

CROCODILE SPECIALIST GROUP NEWSLETTER

VOLUME 42 No. 1 • JANUARY 2023 - MARCH 2023



IUCN • Species Survival Commission

CROCODILE

SPECIALIST

GROUP

NEWSLETTER

VOLUME 42 Number 1
JANUARY 2023 - MARCH 2023

IUCN Species Survival Commission

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Cover: In March 2023, Alejandro Larriera (CSG Deputy Chair) marked the 40th anniversary of working with *Caiman latirostris*. These early efforts laid the foundation for the initiation of Proyecto Yacaré in Argentina. See page 3 for details.

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

CSG Newsletter

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

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

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Editorial

As I informed the CSG membership recently, Tom Dacey, the CSG's Executive Officer since 2005, will retire in early April 2023. It is with a touch of sadness that we see Tom step down after 18 years in the role. On behalf of the CSG membership, I again thank Tom for his dedicated service, and the significant contribution that he has made to the operation of the CSG. We wish Tom all the best in his retirement.

Sally Isberg (csg@wmi.com.au) will replace Tom Dacey as CSG Executive Officer. As many members are aware, Sally and her Red List team have done a fantastic job with the IUCN Red List assessments, and we envisage that Sally will bring the same energy and enthusiasm into the Executive Officer role.

Alejandro Larriera, CSG Deputy Chair, celebrated a personal milestone in March, which marked 40 years since the first *Caiman latirostris* eggs literally "hatched in his hands". This early work by Alejandro, initiated to assist in the recovery of the wild *C. latirostris* population in Santa Fe Province of Argentina, laid the foundation for the establishment of Proyecto Yacare. In a recent editorial in "El Litoral" (21 March 2023), Alejandro talks about the multidisciplinary efforts involved in getting Proyecto Yacare off the ground (https://www.ellitoral.com/opinion/yacare-santa-fe-humedales-huevos-aniversario-peones-rurales-granja-esmeralda_0_rwHa19w7vN.html). The program has seen a multitude of people involved over the last 40 years, and so it is easy to forget that these types of initiatives often begin due to the efforts of a lone champion - like Alejandro.

The long-standing issue of the proposed California ban of alligator and crocodile products into that state, finally reached a result. On 7 March 2023, after almost 4 years of litigation, California's Eastern District Federal Court ruled in favor of the leather industry, declaring that California's trade ban was invalid. Californian markets will thus remain open to alligator and crocodile leather products going forward. See page 6 for details.

On 27 March 2023, the CITES Secretariat issued a notification recommending a suspension of all commercial trade of CITES-listed species from Mexico, effective immediately. Following CoP19, Mexico was required to develop a draft compliance action plan with respect to the regulation of illegal fishing in Vaquita (*Phocoena sinus*) refuge and zero-tolerance areas. The plan submitted was not considered adequate by the CITES Secretariat, resulting in the recommendation to suspend trade, which includes crocodilians. US Fish and Wildlife Service implemented the trade suspension immediately, thus potentially shutting down the western boot industry in the USA. On 13 April 2023, the CITES Secretariat withdrew the recommendation to suspend trade, after Mexico's revised plan was deemed to comply

with SC75 requirements, and assessed as adequate. See page 6 for details.

I congratulate Marisa Tellez and collaborators (Jorge Brocca, Juana Peña, Ramón Espinal, Bobby Greco) on the success of their application for a SSC Internal Grant (<https://www.iucn.org/our-union/commissions/species-survival-commission/partners-and-donors/partnership-and-grants>). The project "Population Recovery of American crocodile (*Crocodylus acutus*) in Lago Enriquillo through Head-start" aims to intends to reignite interest and knowledge about *C. acutus* in the Dominican Republic through a head-start, protection, and monitoring program, while simultaneously interacting with communities to re-build pride and stewardship of crocodiles and their habitats. The project will build on work that has been carried out by researchers in that country.

The 50th anniversary of CITES and World Wildlife Day were celebrated on 3 March 2023. In recognition of the work that CITES does and the collaborative work for conservation that goes on globally, the theme for World Wildlife Day this year was "Partnerships for Wildlife Conservation". I was delighted to see Christy Plott (CSG Vice Chair for Industry and Trade) invited to speak at the event held in Washington DC, where she highlighted the recovery of the American alligator (*Alligator mississippiensis*) as a successful partnership story. See page 7 for details.

Congratulations are extended to Sudhakar Kar, who was honoured with the "Odisha Wildlife Conservation Award" for his dedicated and outstanding research work on Saltwater crocodiles (*Crocodylus porosus*) and other wildlife species over 47 years. The award was presented during the first Odisha Wildlife Conclave held at Jaydev Bhawan, Bhubaneswar, on the occasion of World Wildlife Day. See page 12 for details.

I again applaud the efforts of the CrocFest organisers and their team, who raised \$US50,000 for research on Black caiman (*Melanosuchus niger*) at Summer CrocFest (December 2022). I also take this opportunity to congratulate Ruth Elsey, who was announced as the recipient of the Ralf Sommerlad Crocodile Conservation Award at Summer CrocFest 2022 (see page 4).

"Croc School CrocFest" will be held on 12 May 2023, at St. Augustine Alligator Farm Zoological Park. The event will be held in conjunction with the AZA Croc School, which celebrates its 20th anniversary (see page 4).

Dates for the 27th CSG Working Meeting, to be held in Darwin, in the Northern Territory of Australia, are now confirmed as 16-19 April 2024, with workshops (eg drone, veterinary) to be held on 14 April and the meeting of CSG Steering Committee on 15 April. It is anticipated that the meeting website will be launched soon, at which time details will be available on venue, registration, accommodation, program, etc. See also page 4.

Grahame Webb, CSG Chair (gwebb@wmi.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 three students in the January-March 2023 quarter, and four applications are currently under review.

1. Micaela Mazaratti (Argentina): Effect of incubation temperature on the development of reproductive structures in *Caiman latirostris*.
2. Tyler Hunt (USA): The visual fields of Crocodylia.
3. Camila Chacón (Argentina): Gene expression patterns of lipid metabolism as biomarkers of environmental pollution in *Caiman latirostris*.

Dr. Sally Isberg, *CSG Executive Officer* (csg@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 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.

As soon as the meeting website is launched, details will be available on venue, registration, accommodation, program, etc.

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

CrocFest

“Winter CrocFest 2022” took place on 10 December 2022 at St. Augustine Alligator Farm Zoological Park, St. Augustine, Florida, USA. The event attracted some 300 participants and raised \$US50,000 to support the first census in 50 years of the Black caiman (*Melanosuchus niger*) in the northeast portion of its range - Guyana, French Guiana and Suriname. This research effort will be led by Robinson Botero-Arias, who will also utilize drones to survey areas that are inaccessible on foot, as well as satellite tracking.

At the event, Dr. Ruth Elsey was announced as the recipient of the Ralf Sommerlad Crocodile Conservation Award, which is presented to an individual or organization who has demonstrated outstanding commitment and contributions to crocodilian captive husbandry and conservation (Fig. 1).

“Croc School CrocFest 2023” will be held on 12 May 2023, at St. Augustine Alligator Farm Zoological Park (eg see https://www.facebook.com/crocpests/?locale=pt_BR). It will held in

conjunction with the AZA Croc School, which celebrates its 20th anniversary.

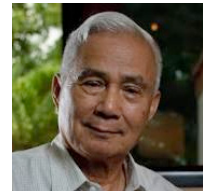


Figure 1. Curt Harbsmeier announces Dr. Ruth Elsey as recipient of the Ralf Sommerlad Crocodile Conservation Award, at Winter CrocFest 2022.

In Memoriam

Angel Alcala (1929-2023)

Angel Alcala had a long involvement with the conservation of Saltwater (*Crocodylus porosus*) and Philippine (*C. mindorensis*) crocodiles in the Philippines. This involvement began in 1980, when he established a crocodile breeding facility at Silliman University's marine laboratory. Progeny from this breeding program were sent to Gladys Porter Zoo in 1988 as part of the North American Philippine Crocodile Co-operative Breeding and Conservation Program. He and collaborators published the first scientific account of Philippine crocodile breeding habits and early life.



In 1983, Alcala and Andy Ross produced the first distribution map for *C. mindorensis*, which became the blueprint for researchers and conservationist to explore other extant populations and suitable habitats for the species. In 1987, these efforts culminated in the establishment of the RP-Japan Crocodile Farming Institute in Palawan, the primary objectives of which were to conserve the two species of crocodile in the Philippines, and introduce crocodile farming technology to Filipino farmers and develop an alternative means of livelihood.

In 2015 he was invited to be Chair of *Crocodylus Porosus* Philippines, Inc., which has various ongoing projects involving the conservation of Philippine crocodiles. As a pioneer of crocodile conservation in the Philippines, he led the organisation with wisdom, integrity, and passion. He would often say at meetings, “If I only could go back in time, I would have studied crocodiles in my younger years”. Undoubtedly, his leadership has benefited many communities living alongside crocodiles.

Considered the father of Philippine marine protected areas, and declared a national scientist in 2014, Alcala popularised

the “No take zone” and “spillover effect” management. Alcalá’s work as a herpetologist led to the discovery of 50 new species of reptiles and amphibians in the country. He served in various government posts, including Secretary of the Department of Environment and Natural Resources from 1992 to 1995.

Goff Letts (1928-2023)

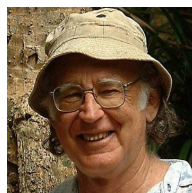


Godfrey (“Goff”) Letts was a well-qualified, respected and truly remarkable person, who contributed a great deal to the Northern Territory and its crocodile program. As a qualified young veterinarian, Goff moved from Victoria to the Northern Territory in 1957, as District Veterinary Officer and Assistant Director of the NT Animal Industries Branch. At that time, the Northern Territory was a large but remote Commonwealth Territory, with around 32,000 people, half of whom were Aboriginal. In 1963-70, Goff was Director of Primary Industries, and Chair of the NT Wildlife Advisory Council. He became involved in politics, and was Majority Leader in the first legislative Assembly (1967-77), and is considered the “father” of self-government in the Northern Territory, granted in 1978.

As Director of the Conservation Commission of the NT (1980-1984), with Tom Dacey as his Deputy, many of the pivotal decisions concerning crocodile management, including the transfer of the Saltwater crocodile (*C. porosus*) population from Appendix I to Appendix II of CITES, were made under his guidance. There were complex international politics involved, and Goff, myself and Charlie Manolis worked closely together, on many occasions travelling to international meetings to put the Northern Territory’s case forward. So many funny stories and friendships resulted.

In 1985, Goff relocated back to Victoria, where he was heavily involved in water management, but he always kept in contact with the Northern Territory and the many colleagues and friends he had made. A very skilled writer, from a family involved in regional newspapers, he often wrote about his early experiences, and in 2021 published “Where Brolgas Dance”, relating stories about his life and experiences in the Northern Territory - all coloured with a wonderful sense of humour that he seemed to bring to all occasions, and a great moral compass. Goff will be sadly missed by many, but his contribution - especially to the Northern Territory - will live on.

Alistair Graham (1938-2023)



News that Alistair Graham had passed away was greeted sadly by those who knew him. He was a great lateral and bold thinker, and contributed much to wildlife conservation and management, particularly with crocodiles. Alistair was one of the first to challenge the conservation paradigm, that had its roots in colonial times, that strict protection was the only conservation could be pursued. He argued this was often designed to please

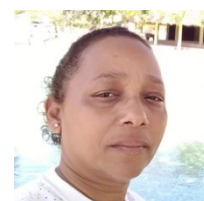
distant people in distant lands, rather than to assist local people and empower their involvement in conservation.

Working in East Africa in 1964-77, Alistair was among the first researchers to develop aerial survey as a basic management tool. In the Okavango River (Botswana), he devised and implemented an aerial technique for mapping and monitoring Nile crocodile (*Crocodylus niloticus*) nesting, and developed a management program for the sustainable use of crocodiles. His first book, “The Gardeners of Eden” (1973), argued convincingly that conservation based on management and sustainable use was an obvious way forward, and buried into the reasons why this approach had often been rejected. His work on the Lake Rudolf population of *C. niloticus*, which involved harvesting a large number of individuals, challenged the CSG mantra of the day, yet provided a wealth of information on crocodile populations as a functioning unit. Immortalised through his book “Eyelids of Morning. The Mingled Destinies of Crocodiles and Men” (1973), with photographer Peter Beard, the Lake Rudolf study was a pivotal one.

In late-1979, Alistair relocated to Papua New Guinea, where he developed a program to monitor crocodile populations through nesting effort in the Sepik and Fly River basins. He also assisted in the drafting of new legislation to regulate the crocodile skin industry in PNG, that recognised community use of the resource as a primary form of exploitation. He worked closely with Rom Whitaker and a string of other researchers. In 1981, he moved to Darwin, and was involved in the establishment of one of the early crocodile farms, where he was a constant source of advice and encouragement. He was later involved with higher education in the Northern Territory, was Government Conservator on Christmas Island (2003-2006), and then moved to Western Australia where he worked on fire control and joined the WA Department of Parks and Wildlife.

In 2001, he published a new book, “The Rape and Murder of Mother Nature”, as “*better conservation of nature remains my preoccupation*”. It expanded insights from his previous books, and in his words, “*This explains why reason, which we could theoretically use to refine our behaviour, is helpless in the face of ego-driven competition among our leaders, and why monumental problems are looming*”. Alistair’s contribution to understanding why rational conservation is so often replaced with irrational conservation was very significant and deserves much more attention that it has received.

Juana Peña Flores (1970-2023)



Juana dedicated more than a decade to implementing the Ramsar Convention in the Dominican Republic, with a particular focus on wetland monitoring, Ramsar site designation, the Caribbean Regional Initiative, and coordinating the Regional Mangrove and Coral Initiative. In 2007, she began monitoring American crocodiles (*Crocodylus acutus*) in Lago Enriquillo and Isla Cabritos National Park, and played a crucial role in the

conservation of crocodiles in the Dominican Republic until her final days.

Recently, Juana played an active role in Ramsar CoP14, contributing to the workshop on Governance and Capacity Development in the “Rational Use of Caribbean Wetlands for the Mitigation of Climate Change and Conservation of its Ecosystem Services” project, held in Belize on 10-21 February 2023 under the Caribbean Regional Initiative.

On local and regional levels, Juana’s influence and teachings will continue through the many people she has impacted. We can take comfort in the fact that she has left a positive mark on the world through her guidance and wisdom, and though she may be physically gone, her legacy will live on. Her dedication, commitment, enthusiasm, friendship, and sense of humor were remarkable, and will be missed.

Text provided by Grahame Webb, Charlie Manolis, Rainier Manalo and Joel Espinal.

CITES Recommendation for Trade Suspension on Mexico Withdrawn

At its 75th meeting in Panama (13 November 2022), the CITES Standing Committee agreed to various recommendations for Mexico on Totoaba (*Totoaba macdonaldi*) (https://cites.org/sites/default/files/documents/SC/75/agenda/E-SC75-07-05_0.pdf). In summary, Mexico was required to develop a draft compliance action plan that clearly outlined steps to urgently progress implementation, in particular preventing illegal fishers and unauthorized vessels from entering the Vaquita (*Phocoena sinus*) refuge and zero-tolerance areas, and maintaining them as gillnet net-free zones.

As the finalised plan submitted by Mexico by the deadline of 28 February 2023 was not considered adequate by the CITES Secretariat, CITES Notification No. 2023/037 was issued on 27 March 2023, recommending a suspension of all commercial trade of CITES-listed species from Mexico, effective immediately (https://cites.org/sites/default/files/documents/SC/75/agenda/E-SC75-07-05_0.pdf).

The trade suspension included crocodilians and other species, and potentially shut down the western boot industry in the USA, that utilizes hundreds of thousands of exotic leather skins each year. At CoP17 (2016), the Parties excluded the Nile crocodile from a similar CITES trade suspension that Madagascar was facing. But this is not possible with regard to the current situation with Mexico, and the recommendation for a trade suspension would remain in effect until a revised compliance action plan from Mexico was considered adequate by the CITES Secretariat.

A high-level Mexican delegation visited Geneva on 27-30 April 2023, and worked with the CITES Secretariat to revise the Totoaba action plan. The plan, submitted on 7 April 2023 was assessed as being adequate and complying with the

requirements as set out by SC75. Accordingly, on 13 April 2023, the CITES Secretariat withdrew the recommendation for a trade suspension (Notification No. 2023-046; <https://cites.org/sites/default/files/notifications/E-Notif-2023-046.pdf>). The swift action by the Mexican Government to address this issue is commended.

Christy Plott, *CSG Vice Chair for Industry and Trade* (christyplott@amtan.com).

California Ban Declared Invalid

On 7 March 2023, California’s Eastern District Federal Court ruled in favor of the alligator and crocodile leather industry, declaring that the state of California’s trade ban on these species was invalid. The case - *April in Paris v. Becerra* - was decided after nearly four years of litigation, and means that California markets will remain open to alligator and crocodile leather products going forward.



The core legal question in *April in Paris* was whether the US Endangered Species Act (“ESA”) and its implementing regulations preempted the California law with respect to alligators and crocodiles. In the USA, “federal preemption” is a constitutional doctrine that resolves conflicts between federal and state laws in favor of federal law as the “supreme law of the land”. In essence, states are allowed to pass their own laws on certain issues as long as those laws do not conflict with federal law.

With regard to the ESA, the general rule is that any species listed as endangered or threatened under the federal law is prohibited from commercial trade. In theory, this level of protection serves as a floor, by which states are allowed to implement greater protections for these species if they so choose. However, some CITES Appendix-II species are exempted from the ESA’s ban on commercial trade via “special rules,” which are federal regulations under the ESA that set out specific requirements to ensure all trade in these species is sustainable. Notably, all three species at-issue in *April in Paris* (ie *Alligator mississippiensis*, *Crocodylus niloticus*, *C. porosus*), are subject to these ESA special rules authorizing commercial trade.

In terms of federal preemption, the ESA expressly provides that states are not allowed to (i) authorize activities that are prohibited by the federal law, or (ii) prohibit what is authorized by the federal law. In *April in Paris*, the Court found that because the ESA’s special rules for alligators and crocodiles authorize their commercial trade, California’s state law prohibiting their trade was invalid. The case is now being resolved for a final judgment.

Bret Sparks, *Kelley Drye & Warren LLP, Texas, USA.*

50th Anniversary of CITES and UN World Wildlife Day

The 50th anniversary of CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) and the United Nations World Wildlife Day were celebrated on 3 March 2023. This year's theme, "Partnerships for Wildlife Conservation", was an acknowledgment of the various partnerships around the world that contribute to conservation and recovery of species and the safeguarding of habitats.

The official World Wildlife Day 2023 event was held in Washington DC, at National Geographic Society's Grosvenor Auditorium, where a number of keynote speakers addressed a small audience of invited members and the world via livestream. Notable speakers included CITES Secretary-General Ivonne Huguero and US Secretary of Interior, Deb Haaland. One of the partnership stories that was highlighted in this year's World Wildlife Day was the recovery of the American alligator (*Alligator mississippiensis*), presented by Christy Plott (CSG Vice Chair for Industry and Trade) (Fig. 1).



