, R.L., Santos-Duran, G. and Milinkovitch, M.C. (2023). Protocol for the rapid intravenous *in ovo* injection of developing amniote embryos. STAR Protocols 4(2): 102324.

Summary: We present a technique for precise drug delivery into the vascular system of developing amniote embryos via injection into chorioallantoic veins underlying the eggshell membrane. We describe steps for incubating and candling eggs, removing the shell to expose underlying veins, and precise intravenous injection. In addition to chicken embryos, this protocol is applicable to other amniote species that lay hard-shell eggs, including crocodiles and tortoises. This technique is rapid, is reproducible, is of low cost, and will provide an important resource for developmental biologists.

For complete details on the use and execution of this protocol, please refer to: Cooper, R. and Milinkovitch, M. (2023). Transient agonism of the sonic hedgehog pathway triggers a permanent transition of skin appendage fate in the chicken embryo. Science Advances (https://doi.org/10.1126/sciadv.adg9619).



Ristevski, J., Willis, P.M.A., Yates, A.M., White, M.A., Hart, L.J., Stein, M.D., Price, G.J. and Salisbury, S.W. (2023). Migrations, diversifications and extinctions: the evolutionary history

of crocodyliforms in Australasia. Alcheringa: An Australasian Journal of Palaeontology (https://doi.org/10.1080/03115518.2023.2201319).

Abstract: Crocodyliform palaeontology in Australasia has a productive research record that began in the late 19th century and continues today. In this study, we summarize the current understanding on the taxonomic diversity and phylogenetic relationships of Australasian crocodyliforms based on first-hand knowledge of relevant fossil material and a review of the published literature. The currently known fossil record of Crocodyliformes in Australasia spans more than 113 million years, from the Early Cretaceous to the Holocene, and largely consists of body fossils discovered on continental Australia. Whilst only two crocodyliform genera are recognized from Australasia's Mesozoic, the Cenozoic is distinguished by a remarkable taxonomic diversity of crocodylian crocodyliforms. By far the most common crocodylians from Australasia are members of Mekosuchinae, whose fossils are unambiguously known from the early Eocene until the Holocene. In addition to mekosuchines, during the Cenozoic Australasia was also inhabited by gavialoids and species of *Crocodylus*, with four extant species of the latter being the only surviving crocodylians in Australia and New Guinea. The phylogenetic relationships of Australasia's crocodylians, particularly mekosuchines, have been a topic of interest to palaeontologists for over two decades. We performed several phylogenetic analyses to test the relationships of Mekosuchinae and other extinct crocodylians. Most results from our analyses found Mekosuchinae as a basal crocodyloid clade within Longirostres. However, some of the results recovered an alternative position for the majority of mekosuchines outside of Longirostres and the Late Cretaceous-early Paleogene Orientalosuchina as its deeply nested subclade. These results suggest that Mekosuchinae had its origins in Asia during the Cretaceous, and that mekosuchines arrived from southeast Asia into Australia no later than the late Paleocene. If this hypothesis is correct, then Mekosuchinae would no longer be an Australasian endemic clade since mekosuchines also seem to have persisted on continental Asia until the late Eocene.

Odetti, L.M., Chacón, C.F., Siroski, P.A., Simoniello, M.F. and Poletta, G.L. (2023). Effects of glyphosate, 2,4-D, chlorantraniliprole, and imidacloprid formulations, separately and in mixtures in *Caiman latirostris* hatchlings. Toxicology and Applied Pharmacology 469: 116544 (doi: 10.1016/j.taap.2023.116544).

Abstract: The present study demonstrated the potential of glyphosate (GLY), 2,4-dichlorophenoxyacetic acid (2,4-D), imidacloprid (IMI) and chlorantraniliprole (CAP) separately and in mixtures to induce oxidative stress and DNA damage in *Caiman latirostris* hatchlings. Under controlled condition, an embryonic exposure to these pesticides was done at concentrations recommended for soybean crops. Treatments were: negative control, GLY, 2,4-D, IMI, CAP, mixture 1 (M1): GLY + 2,4-D, M2: IMI + CAP and M3: GLY + 2,4-D + IMI + CAP. At hatching, blood samples were taken for the evaluation of genotoxicity, oxidative damage to lipids and DNA, the enzymatic activity of catalase (CAT) and superoxide dismutase (SOD), and the expression level of their corresponding genes (catalase: cat and superoxide dismutase: sod). It has been shown that IMI, M2 and M3 induced a significant inhibition of CAT activity while no effect was observed on SOD. In turn, lipid peroxidation was significantly higher in individuals exposed to IMI, and to all the mixtures. Besides, genotoxicity and oxidative DNA damage were observed in all exposed groups. The results of mRNA expression showed no difference at transcription levels. In the same way, no alterations in growth parameters were recorded at hatching. Regarding to the mixtures, we observed a potentiating action of IMI on M3 in lipid peroxidation as well as independent action on oxidative DNA damage and genotoxicity parameters. Our results highlight the importance of investigating the effect of pesticides and their mixtures considering the potential consequences to caimans living in natural environments.

Tohmadlae, P., Klinlokai, N., Jantaratch, N., Worawattanamateekul, W. and Hinsui, J. (2023). Extraction of by-products from Nile tilapia and Siamese crocodile scales. *Burapha Science Journal* 28(2): 894-912.

Abstract: Nile tilapia scales are waste from chill/frozen fish fillets processing industries. Crocodile scales are waste from crocodile leather making process. However, valuable substances in the scales of both tilapia and crocodile could be extracted that can be used as raw materials for by-products in food industries. The objective of this study was to extract by-products from Nile tilapia and Siamese crocodile scales for food supplements. The composition of functional groups contained in dried Nile tilapia and Siamese crocodile scales was determined by Fourier-transform infrared (FTIR) Spectroscopy. Tilapia and crocodile scales were treated with sodium chloride, sodium hydroxide, sulfuric acid and citric acid before gelatin extraction at 50°C for 3 h then collagen type were evaluated by SDS-PAGE. The residue scales were treated with sodium hydroxide and hydrochloric acid for chitin-chitosan extraction then degree of deacetylation and FTIR Spectroscopy were analyzed. Sodium carbonate was added in sulfuric acid treatment solution for calcium precipitation then minerals contents and FTIR Spectroscopy were analyzed. FTIR result was showed that the scales contained collagen, calcium and chitin. The FTIR result related to extraction of gelatin, chitin-chitosan and calcium powder. Gelatin was collagen type I, chitin-chitosan was degree of deacetylation more than 40% and calcium powder contained calcium, phosphorus, magnesium and iron. Crocodile calcium powder contain high calcium (35.96%). These extraction of valuable substances for food supplements were value and reduce waste and environment pollution.

Madrigal, M., De La Paz, K. and Owerkowicz, T. (2023). Pulmonary bypass shunt is turned off during walking in the American alligator (*Alligator mississippiensis*). Abstract presented at American Physiology Summit 2023 meeting, Comparative and Evolutionary Physiology Section Scholander Award Competition and Trainee Poster Session. Volume 38, Issue S1.

Abstract: In non-avian reptiles, the pulmonary bypass (right-to-left) shunt directs blood away from lungs via the left aorta (LAo). At times of elevated oxygen demand, such as exercise or digestion, animals can boost systemic oxygen delivery by either increasing pulmonary bypass shunting to augment cardiac output or reducing the shunt to maximise arterial oxygen content. Previous studies on squamates and turtles showed the shunt is reduced when oxygen demand rises. In contrast, a recent study showed increased shunting during digestion in the American alligator, but whether a similar response occurs during exercise has not been reported to date. We investigated the effects of terrestrial locomotion on blood flow and shunting pattern in female juveniles of the American alligator (n= 6; body mass 700-1100g). Perivascular probes were chronically implanted on the major vessels of the outflow tract: the left aorta (LAo), the left pulmonary artery (LPA), the common carotid artery (CCA), and the right aortic arch jointly with the right subclavian artery (RAo+SCA). Shunt fraction was calculated as LAo flow relative to the right ventricular output (= LAo + 2XLPA). Experiments were performed in a walk-in environmental chamber on animals fasted for a week and equilibrated to 30°C. Upon instrumentation and recovery from surgery, animals were exercised on a level treadmill (0.5 km/h) until exhaustion. Blood flows were recorded continuously before, during and after (10+ min) exercise. Systolic blood flow in the LAo was in the forward direction (shunt on) in alligators at rest, became retrograde (shunt off) immediately upon onset of exercise, and turned anterograde (shunt on again) during recovery. Compared with flow rate values obtained at rest (1.64 ± 0.30 ml/kg/min), average (systolic and diastolic) flow in the LAo decreased significantly during exercise (0.65 ± 0.46 ml/kg/min), and gradually increased with time during recovery (to 1.52 ± 0.28 ml/kg/min in the 10th min post-exercise). In contrast, blood flow in other instrumented vessels increased during exercise, and gradually decreased during recovery. Shunt fraction was highly variable in resting animals (0.4-11.5%),

decreased significantly during exercise, remained depressed in the 1st min post-exercise and increased gradually during recovery to ($p < 0.05$, mixed model ANOVA, post-hoc Dunnett's test with rest as control). This suggests that alligators turn the pulmonary bypass shunt off during acute bouts of terrestrial exercise. According to the Fick Principle, crocodilians favour increasing arterial oxygen content, by reducing admixture of oxygenated and deoxygenated bloodstreams, over augmenting cardiac output with shunt flow. Thus, despite profound differences in their heart morphology, crocodilian and non-crocodilian "reptiles" exhibit the same response - turning the shunt off - at times of elevated oxygen demand. Whether this is modulated by exercise-induced sympathetic stimulation remains to be tested.

Walter, C., Cramberg, M. and Young, B.A. (2023). The gator grapple: pedal anchoring in the American alligator (*Alligator mississippiensis*). *Amphibia-Reptilia* (doi: <https://doi.org/10.1163/15685381-bja10141>).