Figure 1. Christy Plott (far left) presented recovery of American alligator as a "partnership story".



Figure 2. Left: Christy Plott with Christine Lippai (CSG Deputy Chair). Right: Christy Plott with Matthias Loether (Chair, CITES Animals Committee).

CITES Secretary-General Ivonne Huguero, remarked, "We are at a crucial moment confronting a crisis of rapid biodiversity loss, changing climate and rising pollution on our planet. For the last half a decade, CITES Parties and stakeholders

have been building partnerships to support the conservation of our wildlife. Those partnerships must be continued and strengthened to address our environmental challenges and allow us to achieve our shared vision to change our relationship with nature and not ask from it more than it can give us. Washington DC is the birthplace of CITES, and there is no more fitting place to renew our commitment and embark on the next 50 years of our work."

Martha Williams, Director of the US Fish and Wildlife Service noted, "This year marks the 50th anniversaries of CITES and the US Endangered Species Act, both of which are vital to the protection of numerous species in the face of climate change, wildlife trafficking, habitat loss and fragmentation, and other challenges. The successful recovery of species under CITES and the ESA underscores the importance of partnerships - including engaging with Indigenous people and rural and local communities - to protect our planet for future generations."

World Wildlife Day 2023 may be viewed on YouTube (https://www.youtube.com/watch?v=Ua_52T4vkFc).

"IUCN SSC Guidelines on Human-Wildlife Conflict & Coexistence" Launched

The "Guidelines on Human-Wildlife Conflict & Coexistence" (IUCN 2023) are now available (<https://portals.iucn.org/library/sites/library/files/documents/2023-009-En.pdf>). Developed by the Human-Wildlife Conflict & Coexistence Specialist Group (HWCCSG), they aim to provide foundations and principles for good practice, with clear, practical guidance on how best to tackle conflicts and enable coexistence with wildlife. They also aim to improve management of human-wildlife conflict globally, supporting efforts to be pursued through well-informed, holistic and collaborative processes that take into account underlying social, cultural and economic contexts (HWCCSG 2023).



IUCN SSC guidelines
on human-wildlife conflict
and coexistence



The launch of the Guidelines coincided with the International Conference on Human-Wildlife Conflict and Coexistence, held in Oxford, UK, on 30 March-1 April 2023 (www.hwconference.org/). A summary of the conference will be provided in the April-June issue of the CSG Newsletter.

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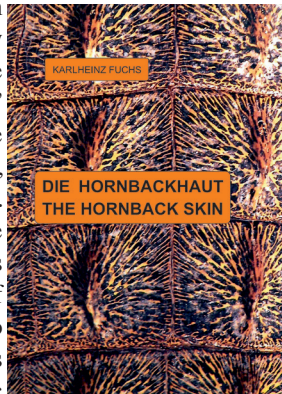
IUCN (2023). IUCN SSC Guidelines on Human-Wildlife Conflict and Coexistence. First edition. IUCN: Gland, Switzerland.

Book Review

“Die Hornbackhaut – The Hornback Skin”

Since CITES came into force (1975) and different countries adopted enacting legislation for CITES (sometime stricter), virtually all trade in crocodilians or their body parts has required identification to species. Checks and verification by appropriate border controls, at points of export and import, are part of the regulation process. This is clearly no easy task, because any part of a crocodilian in trade, from whole live animals to blood or tissue samples, is considered a “specimen” in the context of CITES. Nevertheless, the majority of trade comprises raw or tanned skins, and finished products, ranging from watchstraps, with small pieces of skin, to belts, wallets, handbags, luggage and clothing, with increasingly large amounts of skin. Thus the identification of skins and products has been the main focus of efforts to assist border inspections.

A very significant contribution to this problem was made by Karlheinz Fuchs, when he published “Die Krokodilhaut” (1974), later published as “The Crocodile Skin” (2006) in English, with assistance from the CSG. This work primarily described the scale patterns on the belly skins (ventral and lateral surfaces) of all species, and drew attention to geographic variation in the skins of some species with taxonomic significance. This new publication, “Die Hornbackhaut – The Hornback Skin” (2023), by Karlheinz Fuchs, in both German and English, focusses on the hornback skin - the dorsal surface, from behind the head to the tail tip, including the post-occipitals and the nuchal rosette, which are often featured on products, but which are particularly hard to identify.

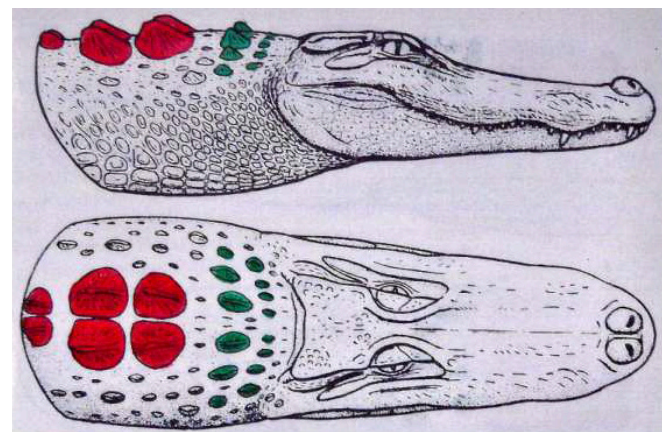
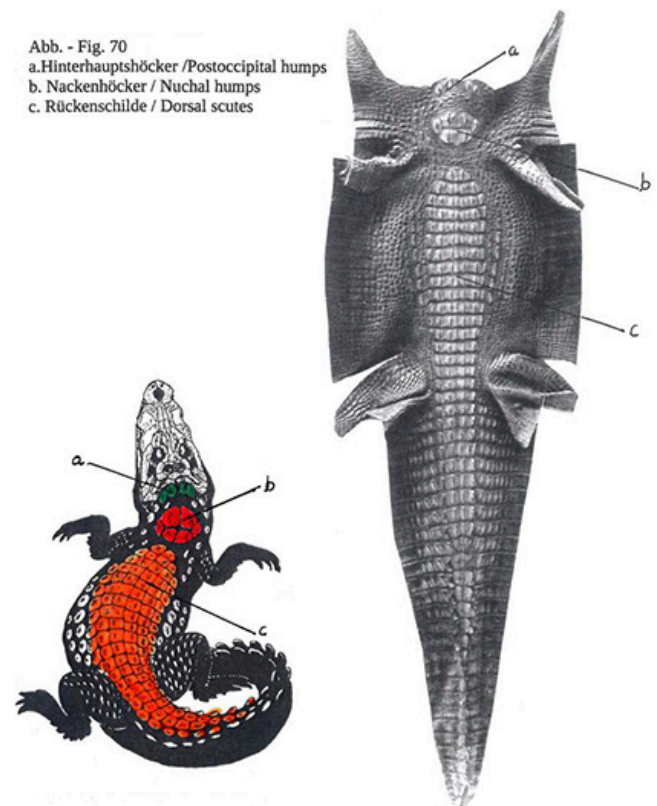


The treatment of most species uses diagrams in which the general arrangement of post-occipitals and the nuchal rosette is well described (Wermuth and Fuchs 1978), and each treatment is accompanied by a distribution map (Trutnau and Sommerlad 2006), which gives border control personnel an extra tier of information with which to validate or question a particular export or import.

The extent of individual variation in the pattern of post-occipitals, and the osteoderms comprising the nuchal rosette, has seldom been described and quantified in individual species, but with this book, perhaps more attention will be focussed on it. With *Crocodylus johnstoni*, the diagram did not include the second row of scutes on the nuchal rosette, and perhaps the growing number of people working on individual species will find similar details. Regardless, the work will greatly assist in what is otherwise a very difficult identification problem.

Karlheinz Fuchs is a tannery engineer, with a long and pioneering involvement in the crocodile skin tanning industry.

He has travelled extensively, and published his findings widely, so that others can benefit from the knowledge he has accumulated. This is another important contribution to our ability to ensure trade in crocodile skins and products is legal and verifiable. I strongly recommend the book to people involved in these issues.



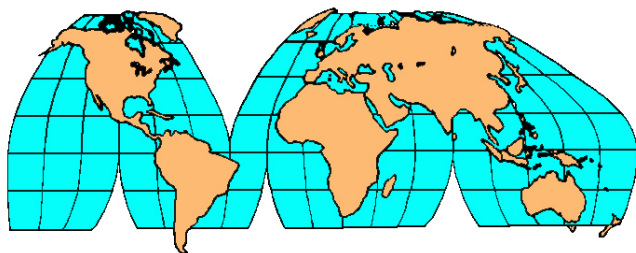
The book can be purchased (28€ + postage) directly from Karlheinz Fuchs (E-mail: ingridfuchsdauborn@t-online.de).

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Review provided by Professor Grahame Webb, CSG Chair.

Regional Reports



Latin America and the Caribbean

Belize

EFFECTS OF ILLEGAL FEEDING PRACTICES AND URBANISATION ON BEHAVIOUR OF WILD AMERICAN CROCODILES (*CROCODYLUS ACUTUS*) ON AMBERGRIS CAYE, BELIZE. The American crocodile (*Crocodylus acutus*) occupies the largest range of any crocodilian in the New World, inhabiting coastal estuaries and lagoons, mangrove forests, as well as freshwater rivers and lakes across its neotropical range (Platt and Thorbjarnarson 2000; Tellez and Boucher 2018). Belize is a small country (22,000 km²), in which *C. acutus* was previously considered Critically Endangered (Platt and Thorbjarnarson 2000). Results from surveys at that time indicated one of the lowest encounter rates for this species across its range (0.28 crocodiles/km). An on-going country-wide survey program aims to confirm the current status of *C. acutus* in Belize, and the extent to which recovery may have been impacted by increased coastal development, pollution and mangrove deforestation (Tellez and Kohlman 2019).

Ambergris Caye has one of the highest populations of *C. acutus* relative to other nearby cayes (Chenot-Rose 2013). It forms the southernmost extent of the Mexican Yucatán Peninsula, and is located approximately 0.8 km from the Belize Barrier Reef, a UNESCO World Heritage Site (Sweetman *et al.* 2018). The proximity to these reef ecosystems has made the island the most important tourist destination in Belize, as well as the country's economic hub (Sweetman *et al.* 2018). The town of San Pedro is considered the epicentre of industry and tourism on the island, which has seen a 432% increase in human population between 2000 and 2017 (Statistical Institute of Belize 2017). This increase in human population size and the rapid (unsustainable) development of infrastructure across the island has caused an acceleration of illegal wildlife activities (eg feeding crocodiles for tourism), deforestation, pollution and landscape transformation over the last two decades (Sweetman *et al.* 2018). American crocodiles are protected under the *Belize Wildlife Act 1981 (Act No. 4 of 1981)* (<https://leap.unep.org/countries/bz/national-legislation/wildlife-protection-act-1981-act-no-4-1981>), which states that it is illegal to feed, capture, or harass crocodiles, in addition to possessing or selling crocodile teeth, skin, bones, or meat. Despite this protection, illegal tourism-driven activities involving crocodiles are a common issue on Ambergris Caye.

Species have evolved different reactions or interactions to humans through the development of situation-specific responses. These responses are formed from a combination of active learning and inherent behaviour that have been selected for (Whittaker and Knight 1998). Unfortunately, the altered behaviour of the animal caused by humans can be detrimental to the wild population as it can increase susceptibility to illegal hunting given the lack of fear of humans. This learned lack of fear of humans could also increase the likelihood of a negative interaction between a human and animal (eg an attack) (Whittaker and Knight 1998). Overall, the responses wildlife has to interactions with humans can be classified into three main categories - "attraction", "habituation" and "avoidance" (Knight and Cole 1991). The attraction response exhibited by wildlife toward people was the focus of this study, as altering the crocodiles' natural behaviour toward people can lead to dangerous interactions. Attraction is defined as the strengthening of an animal's behaviour due to positive reinforcement and implies movement toward the stimuli. This stimulus is most associated with humans supplying food to an individual or a population, but includes other stimuli such as shelter, or an altered habitat (eg birds congregating at a bird bath) (Knight and Cole 1991).

This study aims to examine how illegal feeding practices alter crocodile behaviour towards humans on Ambergris Caye. Considering the continued accelerated development in parallel to the expanding human population of Ambergris Caye, negative interactions between humans and crocodiles are likely to increase. Our study aims to provide preliminary data on the negative behavioural changes exhibited by crocodiles toward humans when provided with food stimulus, in the form of illegal unstructured feeding events for tourism.

Methodology

We recorded the response of wild *C. acutus* to human presence at known illegal feeding sites on Ambergris Caye versus the response of wild *C. acutus* within the island's nature reserve, to assess the effect of illegal feeding practices on the behaviour of each population toward humans. A total of 27 individual crocodiles was observed during the study across San Pedro Town (designated as Group A; Fig. 1) and Bacalar Chico Natural Reserve (designated as Group B; Fig. 2).



Figure 1. Location of Group A survey at dock behind Topsy Lobster Bar and Grill (17.96179, -87.93451).

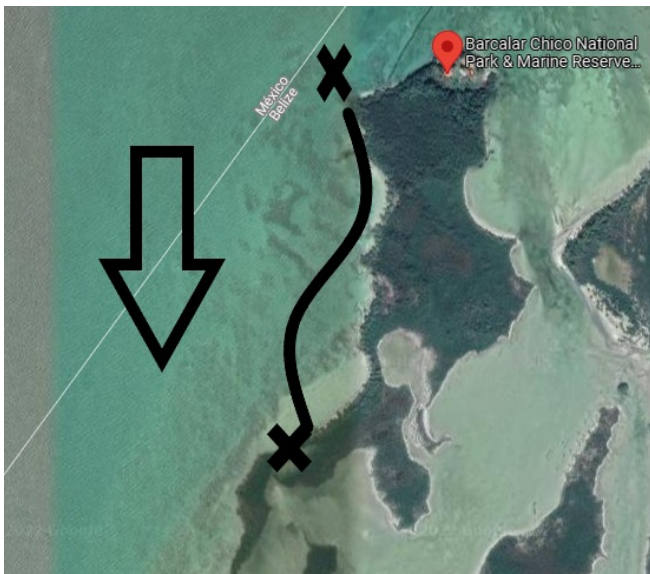


Figure 2. Group B survey route (line) in Bacalar Chico Natural Reserve (18.153100, -87.892617).

Crocodiles from Group A had been subjected to illegal feeding and high levels of urbanisation in their environment within a mangrove cove just north of San Pedro Town. Local community members and businesses have been illegally feeding crocodiles for approximately 10 years as a tourism activity. Group B (control) was in BCNR, which has low levels of urbanisation and human interference compared to San Pedro Town.

Group A was surveyed on 19 August 2021, and again on 22 August 2021, with 6 different crocodiles being observed in each survey. Each survey lasted 3 hours (1700–2000 h). Air and water temperatures, along with salinity and GPS coordinates, were recorded at the beginning of a survey. Start

time for surveys was 1700 h, as this was the usual time that restaurant staff fed crocodiles for tourists. For Survey 1, we asked a member of staff to lead us down to the location and “call” the crocodiles and begin a routine feeding session as we began the behavioural survey. Consistency in our arrival time, and our behaviour as “tourists” was essential as crocodiles remember patterns, voices, and can distinguish between humans that have fed them, and humans that have harmed or attempted to capture them before (Augustine *et al.* 2012).

For Survey 2, we walked up the dock to emulate tourists being brought to the feeding location, but without food stimulus or restaurant staff. We splashed the water with branches to signal our presence on the dock, then stood and observed the crocodile's behaviour in response to our presence, splashing the water every few minutes with mangrove branches to represent activity on the dock.

At BCNR, we chose the west shore for the survey as it was easily accessible by boat and known to have a significant population of crocodiles. Again, air and water temperatures, along with salinity and GPS coordinates, were recorded at the beginning of the survey. The boat moved along the river at a consistent speed of ~8 km/h, with a member of the team at the bow of the boat using a spotlight to locate crocodiles. Once a crocodile was spotted, we recorded GPS coordinates, an estimate of size, along with the type of environment it was in (eg underneath mangroves, open water, etc.). We then approached the crocodile at same speed (~8 km/h) until it evaded the boat. We classified “evading” as submerging underwater or retreating away from the boat rapidly. We recorded the distance at which crocodiles retreated from human presence, along with their behavioural responses to humans (Table 1). A total of 15 crocodiles was observed.

At both sites, we recorded the responses of the crocodiles to our presence using the observational parameters that were closely adapted from the list of characterised behaviour and description of activities observed for *C. acutus* in Belize, created by Boucher *et al.* (2021). Behavioural responses of Group A are in Table 1.

Results

We used a two-tailed t-test and general linear models to determine if there was a significant difference in attraction towards humans between Group A and Group B (RStudio version 4.1.1, 2021-08-10). Our analysis using a general linear model revealed a statistically significant difference between Group A and Group B in regards to the distance (m) that crocodiles allowed humans to approach/be present before evading the situation ($P = 0.00000249$, $p < 0.05$). In Group A, 100% of crocodiles ($n = 12$) actively approached researchers (Fig. 3).

A two tailed t-test showed that there was no significant difference in the evading distance between Survey 1 (food presented) and Survey 2 (food not presented) in Group A

Table 1. Behavioural activities of Groups A and B (following Boucher *et al.* 2021).

Category	Behaviour	Description of activities	Group A	Group B
Agonistic	Interspecific aggression	Chasing with intent	Yes	-
		“Head oblique tail arched” display	Yes	-
Maintenance	Foraging	Stalking humans on dock	Yes	-
		Striking out from ambush position	Yes	-
		Lifting head to consume prey	Yes	-
Locomotion	Movement in response to stimulus	Swimming on water surface towards stimulus	Yes	-
		Swimming on water surface, away from stimulus	-	Yes
		Floating on water surface, full body exposed	Yes	-
		Submerging full body	Yes	Yes
		Only head exposed	Yes	Yes
		Movement from shallow to deeper water	-	Yes
Social signalling	Non-aggressive interspecific communication	Tail raised, body posture inflated, back raised	Yes	-

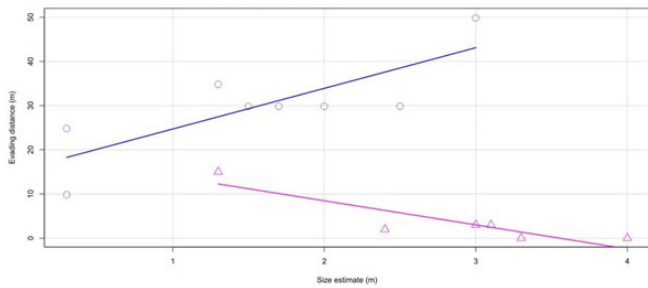


Figure 3. Evading distance for different-sized *C. acutus* in Group A (fed; triangles) and Group B (circles).

($P = 0.6997$). In Group A, the lack of fear exhibited by the crocodiles was most prevalent in the largest individuals (3+ m) (Fig. 3).

In Group B, 100% of individuals over 2 m in length did not allow researchers to approach within 30 m once spotted, opting to submerge completely or evade rapidly in the opposite direction.

We observed 10 behavioural activities in Group A and 4 in Group B, of which only 2 were common to both groups (Table 1).

Conclusions

The timid and shy behaviour that *C. acutus* exhibits towards human presence highlights them as a fantastic candidate for co-existence throughout their neo-tropical range. Local communities altering crocodile behaviour via unstructured feeding events will likely lead to negative consequences for both crocodiles and the safety of visitors and community members alike. The feeding of crocodiles for tourism in Belize is considered to be linked to attacks on humans, with two attacks on tourists occurring recently in the country. In 2019, a 33-year-old American tourist received over 100 stitches in her hand and arm after being grabbed by a ~3.8 m long crocodile just south of San Pedro Town (Anon. 2019).

The woman was swimming in an area where reports of illegal feeding events were occurring (ACES Wildlife Rescue, unpub. data). In April of 2022, a man spear-fishing near the split on Caye Caulker in a location known for indirect feeding by nearby businesses, was also attacked (Anon. 2022).

Our small dataset illustrates a possible link between illegal unstructured feeding events and change in crocodile behaviour (ie causing crocodiles to lose fear of humans and actively approach them in search of food). This may negatively affect the safety of local communities and tourists in the area, leading to dangerous interactions with this generally timid species. Our results also show that previously-fed crocodiles keep their attraction behaviour toward humans, even if future encounters with people don't involve a food stimulus. When researchers approached Group A with the usual food source (scraps from restaurant kitchen) the crocodiles approached quickly and visibly, swimming on the surface of the water with no intent to conceal their approach. When we returned to the site without food, the crocodiles approached slowly and fully submerged, displaying the foraging tactic of stalking prey, only breaking the surface to strike out at the mangroves being splashed by researchers simulating activity on the dock.

The specific behavioural activities we recorded carried out by the crocodiles further highlight the change in behaviour of these animals in response to a food stimulus. Group A demonstrated 10 different behavioural activities in the presence of humans, with Group B only demonstrating 4. Group A demonstrated 6 behavioural activities associated with direct attraction toward human stimulus (Table 1), including stalking and striking out at humans, and directly approaching humans on the surface of the water. Group B did not exhibit any of these attraction behaviours, instead only displaying avoidance manoeuvres (Table 1). Our results suggest that the feeding of wild crocodiles for tourism can lead to an increase in the overall number of exhibited behaviours by crocodiles in the presence of humans as they lose their natural fear of people. This may cause individuals to be more susceptible to illegal hunting and other human harassment. Our results also

show that Group A and Group B react oppositely to human presence, with Group A actively approaching and engaging in foraging behaviour, while Group B stuck strictly to aversion behaviours.

This short study was intended to provide basic preliminary data on how altering crocodile behaviour could pose a threat to the safety of communities. More research and data is warranted to further corroborate the link between behaviour alteration and increase negative interactions between crocodiles and humans. Furthermore, future research into this topic could be used to advise developing ecotourism industries across Latin America and the Caribbean on how to ethically and safely interact with crocodiles and their surrounding ecosystem

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South Asia and Iran

India

LIFETIME ACHIEVEMENT AWARD TO DR. SUDHAKAR KAR. Sudhakar Kar, former Senior Research Officer of the Odisha Forest Department, and long-time CSG member, was honoured with the "Odisha Wildlife Conservation Award" jointly by Nature and Wildlife Conservation Society of Odisha (NWCSO) and Ever Green Forum, for his dedicated and outstanding research work on Estuarine crocodiles (*Crocodylus porosus*) and other wildlife species over 47 years.

The award was presented by Shri Aswini Kumar Patra, the Honourable Minister for Tourism and Culture of the Government of Odisha, in the presence of dignitaries during the first Odisha Wildlife Conclave held at Jaydev Bhawan, Bhubaneswar, on the occasion of World Wildlife Day (3 March 2023).

On this same occasion, the second edition of "Panira Raja Kumbhira" (Crocodile: The King of Water), authored by Lala A.K. Singh and Sudhakar Kar, was released by the Honourable Minister (Fig. 1).



Figure 1. Award function and release of the 2nd edition of "Panira Raja Kumbhira" at the Odisha Wildlife Conclave. From left to right; Lala Singh, Prakash Chandra Jena (President, Ever Green Forum), Sudhakar Kar, Sri Saroj Kumar Patnaik (Former Chief Wildlife Warden, Odisha and President, NWCSO), Sri Aswini Kumar Patra (Honourable Minister, Tourism and Culture, Government of Odisha), Sri Debidutta Biswal (PCCF and Head, Forest Force, Odisha), Anup Kumar Nayak (Former Addl. Director General, Project Tiger, Government of India) and Sri Susant Kumar Das (Joint Secretary, NWCSO).

RESULTS OF ANNUAL CENSUS OF ESTUARINE CROCODILES (*CROCODYLUS POROSUS*) IN THE RIVER SYSTEMS IN AND OUTSIDE BHITARKANIKA NATIONAL PARK, ODISHA, INDIA. The Estuarine Crocodile Conservation and Research Programme was implemented by the Odisha Forest Department in Bhitarkanika Wildlife Sanctuary/National Park in mid-1975. During 1976, the first winter census was conducted in the river systems of Bhitarkanika to assess population status of Estuarine crocodiles (*Crocodylus porosus*). The number of Estuarine crocodiles counted in the Bhitarkanika area was 96, including 29 adults (Kar 1980; Kar and Bustard 1989). Between 9 and 12 January 2023, the annual census was again conducted in the river systems of Bhitarkanika National Park/ Sanctuary and associated rivers and creeks of Gahirmatha Wildlife Sanctuary as well as in Mahanadi delta region. In all, 22 teams in 54 segments were engaged to count the crocodile population in the identified rivers and creeks.

The census was conducted during the day and night (Fig. 1). Crocodiles above 1.8 m in length (ie sub-adults and adults) were counted during the day. Hatchlings (<0.6 m), yearlings (0.6<0.9 m) and juveniles (0.9<1.8 m) were primarily counted by spotlight at night. Due to favourable climatic conditions such as extreme cold winter and sunny weather, low day and night air/water temperatures and low tide conditions, counting of crocodiles was very successful.



Figure 1. Suhajore Creek, during ebb tide. Both banks have luxuriant mangrove communities. Rowing boats of around 4.3 m length have been used for conducting day and night counts of crocodiles since January 1976. Photograph: Sudhakar Kar.

A total of 1793 crocodiles was counted, which comprised: 569 hatchlings (31.7%), 388 yearlings (21.6%), 325 juveniles (18.1%), 166 sub-adults (9.3%) and 345 adults (19.2%) (Fig. 2). Of the total, 1417 crocodiles (79.0%) were spotted in Kanika Wildlife Range, which included forest blocks and rivers starting from Khola to Bhitarkanika-Pathasala confluence and beyond in Bramhani-Baitarani River systems, and 268 (14.9%) were in Rajnagar WL Range. Within the Mahanadi delta, 78 crocodiles (4.4%) were counted in Mahakalapada Wildlife Range, and 30 (1.7%) in Gahirmatha Wildlife Range. There was an increase of 9 crocodiles in comparison to the January 2022 census results (Kar 2022).

It is to be noted that with the initiation of the Government of India/FAO/UNDP Project “Crocodile Breeding and Management”, a Crocodile Conservation Project was launched in different states to save three Indian crocodilian species from extinction. The Estuarine Crocodile Conservation and Research Project was implemented successfully by the Odisha Forest Department in Bhitarkanika Wildlife Sanctuary/National Park in mid-1975. Within the last 47 years it has achieved its prime objective of “rear and release” of crocodiles besides protection of the threatened mangrove ecosystem.

Acknowledgements

I am thankful to the Chief Wildlife Wardens, Odisha and Wildlife Wardens of Athagarh Forest Division, as well as Wildlife Wardens of the Bhitarkanika Mangrove (Wildlife) Division, Chandabali/Rajnagar for extending support to conduct the study on population status and trend of Estuarine crocodiles in Bhitarkanika Wildlife Sanctuary/National Park since July 1975.

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Figure 2. From left: Partially white female *C. porosus* (locally known as ‘Sankhua’; 3 m TL); 3.7 m long *C. porosus*; Large (5.5+ m TL) male *C. porosus*. Photographs: Nirakar.

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Recent Publications

Mozar, A. and Prost, S. (2023). An introduction to illegal wildlife trade and its effects on biodiversity and society. Forensic Science International: Animals and Environments 3 (<https://doi.org/10.1016/j.fsiae.2023.100064>).

Abstract: Illegal Wildlife Trade (IWT) is among the most lucrative illegal industries in the world. Its consequences go far beyond direct effects on the species in trade. In this review, we outline the basics of IWT and discuss its cascading consequences on environments, human lives and communities, national stability, and the economy. In addition, we outline structures used in IWT, from subsistence and local use to more complicated configurations, which can include multiple players. Furthermore, while a small fraction of poaching is opportunistic, most of the international IWT is run by organised crime groups. We outline how IWT can be associated with many different crimes like drug trafficking, corruption, or whitewashing. Additionally, many studies have observed a rapidly increasing trend of online trade with endangered and protected species. Moreover, this review gives a short overview of the situation in the European Union (EU) regarding laws and implementation of CITES and highlights that the EU acts as a major source, transit hub, and consumer in IWT. To address the highly dynamic and complicated problem of IWT, research, knowledge exchange, funding, and collaborations in all fields are necessary.

Maslova, M. (2023). Molecular Mechanisms of Environmental Sex Determination in Reptiles. BSc thesis, Charles University, Prague, Czech Republic.

Abstract: Molecular mechanisms underlying environmental sex determination remained elusive for half a century, until just recently, when new insights into the topic were gained. The thesis summarizes current progress on this issue and focuses, among other things, on the role of oxidative stress and regulation of gene expression in the process of sex determination and sex reversal.

Pritz, M.B., Elsey, R.M., Thompson, T.N. and Hsu, E.W. (2023). A rare case of partial skull and brain duplication in a hatchling *Alligator mississippiensis*. Anatomical Record (Hoboken) 306(3): 494-501.

Abstract: Errors in development occur in all vertebrates. When severe, these anomalies are lethal and frequently escape attention. In rare cases, animals with profound malformations are born and can provide a glimpse into structures and their respective function that would otherwise go unnoticed. A rare abnormality in a hatchling *Alligator mississippiensis* is described in which duplication of the skull, face, and brain was incomplete. The rostral skull, face, and associated forebrain, including the olfactory apparatus, were duplicated. However, the caudal skull and brainstem were not. These observations were made with advanced imaging using both computed tomography and magnetic resonance coupled with gross brain dissections. These abnormal features emphasize the complex and intertwined relationship between the development of the brain,

face, and skull which are influenced by certain signaling molecules, possible gene mutation(s), and potential environmental factors.

Guerrero, A., Ortega, F., Martín de Jesús, S. and Pérez-García, A. (2023). Analysis of the anomalies in a Middle Eocene shell of *Neochelys* (Pleurodira, Podocnemididae) from the Duero Basin (Zamora, Spain). Diversity 15: 314.

Abstract: Turtle shells frequently exhibit anomalous osseous modifications on their surface which can sometimes compromise the survival of the organism. Nowadays, despite the large number of anomalies identified in both extant and extinct turtle shells, the etiology, as well as the pathogenesis, of the various osseous modifications remains unknown in most documented extinct representatives. In fact, the interpretation of these anomalies in most fossil turtles is often speculative, the great majority of anomalous osseous modifications being attributed to vertebrate feeding traces, without considering other potential causative agents. In this context, we herein re-analyzed the shell anomalies recognized in an individual determined as *Neochelys* sp. (Pleurodira, Podocnemididae) from the middle Eocene (Lutetian) of the El Tejar fossil site (Corrales del Vino, Zamora, Spain), previously proposed as traumatic injuries resulting from a crocodile attack. The re-evaluation of these osseous alterations through detailed physical examination, comparison through direct observation and from the literature on extant turtles, and the use of the files obtained from a computerized axial tomography scan, allows the proposal of diverse causal agents, none of them supporting the previous interpretation. In addition, information regarding the pathogenesis and stages of the healing of the shell anomalies studied herein is provided.

Hou, Q., Jin, X., Qiu, Y., Zhou, Z., Zhang, H., Jiang, J., Tian, W. and Zhu, C. (2023). Spectral characterization and identification of natural and regenerated leather based on Hyperspectral Imaging System. Coatings 13: 450.

Abstract: Currently, the methods to identify leather materials have limitations, and identifying natural leather types is also relatively complex. In this research, the microstructures of four types of mammalian leathers (cattle leather, pig leather, sheep leather, and deer leather), three kinds of reptilian leathers (crocodile leather, lizard leather, and snake leather) and regenerated leather were characterized by scanning electron microscopy. The spectral curves (from 900 to 1700 nm) of these leather samples were extracted using a hyperspectral imaging system, and their spectral characteristics were analyzed. A method of leather identification by the hyperspectral imaging system combined with chemometrics was established. The results showed that the spectral curves of natural and regenerated leather differed in the number, position, and depth of the characteristic peaks, enabling the classification of regenerated leather by comparative analysis with the naked eye. The first-order derivative processing-principal component analysis-discriminant analysis model achieved a 98% correct classification rate, confirming the hyperspectral imaging system's feasibility in the leather material identification field. We believe that his research is beneficial for the leather industry to understand the classifications scientifically, in order to protect consumer rights and further develop the leather testing industry.

Gônet, J., Bardin, J., Girondot, M., Hutchinson, J. and Laurin, M. (2023). Locomotor and postural diversity among reptiles: palaeobiological implications. Journal of Anatomy (<https://doi.org/10.1111/joa.13833>).

Abstract: The conquest of land by the first tetrapod vertebrates represents a key stage in their evolution. Selection pressures exerted by this new environment on animals led to the emergence of new locomotor and postural strategies that favoured access to different ecological niches and contributed to their evolutionary success.

Today, amniotes show great locomotor and postural diversity, particularly among Reptilia, whose extant representatives include erect bipeds (birds), “semi-erect” quadrupeds (crocodilians) and sprawling quadrupeds (squamates and turtles). But the different steps leading to such diversity remain enigmatic and the type of locomotion adopted by many extinct species raises questions. This is notably the case of certain Triassic taxa such as *Euparkeria* and *Marasuchus*. However, the exploration of the bone microanatomy in reptiles helps to overcome these uncertainties. Indeed, this locomotor and postural diversity is accompanied by great microanatomical disparity. On land, the bones of the appendicular skeleton support the weight of the body and are subject to multiple constraints that partly shape their external and internal morphology. Here we show how microanatomical parameters measured in cross-section, such as bone compactness or the position of the medullocortical transition, can be related to locomotion. Bipedal taxa had a larger medullary cavity than quadrupeds, but no significant difference in terms of compactness. We hypothesise that the different nature of the forces acting on the bone induced by the different postures may explain this result. Using statistical methods that take phylogeny into account (flexible phylogenetic discriminant analyses), we develop different models of locomotion from a sample of femur cross-sections from 51 reptile species. We use these models to infer locomotion and posture in 7 extinct reptile taxa for which they remain debated. Our models produced reliable inferences for taxa that preceded and followed the quadruped/biped and sawling/erect transitions, notably within the Captorhinidae and Dinosauria. For taxa contemporary with these transitions, such as *Terrestriuchus* and *Marasuchus*, the inferences are more questionable. We use linear models to investigate the effect of body mass and functional ecology on our inference models. We show that body mass seems to significantly impact our models in most cases, unlike the functional ecology. Finally, we illustrate how taphonomic processes can impact certain microanatomical parameters, especially the eccentricity of the section. Our study provides insight into the evolution of enigmatic locomotion in various early reptiles. Our models and methods could be used by palaeontologists to infer the locomotion and posture in other extinct reptile taxa, especially when considered in combination with other lines of evidence.

Garcês, A. and Pires, I. (2023). Teratological effects of pesticides in reptiles - a review. Chapter 6 in *Bird and Reptile Species in Environmental Assessment Strategies*, ed. by G. Liwszyc and M.L. Larramendy. The Royal Society of Chemistry: London.

Durando, M., Galoppo, G.H., Tavalieri, Y.E., Zanardi, M.V. and Munoz-de-Toro, M. (2023). What is *Caiman latirostris* teaching us about endocrine disruptors? Chapter 10 in *Bird and Reptile Species in Environmental Assessment Strategies*, ed. by G. Liwszyc and M.L. Larramendy. The Royal Society of Chemistry: London.

Odetti, L.M., Simoniello, M.F., Siroski, P.A. and Poletta, G.L. (2023). The Broad-snouted caiman (*Caiman latirostris*): A model species for environmental pesticide contamination assessment through molecular markers. Chapter 11 in *Bird and Reptile Species in Environmental Assessment Strategies*, ed. by G. Liwszyc and M.L. Larramendy. The Royal Society of Chemistry: London.

Chamberlain, J.R. (2023). Reflections on the Ngeuak and its transmogrifications. *Journal of Lao Languages* 4 (https://www.researchgate.net/profile/James-Chamberlain-4/publication/368566526-Reflections_on_the_Ngeuak_and_its_Transmogrifications/links/63ee3d1231cb6a6d1d09a0c5/Reflections-on-the-Ngeuak-and-its-Transmogrifications.pdf)

Abstract: Of all the zoological and theriomorphic lexicon of Tai, the creature called ‘ngeuak’ is one of the most puzzling. Depending on the language, it takes many forms, as indeed it does in the

various tales and beliefs that surround the creature and its ability to metamorphose into human form when desired. This paper explores the likely linguistic origins of the ngeuak, and its transference from real to mysterious, a process that probably occurred first in Austro-Tai and then from Tai to Austroasiatic where the two stocks have been in contact. There is thus a duality at work here between the quotidian humdrum and purely scientific acts of phonological reconstruction, and the more poetic imaginings of the natural world with its visions of the unseen. These latter appear in the tales not only of Tai speakers but speakers of Austroasiatic languages as well.

Honan, C. and Murray, C.M. (2023). The effect of androgen exposure on cerebral lateralization in the American alligator (*Alligator mississippiensis*). *General and Comparative Endocrinology* (<https://doi.org/10.1016/j.ygcen.2023.114248>).

Abstract: The division of the brain manifests in lateralized physical behaviors, where specific tasks originate from one side of the body. Previous studies have shown that birds and reptiles mediate aggression in their right hemisphere and focus on opponents with their left eye. Degree of lateralization varies between sexes, likely due to androgen inhibition of lateralization in mammals, birds, and fish, but remains untested in herpetofauna. In this experiment, we investigated the effect of androgen exposure on cerebral lateralization in the American Alligator, *Alligator mississippiensis*. Alligator eggs were collected and incubated at female producing temperature with a subset dosed with methyltestosterone *in ovo*. Dosed hatchlings were randomly paired with control individuals and their interactions were recorded. The number of bites initiated by focus from each eye and the number of times an animal was bitten on each side of the body was recorded for each individual to elucidate cerebral lateralization in aggression. Control alligators had a significant bias towards left-eye bite initiation whereas androgen exposed alligators used both eyes indiscriminately. No significance was found in injury patterns. This study suggests that androgen exposure inhibits cerebral lateralization in alligator brains and corroborates right-hemisphere mediation of aggression, something previously unstudied in crocodilians.