Abstract: To resist forward displacement of their body during non-locomotor behaviors such as feeding, American alligators (*Alligator mississippiensis*) hold their hindfeet vertical, then push the foot into the substrate so that the dorsum of the foot forms a contact area with the substrate. Herein this form of bracing is termed pedal anchoring. The purpose of the present study was to describe pedal anchoring and to demonstrate whether it entailed interaction between the hindfoot (pes) of *Alligator* and the substrate that differed from the interactions seen during locomotion. Alligator tracks were studied in the wild, during controlled field trials, and on a mud trackway in the laboratory; in each setting locomotor and pedal anchoring tracks were photographed, cast in Plaster of Paris, then features of the casts quantified. Statistical analysis demonstrated greater variation in the wild tracks, presumably reflecting the larger size and velocity ranges of the alligators involved, and suggested that the mud trackway used during the locomotor trials did not create significant artifact. Tracks produced during locomotion and pedal anchoring by the same alligators, on the same substrate, yielded significantly different quantitative features, different matrices of Pearson correlation coefficients, and different patterns of character distribution following Principal Component Analysis. These results all support the conclusion that pedal anchoring involves fundamentally different interaction between the pes and the substrate than occurs during locomotion.

Prada, L. (2023). The ancient Egyptian origin of a transcultural trope, across classical, Islamic, and Jewish traditions. The first attestation of the crocodile bird in Egyptian, or why Herodotus is not a liar (with the first edition of P. Vienna D 6104). *Zeitschrift für Ägyptische Sprache und Altertumskunde* 150(1): 101-129.

Summary: The article studies the trope of the crocodile bird in its evolution from antiquity to the present day. The story tells of the mutualistic behaviour between the Nile crocodile and an Egyptian bird, typically known as the trochilus. The trope has a complex history: primarily known from classical writers, it spread in fact to Jewish and Islamic traditions, too. The story is universally thought to be an invention of Herodotus. But a demotic papyrus, here published for the first time, proves that the trope of the crocodile bird has its true origin in ancient Egyptian culture.

Abdullahi, S.N., Sani, B., Muhammad, M.H., Abdullahi, A., Faragai, M.L. and Kabir, B.A. (2023). Survey of gastrointestinal parasites in captive wild animals at Zoological Garden, Kano, North Western Nigeria. *Scholarly Journal of Science and Technology Research & Development* 2(5): 1-12.

Abstract: This survey was carried out to determine the prevalence and intensity of gastrointestinal parasites in captive wild animals at Kano Zoological garden between October and December, 2016. One

hundred and seventy-six (176) fecal samples were collected from 43 captive wild animals and examined using direct wet mount, zinc floatation and sedimentation methods. Nine species of intestinal parasites from helminthes (6, 62.7%) and protozoa (3, 32.7%) were identified with an overall prevalence of 39.2%. *Trichuris trichiura* had the highest prevalence (25.6%) among the helminthes, followed by *Strongyloides* sp. (16.2%), *Ascaris lumbricoides* (11.6%) while *Hymenolepis diminuta* and *Entrobrius vamicularis* recorded the least each with 4.6%. There was significant difference of helminthes infection ($P < 0.05$) among the animals. Among the protozoa encountered *Entamoeba histolytica* had the highest of 18.6% prevalence, followed by *Giardia lamblia* and *Balantidium coli* which had 9.3% and 2.3% respectively. No significant difference ($P > 0.05$) was observed in the prevalence rate of protozoa parasites. Multiple infection was recorded in Mona monkey and Dog-faced baboon with four gastrointestinal parasites, followed by sooty mongabey, Red patas monkey, Mona monkey, lion, Nile crocodile, elephant, red dorcas gazelle each with three parasites. Single infections were recorded in spotted hyena, sand fox, tortoise and white dorcas gazelle. There was light infection among all animals examined. It is therefore recommended that periodic epidemiological investigation should be carried out on the prevalence of gastrointestinal parasites in order to curtail the potential danger to visitors, keepers and other captive animals in the zoo.

Bock, S., Loera, Y., Johnson, J., Smaga, C., Haskins, D.L., Tuberville, T., Singh, R., Rainwater, T., Wilkinson, P. and Parrott, B.B. (2023). Differential early-life survival underlies the adaptive significance of temperature-dependent sex determination in a long-lived reptile. *bioRxiv* (<https://doi.org/10.1101/2023.05.24.542140>).

Abstract: Many ectotherms rely on temperature cues experienced during development to determine offspring sex. The first descriptions of temperature-dependent sex determination (TSD) were made over 50 years ago, yet an understanding of its adaptive significance remains elusive, especially in long-lived taxa. One novel hypothesis predicts that TSD should be evolutionarily favored when two criteria are met - (a) incubation temperature influences annual juvenile survival and (b) sexes mature at different ages. Under these conditions, a sex-dependent effect of incubation temperature on offspring fitness arises through differences in age at sexual maturity, with the sex that matures later benefiting disproportionately from temperatures that promote juvenile survival. The American alligator (*Alligator mississippiensis*) serves as an insightful model in which to test this hypothesis, as males begin reproducing nearly a decade after females. Here, through a combination of artificial incubation experiments and mark-recapture approaches, we test the specific predictions of the survival-to-maturity hypothesis for the adaptive value of TSD by disentangling the effects of incubation temperature and sex on annual survival of alligator hatchlings across two geographically distinct sites. Hatchlings incubated at male-promoting temperatures consistently exhibited higher survival compared to those incubated at female-promoting temperatures. This pattern appears independent of hatchling sex, as females produced from hormone manipulation at male-promoting temperatures exhibit similar survival to their male counterparts. Additional experiments show that incubation temperature may affect early-life survival primarily by affecting the efficiency with which maternally transferred energy resources are used during development. Results from this study provide the first explicit empirical support for the adaptive value of TSD in a crocodilian and point to developmental energetics as a potential unifying mechanism underlying persistent survival consequences of incubation temperature.

Alibardi, L. (2023). General aspects on skin development in vertebrates with emphasis on sauropsids epidermis. *Developmental Biology* (<https://doi.org/10.1016/j.ydbio.2023.05.007>).

Abstract: General cellular aspects of skin development in vertebrates are presented with emphasis on the epidermis of sauropsids.

Anamniote skin develops into a multilayered mucogenic and soft keratinized epidermis made of Intermediate Filament Keratins (IFKs) that is reinforced in most fish and few anurans by dermal bony and fibrous scales. In amniotes, the developing epidermis in contact with the amniotic fluid initially transits through a mucogenic phase recalling that of their anamniotes progenitors. A new gene cluster termed EDC (Epidermal Differentiation Complex) evolved in amniotes contributing to the origin of the stratum corneum. The EDC contains numerous genes coding for over 100 types of corneous proteins (CPs). In sauropsids 2-8 layers of embryonic epidermis accumulate soft keratins (IFKs) but do not form a compact corneous layer. The embryonic epidermis of reptiles and birds produces small amount of other, poorly known proteins in addition to IFKs and mucins. In the following development, a resistant corneous layer is formed underneath the embryonic epidermis that is shed before hatching. The definitive corneous epidermis of sauropsids is mainly composed of CBPs (Corneous beta proteins, formerly indicated as beta-keratins) derived from the EDC. CBPs belong to a gene sub-family of CPs unique for sauropsids, contain an inner amino acid region formed by beta-sheets, are rich in cysteine and glycine, and make most of the protein composition of scales, claws, beaks and feathers. In mammalian epidermis CPs missing the beta-sheet region are instead produced, and include loricerin, involucrin, filaggrin and various cornulins. Small amount of CPs accumulate in the 2-3 layers of mammalian embryonic epidermis and their appendages, that is replaced with the definitive corneous layers before birth. Differently from sauropsids, mammals utilize KAPs (keratin associated proteins) rich in cysteine and glycine for making the hard corneous material of hairs, claws, hooves, horns, and occasionally also scales.

Strickland, B.A., Flood, P.J., Kline, J.L., Mazzotti, F.J., Heithaus, M.R. and Trexler, J.C. (2023). An apex predator engineers wetland food-web heterogeneity through nutrient enrichment and habitat modification. *Journal of Animal Ecology* ([doi: 10.1111/1365-2656.13939](https://doi.org/10.1111/1365-2656.13939)).

Abstract: The potential for animals to modify spatial patterns of nutrient limitation for autotrophs and habitat availability for other members of their communities is increasingly recognized. However, net trophic effects of consumers acting as ecosystem engineers remain poorly known. The American alligator *Alligator mississippiensis* is an abundant predator capable of dramatic modifications of physical habitat through the creation and maintenance of pond-like basins, but its role in influencing community structure and nutrient dynamics is less appreciated. We investigated if alligators engineer differences in nutrient availability and changes to community structure by their creation of 'alligator ponds' compared to the surrounding phosphorus (P)-limited oligotrophic marsh. We used a halo sampling design of three distinct habitats extending outward from 10 active alligator ponds across a hydrological gradient in the Everglades, USA. We performed nutrient analysis on basal food-web resources and quantitative community analyses, and stoichiometric analyses on plants and animals. Our findings demonstrate that alligators act as ecosystem engineers and enhance food-web heterogeneity by increasing nutrient availability, manipulating physical structure and altering algal, plant and animal communities. Flocculent detritus, an unconsolidated layer of particulate organic matter and soil, showed strong patterns of P enrichment in ponds. Higher P availability in alligator ponds also resulted in bottom-up trophic transfer of nutrients as evidenced by higher growth rates (lower N:P) for plants and aquatic consumers. Edge habitats surrounding alligator ponds contained the most diverse communities of invertebrates and plants, but low total abundance of fishes, likely driven by high densities of emergent macrophytes. Pond communities exhibited higher abundance of fish compared to edge habitat and were dominated by compositions of small invertebrates that track high nutrient availability in the water column. Marshes contained high numbers of animals that are closely tied to periphyton mats, which were absent from other habitats. Alligator-engineered habitats are ecologically important by providing nutrient-enriched 'hotspots' in an oligotrophic system, habitat heterogeneity to marshes, and

refuges for other fauna during seasonal disturbances. This work adds to growing evidence that efforts to model community dynamics should routinely consider animal-mediated bottom-up processes like ecosystem engineering.

Collett, A. (2023). Ontogeny-induced Shape Changes in the Proximal Femur of the American Alligator (*Alligator mississippiensis*). MSc thesis, Southern Connecticut State University, New Haven, Connecticut, USA.

Iijima, M., Darlington, J., Munteanu, V.D., Vliet, K.A. and Blob, R.W. (2023). Scaling of gait, limb posture, forces, and inertial properties in terrestrial locomotion of American alligators across a thousand-fold increase in body mass. Integrative and Comparative Biology (<https://doi.org/10.1093/icb/icad056>).