Abrahms, B., Carter, N.H., Clark-Wolf, T.J., Gaynor, K.M., Johansson, E., McInturff, A., Nisi, A.C., Rafiq, K. and West, L. (2023). Climate change as a global amplifier of human-wildlife conflict. *Nature Climate Change* (<https://doi.org/10.1038/s41558-023-01608-5>).

Abstract: Climate change and human-wildlife conflict are both pressing challenges for biodiversity conservation and human well-being in the Anthropocene. Climate change is a critical yet underappreciated amplifier of human-wildlife conflict, as it exacerbates resource scarcity, alters human and animal behaviours and distributions, and increases human-wildlife encounters. We synthesize evidence of climate-driven conflicts occurring among ten taxonomic orders, on six continents and in all five oceans. Such conflicts disrupt both subsistence livelihoods and industrial economies and may accelerate the rate at which human-wildlife conflict drives wildlife declines. We introduce a framework describing distinct environmental, ecological and sociopolitical pathways through which climate variability and change percolate via complex social-ecological systems to influence patterns and outcomes of human-wildlife interactions. Identifying these pathways allows for developing mitigation strategies and proactive policies to limit the impacts of human-wildlife conflict on biodiversity conservation and human well-being in a changing climate.

Hasan, G., Baloch, H. and Mairaj (2023). Mythical animals in Indo Iranian tribes: A case study of Balochi folklore, science and superstitions. *The Dialogue* 18(1) (<https://journals.qurtuba.edu.pk/ojs/index.php/thedialogue/article/view/710/270>).

Abstract: The animals which subdue human supremacy and intelligence with their power and strength are always considered to be possessing special powers in indigenous communities around the world. Like any native population, the Baloch sphere is also replete with the stories of these mythical animals and their special powers which other animal kingdoms are lacking. In this paper, it is revealed how these animals are treated in Balochi folklore, the powers these animals possess, and how the Baloch society uses these supposing powers to enhance their strength.

Borteiro, C., Gutierrez, F., Tedros, M., Kolenc, F. and Verdade, L.M. (2022). Capture methods of *Caiman latirostris* Daudin, 1802 (Crocodylia, Alligatoridae) in northern Uruguay, with notes of defensive and feeding behaviours. *Journal of Neotropical Biology* 19: 153-164.

Abstract: *Caiman latirostris* is a Neotropical crocodilian for which there is scarce natural history information in regard to other species, as also about survey methods used by field researchers. In this work we report the capture methodology implemented during population monitoring in northern Uruguay and some observations about defensive and feeding behaviours. We found the use of a metallic clamp as very useful for capturing juveniles and subadult individuals (<120 cm total length) in vegetated habitats, while a wire snare was used for adults. Regardless locomotor escape, we provide a reappraisal of defensive behaviours in the presence of humans, with comments on tonic immobility. In addition, we suggest an apparent case of carcass consumption (scavenging).

Aubier, P., Jouve, S., Schnyder, J. and Cubo, J. (2023). Diet diversity might explain the differential survival of *Notosuchia* (Crocodyliformes) at the Cretaceous-Palaeogene crisis. *EGU General Assembly 2023*, Vienna, Austria, 24-28 Apr 2023. EGU23-2567 (<https://doi.org/10.5194/egusphere-egu23-2567>).

Abstract: The 24 species of crocodylians, including crocodiles, alligators, caimans, and the gharial, represent the extant diversity of Crocodyliformes. These species poorly reflect the past diversity of this group. Indeed, extinct crocodyliforms include hundreds of species adapted to semi-aquatic but also to terrestrial and marine environments. Characterization of the factors driving the macroevolutionary history of Crocodyliformes has been difficult partially because of this ecological disparity. Indeed, studies working at a global scale (ie at the scale of the Crocodyliformes or more inclusive) have yielded ambiguous or even contradictory results. This highlighted the need for smaller-scaled studies, both from a phylogenetic and stratigraphic point of view. The work presented here is part of this new framework. It focuses on an extinct group of crocodyliforms, the *Notosuchia*, at a specific time interval, the Cretaceous-Palaeogene (K-Pg) crisis. This group was chosen because of three characteristics that made it relevant for deciphering the factors explaining extinction/diversification events: (1) it is homogeneous regarding the living environments: almost all *notosuchians* were fully terrestrial; (2) it exhibits a high degree of ecological diversity with diets ranging from strict herbivory to specialized carnivory, including omnivory; and (3) it crosses a major crisis event, the K-Pg crisis. We tested the impact of body size, using skull length as a proxy, and local palaeotemperature, on the survival/extinction, coded as a binary response variable, at the K-Pg crisis using the phylogenetic logistic regression (PLR). We also investigated the evolution of body size throughout *notosuchian* evolutionary history and its relationship with diet. The analyses were performed on several sets of dated supertrees of *Notosuchia*: two different node dating methods were used on two different topologies. Furthermore, each species was dated by randomly picking an age included in its stratigraphic interval and 100 supertrees were produced for each sets (400 in total). This allowed to account for the effect of the stratigraphic and phylogenetic uncertainties. Finally, to assess the effect of the Adamantina Formation, of uncertain age and from which a high number of specimens come from, we

performed the PLR analyses on all 4 sets of supertrees, including or not all the species belonging to this formation. We found that local palaeotemperature does not explain the survival/extinction while body size do when all the species from the Adamantina Fm are considered to have faced the crisis: the larger *notosuchians* were, the higher their probability of survival was. Furthermore, *Notosuchia* showed a trend towards larger body sizes during the Cretaceous. This trend is driven by the apparition of specialized carnivorous species having significantly larger body sizes than omnivorous ones. Thus, diet rather than just body size might explain the survival/extinction of *notosuchians* at the K-Pg crisis. Because the relationship between survival and body size is only significant when all the species belonging to the Adamantina Fm are considered to have faced this crisis, we corroborates previous studies which found this formation to have a Lagerstätten effect.

Williams, S.A., Lay, F.T., Bindra, G.K., Banjara, S., Poon, I.K.H., Phan, T.K., Kvensakul, M. and Hulett, M.D. (2023). Crocodile defensin (CpoBD13) antifungal activity via pH-dependent phospholipid targeting and membrane disruption. *Nature Communications* 14(1) (doi: [10.1038/s41467-023-36280-y](https://doi.org/10.1038/s41467-023-36280-y)).

Abstract: Crocodilians are an order of ancient reptiles that thrive in pathogen-rich environments. The ability to inhabit these harsh environments is indicative of a resilient innate immune system. Defensins, a family of cysteine-rich cationic host defence peptides, are a major component of the innate immune systems of all plant and animal species, however crocodilian defensins are poorly characterised. We now show that the saltwater crocodile defensin CpoBD13 harbors potent antifungal activity that is mediated by a pH-dependent membrane-targeting action. CpoBD13 binds the phospholipid phosphatidic acid (PA) to form a large helical oligomeric complex, with specific histidine residues mediating PA binding. The utilisation of histidine residues for PA engagement allows CpoBD13 to exhibit differential activity at a range of environmental pH values, where CpoBD13 is optimally active in an acidic environment.

Rogerson, G., Bock, S., Loera, Y., Parrott, B. and Mulley, J.F. (2023). Incubation temperature alters stripe formation and head colouration in American alligator hatchlings and is unaffected by E2-induced sex reversal. *Journal of Experimental Biology* (doi: [10.1242/jeb.245219](https://doi.org/10.1242/jeb.245219)).

Abstract: Considerations of the impact climate change has on reptiles are typically focused on habitat change or loss, range shifts, and skewed sex ratios in species with temperature-dependent sex determination. Here, we show that incubation temperature alters stripe number and head colouration of hatchling American alligators (*Alligator mississippiensis*). Animals incubated at higher temperatures (33.5°C) had, on average, one more stripe than those at lower temperatures (29.5°C), and also had significantly lighter heads. These patterns were not affected by estradiol-induced sex reversal, suggesting independence from hatchling sex. Therefore, increases in nest temperatures as a result of climate change have the potential to alter pigmentation patterning, which may have implications for offspring fitness.

Carfagno, A., Lin, S.-C., Chafra, L., Akhrymuk, I., Callahan, V., Po, M., Zhu, Y., Altalhi, A., Durkin, D.P., Russo, P., Vliet, K.A., Webb-Robertson, B.-J., Kehn-Hall, K. and Bishop, B. (2023). Bioprospecting the American alligator peptidome for antiviral peptides against Venezuelan equine encephalitis virus. *Proteomics* 23(5): e2200237.

Abstract: The innate immune protection provided by cationic antimicrobial peptides (CAMPs) has been shown to extend to antiviral activity, with putative mechanisms of action including direct interaction with host cells or pathogen membranes. The

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

Heiss, E., Gignac, P.M., Porro, L.B. and Lemell, P. (2023). Convergence of aquatic feeding modes in the Sauropsida (crocodiles, birds, lizards, snakes and, turtles). Pp. 141-181 in *Convergent Evolution. Fascinating Life Sciences*, ed. by V.L. Bels and A.P. Russell. Springer: Cham.

Abstract: The Sauropsida includes the extant crocodiles, birds, turtles, lizards and snakes. With roughly 30,000 described species, it is not only the largest phylogenetic group within Amniota, but the largest extant group within all tetrapods. Like many other tetrapod branches, sauropsids have evolved many adaptations to aquatic lifestyles: from species that occasionally feed in aquatic habitats to fully aquatic forms that only rise to the water's surface for breathing. As amniotes, sauropsids can safely be considered primarily terrestrial vertebrates and any adaptations to aquatic life and feeding can be regarded as secondary features. Sauropsids show a very broad spectrum of convergently-evolved adaptations for aquatic feeding, from crocodylian apex predators to high-performance suspension feeding birds, suction feeding in turtles and alga-scraping in marine iguanas. Adaptations for aquatic feeding in sauropsids have evolved multiple times independently, both between and within groups. For example, suction feeding has evolved independently in turtles and birds; extremely fast forward strikes by straightening of the curved postcranial vertebral column in birds and snakes; and suspension feeding in mallards, flamingoes and sea-birds. In the following sections, we summarize the diverse adaptations to aquatic feeding in crocodylians, birds, lepidosaurs and turtles and highlight convergence and homologies where appropriate.

Barham, K.E., Baker, C.J., Franklin, C.E., Campbell, H.A., Frère, C.H., Irwin, T.R. and Dwyer, R.G. (2023). Conditional alternative movement tactics in male crocodiles. *Behavioral Ecology and Sociobiology* 77: 31.

Abstract: In species where conflict is costly, individuals adopt alternative movement tactics to minimise the risk of competitive interactions. Dominant males often maintain defined territories, while less competitive males may be forced to adopt alternative tactics to maximise fitness and reduce conflict. However, the extent to which males switch tactics according to current social or physiological status is poorly understood. Using implanted acoustic tags and a fixed array of tracking receivers, we investigated how the behaviour of 78 male estuarine crocodiles (*Crocodylus porosus*) shifted over an 11-year period in relation to ontogeny, body condition, and the extent of physical injuries. We discovered that male crocodiles sorted into three common movement classes, with 51% of males maintaining the same movement class across consecutive years (max.= 9 years). Males >4 m in total length maintained confined territories both within and across years and had the greatest extent of injuries and the highest condition score, indicative of territory holders. In contrast, smaller males sorted into high movement roamer or low movement site-philopatric tactics, where the tactic an individual adopted was less stable between years and did not

correlate with condition or external injuries. Our study reveals the socio-biological mechanisms by which estuarine crocodiles coexist within a restricted habitat.

Baker, C.J., Frere, C.H., Franklin, C.E., Campbell, H.A., Irwin, T.R. and Dwyer, R.G. (2023). Long-term tracking reveals a dynamic crocodylian social system. *Animal Behavior* 199 (<https://doi.org/10.1016/j.anbehav.2023.02.015>).

Abstract: Animal social systems are inherently dynamic, with individuals moderating how they associate with conspecifics according to spatiotemporal shifts in population demography and resource availability. Understanding such variation is important not only to further our knowledge of a species' ecology but also to gain insights into the factors influencing the evolution of animal social systems. Using a 10-year acoustic telemetry data set containing the movements and co-occurrences of 166 tagged individuals, we investigated how time of year, individual sex and maturity status affect the social organization and connectivity of a wild population of estuarine crocodiles, *Crocodylus porosus*. We found that our tagged population of crocodiles displayed social structure, where individuals segregated spatially into distinct communities along 120 km of river and estuary. The social organization and structure of these communities were temporally dynamic, with association rates and the connectedness of individuals peaking during the dry season before disintegrating prior to the onset of the wet season. The formation of communities was found to coincide with an increase in the frequency of co-occurrence events between mature and mature-immature dyads prior to the onset of the mating season. Together these findings indicate that estuarine crocodiles have a structured social system, where the proximity to the mating season and an individual's maturity status dictate how they associate with conspecifics.

D'Amore, C., Grimaldi, P., Ascione, T., Conti, V., Sellitto, C., Franci, G., Kafil, S.H. and Pagliano, P. (2023). West Nile Virus diffusion in temperate regions and climate change. A systematic review. *Le Infezioni in Medicina* 1: 20-30.

Abstract: West Nile virus (WNV) is a member of the Japanese encephalitis serocomplex, which was first described in 1937 as neurotropic virus in Uganda in 1937. Subsequently, WNV was identified in the rest of the old-world and from 1999 in North America. Birds are the primary hosts, and WNV is maintained in a bird-mosquito-bird cycle, with pigs as amplifying hosts and humans and horses as incidental hosts. WNV transmission is warranted by mosquitoes, usually of the *Culex* spp., with a tendency to spill over when mosquitoes' populations build up. Other types of transmissions have been described in endemic areas, as through transplanted organs and transfused blood, placenta, maternal milk, and in some occupational settings. WNV infections in North America and Europe are generally reported during the summer and autumn. Extreme climate phenomena and soil degradation are important events which contribute to expansion of mosquito population and consequently to the increasing number of infections. Draught plays a pivotal role as it makes foul water standing in city drains and catch basins richer of organic material. The relationship between global warming and WNV in climate areas is depicted by investigations on 16,298 WNV cases observed in the United States during the period 2001-2005 that showed that a 5°C increase in mean maximum weekly temperature was associated with a 32-50% higher incidence of WNV infection. In Europe, during the 2022 season, an increase of WNV cases was observed in Mediterranean countries where 1041 cases were reported based on ECDC data. This outbreak can be associated to the climate characteristics reported during this period and to the introduction of a new WNV-1 lineage. In conclusion, current climate change is causing an increase of mosquito circulation that supports the widest spread of some vector-borne virus including WNV diffusion in previously non-permissible areas. This warrants public health measures to control vectors circulation to reduce WNV and to

screen blood and organ donations.

Ardiantiono, Henkanathgedara, S.M., Sideleau, B., Sheherazade, Anwar, Y., Haidir, I.A. and Amarasinghe, A.A.T. (2023). Integrating social and ecological information to identify high-risk areas of human-crocodile conflict in the Indonesian Archipelago. *Biological Conservation* (<https://doi.org/10.1016/j.biocon.2023.109965>).

Abstract: Crocodile attacks on humans and subsequent retaliations are a pressing issue for saltwater crocodile conservation. As human-crocodile conflict is complex, integrating social and ecological information better explains the drivers and patterns of these interactions. Our study aims to incorporate ecological factors associated with the intensity of crocodile attacks together with social factors of mass media reports to identify high-risk areas of human-crocodile conflict in Indonesia. We compiled reports of crocodile attacks in the 2010-2019 period from media reports, field surveys, and local informants. The presence of attack was estimated by evaluating the influence of habitat, climate, human, and reporting effort. As tone of media coverage can reflect and shape reader's tolerance about a certain issue, we assessed the headline's tone from each media article that reported crocodile attacks from 2017 to 2019. A total of 665 crocodile attacks were recorded and mainly distributed in western and central Indonesia. The estimated number of crocodile attacks was higher in areas with lower forest biomass and human density, and wider cellular network coverage. Negative media coverages were frequently reported in western Indonesia. By combining social information of negative media reporting and the ecological information of crocodile attacks hotspots, we identified 170,500 km² priority risk areas in the western part of Indonesia, a notable 65.8% reduction in area size compared to the attack hotspots. We highlight the application of socio-ecological information in risk prioritization to address the rising trends of negative human-wildlife interactions.

Koue Bi, T.M. (2022). Faune cynegetique exploitée dans la filiere viande de Brousse a l'est de la Côte D'Ivoire. *Sciences de la vie, de la terre et agronomie* 10(2)

Résumé: De janvier à décembre 2018, une étude portant sur la commercialisation de la viande de brousse a été menée à travers une enquête ethnozoologique semi-directive dans les marchés et restaurants des localités d'Akoupé, d'Abengourou et de Bondoukou. L'objectif de cette étude était d'actualiser les connaissances sur les espèces animales exploitées dans la filière viande de brousse à l'Est de la Côte d'Ivoire. Au total, 39 espèces animales ont été recensées dans les trois localités durant la période d'étude. Les Mammifères constituent le groupe zoologique le plus exploité dans ce commerce avec 28 espèces suivies des Oiseaux avec cinq espèces, puis viennent les Ophidiens avec trois espèces. Les Crocodiliens, les Lacertiliens et les Testudines semblent être les groupes les moins exploités car comptabilisent une espèce chacun. Plus de 35% de cette faune présente un statut préoccupant pour la conservation tant au niveau national qu'international. D'ailleurs cinq de ces espèces figurent aussi bien sur la liste rouge de l'UICN que sur celle de la CITES et sur la liste des espèces protégées de la Côte d'Ivoire. Il s'agit du potto de Bosman *Perodicticus potto*, du pangolin à écailles tricuspidées *Phataginus tricuspidis*, du pangolin à longue queue *Phataginus tetradactyla*, du crocodile nain *Osteolaemus tetraspis* et du python de Seba *Python sebae*. Ces résultats constituent une base de données importantes pour la mise en place des mesures de gestion durable des ressources naturelles en Côte d'Ivoire.

Bolotov, I.N., Eliseeva, T.A., Tsiplenkina, I.G., Gofarov, M.Y. and Kondakov, A.V. (2023). Long forgotten record of a freshwater leech on Madagascar indicates a host-associated dispersal event from continental Africa. *Ecologica Montenegrina* 61: 56-67.

Abstract: Madagascar houses a peculiar and largely endemic

biota, having ancient Gondwanan affinities. However, the faunal composite of many invertebrate groups on the island is poorly known. For a long time, it was believed that the freshwater leech fauna of Madagascar contains a salifid species (Salifidae) only. Here, we report on a historical record of *Placobdelloides multistriatus* (Johansson, 1909) (Glossiphoniidae), a widespread African species, from Andrahomana, Southern Madagascar. Franz Sikora (1863-1902), an Austrian traveler and collector, who visited Andrahomana in 1899 to excavate fossils from a cave, collected the leech sample. The two specimens were obtained from an unspecified turtle species. We assume that *P. multistriatus* may have arrived to Madagascar relatively recently (ie in the Late Pleistocene or Holocene) via a long-distance dispersal event from continental Africa with its reptilian hosts such as the Nile crocodile and marsh terrapin. Based on a review of the body of available literature, two more freshwater leech species are known to occur on Madagascar: *Linta* be Westergren & Siddall, 2004 (Salifidae) and *Alboglossiphonia* sp. (Glossiphoniidae). Our findings indicate that Madagascar houses at least three freshwater leech species and that some additional taxa may have been overlooked there due to the scarcity of sampling efforts in the island's freshwater bodies.

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): 17-23.

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 ind/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.

Li, H., Staxäng, K., Hodik, M., Melkersson, K-G. and Rask-Andersen, H. (2023). The ultrastructure of a stria vascularis in the auditory organ of the Cuban crocodile (*Crocodylus rhombifer*). *Frontiers in Cellular Development and Biology* 11 ([doi: 10.3389/fcell.2023.1129074](https://doi.org/10.3389/fcell.2023.1129074)).

Abstract: An endocochlear potential (EP) exists in the mammalian cochlea generated by the stria vascularis and an associated fibrocyte network. It plays an essential role for sensory cell function and hearing sensitivity. In non-mammalian ectothermic animals the endocochlear potential is low and its origin somewhat unclear. In this study, we explored the crocodilian auditory organ and describe the fine structure of a stria vascularis epithelium that has not been verified in birds. Three Cuban crocodiles (*Crocodylus rhombifer*) were analyzed with light and transmission electron microscopy. The

ears were fixed in glutaraldehyde. The temporal bones were drilled out and decalcified. The ears were dehydrated, and embedded and was followed by semi-thin and thin sectioning. The fine structure of the crocodile auditory organ including the papilla basilaris and endolymph system was outlined. The upper roof of the endolymph compartment was specialized into a Reissner membrane and tegmentum vasculosum. At the lateral limbus an organized, multilayered, vascularized epithelium or stria vascularis was identified. Electron microscopy demonstrates that the auditory organ in *C. rhombifer*, unlike in birds, contains a stria vascularis epithelium separate from the tegmentum vasculosum. It is believed to secrete endolymph and to generate a low grade endocochlear potential. It may regulate endolymph composition and optimize hearing sensitivity alongside the tegmentum vasculosum. It could represent a parallel evolution essential for the adaptation of crocodiles to their diverse habitats.

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

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

Pochat-Cottilloux Y., Martin, J.E., Amiot, R., Cubo, J., de Buffrénil, V. (2023). A survey of osteoderm histology and ornamentation among Crocodylomorpha: A new proxy to infer lifestyle? *Journal of Morphology* 284(1) (doi: 10.1002/jmor.21542).

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

function(s) in crocodilians, our observations are discussed in reference to possible ecophysiological peculiarities of Notosuchia in general, and *Iberosuchus* in particular.

Erratum in Corrigendum to: Pochat-Cottilloux Y., Martin, J.E., Amiot, R., Cubo, J., de Buffrénil, V. (2023). A survey of osteoderm histology and ornamentation among Crocodylomorpha: A new proxy to infer lifestyle? *Journal of Morphology* 284(3): e21565.

Dolan, J.K., Stacy, N.I., Lo, M., Ossiboff, R.J. and Lanier, C.J. (2022). What is your diagnosis? Blood film from a Yacare caiman (*Caiman yacare*). *Veterinary and Clinical Pathology* 51(4): 605-608.

Schilliger, L., Paillusseau, C., François, C. and Bonwitt, J. (2023). Major emerging fungal diseases of reptiles and amphibians. *Pathogens* 12: 429.

Abstract: Emerging infectious diseases (EIDs) are caused by pathogens that have undergone recent changes in terms of geographic spread, increasing incidence, or expanding host range. In this narrative review, we describe three important fungal EIDs with keratin trophism that are relevant to reptile and amphibian conservation and veterinary practice. *Nannizziopsis* spp. have been mainly described in saurians; infection results in thickened, discolored skin crusting, with eventual progression to deep tissues. Previously only reported in captive populations, it was first described in wild animals in Australia in 2020. *Ophidiomyces ophidiicola* (formerly *O. ophidiicola*) is only known to infect snakes; clinical signs include ulcerating lesions in the cranial, ventral, and pericloacal regions. It has been associated with mortality events in wild populations in North America. *Batrachochytrium* spp. cause ulceration, hyperkeratosis, and erythema in amphibians. They are a major cause of catastrophic amphibian declines worldwide. In general, infection and clinical course are determined by host-related characteristics (eg nutritional, metabolic, and immune status), pathogens (eg virulence and environmental survival), and environment (eg temperature, hygrometry and water quality). The animal trade is thought to be an important cause of worldwide spread, with global modifications in temperature, hygrometry, and water quality further affecting fungal pathogenicity and host immune response.

Hastings, A.K., Schubert, B.W., Bourque, J.R. and Hulbert, Jr., R.C. (2023). Oldest record of *Alligator* in southeastern North America. *Palaeontologia Electronica*, Article number: 26.1.a6.

Abstract: The genus *Alligator* has been represented by large-bodied, predatory species in southeastern North America for at least 18 million years (early Miocene), in what is now the southeastern United States. However, the first occurrences of the genus were from a smaller-bodied species, *A. prenasalis*, known from South Dakota and Nebraska that are about 34 million years old (latest Eocene to earliest Oligocene). Ancestors of *A. prenasalis* were likewise small-bodied and are from the Great Plains. This 16 million-year-gap has left open questions regarding the arrival and body size shift of *Alligator* from what is now the Great Plains to southeastern North America. Recently studied fossil material from Florida exhibits the oldest occurrence of *Alligator* in the region (about 28-26 million years ago). A well-preserved premaxilla (UF 422816) bears the diagnostic premaxillary ‘notch’ of *Alligator*. Additional material from this and two other Oligocene sites in Florida are indicative of *Alligator* as well. These include well-developed osteoderms, which suggest possible maturity at small body size. As of now, no records of larger *Alligator* from this time (or older) have been recovered from the region, possibly indicating body size may not have increased in *Alligator* until the Miocene.

Wen, Y., Xu, Y., Zhan, J., Li, C., Zhang, Y., Wang, R., Li, E.,

Nie, H. and Wu, X. (2023). Molecular cloning, immunological characterization, and expression analysis of G-Protein Couple Receptor (Gper1) of Chinese alligator during ovarian folliculogenesis and early development. Available at SSRN: <https://ssrn.com/abstract=4383211> or <http://dx.doi.org/10.2139/ssrn.4383211>.

Abstract: The critical role of GPER1 in the functional regulation of oocytes accumulated abundant theories in the early research on model animals. However, the full-length cDNA encoding GPER1 and its role in the folliculogenesis has not been illustrated in crocodiles. The cloning of full-length cDNA encoding GPER1 via 5'RACE and nested PCR, immune-localization and quantitative analysis using RT-PCR and western blot, in parallel with the promoter deletion and the Cis-action transcriptional regulatory mechanisms of GPER1 were investigated in *A. sinensis* including 0.5 months, 3 months and 12 months. Immunoco-localization staining for the germline marker DDX4 and GPER1 demonstrated that DDX4-positive oocytes were clustered tightly together within the nests, whereas scarcely any detectable GPER1 was present in the oocytes nest in Stage I. After that, occasionally GPER1-positive immunosignal was observed in oocytes and somatic cells additional with the PF, and it was mainly located at the granulosa cells or thecal cells within the early PF in the Stage III. The single mutation of the putative SP1 motif, double mutating of Ets/Sp1 and Sp1/CRE binding sites all depressed promoter activities. This result will help to investigate the role of GPER1 in the early folliculogenesis of *A. sinensis*.

Owen, M.G. and Taylor, Z.P. (2023). Patterns of disjunction in western hemisphere birds, amphibians, crocodilians, and mammals. *Physical Geography* (<https://doi.org/10.1080/02723646.2023.2189074>).

Abstract: To assess the patterns and severity of disjunction at multiple taxonomic levels for birds, amphibians, crocodilians, and mammals in the western hemisphere, we compiled over 10,100 species ranges and analyzed each range using ERSI ArcMap (10.8.1). After identifying species ranges that were disjunct by 500 km or more, we calculated the mean distance between the disjunct range polygon and primary polygon (d) and relative disjunct area (A) and analyzed disjunction by geographic area and latitude. Birds are the most commonly disjunct taxa (19.3%), followed by mammals (6.4%) and amphibians (2.8%). According to distance and relative area, birds are more severely disjunct than amphibians and mammals. Geographically, South America is home to the largest number of disjunctions across all taxa and latitudinal trends show that disjunction varies by latitude and, coincident with species richness, peaks in the southern tropics. Similarities in disjunction patterns, particularly between mammals and amphibians, suggest that geographic factors, along with dispersal ability, play a key role in creating disjunct distributions.

Wetterer, J.K., Deem, V. and Osuna, A. (2023). Red imported fire ants at onshore and offshore nests of American alligator, *Alligator mississippiensis*, in a Florida lake. *Herpetology Notes* 16: 219-222.

Ribeiro Sanches, M.A., Borges de Paiva, G., Darros-Barbosa, R., da Silva-Barretto, A.C. and Telis-Romero, J. (2023). Mass transfer modeling during wet salting of caiman meat (*Caiman crocodilus yacare*) at different brine temperatures. *Meat Science* 199 ([doi: 10.1016/j.meatsci.2023.109128](https://doi.org/10.1016/j.meatsci.2023.109128)).

Abstract: Caiman meat is considered exotic and its consumption has significantly increased due to its nutritional quality. This study aimed to evaluate the kinetics of water content (WC) and salt content (SC) at different temperatures (1, 5, 10 and 15°C) and to evaluate the use of mathematical models to predict the mass transfer kinetics until equilibrium conditions during the wet salting of caiman tail fillets. Moisture and chloride analyses were performed throughout the wet salting process. Four models (Peleg; Weibull; Zugarramurdi

and Lupín; Diffusion) were tested to predict WC and SC kinetics in caiman tail fillets subjected to wet salting. The increase in the temperature resulted in a reduction ($P<0.05$) in WC and an increase ($P<0.05$) in SC. Nonlinear effects on WC and SC kinetics were observed between the different temperatures evaluated. Furthermore, the effective diffusion coefficients (D_w and D_s) increased ($P<0.05$) with increasing temperature. Peleg, Weibull, Zugarramurdi and Lupín, and the Diffusion model satisfactorily represented WC and SC rates throughout the process. The kinetic behavior of the parameters of the models corroborated the effects of temperature on those parameters. Peleg was the best model for predicting WC and SC kinetics, and Zugarramurdi and Lupín was the best for predicting the equilibrium conditions of the process (WC^∞ SC^∞), all parameters which can be used to describe the mass transfer kinetics during wet salting of caiman tail fillets.

Liu, D., Chen, J.-T., Tsai, J.-C., Li, C.-W., Lin, C.-X., Qu, Y.-F., Du, Y. and Ji, X. (2023). Embryonic thermosensitivity and hatchling morphology differ among three species of crocodilians farm-raised in China. *Aquaculture* (<https://doi.org/10.1016/j.aquaculture.2023.739460>).

Abstract: We incubated eggs of three species of crocodilians farm-raised in China at three (*Crocodylus porosus* at 29, 31 and 33°C) or four (*C. niloticus* and *C. siamensis* at 29, 30, 31 and 33°C) constant temperatures to examine differences in hatching success, incubation length and hatchling morphology among species and among temperature treatments. The lowest and highest temperatures are respectively close to the lower and upper thermal limits to which embryonic crocodilians can tolerate. The three species differed morphologically at hatching. Hatching success did not differ among *C. niloticus* eggs incubated at 29, 30, 31 and 33°C, and hatchlings hatched at these temperatures did not differ from each other in body size, mass and shape. Hatching success did not differ among *C. porosus* eggs incubated at 29, 31 and 33°C, but the lowest temperature resulted in premature hatchlings. Hatching success at 29°C was extremely low in *C. siamensis*. Morphologically, *C. siamensis* hatchlings hatched at 30°C and 31°C formed a group, which slightly differed from that formed by hatchlings hatched at 33°C. Data from the present study and literature allow us to draw the following three conclusions. First, temperatures within the range from 29°C to 33°C are suitable for incubation of *C. niloticus* eggs. Second, temperatures within the range from 30°C to 33°C are suitable for embryonic development in *C. porosus* and *C. siamensis*. Third, the temperature of 29°C adversely affects embryonic development in *C. porosus* and *C. siamensis*.

Rodríguez-Caro, R.C., Graciá, E., Blomberg, S.P., Cayuela, H., Grace, M., Carmona, C.P., Pérez-Mendoza, H.A., Giménez, A. and Salguero-Gómez, R. (2023). Anthropogenic impacts on threatened species erode functional diversity in chelonians and crocodilians. *Nature Communications* 14(1): 1542 ([doi: 10.1038/s41467-023-37089-5](https://doi.org/10.1038/s41467-023-37089-5)).

Abstract: The Anthropocene is tightly associated with a drastic loss of species worldwide and the disappearance of their key ecosystem functions. The orders Testudines (turtles and tortoises) and Crocodilia (crocodiles, alligators, and gharials) contain numerous threatened, long-lived species for which the functional diversity and potential erosion by anthropogenic impacts remains unknown. Here, we examine 259 (69%) of the existing 375 species of Testudines and Crocodilia, quantifying their life history strategies (ie trade-offs in survival, development, and reproduction) from open-access data on demography, ancestry, and threats. We find that the loss of functional diversity in simulated extinction scenarios of threatened species is greater than expected by chance. Moreover, the effects of unsustainable local consumption, diseases, and pollution are associated with life history strategies. In contrast, climate change, habitat disturbance, and global trade affect species independent of their life history strategy. Importantly, the loss of functional diversity

for threatened species by habitat degradation is twice that for all other threats. Our findings highlight the importance of conservation programmes focused on preserving the functional diversity of life history strategies jointly with the phylogenetic representativity of these highly threatened groups.

Maganga, G.D., Makouloutou-Nzassi, P., Boundenga, L., Landjekpo, H.N.M., Bangueboussa, F., Mebaley, T.N., Mounioko, F. and Gbati, O.B. (2023). Gastrointestinal polyparasitism in bushmeat in Zadié Department in Northeast Gabon. *Veterinary Science* 10(3) (doi: 10.3390/vetsci10030229).

Abstract: Wild animals harbor pathogens that can be infectious agents for humans, including parasites. This study aimed to identify gastrointestinal parasites and assess their prevalence and the potential risk for humans associated with consuming these animals. The research was conducted from August to December 2019. Parasitological analyses were carried out on the feces and intestines of 113 wild animals, including antelopes (24), duikers (58), porcupines (18), small monkeys (*Cercopithecus*) (8), nandinia (2), pangolin (1), genet (1), and a crocodile (1), from the Zadié Department in the province of Ogooué-Ivindo in the northeast of Gabon. The results revealed 15 taxa of gastrointestinal parasites, including 9 nematodes: Strongylids (61/113), *Strongyloides* spp. (21/113), *Ascaris* spp. (21/113), *Trichuris* spp. (39/113), *Capillaria* spp. (9/113), *Protostrongylus* spp. (5/113), *Enterobius* spp. (8/113), *Toxocara* spp. (7/113) and *Mammomonogamus* spp. (5/113); three species of protozoa, namely *Balantidium* spp. (12/113), *Eimeria* spp. (17/113), and *Entamoeba* spp. (9/113); two species of trematodes, namely *Fasciola* spp. (18/113) and *Paramphistomum* spp. (21/113); and cestode species, *Taenia* spp. (1/113). The prevalence of gastrointestinal parasitism in these animals was 85.84% (97/113). In addition, among these parasitic taxa, some are potential pathogens for humans, such as *Ascaris* spp., *Balantidium* spp., *Entamoeba* spp., and *Taenia* spp. The consumption of games, particularly offal, infested by these parasites, could threaten human health.

Mohr, S.R., Acorn, J.H. and Currie, P.J. (2023). Putative avian teeth from the Late Cretaceous of Alberta, Canada, are more likely from crocodylians. *PLoS One* 18(3): e0283581.

Abstract: Isolated teeth, previously referred to Aves, are more common than other bird fossils from the Late Cretaceous of Alberta. However, there are no known morphological synapomorphies that distinguish isolated bird teeth, and features of these teeth are generally shared with those of non-avian theropods and crocodylians. Here, specimens ranging from Late Santonian to Late Maastrichtian in age are described and qualitatively categorized into morphotypes, most of which strongly resemble teeth of extant juvenile and some fossil crocodylians. Variation within this sample of teeth may therefore reflect the heterodont dentition of crocodylians, rather than avian species diversity. Quantitative analysis Principal Component Analysis was mostly uninformative, with limited overlap between putative avian teeth and those of known Cretaceous birds, crocodylians, and non-avian theropods. The reassignment of these putative avian teeth to Crocodylia has important ramifications for our understanding of the evolutionary history of Cretaceous birds.

Srisuksai, K., Parunyakul, K., Santativongchai, P., Phaonakrop, N., Roytrakul, S., Tulayakul, P. and Fungfuang, W. (2023). Antioxidant activity of crocodile oil (*Crocodylus siamensis*) on cognitive function in rats. *Foods* 12(4) (doi: 10.3390/foods12040791).

Abstract: Crocodile oil (CO) is rich in monounsaturated fatty acids and polyunsaturated fatty acids. The antioxidant activity and cognitive effect of monounsaturated fatty acids and polyunsaturated fatty acids have been largely reported. This work aimed to investigate the effect of CO on antioxidant activity and cognitive function in rats. Twenty-one rats were divided into three treatment groups: (1)

sterile water (NS), (2) 1 mL/kg of CO (NC1), and (3) 3 mL/kg of CO (NC3). Rats underwent oral gavage once daily for 8 weeks. CO treatment decreased the triglycerides level significantly compared with that in the NS group. CO had a free radical scavenging ability greater than that of olive oil but had no effect on levels of antioxidant markers in the brain. Expression of unique proteins in the CO-treatment group were correlated with the detoxification of hydrogen peroxide. Rats in the NC1 group had better memory function than rats in the NC3 group. Expression of unique proteins in the NC1 group was correlated with memory function. However, CO did not cause a decline in cognitive function in rats. CO can be an alternative dietary oil because it has a hypolipidemia effect and antioxidant activity. In addition, CO did not cause a negative effect on cognitive function.

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

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

Lourenço-de-Moraes, R., Campos, F.S., Cabral, P., Silva-Soares, T., Nobrega, Y.C., Covre, A.C. and França, F.G.R. (2023). Global conservation prioritization areas in three dimensions of crocodylian diversity. *Scientific Reports* 13(1): 2568.