Abstract: Scaling of body shape, gait, limb kinematics, and kinetics can inform about mechanical and energetic constraints influencing animal locomotion on land. However, our knowledge of terrestrial locomotion among tetrapods is biased towards animals that use parasagittal limb postures (mammals and birds). Whether species that use non-parasagittal limb postures (eg crocodylians and lizards) share similar scaling principles remains uncertain, especially towards the larger end of the body size spectrum. Here, we compare new data from large adult American alligators (140-223 kg) with previous data from smaller individuals (0.2-5.6 kg) to evaluate the scaling of gait, limb posture, ground reaction forces, and inertial properties of body segments over a size range spanning three orders of magnitude. Larger alligators walked with higher relative stride frequencies and shorter relative stride lengths at equal dimensionless speeds, suggesting that alligators prioritize stance phase mechanical work reduction at the expense of higher costs for swing as they increase in size. Limb posture also changed with body mass: ~1 kg and larger alligators typically used more adducted and extended limbs, which is expected to mitigate limb muscle forces during stance. Ground reaction forces were increasingly hindlimb dominant as alligators grow to larger size, paralleled by a posterior shift in the center of mass. Counterintuitively, the forelimb grew faster in mass than the hindlimb, possibly because recruited muscle volume is closer to its maximum capacity in the forelimb, compelling larger alligators to keep up with increased mechanical demands via muscle growth more for the forelimb than the hindlimb. These results highlight the numerous changes in body proportions and locomotor performance that are required among animals that use non-parasagittal limb posture, as they grow from neonatal sizes into large adults.

Howell, H.J. (2023). The Ecology, Conservation, and Management of the Everglades' Herpetofaunal Community. PhD thesis, University of Miami, Coral Gables, Florida, USA.

Abstract: The Everglades ecosystem is a globally unique ecosystem that is recognized as a natural world heritage site, North America's only sub-tropical preserve, the largest sawgrass prairie in the world, and is home to nearly 6 dozen threatened or endangered species. Unfortunately, like many other ecosystems, the Everglades has been subjected to a wide variety of anthropogenic impacts that include wholesale habitat destruction, dramatic changes in sheet water flow, large numbers of invasive species, and consumptive exploitation both through overharvesting of fauna and resource acquisition. While the impact of these changes has been documented extensively for taxa such as wading birds, small mammals, and fishes, almost nothing has been documented about long-term changes in herpetofaunal abundance, distribution, or community composition. To address this lacuna, I utilized long-term data analysis, landscape level experiments, natural history studies, and population and community ecology analysis. In Chapter 2, I analyzed three long-term datasets that monitored amphibian abundances in the Everglades ecosystem across multiple decades. Chapter 3 utilized a multi-year, landscape scale experiment to determine the impacts of changing hydrological

regimes on the Everglades herpetofaunal community. Chapter 4 used a combination of morphological analysis and DNA barcoding to analyze the dietary components of the two giant salamanders (the Greater Siren (*Siren lacertina*) and the Two-Toed Amphiuma (*Amphiuma means*) in the Everglades. Chapter 5 further expounds on the ecology and natural history of the giant salamanders by using the largest multi-year capture-mark-recapture study on both species to estimate population demographics and a multi-year radio tracking study to determine seasonal movement patterns and estimate home-range sizes. Finally, Chapter 6 reports the result of an Everglades wide amphibian sampling project that was designed to understand the environmental drivers of amphibian abundance and community composition across the Greater Everglades Ecosystem. Overall, my dissertation seeks to understand long-term trends in Everglades' amphibian abundances, develop a better understanding of key species' natural history, and then use observational and experimental studies to predict how future environmental changes and management strategies will impact the herpetofaunal community.

Hinrichsen, R.A. (2023). Aggregation of Leslie matrix models with application to ten diverse animal species. Population Ecology ([doi: 10.1002/1438-390X.12149](https://doi.org/10.1002/1438-390X.12149)).

Abstract: Some grouping is necessary when constructing a Leslie matrix model because it involves discretizing a continuous process of births and deaths. The level of grouping is determined by the number of age classes and frequency of sampling. It is largely unknown what is lost or gained by using fewer age classes, and I address this question using aggregation theory. I derive an aggregator for a Leslie matrix model using weighted least squares, determine what properties an aggregated matrix inherits from the original matrix, evaluate aggregation error, and measure the influence of aggregation on asymptotic and transient behaviors. To gauge transient dynamics, I employ reactivity of the standardized Leslie matrix. I apply the aggregator to 10 Leslie models developed for animal populations drawn from a diverse set of species. Several properties are inherited by the aggregated matrix: (a) it is a Leslie matrix; (b) it is irreducible whenever the original matrix is irreducible; (c) it is primitive whenever the original matrix is primitive; and (d) its stable population growth rate and stable age distribution are consistent with those of the original matrix if the least squares weights are equal to the original stable age distribution. In the application, depending on the population modeled, when the least squares weights do not follow the stable age distribution, the stable population growth rate of the aggregated matrix may or may not be approximately consistent with that of the original matrix. Transient behavior is lost with high aggregation.

Agüero-Chapin, G., Antunes, A. and Marrero-Ponce, Y. (2023). Editorial: A 2022 update on computational approaches to the discovery and design of antimicrobial peptides. Antibiotics 12: 1011.

Yektaseresht, A., Soltanian, S., Gholamhosseini, A., Safaiean, S. and Kordestani, H. (2023). Evaluation of serum complement activity in Mugger crocodiles (*Crocodylus palustris*). Iranian Scientific Fisheries Journal 32(2): 63-67.

Abstract: Little is known about complement system as a component of innate immunity of the ectothermic vertebrates such as crocodiles. Serum complement is valuable tool in determining the health status of turtles. In this research effect of concentration, volume and temperature on alternative complement pathway activity of Mugger crocodiles (*Crocodylus palustris*) using standard haemolytic assays was studied. For this purpose, *C. palustris* serum complement hemolysis in different concentrations, volumes and temperatures was measured. Results indicated significant relation between relation measured hemolysis and concentration, volume and temperature ($p < 0.05$). The measure of hemolysis in various concentrations (25%, 50% and 100%), volumes (10, 20, 30 μ L) and temperatures (5-

35°C) were significantly increased ($p < 0.05$). The results show that alternative complement pathway activity of crocodiles might affect concentration, volume and temperature that it caused increased non-specific immunity and the resistance to the outbreak of diseases.

Navarro, T.G., Cerda, I.A. and Pol, D. (2023). Microstructural characterization and growth dynamics in *Notosuchus terrestris*, a Mesoeucrocodylia crocodyliform from the Upper Cretaceous of Northern Patagonia, Argentina. Cretaceous Research (<https://doi.org/10.1016/j.cretres.2023.105607>).

Abstract: The clade Notosuchia was the most successful lineage of Crocodyliformes during the Cretaceous in Gondwana, and was particularly diverse during the Late Cretaceous of South America. The clade has been extensively analysed in terms of their morphology and phylogenetic relationships, but studies on their paleobiology from a paleohistological viewpoint are still scarce. In this contribution we take this approach in order to infer different paleobiological aspects of *Notosuchus terrestris*, such as the relative growth rate, growth strategies, intraskeletal and intraspecific variation, as well as evaluation of maturity and age assessment. We conducted paleohistological studies on long bones of 6 individuals assigned to *Notosuchus terrestris* from the Upper Cretaceous of Northern Patagonia, Argentina. The cortical bone in *N. terrestris* is mainly formed by well vascularized woven fibred bone/parallel fibred bone. With the exception of the smaller individual, cyclical growth marks are recorded in all individuals but their number and distribution are variable. *N. terrestris* experienced a high growth rate interrupted by periods of decreased or even arrested growth. This growth strategy clearly differs from the reported for other advanced notosuchians as *Adamantina*, revealing important variation with regard to this parameter in the clade. The sexual maturity in *N. terrestris* was reached before complete fusion of the caudal vertebrae. There is not a clear correlation between body size and ontogenetic stage in *N. terrestris*. This inconsistency could be due to sexual dimorphism and/or, more probably, developmental plasticity.

Booth, W., Levine, B.A., Corush, J.B., Davis, M.A., Dwyer, Q., De Plecker, R. and Schuett, G.W. (2023). Discovery of facultative parthenogenesis in a new world crocodile. Biology Letters 19(6): 20230129.

Abstract: Over the past two decades, there has been an astounding growth in the documentation of vertebrate facultative parthenogenesis (FP). This unusual reproductive mode has been documented in birds, non-avian reptiles—specifically lizards and snakes—and elasmobranch fishes. Part of this growth among vertebrate taxa is attributable to awareness of the phenomenon itself and advances in molecular genetics/genomics and bioinformatics, and as such our understanding has developed considerably. Nonetheless, questions remain as to its occurrence outside of these vertebrate lineages, most notably in Chelonia (turtles) and Crocodylia (crocodiles, alligators and gharials). The latter group is particularly interesting because unlike all previously documented cases of FP in vertebrates, crocodilians lack sex chromosomes and sex determination is controlled by temperature. Here, using whole-genome sequencing data, we provide, to our knowledge, the first evidence of FP in a crocodilian, the American crocodile, *Crocodylus acutus*. The data support terminal fusion automixis as the reproductive mechanism; a finding which suggests a common evolutionary origin of FP across reptiles, crocodilians and birds. With FP now documented in the two main branches of extant archosaurs, this discovery offers tantalizing insights into the possible reproductive capabilities of the extinct archosaurian relatives of crocodilians and birds, notably members of Pterosauria and Dinosauria.

Young, B.A. and Cramberg, M. (2023). The anatomical basis of amphibious hearing in the American alligator (*Alligator mississippiensis*). Anatomical Record (Hoboken) (doi: 10.1002/

ar.25272).

Abstract: The different velocities of sound (pressure waves) in air and water make auditory source localization a challenge for amphibious animals. The American alligator (*Alligator mississippiensis*) has an extracolumellar cartilage that abuts the deep surface of the tympanic membrane, and then expands in size beyond the caudal margin of the tympanum. This extracolumellar expansion is the insertion site for two antagonistic skeletal muscles, the tensor tympani, and the depressor tympani. These muscles function to modulate the tension in the tympanic membrane, presumably as part of the well-developed submergence reflex of *Alligator*. All crocodilians, including *Alligator*, have internally coupled ears in which paratympanic sinuses connect the contralateral middle ear cavities. The temporal performance of internally coupled ears is determined, in part, by the tension of the tympanic membrane. Switching between a “tensed” and “relaxed” tympanic membrane may allow *Alligator* to compensate for the increased velocity of sound underwater and, in this way, use a single auditory map for sound localization in two very different physical environments.