Abstract: Crocodylians are a taxonomic group of large predators with important ecological and evolutionary benefits for ecosystem functioning in the face of global change. Anthropogenic actions affect negatively crocodylians' survival and more than half of the species are threatened with extinction worldwide. Here, we map and explore three dimensions of crocodylian diversity on a global scale. To highlight the ecological importance of crocodylians, we correlate the spatial distribution of species with the ecosystem services of nutrient retention in the world. We calculate the effectiveness of global protected networks in safeguarding crocodylian species and provide three prioritization models for conservation planning. Our results show the main hotspots of ecological and evolutionary values are in southern North, Central and South America, west-central Africa, northeastern India, and southeastern Asia. African species have the highest correlation to nutrient retention patterns.

Twenty-five percent of the world's crocodilian species are not significantly represented in the existing protected area networks. The most alarming cases are reported in northeastern India, eastern China, and west-central Africa, which include threatened species with low or non-significant representation in the protected area networks. Our highest conservation prioritization model targets southern North America, east-central Central America, northern South America, west-central Africa, northeastern India, eastern China, southern Laos, Cambodia, and some points in southeastern Asia. Our research provides a global prioritization scheme to protect multiple dimensions of crocodilian diversity for achieving effective conservation outcomes.

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

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

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

Abstract: O'Dea *et al.* (2022) (Pleistocene sea level changes and crocodile population histories on the isthmus of panama: a comment on Avila-Cervantes *et al.* (2020). *Evolution*, 76(11), 2778-2783. <https://doi.org/10.1111/evo.14610>) question our hypothesis that sea-level changes during the past glaciation played a role in restricting gene flow between Pacific and Caribbean *Crocodylus acutus* in Panama. They argue that an error in sea-level high-stand reconstruction during the last interglacial period (118-130 ka) does not support our hypothesis. Although they are correct in our high-stand reconstruction error, overlooked the point in that we were

presenting a model of restricted gene flow across the Panamanian Isthmus during low sea levels. We review the assumptions of gene demographic methods, emphasizing that we were focusing on times of genetic divergence. We expand here why gene flow between these coastal populations could have been restricted during the last glacial maximum (19-26.5 ka) and the 50,000 years preceding it when sea levels were lower than today. O'Dea *et al.* suggest local climates may have played larger roles than sea levels. We demonstrate that paleoclimate estimates for the past 3.3 Ma in Panama are within the bounds of extant *C. acutus*. The importance of Ice Age Sea-level dynamics on Neotropical species was likely profound and should be incorporated into evolutionary studies of these taxa.

De Cupere, B., Van Neer, W., Colmenero, V.B. and Jiménez Serrano, A. (2023). Newly discovered crocodile mummies of variable quality from an undisturbed tomb at Qubbat al-Hawā (Aswan, Egypt). *PLoS One* 18(1): e0279137.

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

Lacerda, G.M.C., de A. Santana, J., de Araujo Filho, J.A. and Ribeiro, S.C. (2023). Checklist of parasites associated with 'reptiles' in Northeast Brazil. *Journal of Helminthology* 97 (doi: [10.1017/S0022149X22000785](https://doi.org/10.1017/S0022149X22000785)).

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

Kojima, L.V., Tuberville, T.D. and Parrott, B.B. (2023). Integrating

mercury concentrations in American alligators (*Alligator mississippiensis*) with hunter consumption surveys to estimate exposure risk. *Environmental Toxicology and Chemistry* 42(2): 525-534.

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

Emam, M.M., Houssein, E.H. and Ghoniem, R.M. (2023). A modified reptile search algorithm for global optimization and image segmentation: Case study brain MRI images. *Computers in Biology and Medicine* 152 (doi: 10.1016/j.combiomed.2022.106404).

Abstract: In this paper, we proposed an enhanced reptile search algorithm (RSA) for global optimization and selected optimal thresholding values for multilevel image segmentation. RSA is a recent metaheuristic optimization algorithm depending on the hunting behavior of crocodiles. RSA is inclined to inadequate diversity, local optima, and unbalanced exploitation abilities as other metaheuristic algorithms. The RUNge Kutta optimizer (RUN) is a novel metaheuristic algorithm that has demonstrated effectiveness in solving real-world optimization problems. The enhanced solution quality (ESQ) in RUN utilizes the thus-far best solution to promote the quality of solutions, improve the convergence speed, and effectively balance the exploration and exploitation steps. Also, the Scale factor (SF) has a randomized adaptation nature, which helps RUN in further improving the exploration and exploitation steps. This parameter ensures a smooth transition from exploration to exploitation. In order to mitigate the drawbacks of the RSA algorithm, this paper proposed a modified RSA (mRSA), which combines the RSA algorithm with the RUN. The ESQ mechanism and the scale factor boost the original RSA's performance, enhance convergence speed, bypass local optimum, and enhance the balance between exploitation and exploration. The validity of mRSA was verified using two experimental sequences. First, we applied mRSA to CEC'2020 benchmark functions of various types and dimensions, showing that mRSA has more robust search capabilities than the original RSA and popular counterpart algorithms concerning statistical, convergence, and diversity measurements. The second experiment evaluated mRSA for a real-world application to solve magnetic resonance imaging (MRI) brain image segmentation. Overall experimental results confirm that the mRSA has a strong optimization ability. Also, mRSA method is a more successful multilevel thresholding segmentation and outperforms comparison

methods according to different performance measures.

Turner, M.L. and Gatesy, S.M. (2023). Inner workings of the alligator ankle reveal the mechanistic origins of archosaur locomotor diversity. *Journal of Anatomy* 242(4): 592-606.

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

Pritz, M.B. (2023). Nuclei and tracts in the pretectum and associated tegmentum of crocodiles. *Journal of Comparative Neurology* 531(3): 415-450.

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

Gutiérrez-Ibáñez, C., Kettler, L., Pilon, M.C., Carr, C.E. and Wylie, D.R. (2023). Cerebellar inputs in the American alligator (*Alligator mississippiensis*). *Brain, Behavior and Evolution* 98(1): 44-60.

Abstract: Crocodylians (alligators, crocodiles, and gharials) are the closest living relatives to birds and, as such, represent a key clade to understand the evolution of the avian brain. However, many aspects of crocodylian neurobiology remain unknown. In this paper, we address an important knowledge gap as there are no published studies of cerebellar connections in any crocodylian species. We

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

Odetti, L.M., López González, E.C., Siroski, P.A., Simoniello, M.F. and Poletta, G.L. (2023). How the exposure to environmentally relevant pesticide formulations affects the expression of stress response genes and its relation to oxidative damage and genotoxicity in *Caiman latirostris*. Environmental Toxicology and Pharmacology 97 (doi: 10.1016/j.etap.2022.104014).

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

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

Abstract: The vertebrate trigeminal nerve is the primary mediator of somatosensory information from nerve endings across the face, extending nerve branches through bony canals in the face and mandibles, terminating in sensory receptors. Reptiles evolved several extreme forms of cranial somatosensation in which enhanced trigeminal tissues are present in species engaging in unique mechanosensory behaviors. However, morphology varies by clade and ecology among reptiles. Few lineages approach the extreme degree of tactile somatosensation possessed by crocodylians, the only remaining members of a clade that underwent an ecological transition from the terrestrial to semiaquatic habitat, also evolving a specialized trigeminal system. It remains to be understood how trigeminal osteological correlates inform how

adaptations for enhanced cranial sensation evolved in crocodylians. Here we identify an increase in sensory abilities in Early Jurassic crocodylomorphs, preceding the transitions to a semiaquatic habitat. Through quantification of trigeminal neurovascular canal branching patterns in an extant phylogenetic bracket we quantify and identify morphologies associated with sensory behaviors in representative fossil taxa, we find stepwise progression of increasing neurovascular canal density, complexity, and distribution from the primitive archosaurian to the derived crocodilian condition. Model-based inferences of sensory ecologies tested on quantified morphologies of extant taxa with known sensory behaviors indicate a parallel increase in sensory abilities among pseudosuchians. These findings establish patterns of reptile trigeminal ecomorphology, revealing evolutionary patterns of somatosensory ecology.

Ehsan, M.N., Riza, M., Pervez, M.N., Khyum, M.M.O., Liang, Y. and Naddeo, V. (2023). Environmental and health impacts of PFAS: Sources, distribution and sustainable management in North Carolina (USA). Science of the Total Environment (doi: 10.1016/j.scitotenv.2023.163123).

Abstract: Poly- and perfluoroalkyl substances (PFAS) are a class of manufactured chemicals that have recently attracted a great deal of attention from environmental regulators and the general public because of their high prevalence, resistance to degradation, and potential toxicity. This review summarizes the current state of PFAS and its effects on the environment of North Carolina, USA. Specific emphasis has been placed to identify i) the sources of PFAS in North Carolina ii) distribution of PFAS in different environmental segments of North Carolina, including surface water, groundwater, air, and sediment iii) drinking water contamination iv) impact of PFAS on human health v) PFAS accumulation in fish and other biota vi) status of PFAS removal from drinking water and finally vi) socioeconomic impact of PFAS uncertainties. Continuous discharges of PFAS occur in the North Carolina environment from direct and indirect sources, including manufacturing sites, firefighting foam, waste disposal and treatment plants, landfill leachate, and industrial emissions. PFAS are widespread in many environmental segments of North Carolina. They are more likely to be detected in surface and groundwater sediments and can enter aquatic bodies through direct discharge and wet and dry deposition of emissions. Eventually, some adverse effects of PFAS have already been reported in North Carolina residents who could have been exposed to the chemicals through contaminated drinking water. Furthermore, PFAS were also found in blood samples from fish and alligators. PFAS were confirmed to be present in water, sediment, organic compounds, and aquatic species at all levels of the food web. However, there is still a substantial amount of work to be done to understand the actual contamination by PFAS in North Carolina comprehensively.

Lloyd-Jones, L.R., Brien, M.L., Feutry, P., Lawrence, E., Beri, P., Booth, S., Coulson, S., Baylis, S.M., Villiers, K., Taplin, L.E. and Westcott, D.A. (2023). Implications of past and present genetic connectivity for management of the saltwater crocodile (*Crocodylus porosus*). Evolutionary Applications (https://doi.org/10.1111/eva.13545).

Abstract: Effective management of protected species requires information on appropriate evolutionary and geographic population boundaries and knowledge of how the physical environment and life-history traits combine to shape the population structure and connectivity. Saltwater crocodiles (*Crocodylus porosus*) are the largest and most widely distributed of living crocodilians, extending from Sri Lanka to Southeast Asia and down to northern Australia. Given the long-distance movement capabilities reported for *C. porosus*, management units are hypothesised to be highly connected by migration. However, the magnitude, scale, and consistency of connection across managed populations are not fully understood. Here we used an efficient genotyping method that combines DArTseq and sequence capture to survey 3000 high-quality genome-wide

single nucleotide polymorphisms from 1176 *C. porosus* sampled across nearly the entire range of the species in Queensland, Australia. We investigated historical and present-day connectivity patterns using fixation and diversity indices coupled with clustering methods and the spatial distribution of kin pairs. We inferred kinship using forward simulation coupled with a kinship estimation method that is robust to unspecified population structure. The results demonstrated that the *C. porosus* population has substantial genetic structure with six broad populations correlated with geographical location. The rate of gene flow was highly correlated with spatial distance, with greater differentiation along the east coast compared to the west. Kinship analyses revealed evidence of reproductive philopatry and limited dispersal, with approximately 90% of reported first and second-degree relatives showing a pairwise distance of <50 km between sampling locations. Given the limited dispersal, lack of suitable habitat, low densities of crocodiles and the high proportion of immature animals in the population, future management and conservation interventions should be considered at regional and state-wide scales.

Ariyaphong, N., Wongloet, W., Wattanadilokchatkun, P., Panthum, T., Singchat, W., Thong, T., Lisachov, A., Ahmad, S.F., Muangmai, N., Han, K., Duengkae, P., Temsiripong, Y. and Srikulnath, K. (2023). Should the identification guidelines for Siamese crocodiles be revised? Differing post-occipital scute scale numbers show phenotypic variation does not result from hybridization with Saltwater crocodiles. *Biology* 12: 535.

Abstract: Populations of Siamese crocodiles (*Crocodylus siamensis*) have severely declined because of hunting and habitat fragmentation, necessitating a reintroduction plan involving commercial captive-bred populations. However, hybridization between Siamese and saltwater crocodiles (*C. porosus*) has occurred in captivity. Siamese crocodiles commonly have post-occipital scutes (P.O.) with 4-6 scales, but 2-6 P.O. scales were found in captives on Thai farms. Here, the genetic diversity and population structure of Siamese crocodiles with large P.O. variations and saltwater crocodiles were analyzed using mitochondrial DNA D-loop and microsatellite genotyping. Possible crocodile hybrids or phenotypic variations were ascertained by comparison with our previous library from the Siam Crocodile Bioresource Project. Siamese crocodiles with <4 P.O. scales in a row exhibit normal species-level phenotypic variation. This evidence encourages the revised description of Siamese crocodiles. Moreover, the STRUCTURE plot revealed large distinct gene pools, suggesting crocodiles in each farm were derived from distinct lineages. However, combining both genetic approaches provides evidence of introgression for several individual crocodiles, suggesting possible hybridization between Siamese and saltwater crocodiles. We proposed a schematic protocol with patterns observed in phenotypic and molecular data to screen hybrids. Identifying non-hybrid and hybrid individuals is important for long-term *in situ/ex situ* conservation.

Nailius, C.P. (2023). Strategi penyesuaian diri anggota keluarga leobisa setelah berhenti melakukan ritual memberi makan buaya di kolbano. *Jurnal Inovasi Penelitian* 3(11): 7965-7978.

Abstract: The ritual of feeding crocodiles to the Timorese people, especially in the village of Kolbano, has been going on for a long time and has become an important element of local people's lives. However, as time went on, ritual activity began to fade, starting from the colonial period and the spread of Christianity became the starting point for the tradition of feeding crocodiles. The people who performed the ritual had to be dismissed and had to follow the rules of Christian teaching. It was from this incident that the Kolbano village community had to adapt themselves, especially members of the Leobisa family who were the perpetrators of the crocodile feeding ritual. The purpose of this study was to find out the adaptation strategies carried out by actors when they stopped performing rituals. This study uses qualitative research methods

with a descriptive-phenomenological approach to collecting data using interview and observation techniques. The results of the study show that there is an interpersonal relationship with the family, work activities as stress coping, and a positive self-image as an adjustment strategy.

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.

Syafutra, R., Apriyani, R., Heri, Karsina, L. and Wulan, N.A.N. (2023). Mitigasi konflik manusia-buaya muara di desa kayu besi dan bukit layang, Kabupaten Bangka. *Jurnal Pengabdian Kepada Masyarakat Nusantara* 4(1): 565-572.

Abstract: This Community Service (CS) project was conducted due to the high intensity of saltwater crocodile attacks on the people of Kayu Besi and Bukit Layang Villages, Bangka Regency, Bangka Belitung Islands Province. This project used three methods in stages, ie: (1) Unstructured Interview, (2) Focus Group Discussion (FGD), and (3) Socialization. The interview results showed that the people in both villages had lack of knowledge and negative attitude and perception toward saltwater crocodile. The FGD results showed that the people in both villages: (1) asked for socialization on mitigation conflict between human-saltwater crocodile, (2) frequently disposed carcasses in the watersheds in both villages, and (3) asked for solutions to anticipate casualties due to the human-saltwater crocodile conflict. The socialization on the mitigation of human-saltwater crocodile conflict was held immediately after the FGD. The unfinished follow-up of the FGD results will be held in the next project. In the end, this CS project offered impacts on increasing knowledge and improving attitude and perception of the people towards saltwater crocodile in both villages.

Smolensky, N.L., Fitzgerald, L. and Winemiller, K.O. (2023). Trophic ecology of African Dwarf crocodiles (*Osteolaemus* spp.) in perennial and ephemeral aquatic habitats. *Journal of Herpetology* 57(1): 60-69.

Abstract: Crocodilians occupy diverse aquatic and riparian habitats,

and through their movements and ontogenetic niche shifts, link the flow of energy and nutrients between aquatic and terrestrial food webs. We analyzed the trophic ecology of African dwarf crocodiles *Osteolaemus tetraspis* and *O. osborni* at one site for each species in Cameroon by analyzing carbon and nitrogen stable isotope ratios. We hypothesized that *Osteolaemus* species inhabiting a perennial river would be primarily associated with aquatic food webs, whereas those inhabiting a small ephemeral stream would assimilate significant fractions of terrestrial-derived material into their biomass. We also hypothesized that *Osteolaemus* species would undergo ontogenetic trophic shifts, including changes in vertical trophic position (TP). We found that crocodiles in both systems assimilated material from both terrestrial and aquatic-based food chains, and therefore provide a trophic link between habitats. In the perennial river, aquatic gastropods, fish, and amphibians were estimated to have higher maximum feasible contributions to crocodile biomass than terrestrial invertebrates. Prey contributions to crocodile biomass in the ephemeral stream could not be estimated because model results suggested that at least one important prey had not been sampled. Even though isotopic overlap was high between juveniles and adults, and between sexes, ontogenetic shifts in TP were apparent in both *Osteolaemus* populations.

Cortes, E.L.R. (2023). Tracking crocodiles in markets, farms, and mangroves. *ReVista* (Cambridge) 22(2) 1-22.

Thevenet, J., Kehy, M., Boyer, N., Pradeau, A., Papet, L., Gaudrain, E., Grimault, N. and Mathevon, N. (2023). Sound categorization by crocodilians. *iScience* 26: 106441.

Abstract: Rapidly sorting the information contained in a stream of stimuli is a major challenge for animals. One cognitive mechanism for achieving this goal is categorization, where the receiving individual considers a continuous variation of a stimulus as belonging to discrete categories. Using playback experiments in a naturalistic setup, here we show that crocodiles confronted with an acoustic continuum ranging from a frog call to a crocodile call classify each acoustic variant into one of these two categories, establishing a meaningful boundary where no acoustic boundary exists. With GO/NO-GO experiments, we then observe that this boundary is defined along the continuum following learning. We further demonstrate that crocodilians rely on the spectral envelope of sounds to categorize stimuli. This study suggests that sound categorization in crocodilians is a pre-wired faculty allowing rapid decision-making and highlights the learning-dependent plasticity involved in defining the boundary between sound categories.

Huntley, B.J. (2023). The mangrove biome. Pp. 383-391 in *Ecology of Angola*. Springer: Cham.