Abdel-Kader, S., Abbas, I.M. and Abu-Zidan, F.M. (2023). Management of animal bites: A global perspective. Pp. 401-410 in Textbook of Emergency General Surgery. Springer: Cham.

Abstract: The relationship between for humans, animals, and environment is balanced since human existence. Animal bites humans is a major neglected global health problem. Dog and cat bites are most common in USA and Europe, snake bites in east Asia, and crocodile and camel bites in Africa. We aim to lay the principles of managing these animal bites. Bites located on the hands, arms, and legs comprise 70-80% of animal bites. The head and neck are involved in 10-30%. The occurrence of wound infection depends on the nature and location of the wound, the patient's immunity, and the type of attacking animal. Principles of managing animal bites include addressing immediate life-threatening injuries; taking a detailed history of the animal bite; evaluating tetanus and rabies risk; administering antibiotics and antivenom (when needed); wound debridement and revision; addressing the risk of necrotizing fasciitis and compartment syndrome, and finally delayed closure/skin graft and fracture management when the wound becomes clean. Using the Haddon matrix is very useful for injury prevention. It includes preventing the animal bite before it occurs, reducing its impact if it occurs, and treating it properly after it occurs.

Gour, R. (2023). Predation by Mugger crocodiles (*Crocodylus palustris*) on Spotted Deer (*Axis axis*). Reptiles & Amphibians 30: e19754.

Manley, G.A. (2023). Evolution of diversity in the auditory papillae of reptiles. Diversity 15(6): 730.

Abstract: The independent origins of middle ears in testudines, lepidosaurs, and archosaurs in the Triassic led to lineage-specific developments in their auditory epithelia. In comparison to the inferred ancestral state, little changed in testudines, but archosaurs and most lepidosaurs evolved longer, differentiated auditory papillae. In archosaurs, sensory hair cells specialized across and along the papillae, resulting in mainly sensory tall hair cells and mainly mechanically active short hair cells. Crocodilians have 5 mm-long papillae, but relatively low upper frequency limits at around 4 kHz. Avian papillae are mostly 3 to 5 mm in length, being shorter in small species; in owls they exceptionally reach almost 12 mm and have an upper limit of above 10 kHz. Lepidosaurs retained the ancestral papilla as a low-frequency responsive area with one type of hair cell, but most added newly evolved areas (of max. 2 mm length) consisting of oppositely oriented hair cells responding to frequencies above 1 kHz. Initially, these areas flanked both ends of the ancestral area and were redundant in their responses

to sound. The evolution of specific configurations in most families eliminated this redundancy, but the paths taken resulted in diverse anatomies that show high degrees of family specificity. Despite these differences, the high-frequency hearing limit of lepidosaurs rarely exceeds 5 kHz.

Barreto-Lima, A.F., Rodrigues, M.P.L., Costa, F.R.F., Moura Filho, A.E., Campos, Y.L., Lima, D.C. and Gonzalez, R.C. (2023). First record of *Caiman latirostris* (Daudin, 1802) from the state of Ceará, Northeastern Brazil. *Herpetology Notes* 16: 411-414.

Zemaitis, K.J. (2023). Site Specific Ontogenetic Drivers of Mercury Concentrations in American Alligators. MSc thesis, University of Georgia, Athens, Georgia, USA.

Abstract: Mercury (Hg) is a ubiquitous ecological contaminant, with elevated exposure risk stemming from anthropogenic activity. Due to the propensity of certain metals to bioaccumulate over time and biomagnify across trophic levels, long-lived apex predators can carry significant body burdens in affected ecosystems. Yet, how interactions between organismal ontogeny and habitat contribute to variation in exposure is not well resolved. Total Hg, carbon ($\delta^{13}C$), and nitrogen ($\delta^{15}N$) isotopic ratios were assessed in blood samples ($n=133$) across three distinct habitats in the southeastern US to investigate how size and dietary shifts in the American alligator (*Alligator mississippiensis*) influence Hg accumulation. Collectively, findings demonstrate that whereas Hg concentrations in *A. mississippiensis* are primarily driven by site-level dynamics, diet and size are linked to individual variation within populations, suggesting that organismal ontogeny interacts with site-specific contamination and ecological factors to affect Hg body burdens. Further exploration of patterns associated with individual variation is recommended.

Bock, S. (2023). Temperature-dependent Sex Determination in the American Alligator: Ecological Drivers, Proximate Mechanisms, and Evolutionary Implications. PhD thesis, University of Georgia, Athens, Georgia, USA.

Abstract: Interactions between developing embryos and their environment have broad ecological and evolutionary implications. This is clearly exemplified in species with temperature-dependent sex determination (TSD), in which thermal cues experienced during a discrete window of development irreversibly determine offspring sex. This dissertation uses TSD in the American alligator (*Alligator mississippiensis*) as a model to address fundamental questions regarding the processes governing developmental plasticity. We investigate the ecological drivers of variation in nest thermal environments, the proximate mechanisms by which thermal cues establish sexually dimorphic phenotypes, and the adaptive consequences of links between incubation temperature and hatchling survival. In Chapter 2, using a multi-year dataset of alligator nest temperatures, we show that while intra-annual nest temperature variation is associated with maternal nest site choice, trends in maximum air temperatures drive variation in mean nest temperatures across years. Consequently, future climatic scenarios are predicted to yield substantial shifts in mean nest temperatures and resulting offspring sex ratios across the species' range, though the specific outcomes vary widely between emission scenarios. In Chapter 3, we explore the mechanistic underpinnings of TSD and, through a series of temperature and exogenous hormone treatments, clarify the relative contributions of thermal and endocrine cues in establishing sexually dimorphic phenotypic trajectories. Upstream chromatin modifiers are among a subset of genes for which expression is regulated solely by incubation temperature and not endocrine signals. In Chapter 4, we examine how the transcriptional dynamics of chromatin modifiers, KDM6B and JARID2, and testis-associated genes, SOX9 and DMRT1, respond to thermal fluctuations between female- and male-promoting temperatures that

are frequently observed in wild nests. Findings suggest embryos integrate opposing environmental signals during TSD via a temporal hierarchy of responses wherein post-transcriptional regulation and expression of chromatin modifiers respond relatively rapidly to transient thermal cues while downstream effector genes lag behind. In Chapter 5, we test how incubation temperature and phenotypic sex influence alligator hatchling survival. We find that male-promoting temperatures confer higher survival regardless of sex and when considered in the context of alligator reproductive ecology, our results provide evidence for differential survival-to-maturity as a driver of the adaptive value of TSD.

Crawford, T.G. (2023). Towards a Decision-making Culture in Wildlife Management: An Integrative Study of Scientific Decision Support. PhD thesis, University of Georgia, Athens, Georgia, USA.

Abstract: Decisions made on our behalf by managers of the public trust are inherently complex. Tradeoffs are inevitable and choices are required despite pervasive uncertainty. First, focusing narrowly on the issue of scientific uncertainty at the species population level - the micro-scale, I consider data limitations and analytical constraints that make scientific inferences about population biology and demographic processes difficult. More specifically, I developed a novel integrated population model for American alligators (*Alligator mississippiensis*) to improve agency understanding of alligator population dynamics despite multiple interacting sources of uncertainty. I then verified model behavior using simulation. Second, zooming out to consider how science informs management - the meso scale, I address technical challenges limiting direct application of available research and monitoring data in policy deliberations. In my second empirical chapter, I implemented a genetic algorithm to identify an alligator harvest policy that sets annual harvest quotas to optimize long-term management objectives based on data from existing monitoring programs. The forward-looking approach accounts for multiple sources of uncertainty and can be tailored to other species with complex life histories and different agency contexts. Lastly, at the broadest level - the meta scale, I examined collaborative applications of structured decision making (SDM) in wildlife conservation and management through the lens of relational power. In my third and final empirical chapter, I present an autoethnography to illuminate how individual and institutional relationships shape SDM practice and its portrayal in the peer-reviewed literature. My dissertation demonstrates robust and flexible analytical tools that can help resource managers translate scientific research and monitoring data into actionable knowledge. It also speaks to the insufficiency of focusing exclusively on the technical dimensions of making science useful to managers.

Brunell, A.M., Deem, V., Bankovich, B., Bled, F. and Mazzotti, F.J. (2023). Effects of translocation on American crocodile movements and habitat use in South Florida. *The Journal of Wildlife Management* (doi: 10.1002/jwmg.22427).

Abstract: The range of the threatened American crocodile (*Crocodylus acutus*) in the United States is limited to the southernmost parts of Florida. As this species has recovered concurrently with an increasing human population, human-crocodile conflicts have also increased. Resolving conflicts can involve translocating crocodiles; however, they often return to the site from which they were removed. We examined the effects of translocation on crocodile movements, habitat use, body condition, and survival in Florida, USA, in 2018-2019 to refine recommendations for managers considering translocation to resolve human-crocodile conflict. We captured and attached global positioning system (GPS) units to 17 crocodiles, 10 of which served as a reference group (free-ranging crocodiles released at their capture site) and 7 served as a treatment group (crocodiles that were translocated 14-158 km from their capture site). We collected location data from individual crocodiles for 34-661 days (mean = ~250 days for each group). Body condition was similar for both groups. Corticosterone levels measured periodically during

handling indicated that crocodiles experienced increasing stress levels during handling. Three crocodiles translocated ≤ 45 km from their original capture site returned to that location within 13 days. Three crocodiles translocated ≥ 110 km did not return. One female translocated 152 km was recaptured 0.42 km from its original capture site 965 days after its release. We identified 2 states of characteristic movement patterns: state 1 indicated individuals moving slowly and somewhat randomly, and state 2 indicated individuals exhibiting fast, active directional movement. Translocated individuals were more likely than reference individuals to switch to, and stay in, state 2. Because of concerns regarding return rates and heightened stress as a result of capture and translocation, we suggest crocodile translocations have limited conservation value and may only be worth considering once all other reasonable options are exhausted.

English, C.J., Taylor, Z., Cramberg, M. and Young, B.A. (2023). Dynamic asymmetry in cerebrospinal fluid pressure: An indicator of regional differences in compliance. *Surgical Neurology International* (doi: 10.25259/SNI_365_2023).

Abstract: Dural compliance influences the shape and magnitude of the cerebrospinal fluid (CSF) pulsations. In humans, cranial compliance is approximately 2× greater than spinal compliance; the differential has been attributed to the associated vasculature. In alligators, the spinal cord is surrounded by a large venous sinus, which suggests that the spinal compartment may have higher compliance than is found in mammals. Pressure catheters were surgically implanted into the cranial and spinal subdural spaces of 8 subadult American alligators (*Alligator mississippiensis*). The CSF was propelled through the subdural space by orthostatic gradients and rapid changes in linear acceleration. CSF pressure recordings taken from the cranial compartment were consistently, and significantly, larger than those taken from the spinal compartment. After the myodural bridge of *Alligator* was surgically released, the asymmetry in CSF pressure was decreased. Unlike the situation in humans, the spinal compartment of *Alligator* has greater compliance than the cranial compartment, presumably due to the presence of the large spinal venous sinus surrounding the dura. The change in CSF pressures after myodural surgical release supports the hypothesis that the myodural bridge functions, at least in part, to modulate dural compliance and the exchange of CSF between the cranial and spinal compartments.

Hassan, R., Gani, M.I.Z.A., Hassan, M.A. and Denel, A. (2023). Density and management of estuarine crocodile in Samarahan river basin, Sarawak, Malaysian Borneo. *Songklanakarin Journal of Science and Technology* 45(1): 19-23.

Abstract: Estuarine crocodile, *Crocodylus porosus* is the most common crocodile found in Sarawak, Malaysia. Despite its importance in ecological services, socio-economy and cultural belief, crocodiles are still considered pests due to frequent human crocodile conflicts (HCC) resulting in either injuries or death. This study determined the density of crocodiles in three selected rivers within Samarahan River Basin (SRB) of Sarawak, using a standard night spotting technique over a three-year period (2019-2021). The average density of crocodiles in SRB is showing an increasing trend, although there is active removal of the animals from the rivers either by commercial hunting or by relocation of certain individuals as immediate response to HCC. This paper also describes conservation initiatives carried out in SRB aiming to use crocodile as a resource in bioeconomy, which supports the United Nations Sustainable Development Goals.

Pereira, A.C., Mancuso, C.J., Newsome, S.D., Nardoto, G.B. and Colli, G.R. (2023) Agricultural input modifies trophic niche and basal energy source of a top predator across human-modified landscapes. *Frontiers in Ecology and Evolution* 11: 1053535.

Abstract: Land-use conversion and resulting habitat fragmentation can affect the source(s) of primary productivity that fuels food webs and alter their structure in ways that leads to biodiversity loss. We investigated the effects of landscape modification on food webs in the Araguaia River floodplain in central Brazil using the top predator, and indicator species *Caiman crocodilus* (Crocodylia, Alligatoridae). We measured carbon ($\delta^{13}\text{C}$) and nitrogen ($\delta^{15}\text{N}$) isotope values of three tissues with different isotopic incorporation rates to evaluate spatial and temporal changes in caiman isotopic niche width with hierarchical Bayesian models that accounted for habitat use, intraspecific trait variation (sex and body size), and landscape attributes (composition and configuration). We also measured $\delta^{13}\text{C}$ values of essential amino acids to assess if different primary producers are fueling aquatic food webs in natural and anthropogenic areas. Spatial analysis showed that caiman in agricultural areas had larger isotopic niche widths, which likely reflects some use of terrestrial resources in environments dominated by C4 plants. Patterns in $\delta^{13}\text{C}$ values among essential amino acids were clearly different between natural and anthropogenic habitats. Overall, our findings suggest that caimans can persist in heterogeneous landscapes fueled by natural and agricultural energy sources of energy, which has implications for effectively managing such landscapes to maximize biodiversity.

da Silva, A.R., Braga-Pereira, F., Martins Borges, A.K., de Oliveira, J.V., Gomes da Silva, M.X. and Nóbrega Alves, R.R. (2023). Bioecological representations and social characteristics of students influence their attitudes toward wild vertebrates. *Journal of Ethnobiology and Ethnomedicine* 19: 25.

Abstract: The origin of different human emotions directed towards animals (whether in the utilitarian, affective, conflictual, or cosmological context) is strongly influenced by sociocultural factors, although our genetic predispositions also play an important role in the origin of these emotions. Such emotions guide people's representations of different species, which in turn affect their attitudes toward them. For this reason, understanding the factors that guide such attitudes becomes a key element in making conservationist decisions. In this sense, the main objective of this study was to analyze how sociocultural characteristics and bioecological representations can influence students' attitudes of empathy or antipathy towards vertebrate species; as well as which classes and species are related to greater and lesser support in people for their conservation. To do so, 667 interviews were conducted with students from urban (n= 1) and rural (n= 2) schools in the Brazilian semi-arid region. We used mixed generalized linear models (GLMM) to examine the effect of social factors and bioecological representations on empathy and antipathy attitudes and multiple factor analysis (MFA) to examine the relationship between the biological characteristics of the animals (positive or negative) and the attitudes toward them (antipathetic or empathetic). Through GLMM, we found that students from the urban area and from lower school levels are more extreme in their responses, more frequently expressing both empathy and antipathy towards wild animals. Regarding gender, women had a higher frequency of responses associated with aversion than men for species perceived as dangerous and poisonous (p<0.001). Through the MFA, we found greater support (empathy) for the conservation of fish species (31.56%), birds (29.37%) and mammals (25.94%), with emphasis on the Red-cowled cardinal (*Paroaria dominicana*) and clownfish (*Amphiprion ocellaris*) species, and less support (antipathy) for reptile and amphibian species such as rattlesnakes (*Crotalus durissus*) and horned frogs (*Ceratophrys joazeirensis*). The attitudinal ambivalence reflected by varying empathy for certain species and antipathy to others has important implications for wildlife conservation. Understanding the socioeconomic factors and emotions that influence attitudes towards animals can enable integrating educational strategies for the conservation of species, especially those which are culturally important.

Pochat-Cottilloux, Y., Rinder, N., Perrichon, G., Adrien, J., Amiot,

R., Hua, S. and Martin, J.E. (2023). The neuroanatomy and pneumaticity of *Hamadasuchus* (Crocodylomorpha, Peirosauridae) from the Cretaceous of Morocco and its paleoecological significance for altirostral forms. *Journal of Anatomy* (doi: 10.1111/joa.13887).

Abstract: We describe the endocranial structures of *Hamadasuchus*, a peirosaurid crocodylomorph from the late Albian-Cenomanian Kem Kem group of Morocco. The cranial endocast, associated nerves and arteries, endosseous labyrinths, and cranial pneumatization, as well as the bones of the braincase of a new specimen, are reconstructed and compared with extant and fossil crocodylomorphs, which represent different lifestyles. Cranial bones of this specimen are identified as belonging to *Hamadasuchus*, with close affinities with *Rukwasuchus yajabaliyekundu*, another peirosaurid from the 'middle' Cretaceous of Tanzania. The endocranial structures are comparable to those of *R. yajabaliyekundu* but also to baurusuchids and sebecids (sebecosuchians). Paleobiological traits of *Hamadasuchus*, such as alert head posture, ecology, and behavior are explored for the first time, using quantitative metrics. The expanded but narrow semicircular canals and enlarged pneumatization of the skull of *Hamadasuchus* are linked to a terrestrial lifestyle. Continuing work on the neuroanatomy of supposedly terrestrial crocodylomorphs needs to be broadened to other groups and will allow to characterize whether some internal structures are affected by the lifestyle of these organisms.

Ramadani, Afriyansyah, B. and Hamidy, A. (2023). Population and habitat characteristics of the saltwater crocodile (*Crocodylus porosus*, Schneider 1801) in the Antan River, Jebus-Parittiga District, West Bangka. *Jurnal Biologi Indonesia* 19(1): 17-13.

Abstract: Saltwater crocodile (*Crocodylus porosus*) is the largest and longest crocodilian species in the world. The increasing human activities along river have been caused habitat degradation in watersheds. On the other hand, the crocodile population may have increased after decades of protection. Rivers that are habitat for crocodiles and have increased human occupancy have led to increase conflicts with crocodiles. This increasing cases requires the management authorities to immediately issue policies based on scientific data. Population data and habitat characteristics of saltwater crocodiles in the Bangka Belitung Islands are not yet available. The research with the aim to know the population condition and habitat characteristics of the saltwater crocodile in the Antan River, Bangka Belitung Islands, was conducted using visual encounter survey method along 5 km. Observations were made in three time periods, namely morning, afternoon, and evening with 8 repetitions per period. Population were analyzed using the encounter rate formula, while the habitat characteristics were described descriptively. During the research, we only found one adult and this individual was sighted in the morning, afternoon and evening. This study also confirms that crocodile surveys should be conducted at night. The encounter rate at the study site was 1.13 individuals/km. This value indicates that the population is small. The habitat type in the Antan River is a mangrove ecosystem with a depth of around 2.55 m, water brightness 38.6%, water temperature 29.18°C, salt content 0.89%, and water pH 6.09. Although only one adult individual is found, it requires attention because in general conflict cases occur in adult individuals.

Kirchhof, S., Wasonga, V., Mazuch, T., Spawls, S. and Malonza, P.K. (2023). An annotated checklist of the herpetofauna of the Sibiloi National Park in northern Kenya based on field surveys. *Amphibian & Reptile Conservation* 17(1/2): 1-18 (e324).