Abstract: The cold Benguela Current passing along Angola's Atlantic Ocean coast accounts for its mangrove communities lying 20° latitude north of those of the Indian Ocean Coast of Africa, bathed by the warm Mozambique Current. This chapter draws on the limited literature available on Angola's mangrove forests and seagrass meadows that constitute its Mangrove Biome. Comprising only five of the world's 55 mangrove species, and two of the world's 70 species of seagrasses, Angola's mangrove communities cover a very limited area compared with other tropical countries. This is due to Angola's steeply shelving coastline, with small lagoons and mudflats at the mouths of its rivers. However, they provide excellent opportunities for the study of the complex adaptations of plants to regular changes in water salinity and to growth in waterlogged, anoxic soil. The adaptations include stilt roots, with specialised absorptive pores, roots containing porous aerenchyma tissue for oxygen transfer, and reproductive propagules that develop into seedlings while still attached to the tree. The mudflats of coastal lagoons support two species of seagrass (highly specialised angiosperms that are permanently submerged). Seagrass meadows

provide habitat for a wide diversity of marine animals, while mangrove forests shelter several crocodile and primate species.

Bendella, M., Hunt, A., Benyoucef, M. and Bouchemla, I. (2023). The first Mesozoic vertebrate coprolites from Algeria. *Ichnos* (<https://doi.org/10.1080/10420940.2023.2187387>).

Abstract: Nine morphotypes of coprolites, including *Heteropolacopros texaniensis*, *Liassocopros* isp., *Hyronocopros amphipola*, *Eucoprus* isp. 1, *Eucoprus* isp. 2, Morphotype 1, Morphotype 2, Morphotype 3, and Morphotype 4, are distinguished from the basal Late Cretaceous (Lower Cenomanian) of the 'Continental Intercalaire' deposits at Gara Samani (Sahara, southern Algeria). This coprofauna is the first to be identified, described and illustrated from the Mesozoic of Algeria. It adds new information on the trace-fossil assemblages previously reported from the Cretaceous localities of North Africa. The Gara Samani coproassociation marks the youngest occurrence of the ichnogenera *Heteropolacopros* and *Hyronocopros*. Most coprolites were produced by ichthyophagous carnivores, such as crocodiles, theropods (*Spinosaurus*) and different kinds of fish.

Nishan, K.C., Neupane, B., Belbase, B., Dharmi, B., Bist, B.S., Basyal, C.R. and Bhattarai, S. (2023). Factors influencing the habitat selection of Mugger crocodile (*Crocodylus palustris*) and its conservation threats in the Rapti River of Chitwan National Park, Nepal. *Global Ecology and Conservation* 42: e02406.

Abstract: Mugger crocodiles (hereafter called muggers) are the apex predator and keystone species in slow flowing freshwater ecosystem. They play an important role in its functioning by distributing nutrients and increasing primary productivity. Muggers have a sympatric distribution with gharials in the Rapti and Narayani River of Chitwan National Park, but more research and conservation attention has been focused on gharials in Nepal. The inadequate availability of information on the occupied habitats of muggers restrict their evidence-based conservation and management. Therefore, we investigated the ecological factors affecting the habitat selection of muggers and its conservation threats in the Rapti River. We conducted a preliminary survey, followed by a detailed habitat survey, conducted in February and March 2022. During the detailed habitat survey, the pre-defined habitat characteristics were recorded at each station spaced at 500 m intervals along the river as well as the locations where muggers were sighted. We used a generalized linear model (glm) under the binomial family with a logit link function to analyze the factors influencing the habitat selection of muggers. The dependent variable was the presence or absence of muggers at sampling points and the independent variables included: river bank aspect, river width, mid-river depth, river bank substrate type, river bank slope, water current, invasive alien plant species, and anthropogenic disturbances. In addition, a relative whole-site ranking method was employed to determine the most prevalent threats to the mugger. During the survey period, we recorded a total of 46 mugger individuals, 74% were observed basking and 26% were observed submerged in the river. The highest percentage of muggers (39.1%) was observed on the sandy river bank, followed by the grass and forest bank (19.5%), and clay and sandy bank (15.1%), respectively. Only the river banks with moderate (15-25°) and moderately steep (25-35°) slopes were found to be the significant factors influencing the occurrence of muggers. Fishing and extraction of river materials, and disposal of garbage and solid waste were ranked as the most prevalent conservation threats. For the long-term conservation of muggers in the Rapti River, effective habitat management plans and strategies are required to control illegal anthropogenic activities such as fishing, sand mining, and boulder quarrying. Research on spatio-temporal partitioning between mugger and gharials is recommended to understand how resources are shared by the species.

Siddiqui, R. and Khan, N.A. (2023). Microbiome and One Health: Potential of novel metabolites from the gut microbiome of unique species for human health. *Microorganisms* 11: 481.

Rehman, M.N.U., Dawar, F.U., Zeng, J., Fan, L., Feng, W., Wang, M., Yang, N., Guo, G. and Zheng, J. (2023). Complete genome sequence analysis of *Edwardsiella tarda* SC002 from hatchlings of Siamese crocodile. *Frontiers in Veterinary Science* 10 (<https://doi.org/10.3389/fvets.2023.1140655>).

Abstract: *Edwardsiella tarda* is a Gram-negative, facultative anaerobic rod-shaped bacterium and the causative agent of the systemic disease “Edwardsiellosis”. It is commonly prevalent in aquatic organisms with subsequent economic loss and hence has attracted increasing attention from researchers. In this study, we investigated the complete genome sequence of a highly virulent isolate *E. tarda* SC002 isolated from hatchlings of the Siamese crocodile. The genome of SC002 consisted of one circular chromosome of length 3,662,469 bp with a 57.29% G+C content and four novel plasmids. A total of 3,734 protein-coding genes, 12 genomic islands (GIs), 7 prophages, 48 interspersed repeat sequences, 248 tandem repeat sequences, a CRISPR component with a total length of 175 bp, and 171 ncRNAs (tRNA = 106, sRNA = 37, and rRNA = 28) were predicted. In addition, the coding genes of assembled genome were successfully annotated against 8 general databases (NR= 3618/3734, COG= 2947/3734, KEGG= 3485/3734, SWISS-PROT= 2787/3734, GO= 2648/3734, Pfam= 2648/3734, CAZy= 130/3734, and TCDB= 637/3734) and four pathogenicity-related databases (ARDB= 11/3734, CARD= 142/3734, PHI= 538/3734, and VFDB= 315/3734). Pan-genome and comparative genome analyses of the complete sequenced genomes confirmed their evolutionary relationships. The present study confirmed that *E. tarda* SC002 is a potential pathogen bearing a bulk amount of antibiotic resistance, virulence, and pathogenic genes and its open pan-genome may enhance its host range in the future.

Vyas, R. (2023). The mysterious deaths of Mugger crocodiles (*Crocodylus palustris*) near Vadodara, Gujarat, India. *Reptiles & Amphibians* 30: e18141.

Bertone, S., Godahewa, A., Balaguera-Reina, S.A., Briggs-Gonzalez, V. and Mazzotti, F.J. (2023). First successful nest for the Vulnerable American crocodile *Crocodylus acutus* population on the west coast of Florida, USA. *Oryx* (<https://doi.org/10.1017/S0030605322001119>).

Abstract: The American crocodile *Crocodylus acutus* occurs across the Americas, with its northernmost distribution being in South Florida, USA. This species has undergone severe declines across its range and is categorized globally as Vulnerable on the IUCN Red List and as Threatened on the U.S. Federal Endangered Species List. Long-term monitoring studies in the USA have documented a shift in American crocodile nesting activity and an expansion of its range throughout the southern and eastern coasts of South Florida. However, no successful American crocodile nests have been recorded until now on the west coast of South Florida. Here we document the American crocodile nest monitoring conducted during 1997-2021 at Rookery Bay National Estuarine Research Reserve and the first successful nest from the west coast of South Florida for *C. acutus*. Marco Airport and McIlvane Marsh are the two main American crocodile nesting areas identified at the Reserve, with 92 nests and 3,586 eggs recorded during 1997-2021. We found most nests at Marco Airport (95.7%) and only four nests (4.3%) at McIlvane Marsh. To date, none of the nests found at Marco Airport have produced successful hatchlings. In contrast, hatchlings have been produced at McIlvane Marsh since nests were first documented there in 2020. We discuss the implications of our findings in terms of the future conservation of the species.

Sy, E.Y. and Lorenzo II, A.N. (2023). Online trade of live crocodilians in the Philippines. *Journal of Nature Studies* 21(2): 1-14

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

Xie, Z., Shi, P., Yang, X. and Lu, M. (2023). Morphological study in heart of wild Chinese alligator (*Alligator sinensis*). *International Journal of Morphology* 41(1) (<http://dx.doi.org/10.4067/S0717-95022023000100324>).

Abstract: The Chinese alligator (*Alligator sinensis*) belongs to the genus *Alligator*, which is a unique crocodile in China. In order to study the macroscopic structure of the heart of Chinese alligator, we performed detailed cardiac anatomy on five specimens. The heart is in the cranial mediastinum. It is caudally involved by the liver cranial margins, and ventrally by the ribs, intercostal muscles, and sternum and dorsally by the lungs. The wild Chinese alligator heart is a typical four-chamber heart, with two (right and left) atria and ventricles, left and right aorta, pulmonary artery and subclavian artery branch from the aorta. Morphology measures the circumference (129.36 mm), weight (44.14 g), and length of the heart from apex to bottom (52.50 mm). Studies have shown that the shape of the wild Chinese alligator's heart is consistent with the anatomy of other crocodiles.

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

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

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

Baker, C. (2023). Using Spatial Ecology to Reveal Sociality: the Movement Ecology, Behaviour, and Social Structure of the Estuarine

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

systems of other non-group living species, providing a more holistic understanding of animal sociality and evolution.

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

Abstract: Human-wildlife co-existence is a prerequisite for protected area conservation. Many studies have been carried out on human-wildlife conflict and local communities' exploitation of protected areas resources besides a long established practice of community-based conservation by Uganda Wildlife Authority. However, there has been limited information to deepen the understanding and broaden knowledge on human-wildlife co-existence so as to bolster the strategies used by local communities and UWA. To fill this gap, a study was carried out in Queen Elizabeth National Park to generate information that can enhance the co-existence between wildlife and local communities. Specifically, the study examined the benefits obtained by the adjacent communities from the park and how the people co-existed with wild animals. A cross sectional research design with qualitative and quantitative approaches of data collection was adopted. A structured questionnaire was administered to collect data from 309 respondents randomly sampled from Kyambura, Katwe, Kazinga and Muhokya parishes surrounding the park. Questionnaire responses were edited, coded and entered in the STATA 15 to create data file and later used to generate statistical summary. Qualitative information from key informant interviews was summarized and presented as a narrative. Results show that the local communities benefited from the park in a number of ways. They caught different fish types especially tilapia from Lake Edward and Lake George, harvested wild food plants and obtained bush meat from hippopotamus and Uganda kob that were top listed. It was also noted that different tribes preferred different types of bush meat. For example, the Basongora liked rabbit meat; the Congolese chose monkey meat while the Bakonjo preferred meat of hippopotamus. Local people also harvested herbal medicines mainly the leaves, roots and bark of a number of plants especially *Kigelia africana*, *Aloe vera* and *Mondia whitei*. Body parts of elephants, lions and hippopotamus were reportedly used for treatment of a number of ailments including wounds, mental illness, cancer, epilepsy, tuberculosis, skin rash, cough and many others. The local people also collected water from the park for washing, cooking, watering home garden vegetables and livestock. Furthermore, local people exploited non-timber forest products and were employed in the park as well as in tourism related enterprises. Human-wildlife coexistence strategies adopted included digging deep and wide trenches to bar non-jumping animals from crossing from the park onto the farmlands and settlements, establishment of apiaries particularly to deter elephants from leaving the park, sprinkling of red pepper powder on the park's boundary and construction of crocodile cages to protect human when collecting water. Based on the results, an integrated and community-based approach to manage the park's resources is recommended and future studies should quantify the benefits of human-wildlife coexistence in the park.

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

Abstract: *Crocodylus moreletii* and *Crocodylus acutus* are two endangered crocodile species endemic to Mexico. In this descriptive cross-sectional study, a total of 58 crocodiles (30 females and 28 males) were examined to determine and evaluate 24 blood biochemical indicators associated with energy, lipid, protein, mineral and enzymatic metabolic processes. Most of the serum biochemistry parameters were similar among sexes by species. However, male crocodiles showed higher triacylglycerol concentration and alkaline phosphatase activity, and lower globulin concentration than females.

There were some significant differences between species. Total bilirubin, triacylglycerol, carbon dioxide, and hydrogen carbonate were higher in *C. moreletii*, and urea nitrogen, creatinine, alanine aminotransferase, and aspartate aminotransferase were higher in *C. acutus*. These reference values are very important for the protection of crocodiles. The calculated confidence intervals could be used to detect alert situations when at least 5% of the sampled crocodiles would fall outside of the calculated reference interval for a given parameter.

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

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

Guedes, J.J.M., Moura, M.R. and Diniz-Filho, J.A.F. (2023). Species out of sight: elucidating the determinants of research effort in global reptiles. Ecography (<https://doi.org/10.1111/ecog.06491>).

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

alternative.

Schleuning, M., García, D. and Tobias, J.A. (2023). Animal functional traits: Towards a trait-based ecology for whole ecosystems. Functional Ecology (<https://doi.org/10.1111/1365-2435.14246>).

Abstract: 1. Functional traits and associated trait-based concepts have driven rapid innovation in ecology over recent years, with most progress based on insights from plants. However, plants are almost entirely restricted to a single trophic level, and an over-reliance on plant traits therefore neglects the complexity and importance of biotic interactions across trophic levels. 2. The need to expand the focus of trait-based ecology to account for trophic complexity has led to an upsurge in attention on animal functional traits and the emergence of new concepts relevant to community ecology, macroecology and ecosystem science. Recent progress in the compilation of global trait datasets for some animal taxa has opened up new possibilities for testing ecological theory. 3. In this Special Focus, we explore how trait-based ecology can expand the scope of investigation from single to multiple trophic levels, how insights from these investigations can be used to upscale understanding from local communities to biogeographical patterns and how this can ultimately help to predict the impacts of global change on ecosystem functions. To address these key questions, we showcase studies on diverse animal taxa ranging in size from springtails to crocodiles and spanning multiple trophic levels from primary consumers to apex predators. 4. This collection of studies shows how precise measurements of morphological or physiological traits can increase mechanistic understanding of community assembly across trophic levels, particularly of the mechanisms underpinning large-scale biodiversity patterns. Furthermore, a clearer picture is emerging of systematic animal responses to environmental change that shape the trait composition of ecological communities and affect ecosystem functioning. 5. The articles in this volume highlight the need to move trait-based ecology beyond the limits of taxonomic boundaries. The integration of trait data and concepts across trophic levels opens up new possibilities for identifying general ecological mechanisms that shape patterns and processes operating at different scales. The identification of key functional traits and their interplay across trophic levels can underpin the development of a trait-based ecology for whole ecosystems, which could eventually enable predictions of the ecosystem-level consequences of biodiversity loss.

D'Acunto, L.E., Pearlstine, L., Haider, S.M., Hackett, C.E., Shinde, D. and Románach, S.S. (2023). The Everglades vulnerability analysis: Linking ecological models to support ecosystem restoration. Frontiers in Ecology and Evolution 11: 1111551.

Abstract: Understanding of the Everglades' ecological vulnerabilities and restoration needs has advanced over the past decade but has not been applied in an integrated manner. To address this need, we developed the Everglades Vulnerability Analysis (EVA), a decision support tool that uses modular Bayesian networks to predict the ecological outcomes of a subset of the ecosystem's health indicators. This tool takes advantage of the extensive modeling work already done in the Everglades and synthesizes information across indicators of ecosystem health to forecast long-term, landscape-scale changes. In addition, the tool can predict indicator vulnerability through comparison to user-defined ideal system states that can vary in the level of certainty of outcomes. An integrated understanding of the Everglades system is essential for evaluation of trade-offs at local, regional, and system-wide scales. Through EVA, Everglades restoration decision makers can provide effective guidance during restoration planning and implementation processes to mitigate unintended consequences that could result in further damage to the Everglades system.

Marvier, M. (2023). Learning to live with large predators. The Proceedings of the National Academy of Sciences 120(15):

Currylow, A.F., Fitzgerald, A.L., Goetz, M.T.H., Draxler, J.L., Anderson, G.E., McCollister, M.F., Romagosa, C.M. and Yackel Adams, A.A. (2023). Natives bite back: depredation and mortality of invasive juvenile Burmese pythons (*Python bivittatus*) in the Greater Everglades Ecosystem. *Management of Biological Invasions* 14(1): 107-122.

Abstract: Burmese pythons (*Python bivittatus* Kuhl, 1820) are one of the world's largest snake species, making them a highly successful and biologically damaging invasive predator in the Greater Everglades Ecosystem, Florida, USA. Though we have knowledge of python diet within this system, we understand very little of other interactions with native species. Effects native species have on invasive pythons, especially in the juvenile size class, are of particular interest as the prevalence of mortalities would inform potential population growth and trophic dynamics with native prey species. Native ophiophagous predators in Florida feed on smaller native snake species and it is unknown if they consistently recognize similarly sized juvenile invasive pythons as prey items. Using radiotelemetry, we found at least four native species within Big Cypress National Preserve that were implicated in juvenile python deaths, including three Florida cottonmouths (*Agkistrodon conanti* Gloyd, 1969), five American alligators (*Alligator mississippiensis* Daudin, 1802), one hispid cotton rat (*Sigmodon hispidus* Say and Ord, 1825), and three mesomammals. One mortality was the result of an attempt to subdue a prey item 106% the size of the python, constituting the largest predator:prey size ratio ever reported in this size class. This finding may indicate that phenotypic variation in individual juvenile pythons includes behavior that could be maladaptive within the novel Florida environment. Here we describe some of the first confirmed cases of non-anthropogenic mortality in juvenile Burmese pythons in Florida and present evidence that invasive pythons in this size class are now being incorporated into the diets of native species in its invasive range.

Jones, K. and Ariel, E. (2023). Reptiles. Chapter 4 in *Pathology and Epidemiology of Aquatic Animal Diseases for Practitioners*, ed. by L. Urdes, C. Walster and J. Tepper. John Wiley & Sons: Hoboken.

Morris, A.W., Smith, I., Chakrabarti, S., Lala, F., Nyagah, S. and Bump, J.K. (2023). Eating an elephant, one bite at a time: predator interactions at carrion bonanzas. *BioRxiv* (<https://doi.org/10.1101/2023.03.31.535158>).

Abstract: Resource specific competition between predators has typically been studied from their interactions at meso-herbivore carcasses, because such carcasses are abundant. Mega-carcasses like those of elephants are rare but unparalleled in the extent of carrion biomass they offer and the long durations they can persist. These rare resource bonanzas can thus provide unique opportunities to understand sympatric species interactions within likely relaxed competitive scenarios. Using remote cameras that were operational 24-h a day, we monitored two elephant carcasses in Tsavo, Kenya, from when they were discovered until they were completely consumed or became inaccessible. While we found high temporal overlaps in activity patterns between all predators, the terrestrial predator guild (lion/leopard/spotted hyena) was not observed to feed simultaneously, suggesting strong interference competition. Based on photo-analysis and video-evidence of exclusion from a carcass, interference competition within the terrestrial predator guild favored lions over hyenas, and hyenas over leopards. The carcass at the terrestrial-aquatic interface showed more simultaneous feeding bouts between predators (crocodile/spotted hyena), indicating either facilitation and/or higher coexistence between predators that typically occupy different niches. We also observed a hippopotamus scavenging from an elephant carcass, thereby documenting a rare instance of a megaherbivore feeding on a megaherbivore. Our

results highlight the importance of monitoring such carcasses through remote cameras, which can significantly add to our existing understanding of food webs and carrion ecology.