Abstract: The xeric Lake Turkana area in northern Kenya is often referred to as the "Cradle of Mankind" due to the abundance of hominin fossils. Sibiloi National Park in the Turkana Basin has been well studied for its fossils, but the extant biodiversity of the park remains largely under-surveyed. Today, the ecosystem is threatened by climate change, increasing human population pressure, poaching

pressure, overgrazing by domestic stock, and a series of major hydropower dams and irrigated agricultural schemes (particularly the Gilgel Gibe III Dam) in Ethiopia, which may have a negative impact on the water supplies of the lake. The Turkana Basin has a high diversity of arid land herpetofauna, particularly terrestrial geckos. However, due the region's remoteness many expected species have never been recorded within the National Park. Here we provide an annotated list of the rich reptile and amphibian fauna based on two recent field surveys, including multiple first records for Sibiloi National Park. The surveys yielded records for 34 species, including 6 amphibians and 28 reptiles (one freshwater turtle, one crocodile, 18 lizards, and 8 snakes). In total, 49 species of herpetofauna are currently known for Sibiloi National Park, including 8 amphibians and 41 reptiles (3 freshwater turtles, one crocodile, 25 lizards, and 12 snakes). Of those, 5 species are protected by the Convention on International Trade in Endangered Species (CITES; Appendices I, II, or III), ie *Trionyx triunguis*, *Crocodylus niloticus*, *Varanus albigularis*, *Varanus niloticus*, and *Eryx colubrinus* (all Appendix II). Three species are listed on the International Union for Conservation of Nature (IUCN) Red List (Vulnerable, Data Deficient), ie *Sclerophrys turkanae*, *Trionyx triunguis*, and *Pelusios broadleyi*. Two species (one toad, *Sclerophrys turkanae*, and one terrapin, *Pelusios broadleyi*) are endemic to Kenya and most likely endemic to the vicinity of Lake Turkana. Overall, the herpetofauna of the Sibiloi National Park already seems to be negatively affected and is further threatened by climate change and land use activity. Furthermore, the area comprises a number of CITES listed and IUCN Red List species other than the herpetofauna, including endemics, that warrant protection and conservation measures to prevent further defaunation.

Wynne, J.J., Tellez, M., Hartwell, K., Reneau, S., Welch, G., Voyles, K.D., Cal, M., Cal, R., Castillo, D. and Champion, J. (2023). Cave-dwelling crocodiles of Central Belize. *International Journal of Speleology* 52(1): 75-81.

Abstract: We provide the results on the first systematic effort to study cave-dwelling crocodiles in central Belize. For nearly three decades, managers at Runaway Creek Nature Reserve have frequently observed crocodile tracks and trackways in caves, while subterranean observations of crocodiles were less frequent. We surveyed five caves previously identified as crocodile habitat by wading (up to waist deep) and kayaking; we also deployed trail cameras in five of six flooded caves. Crocodiles were directly observed in two caves and trail camera footage was captured of a crocodile exiting a third cave. Given that introgression between Morelet's Crocodile (*Crocodylus moreletii* (A.H.A. Duméril & Bibron, 1851)) and the American Crocodile (*Crocodylus acutus* Cuvier, 1807) is high throughout their sympatric range and none of the crocodiles were captured, all individuals were identified as *C. acutus* x *C. moreletii*? Additionally, in the five caves previously identified as crocodile habitat, we identified at least 16 potential prey species including two invertebrate, four fish, one turtle, one bird, several bat, and eight non-bat mammal species via direct observation and trail cameras. Capture, examination, and stomach flushes of cave-dwelling crocodiles, as well as continued monitoring of vertebrates via trail cameras, additional prey species surveys, monitoring of cave temperatures, and developing detailed cave maps of crocodile caves are highly recommended to obtain the information to both characterize crocodile cave use and optimally manage cave resources.

Panda, A., Katdare, S., Gawan, S., Sharma, S.P., Badola, R. and Hussain, S.A. (2023). Population status and factors influencing the distribution of Critically Endangered gharial (*Gavialis gangeticus*) in a regulated unprotected river system in India. *Global Ecology and Conservation* (<https://doi.org/10.1016/j.gecco.2023.e02547>).

Abstract: Gharial (*Gavialis gangeticus*), the last surviving crocodilian member of the family Gavialidae and genus *Gavialis*,

is endemic to the Indian subcontinent and is listed as one of the top priorities Evolutionary Distinct and Globally Endangered reptile species. Historically, the gharial used to occur in all major river systems of the Indian Subcontinent, now found in isolated stretches, mostly within the boundaries of Protected Areas. The gharial population decreased by over 80% between the 1950s and 1960s due to habitat degradation, poaching, and mortality from passive fishing. The gharial population is, however, rebounding due to concerted conservation efforts launched in the mid-1970s. One of the largest gharial populations outside of the Protected Area is in the Gandak River, a transboundary northern tributary of the Ganga. However, the habitat association of gharial in relation to the rising anthropogenic stressors is not well-documented from an ecological standpoint in the Gandak River. The present study assessed the population status and factors influencing the gharial distribution in the Gandak River. A boat-based visual encounter survey were conducted for data collection, and generalized linear models (GLMs) were employed to evaluate the factors influencing gharial distribution. The encounter rate fluctuated along the surveyed river stretches, peaking in the upstream. GLM showed a negative correlation between channel width, livestock, fishing nets, and fishing boats, and we saw a positive correlation with channel depth. We observed a positive association with channel depth while a negative one with channel width, livestock presence, fishing nets, and fishing boats. The observed pattern of encounter rate and negative association with anthropogenic variables indicate spatial avoidance of these factors. Overall, conservation interventions, such as adaptive management strategies to reduce and remove these factors, are required for long-term gharial persistence in the regulated unprotected riverscape.

Toyota, K., Akashi, H., Ishikawa, M., Yamaguchi, K., Shigenobu, S., Sato, T., Lange, A., Tyler, C.R., Iguchi, T. and Miyagawa, S. (2023). Comparative analysis of gonadal transcriptomes between turtle and alligator identifies common molecular cues activated during the temperature-sensitive period for sex determination. *bioRxiv* (doi: <https://doi.org/10.1101/2023.06.09.544319>).

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

Wu, D., Wen, C., Rao, H., Jia, H., Liu, Q. and Abualigah, L. (2023). Modified reptile search algorithm with multi-hunting coordination strategy for global optimization problems. *Mathematical Biosciences and Engineering* 20(6): 10090-10134.

Abstract: The reptile search algorithm (RSA) is a bionic algorithm proposed by Abualigah. et al. in 2020. RSA simulates the whole process of crocodiles encircling and catching prey. Specifically,

the encircling stage includes high walking and belly walking, and the hunting stage includes hunting coordination and cooperation. However, in the middle and later stages of the iteration, most search agents will move towards the optimal solution. However, if the optimal solution falls into local optimum, the population will fall into stagnation. Therefore, RSA cannot converge when solving complex problems. To enable RSA to solve more problems, this paper proposes a multi-hunting coordination strategy by combining Lagrange interpolation and teaching-learning-based optimization (TLBO) algorithm's student stage. Multi-hunting cooperation strategy will make multiple search agents coordinate with each other. Compared with the hunting cooperation strategy in the original RSA, the multi-hunting cooperation strategy has been greatly improved RSA's global capability. Moreover, considering RSA's weak ability to jump out of the local optimum in the middle and later stages, this paper adds the Lens position-based learning (LOBL) and restart strategy. Based on the above strategy, a modified reptile search algorithm with a multi-hunting coordination strategy (MRSA) is proposed. To verify the above strategies' effectiveness for RSA, 23 benchmark and CEC2020 functions were used to test MRSA's performance. In addition, MRSA's solutions to six engineering problems reflected MRSA's engineering applicability. It can be seen from the experiment that MRSA has better performance in solving test functions and engineering problems.

Mejía-Reyes, E., Cedeño-Vázquez, R., Gómez-Álvarez, G. and Villegas, A. (2023). Relationships between female size, egg size, clutch size, and hatchling size in Morelet's crocodile. *Theriogenology Wild 3* (<https://doi.org/10.1016/j.therwi.2023.100043>).

Abstract: Resources are limited by the environment in which an individual is found and can be influenced by natural selection. Evolutionary trade-offs in the reptilian reproductive effort literature have focused on optimal egg size. The objective of this study was to test egg size, clutch size, female size and hatching size in Morelet's Crocodile (*Crocodylus moreletii*). Thirteen nests, 13 post-oviposition females, and 434 eggs were evaluated, from which 292 (67.2%) neonates hatched. No correlation was found between clutch size and egg size; however, the Gaussian model best explained the relationship between egg volume and mass. The relationship between TL of the female and egg size may be explained in that the size of the egg has a defined limit even when the female continues to increase in TL. Other factors may influence clutch size, such as environmental factors, reproductive adult quality, diet, the of the females, and captive conditions.

Spiekman, S.N.F. (2023). A revision and histological investigation of *Saltoposuchus connectens* (Archosauria: Crocodylomorpha) from the Norian (Late Triassic) of south-western Germany. *Zoological Journal of the Linnean Society XX* (<https://doi.org/10.1093/zoolinnean/zlad035>).

Abstract: Crocodylomorpha is the stem-lineage of modern crocodylians and the only pseudosuchian (ie crocodylian-line archosaurs) clade that survived the Triassic-Jurassic mass extinction event. Its earliest members, the non-crocodyliform crocodylomorphs, also known as 'sphenosuchians', were terrestrial and mostly small-bodied (<2 m long), although some large-bodied forms are known. *Saltoposuchus connectens* is one of the first described crocodylomorph species but it remains poorly studied, in part due to its contentious taxonomy. Here, all referred *Saltoposuchus* specimens are described in detail for the first time and its taxonomy is revised, with additional taxonomic implications for the British crocodylomorph *Terrestrisuchus gracilis* and the coelophysoid theropod *Procompsognathus triassicus*. *Saltoposuchus connectens* is clearly distinguished from *Terrestrisuchus gracilis* based on both cranial and postcranial features. The phylogenetic analysis finds that *Saltoposuchus connectens*, *Terrestrisuchus gracilis*, and *Litargosuchus leptorhynchus* form a clade of gracile, long-legged crocodylomorphs, identified as Saltoposuchidae Crush

1984. A histological section of a femur reveals highly vascularized fibrolamellar tissue in the second-largest specimen of *Saltoposuchus connectens* (SMNS 12596), indicating sustained high growth rates. A similar pattern was previously observed in *Terrestrisuchus* sp., contrasting with slower growth rates in the crocodylomorph *Hesperosuchus agilis*. These findings suggest that saltoposuchids had a high resting metabolic rate and active lifestyle.

Guilfoyle, Jr., K.J. (2023). Refining Stable Isotope Analysis to Detect Wildlife Laundering. PhD thesis, University of Central Florida, Orlando, Florida, USA.

Abstract: The international wildlife trade has caused significant declines in wild populations. Captive breeding can reduce the pressure on wild populations caused by overcollection, but if not properly monitored, wildlife laundering can lead to further population declines. Improving the forensic ability to detect wildlife laundering will assist in monitoring the wildlife trade and enforcing regulations, thereby aiding recovery of wild populations. Stable isotope analysis has grown in importance as a forensic tool, but improvements are needed. Here, stable isotope analysis ($\delta^{13}\text{C}$) on eggshells of captive bred and wild sourced island apple snails (*Pomacea maculata*) distinguished between the two; eggshells of captive bred snails were depleted in ^{13}C relative to eggshells sourced from two wild populations. Thus, routine isotope sampling of eggshell material from purported captive breeding facilities can be used to identify discrepancies that would warrant further scrutiny. To address limitations of single-tissue stable isotope analysis as a forensic tool, I investigated between-tissue comparisons to differentiate between captive bred and wild sourced animals. The $\delta^{13}\text{C}$ values of snail shell and foot muscle were significantly correlated in captive bred snails but not in wild caught snails. Between-tissue relationships therefore can detect wildlife laundering when animals are sampled in bulk. I also tested whether the use of hydroponically grown plants to reduce isotope variability in animal diets - and thereby in the tissues of the captive animals fed them - can increase the sensitivity of stable isotope analysis as a forensic tool. Kale grown hydroponically was significantly less variable in $\delta^{13}\text{C}$ values than kale grown traditionally in soil. As predicted, *P. maculata* fed hydroponically grown kale had significantly less variable shell and foot $\delta^{13}\text{C}$ values, and less variable $\delta^{15}\text{N}$ foot values than snails fed traditionally grown kale. Combined, these experiments strengthen the viability of stable isotope analysis as a forensic tool capable of detecting signs of wildlife laundering.

Siddiqui, R., Maciver, S.K., Anuar, T.S. and Khan, N.A. (2023). Bacterial flora varies throughout the saltwater crocodile (*Crocodylus porosus*) gastrointestinal tract. American Journal of Veterinary Research (doi: 10.2460/ajvr.23.03.0061).

Abstract: The objective of this study was to determine bacterial flora throughout the gastrointestinal tract of a saltwater crocodile (*Crocodylus porosus*) using 16S rRNA gene analysis. A convention on international trade in endangered species of wild fauna and flora (CITES) registered crocodile farm, provided a healthy male saltwater crocodile, *C. porosus* for this study. Three samples were taken from the oral cavity, 3 samples from the proximal region of the small intestine (jejunum), and 3 samples from the distal part of the large intestine of the gastrointestinal tract of *C. porosus* were obtained using sterile cotton swabs. Next, swabs were placed in 15 mL sterile centrifuge tubes, individually, and kept on ice for immediate transportation to the laboratory. This was followed by 16S rRNA gene analysis using specific primers (341F-CCTAYGGGRBGCASCAG, and 806R-GGACTACNNGGTATCTAAT). Amplicons were sequenced on Illumina paired-end platform, and bacterial gastrointestinal communities, the relative abundance of taxa, and principal component and coordinate analysis were performed. The findings revealed that bacterial community structures from differing regions exhibited several differences. The number of observed bacterial operational taxonomic units (OTUs) was 153

in the oral cavity, 239 in the small intestine, and 119 in the large intestine of *C. porosus*. The small intestine reflects the highest richness. In contrast, the large intestine exhibited the least richness of microbial communities. Relative abundance of taxa showed that Proteobacteria, Bacteroidetes, and Firmicutes were dominant in all 3 sample sites. *Pseudomonas* differed in the oral cavity and the large intestine, with the latter exhibiting less distribution of *Pseudomonas*. *Stenotrophomonas* and *Castellaniella* were higher in the oral cavity, while the relative abundance of *Comamonas* and *Salmonella* was higher in the small intestine. Conversely, the relative abundance of *Salmonella* and *Pannonibacter* was augmented in the large intestine. For the first time, this study demonstrates the bacterial diversity along the segments of the gastrointestinal tract of *C. porosus*. Bacterial flora varies throughout the gastrointestinal tract. Although further studies using large cohorts are warranted; however, our findings suggest that microbiome composition may have the potential as a biomarker in determining the overall health and well-being of *C. porosus*.

Mandhata, C.P., Bishoyi, A.K., Sahoo, C.R., Maharana, S. and Padhy, R.N. (2023). Insight to biotechnological utility of phycochemicals from cyanobacterium *Anabaena* sp.: An overview. Fitoterapia (doi: 10.1016/j.fitote.2023.105594).

Abstract: Cyanobacteria (blue-green algae) are well-known for the ability to excrete extra-cellular products, as a variety of cyanochromophores (phycocyanins) of curio with several extensive therapeutic applications. Among these phycocyanins, the cyanotoxins from certain water-bloom forming taxa are toxic to biota, including crocodiles. Failure of current non-renewable source compounds in producing sustainable and non-toxic therapeutics led the urgency of discovering products from natural sources. Particularly, compounds of the filamentous N_2 -fixing *Anabaena* sp. have effective antibacterial, antifungal, antioxidant, and anticancer properties. Today, such newer compounds are the potential targets for the possible novel chemical scaffolds, suitable for mainstream-drug development cascades. Bioactive compounds of *Anabaena* sp. such as, anatoxins, hassallidins and phycobiliproteins have proven their inherent antibacterial, antifungal, and antineoplastic activities, respectively. Herein, the available details of the biomass production and the inherent phyco-constituents namely, alkaloids, lipids, phenols, peptides, proteins, polysaccharides, terpenoids and cyanotoxins are considered, along with geographical distributions and morphological characteristics of the cyanobacterium. The acquisitions of cyanochromophores in recent years have newly addressed several pharmaceutical ailments, and the understanding of the associated molecular interactions of phycochemicals have been considered, for plausible use in drug developments in future.

Masheka, A., Zvidzai, C.J. and Mpfu, A. (2023). Awareness, acceptance and usage of ready-to-use supplementary foods in Zimbabwe. The Information Technologist 20(1): 19-36.

Abstract: This research aimed to determine the awareness, acceptability, and utilisation of Ready-to-Use Supplementary Foods in Zimbabwe. Household coping strategies were investigated. Convenience sampling and face-to-face interviews using a structured questionnaire were used to gather data. Two hundred and eighteen voluntary individuals from the 10 provinces of Zimbabwe were purposively selected and interviewed. Many participants (77.98%) had heard about the Ready-to-Use Supplementary Food (RUSF). Most participants had not consumed RUSF (94.14%) while 5.86% of the participants had consumed RUSF prior to this survey. Exclusion and inclusion criteria left out many needy people. Some participants complained that very little RUSF was given to very few people due to distribution of inadequate quantities and pilferage. RUSF usage was very low. Coping household strategies included group purchasing and sharing of bulk basic goods on discount from wholesalers. Depending on wild fruits, tubers, and vegetables as well as drying food for later use increased. Illegal

street forex deals, illegal gold and diamond mining, and illegal fishing proliferated. Marketing of second hand clothes and new clothes by runner agencies became popular. Batter trade, consuming unusual foods like crocodile meat and insects, division of villages such that in small villages all people got rations every time the donors distributed foods, getting food from chiefs' granaries, farm brick molding, temporary employment in farms, and skipping of the border by family members to work in foreign countries helped during shocks. The majority of the participants (90.83%) accepted RUSF and recommended its commercialization. RUSFs could be used to prevent and reduce malnutrition.

Pethiyagoda, R. (2023). Policing the scientific lexicon: The new colonialism? *Megataxa* 10(1): 20-25.

Briggs, W.M. (2023). On Broken Science. Net Zero Watch.

This paper is edited from the transcript of a talk given by Professor Briggs at Hillsdale College, Michigan in April 2023. The talk was an invited contribution under the auspices of the Broken Science Initiative, <https://brokenscience.org/>.

Toomey, A.H. (2023). Why facts don't change minds: Insights from cognitive science for the improved communication of conservation research. *Biological Conservation* 278 (<https://doi.org/10.1016/j.biocon.2022.109886>).

Abstract: Conservation scientists increasingly seek to find ways to implement their research for improved policy and practice. However, such efforts may be ineffective, or even counterproductive, if they are based on outdated models of science communication and behavioral change. Insights from fields that study how information is processed in the brain, how and why humans make decisions and take action, and how change spreads across social networks can support and improve existing efforts to translate conservation research into practice and policy. However, little of this research has made its way into the conservation science literature, thus limiting the power of these ideas to influence how research is communicated and how impact is understood. This paper seeks to address this gap by discussing four common myths about how to best communicate science for decision-making, namely, that facts change minds, scientific literacy will lead to enhanced research uptake, individual attitude change will shift collective behaviors, and broad dissemination is best. The article provides four alternative insights that can support effective science communication and impact: engaging the social mind for optimal decision-making, understanding the power of values, emotions, and experience in swaying minds, changing collective behavior, and thinking strategically for biggest impact. If we can understand how people process information, we can design interventions based on the best possible evidence of how humans make decisions for conservation management and policy.

Habarugira, G., Harrison, J.J., Moran, J., Suen, W.W., Colmant, A.M.G., Hobson-Peters, J., Isberg, S.R., Bielefeldt-Ohmann, H. and Hall, R.A. (2023). A chimeric vaccine protects farmed saltwater crocodiles from West Nile virus-induced skin lesions. *NPJ Vaccines* 8(1) (doi: [10.1038/s41541-023-00688-w](https://doi.org/10.1038/s41541-023-00688-w)).

Abstract: West Nile virus (WNV) causes skin lesions in farmed crocodiles leading to the depreciation of the value of their hides and significant economic losses. However, there is no commercially available vaccine designed for use in crocodilians against WNV. We tested chimeric virus vaccines composed of the non-structural genes of the insect-specific flavivirus Binjari virus (BinJV) and genes encoding the structural proteins of WNV. The BinJV/WNV chimera, is antigenically similar to wild-type WNV but replication-defective in vertebrates. Intramuscular injection of two doses of BinJV/WNV in hatchling saltwater crocodiles (*Crocodylus porosus*) elicited a

robust neutralising antibody response and conferred protection against viremia and skin lesions after challenge with WNV. In contrast, mock-vaccinated crocodiles became viraemic and 22.2% exhibited WNV-induced lesions. This suggests that the BinJV/WNV chimera is a safe and efficacious vaccine for preventing WNV-induced skin lesions in farmed crocodilians.

Marco, M., Chiarenza, A., Delfino, M., Fabbri, M., Milocco, K. and Fanti, F. (2023). *Acynodon adriaticus* from Villaggio del Pescatore (Campanian of Italy): anatomical and chronostratigraphic integration improves phylogenetic resolution in Hylaeochampsidae (Eusuchia). *Cretaceous Research* (<https://doi.org/10.1016/j.cretres.2023.105631>).

Abstract: The hylaeochampsid crocodylomorph *Acynodon adriaticus*, from the uppermost Cretaceous 'Villaggio del Pescatore' site, belongs to an early diverging lineage in Eusuchia. Here an additional specimen, MCSNT 57031, is osteologically and osteohistologically described in detail. After integrating this morphological information together with the recent chronostratigraphic recalibration of the site to the lower-middle Campanian, the tip-dated Bayesian phylogenetic analysis recovers this taxon in a monophyletic clade with the Spanish *Acynodon iberoccitanus*. Conflicting results from the maximum parsimony analyses and discussion on the intraspecific variability between the specimens assigned to *A. adriaticus* highlights the need for a detailed morphological description and integration with an updated phylogenetic scaffold, in order to resolve the monophyly of the genus *Acynodon* and the relationships of these branch of early diverging eusuchians. The curious discrepancy between morpho- and osteo-skeletal maturity suggest unique ecomorphological adaptations in this Campanian crocodylomorph.

Pritz, M.B. (2023). A different framework to classify preoptic and hypothalamic nuclei in reptiles. *Neuroscience Letters* (<https://doi.org/10.1016/j.neulet.2023.137368>).

Abstract: The preoptic area and the hypothalamus are inextricably linked. Together, they represent an area of the forebrain that is essential for survival of the species. Observations in mammals have suggested a classification of these structures into four rostrocaudal areas and three mediolateral zones. Two species of crocodiles were investigated to determine if this scheme or a modification of it could be applied to these reptiles. The resulting classification identified three rostrocaudal areas based on their respective relationship to the ventricular system: preoptic, anterior, and tuberal and four mediolateral zones: ependyma, periventricular, medial, and lateral. This scheme avoided the cumbersome and complicated nomenclature that has traditionally been used for morphologic studies of these areas in other reptiles, including crocodiles. The present classification is simple, straightforward, and readily applicable to other reptiles.

Sousa Santana, R.L., Lopes de Carvalho, E., Fernandez Conga, D.M., Mayor Aparicio, P., Assuncao Pereira, W.L. and Guerreiro Giese, E. (2023). Redescription of *Brevimulticaecum baylisi* (Travassos, 1933) Sprent (1979) (Nematoda: Heterocheilidae), a parasite of *Caiman crocodilus* (Crocodylia: Alligatoridae) in the north-eastern Peruvian Amazon. *Veterinary Parasitology: Regional Studies and Reports* 43 (<https://doi.org/10.1016/j.vprsr.2023.100905>).

Abstract: *Caiman crocodilus* is among the most abundant and widely distributed predators in the Neotropical region. These animals consume prey such as crustaceans, birds, small mammals, reptiles, amphibians, and fish, which can carry infective larval forms of nematodes. *Brevimulticaecum* has few studies on its morphology available, lacking detailed images. Therefore, the aim of this study was to redescribe *Brevimulticaecum baylisi*, stomach parasite of *Caiman crocodilus*, from subsistence hunting in the Yavari-Mirin River, Peruvian Amazon, using light and scanning electron microscopy. Four caimans were analyzed, and,

macroscopically, all had ulcerative lesions in the stomach caused by this parasite. Histopathology showed an inflammatory infiltrate with a predominance of lymphocytes. Morphological characteristics of nematodes include the presence of three diamond-shaped lips wider than they are long, interlabia pyramidal, excretory pore located above the nerve ring, present intestinal cecum, ventriculus with five ventricular appendages, and long, winged spicules. These morphological characters, added to the number and distribution of the pre- and postcloacal papillae of the male specimens, allowed the identification of these parasites as *B. baylisi*. Scanning electron microscopy of these nematodes showed the presence of a denticular ridge on the inner surface of the lips in both sexes, while in males, the presence of a horseshoe-shaped median papilla was observed on the upper lip of the cloaca. Our research, therefore, adds these characteristics to the original description of *B. baylisi*, in addition to expanding the biogeographical distribution of this parasite.

Cho, Y.-Y. and Tsai, C.-H. (2023). Crocodylian princess in Taiwan: Revising the taxonomic status of *Tomistoma taiwanicus* from the Pleistocene of Taiwan and its paleobiogeographic implications. *Journal of Paleontology* (<https://doi.org/10.1017/jpa.2023.36>).

Abstract: *Toyotamaphimeia* is an extinct crocodylian lineage whose name is derived from a mythological Japanese princess. Here, we re-examine the type specimens of a long-forgotten species: *Tomistoma taiwanicus* from the Pleistocene of Tainan (Taiwan) and revise its taxonomic status to *Toyotamaphimeia taiwanicus* n. comb., leading to the first recognized species of *Toyotamaphimeia* outside Japan. Our phylogenetic analyses also support this taxonomic assignment and, more interestingly, further suggest an East Asian lineage. In addition, *Toyotamaphimeia taiwanicus* n. comb. represents a tropical species, resolving a long-standing puzzle of why *Toyotamaphimeia* only inhabited a much higher latitudinal area (Japan). Given the large body size of *Toyotamaphimeia taiwanicus* n. comb. (~7 m) and the fact that it is geologically older than *Toyotamaphimeia machikanensis* from Japan, we propose a novel evolutionary scenario: the genus *Toyotamaphimeia* originated in Taiwan and evolved to a large body size with gigantothermic physiology, which resulted in migration out of Taiwan and dispersal farther north to Japan. Our taxonomic identification shows the presence of an extinct endemic crocodylian species from the Pleistocene of Taiwan with large-scale paleogeographic implications. This study, with our recent progress in vertebrate paleontology in Taiwan, should provoke more in-depth paleontological research on the Pleistocene extinction.

Yalong, M., Poapolathep, S., Giorgi, M., Khidkhan, K., Klangkaew, N., Phaochoosak, N., Chaiyabutr, N., Wongwaipairoj, T. and Poapolathep, A. (2023). Pharmacokinetic disposition of marbofloxacin after intramuscular administration in estuarine crocodiles (*Crocodylus porosus*). *Journal of Veterinary Pharmacology and Therapeutics* ([doi: 10.1111/jvp.13400](https://doi.org/10.1111/jvp.13400)).

Abstract: To date, the pharmacokinetics of fluoroquinolones in estuarine crocodiles (*Crocodylus porosus*) have been reported for enrofloxacin but not for marbofloxacin (MBF), which is a broad-spectrum antibiotic used only in veterinary medicine. This study investigated the pharmacokinetics of MBF after intramuscular administration at two difference dosages (2 and 4 mg/kg body weight) in estuarine crocodiles and estimated pharmacokinetic/

pharmacodynamic (PK/PD) surrogate parameters for the optimization of dosage regimens. Ten treated estuarine crocodiles were divided into two groups (n= 5) using a randomization procedure according to a parallel study design. Blood samples were collected at assigned times up to 168 h. MBF plasma samples were cleaned up using liquid-liquid extraction and analyzed using a validated high-performance liquid chromatography method with fluorescence detection. A non-compartment approach was used to fit the plasma concentration of MBF vs time curve for each crocodile. The plasma concentrations of MBF were quantifiable for up to 168 h in both groups. The elimination half-life values of MBF were long (33.99 and 39.28 h for 2 and 4 mg/kg, respectively) with no significant differences between the groups. The average plasma protein binding of MBF was 30.85%. According to the surrogated PK/PD parameter (AUC_{0-24} -to-MIC ratio >100-125), the 2 and 4 mg/kg dosing rates should be effective for bacteria with MIC values lower than 0.125 µg/mL and 0.35 µg/mL, respectively.

Nie, H., Xu, Y., Zhang, Y., Wen, Y., Zhan, J., Xia, Y., Zhou, Y., Wang, R. and Wu, X. (2023). The effects of endogenous FSH and its receptor on oogenesis and folliculogenesis in female *Alligator sinensis*. *BMC Zool* 8(1): 8 ([doi: 10.1186/s40850-023-00170-z](https://doi.org/10.1186/s40850-023-00170-z)).

Abstract: The precise mechanisms of hormone action responsible for the full course of events modulating folliculogenesis in crocodilian have not been determined, although histological features have been identified. The *Alligator sinensis* ovarian morphological characteristics observed at 1, 15, 30, 60, 90, and 300 days post-hatching (dph) revealed that the dynamic changes in germ cells varied in different meiotic and developmental stages, confirming that the processes of folliculogenesis were protracted and asynchronous. The presence of endogenous follicle-stimulating hormone (FSH) mRNA and protein expression within the cerebrum at 1 dph, in parallel with the increase in germ cells within the germ cell nests (Nest) from 1 dph to 15 dph, suggested that endocrine regulation of the pituitary-gonad axis is an early event in oogenesis division. Furthermore, the endogenous expression of FSH showed a trend of negative feedback augmentation accompanied by the exhaustion of maternal yolk E2 observed at 15 dph. Such significant elevation of endogenous FSH levels was observed to be related to pivotal events in the transition from mitosis to meiosis, as reflected by the proportion of oogenesis during premeiosis interphase, with endogenous FSH levels reaching a peak at the earliest time step of 1 dph. In addition, the simultaneous upregulation of premeiotic marker STRA8 mRNA expression and the increase in endogenous FSH further verified the above speculation. The strongly FSHr-positive label in the oocytes within Pre-previtellogenic follicles was synchronized with the significant elevation of ovarian cAMP detected at 300 dph, which suggested that diplotene arrest maintenance during early vitellogenesis might be FSH dependent. In addition, preferential selection in asynchronous meiotic initiation has been supposed to act on somatic supportive cells and not directly on germ cells via regulation of FSH that in turn affects downstream estrogen levels. This suggestion was verified by the reciprocal stimulating effect of FSH and E2 on the accelerated meiotic marker SYCP3 and by the inhibited cell apoptosis demonstrated in ovarian cell culture *in vitro*. The corresponding results contribute an expansion of the understanding of physiological processes and shed some light on the specific factors responsible for gonadotropin function in the early folliculogenesis of crocodilians.

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