Hechenleitner, E.M., Fernandez Blanco, M.V., Núñez-Campero, S.R., Fiorelli, L.E. and Bona, P. (2023). Unexpected morphological variability in the eggshells of the South American caimans *Caiman latirostris* and *Caiman yacare*. *Scientific Reports* 13: 4894.

Abstract: Eggshell morphology is a valuable indicator of the local conditions within the nests of modern crocodilians and birds. In contrast to these latter, the anatomical structure of the eggshells of most crocodilian species is practically unknown. Here, we provide the first characterization of crocodilian eggshells, using x-ray micro-CT scans. We studied eggshells of *Caiman latirostris* and *Caiman yacare* from various developmental stages that coincide with the beginning of embryonic ossification. The new 3D renderings revealed complex ornamentation, unique among crocodilians, and amphora-shaped pore canals, some of which converge in single pore openings. We also documented a high density of pore canals with a gas diffusion capacity 45 times higher than the average predicted for modern avian eggshells. The external ornamentation and the thickness of the compact layer of the eggshells (ie excluding ornamentation) showed ontogenetic and interspecific differences that could be related to nesting materials and nesting areas selected by each species. The shell features described here evidence a greater structural complexity than previously recognized in phylogenetically close, sympatric crocodilian species. Further comprehensive morphological analyses on other modern and fossil crocodilian eggshells using micro-CT technology will shed new light on the evolution of reproductive strategies in this intriguing archosaur clade.

Lindholm, A., Godfrey, S.J., Ward, L.W. and Collareta, A. (2022). A gar-bitten vertebrate coprolite from the Neogene of the Atlantic Coastal Plain, USA, and a new ichnospecies of *Machichnus* Mikuláš et al., 2006. *Ichnos* 9(3-4) (<https://doi.org/10.1080/10420940.2023.2182300>).

Abstract: Vertebrate-bitten coprolites are seemingly rare; nonetheless, within the past dozen years, a handful of these composite trace fossils have been found and described. Here, we describe a single crocodile coprolite from the Lower Miocene Calvert Formation in New Kent County, Virginia, USA, showing bite marks. The size and morphology of the coprolite is consistent with a crocodilian origin. Seven parallel, gently curving gouges, of biogenic origin, disrupt the surface of the coprolite. As it is a medium preserving bite marks, this coprolite qualifies as a morderolite. Furthermore, because of the presence of larger/deeper primary, and finer secondary gouges, which we interpreted as individual tooth marks, the identity of the vertebrate that bit the coprolite is most likely gar (*Lepisosteidae*). Because other comparable coprolites preserving similar sets of primary and secondary gouges are known, this unique trace fossil is given a new ichnotaxonomic name, *Machichnus dimorphodon* isp. nov. Many more much smaller markings, interpreted as feeding traces by smaller organisms (possibly invertebrates) also ornament the surface of the coprolite.

Amavet, P.S., Pacheco-Sierra, G., Uhart, M.M., Prado, W.S. and Siroski, P.A. (2023). Phylogeographical analysis and phylogenetic inference based on the cytochrome b gene in the genus *Caiman* (Crocodylia: Alligatoridae) in Central and South America. *Biological Journal of the Linnean Society* 138(3): 289-303.

Abstract: The genus *Caiman* is one of the most taxonomically conflicted among crocodilians. *Caiman crocodilus* has four subspecies: *Caiman crocodilus crocodilus*, *Caiman crocodilus fuscus*, *Caiman crocodilus chiapasius* and *Caiman crocodilus apaporiensis*, but some studies recognize *Caiman yacare* as

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

Chen, X., Jähnig, S.C., Jeschke, J.M., Evans, T.G. and He, F. (2023). Do alien species affect native freshwater megafauna? *Freshwater Biology* (doi: [10.1111/fwb.14073](https://doi.org/10.1111/fwb.14073)).

Abstract: Freshwater megafauna species (ie animals that can reach a body mass ≥ 30 kg, including fish, reptiles, mammals, and amphibians) play important roles in freshwater systems (eg by influencing habitat structure, trophic dynamics, or the dispersal of smaller species). As they tend to be large and charismatic, they may also function as flagship umbrella species in future freshwater conservation initiatives. Despite this, as a group they are highly threatened, and our knowledge of the nature of these threats is limited. In this study, we aim to improve our understanding of the impacts of alien species on native freshwater megafauna. We undertook the first global assessment of the impacts of alien species on native freshwater megafauna using the Environmental Impact Classification for Alien Taxa (EICAT) framework. We conducted a literature review to identify published and grey literature on impacts, which we quantified and categorised by their severity and type, following the EICAT guidelines. Negative impacts on native freshwater megafauna were caused by 61 alien species from a diverse range of taxonomic groups, including both freshwater and terrestrial alien species, and both vertebrates and invertebrates. They adversely affected 44 of 216 native freshwater megafauna species, including amphibians, fish, mammals, and reptiles. The Great Lakes Basin had the highest number of affected megafauna species (6 of the 14 freshwater megafauna species it supports, mainly fish). Impacts occurred through a broad range of mechanisms (10 of the 12 identified mechanisms under EICAT); predation and competition were the most frequently reported mechanisms. Some impacts were relatively minor, adversely affecting the performance of individuals of native freshwater megafauna species. However, some reported impacts did cause declining populations of native freshwater megafauna species, and one impact contributed to the local extinction of the ship sturgeon (*Acipenser nudiiventris*) in the Aral Sea. The vulnerability of native freshwater megafauna species to different types of impact varies during different life-cycle stages (egg, juvenile, and adult). Our understanding of impacts posed by alien species on native freshwater megafauna is limited because data are unavailable for many regions, particularly the Global South, including hotspots for freshwater megafauna diversity such as the Amazon, Congo, Mekong, and Ganges-Brahmaputra basins. Freshwater megafauna species are often subject to multiple threats, which makes it difficult to determine the significance of alien species impacts relative to other threats such as habitat degradation and overexploitation. In addition, short-term studies are likely to be masking the severity of the impacts identified. We call for more long-term studies that attempt to identify population-level impacts, and for studies that identify impacts in data-deficient regions. The EICAT assessments undertaken for this study will be reviewed by the EICAT Authority and subsequently incorporated into the IUCN EICAT database. They may be used to guide future research and

conservation actions.

Nordberg, E.J. and McKnight, D.T. (2023). Seasonal, environmental and anthropogenic influences on nocturnal basking in turtles and crocodiles from North-Eastern Australia. *Austral Ecology* (doi: [10.1111/aec.13320](https://doi.org/10.1111/aec.13320)).

Abstract: Many ectotherms bask in the sun as a behavioural mechanism to increase body temperature and facilitate metabolism, digestion or gamete production, among other functions. Such behaviours are common during the day, but some nocturnal species are also known to thermoregulate at night, in the absence of solar radiation, through shifts in body posture or microhabitat selection. Additionally, recent work has documented nocturnal basking in freshwater turtles in tropical Australia, though the purpose of the behaviour remains unknown. Here, we have built upon that work to test: 1. seasonal differences, 2. the influence of environmental factors and 3. the influence of anthropogenic development (eg river-front houses) on nocturnal basking behaviour. We visually surveyed transects repeatedly at night on the Ross River, Townsville, QLD, Australia from March to November 2020 and documented nocturnal basking in both freshwater turtles (*Emydura macquarii krefftii*) and freshwater crocodiles (*Crocodylus johnstoni*). For both taxa, we found significantly more nocturnal basking activity during the hotter months. Likewise, water surface temperature significantly influenced nocturnal basking in both taxa, especially when water temperatures were both high and warmer than air temperatures. We propose that nocturnal basking provides a mechanism for thermoregulatory cooling when water temperatures are high (eg 30°C) and above preferred temperatures. After accounting for availability in basking habitat, both turtles and crocodiles basked more frequently on the undeveloped side of the river, suggesting avoidance of human activity or disturbance. This study is the first to document nocturnal basking activity temporally throughout the year as well as the first to identify the influences of environmental factors. Nocturnal thermoregulation has been documented in many reptiles, however, thermoregulatory cooling in tropical systems is less well-known.

Green, J., Schmidt-Burbach, J. and Elwin, A. (2023). Taking stock of wildlife farming: A global perspective. *Global Ecology and Conservation* (<https://doi.org/10.1016/j.gecco.2023.e02452>).

Abstract: To meet the global demand for the commercial trade of wildlife and wildlife derived products, wild animals are captured from wild populations or farmed. ‘Wildlife farming’ refers to commercial captive breeding or ranching wild animals in captivity with the intent to generate financial profit. Many countries encourage farming of wild animals to capitalize from consumer demand for wildlife products alongside the belief that captive breeding practises help to protect wild populations by reducing the pressure on the number of animals captured directly from the wild. However, wildlife farming is associated with concerns relating to animal welfare, public health and biodiversity conservation, and case studies demonstrate that farming wildlife does not necessarily alleviate pressure on wild populations. The global scale of wildlife farming, and hence its impact, is currently unknown. Here, we obtained data from published literature to compile a database of wildlife farmed during the period 2000–2020. We also obtained data from Freedom of Information requests to a small number of countries for wildlife farmed during 2021–2022. Our results demonstrate that at least 487 wildlife species are farmed across the world, comprised of at least 27 amphibians, 133 reptiles, 249 birds, and 79 mammals. Of these documented species, 34% are considered either Near Threatened, Vulnerable, Endangered or Critically Endangered by the IUCN Red List of Threatened Species, and 62% are listed on the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) Appendices. Data pertaining to the number of farmed individuals for each species was even more difficult to determine, but reports of between 936,321,047 and 963,711,547 individual

farmed wild animals were recorded in the literature. Commercial breeding operations were recorded in 90 countries worldwide. We suggest that the true number of farmed wildlife is likely to be far higher than the data compiled in our database due to the paucity of publicly available information on this topic and the challenges we faced obtaining data from relevant authorities. We discuss the implications of the scale of the industry, its inadequate transparency, and its relevance for the trade of wild animals and their derivatives as commercial products. To our knowledge this is the first attempt in the literature to summarise the global scope and scale of commercial wildlife farming. We hope this initial inventory can provide insight into the full extent of this industry and its impact on wild animals globally.

Wesson, J.P., O'Dea, M.A. and Hyndman, T.H. (2023). A review of reptile virus experimental infection studies. *Journal of General Virology* 104 (doi [10.1099/jgv.0.001832](https://doi.org/10.1099/jgv.0.001832)).

Abstract: Despite recent advances in molecular techniques, infection studies remain an important tool for biosecurity, veterinary and conservation medicines. Experimental infection studies are performed for many reasons: to investigate causal links between pathogens and disease, to study host species susceptibility, to study immune response to inoculation, to investigate pathogen transmission and to investigate methods for infection control. Experimental infection studies using viruses in reptiles have been conducted sporadically since at least the 1930s and this continues to be a fertile area of research. This review catalogues previously published research in the field. The key parameters of each study are tabulated, providing a summary of more than 100 experiments linked to their original publications. Common themes and trends within the data are discussed.

Oyinloye, M.A., Adeloye, A.A., Odewole, P.O. and Afolabi, B.E.F. (2023). Animal representations in Nigerian art: A review of roles, significance and aesthetics. *yedi: Journal of Art, Design & Science* 30: 33-42.

Abstract: The paper explores literature, as well as Nigeria's national museum's content on the use of animal forms as elements and subjects in traditional Nigerian art from prehistoric to the contemporary time. It identifies the roles, and significance of animals to mankind, as well as appraises their aesthetic value in Visual Art. The paper dwells on Nigerian Indigenous tales associated with animals associated with certain Nigerian cultures such as snakes, lizards and crocodiles among others. Other data was sourced from books, journal articles, pictorial images online, as well as museum's documentations online. Data was qualitatively analysed using art historian methods to descriptively present the data. The study identifies animals as important companions of man; most animals serve as food sources, while some typifies human characters. The study concluded that, animal representations in art were born out of love and regard for them. Nevertheless, they have significantly contributed to the visual aesthetics of the past and present cultures, and therefore need to be preserved for future generations to learn from and also to adopt them for art pieces.

Wroblewski, A.-J. (2023). The makers of *Rhamphichnus* isp. reinterpreted as lepidosaurian and crocodilian, not pterosaurian. *Geobios* (<https://doi.org/10.1016/j.geobios.2022.12.001>).

Abstract: Three ichnospecies of the Late Jurassic trace fossil genus *Rhamphichnus* were first described and interpreted as the walking tracks of non-pterodactyloid pterosaurs like *Rhamphorhynchus*. This despite not resembling any previously identified pterosaur tracks and having a morphology unmatched by pterosaur skeletal elements. To fit the pterosaurian model, elongated imprints of *R. pereiraensis* and *R. lafaurii*, displaying four or five digit impressions were interpreted as manus prints, while shorter, five-digit prints

were interpreted as imprints made by pedes with dislocated metatarsals and disarticulated phalanges. Comparison of published images and descriptions of *Rhamphichnus* isp. to skeletal elements of six contemporaneous non-pterodactyloid taxa, skeletons and tracks from pterodactyloid pterosaurs, and modern and ancient lepidosaurs and crocodilians suggests an alternative interpretation. *R. craysacensis* closely resembles crocodilian (*Crocodylopus* (*Sustenodactylus*) isp.) and crocodylomorph (*Batrachopus* isp.) tracks; its holotype trackway was found 50 cm away from and parallel to a crocodilian swimming trackway with the same sized feet, possibly made by the same individual. *R. pereiraensis* and *R. lafaurii* strongly resemble lepidosaurian tracks and match the size and morphology of contemporary rhynchocephalians. Prints originally interpreted as manual and pedal in *R. pereiraensis* and *R. lafaurii* are reinterpreted and transposed in light of new data from pterosaurian, lepidosaurian, and crocodilian tracks and anatomy. Identification of fossil trackmakers depends on comparisons of a wide range of candidate taxa and elimination of those that cannot be considered further. With this reinterpretation of *Rhamphichnus*, there are no non-pterodactyloid tracks yet identified in the fossil record.

Cullen, T.M., Larson, D.W., Witton, M.P., Scott, D., Maho, T., Brink, K.S., Evans, D.C. and Reisz, R. (2023). Theropod dinosaur facial reconstruction and the importance of soft tissues in paleobiology. *Science* 379(6639): 1348-1352.

Abstract: Large theropod dinosaurs are often reconstructed with their marginal dentition exposed because of the enormous size of their teeth and their phylogenetic association to crocodylians. We tested this hypothesis using a multiproxy approach. Regressions of skull length and tooth size for a range of theropods and extant varanid lizards confirm that complete coverage of theropod dinosaur teeth with extraoral tissues (gingiva and labial scales) is both plausible and consistent with patterns observed in living ziphodont amniotes. Analyses of dental histology from crocodylians and theropod dinosaurs, including *Tyrannosaurus rex*, further indicate that the most likely condition was complete coverage of the marginal dentition with extraoral tissue when the mouth was closed. This changes our perceptions about the appearance and oral configuration of these iconic predators and has broad implications for our interpretations of other terrestrial animals with large teeth.

Burke, P.M.J. and Mannion, P.D. (2023). Neuroanatomy of the crocodylian *Tomistoma dowsoni* from the Miocene of North Africa provides insights into the evolutionary history of gavialoids. *Journal of Anatomy* (doi: [10.1111/joa.13846](https://doi.org/10.1111/joa.13846)).

Abstract: The interrelationships of the extant crocodylians *Gavialis gangeticus* and *Tomistoma schlegelii* have been historically disputed. Whereas molecular analyses indicate a sister taxon relationship between these two gavialoid species, morphological datasets typically place *Gavialis* as the outgroup to all other extant crocodylians. Recent morphological-based phylogenetic analyses have begun to resolve this discrepancy, recovering *Gavialis* as the closest living relative of *Tomistoma*; however, several stratigraphically early fossil taxa are recovered as closer to *Gavialis* than *Tomistoma*, resulting in anomalously early divergence timings. As such, additional morphological data might be required to resolve these remaining discrepancies. '*Tomistoma*' *dowsoni* is an extinct species of gavialoid from the Miocene of North Africa. Utilising CT scans of a near-complete, referred skull, we reconstruct the neuroanatomy and neurosensory apparatus of '*Tomistoma*' *dowsoni*. Based on qualitative and quantitative morphometric comparisons with other crocodylians, the neuroanatomy of '*Tomistoma*' *dowsoni* is characterised by an intermediate morphology between the two extant gavialoids, more closely resembling *Gavialis*. This mirrors the results of recent studies based on the external anatomy of these three species and other fossil gavialoids. Several neuroanatomical features of these species appear to reflect ecological

and/or phylogenetic signals. For example, the ‘simple’ morphology of their neurosensory apparatus is broadly similar to that of other long and narrow-snouted (longirostrine), aquatic crocodyliforms. A dorsoventrally short, anteroposteriorly long endosseous labyrinth is also associated with longirostry. These features indicate that snout and skull morphology, which are themselves partly constrained by ecology, exert an influence on neuroanatomical morphology, as has also been recognised in birds and turtles. Conversely, the presence of a pterygoid bulla in *Gavialis* and several extinct gavialoids, and its absence in *Tomistoma schlegelii*, could be interpreted as a phylogenetic signal of crocodylians more closely related to *Gavialis* than to *Tomistoma*. Evaluation of additional fossil gavialoids will be needed to further test whether these and other neuroanatomical features primarily reflect a phylogenetic or ecological signal. By incorporating such previously inaccessible information of extinct and extant gavialoids into phylogenetic and macroecological studies, we can potentially further constrain the clade’s interrelationships, as well as evaluate the timing and ecological association of the evolution of these neuroanatomical features. Finally, our study supports recent phylogenetic analyses that place ‘*Tomistoma*’ *dawsoni* as being phylogenetically closer to *Gavialis gangeticus* than to *Tomistoma schlegelii*, indicating the necessity of a taxonomic revision of this fossil species.

Fungfuang, W., Srisuksai, K., Santativongchai, P., Charoenlappanit, S., Phaonakrop, N., Roytrakul, S., Tulayakul, P. and Parunyakul, K. (2023). Targeted proteomic analysis reveals that crocodile oil from *Crocodylus siamensis* may enhance hepatic energy metabolism in rats. *Experimental Animals* (doi: 10.1538/expanim.23-0009).

Abstract: The liver is a key organ governing body energy metabolism. Dietary fats influence energy metabolism and mitochondrial functioning. Crocodile oil (CO) is rich in mono- and poly-unsaturated fatty acids that contain natural anti-inflammatory and healing properties. Our study examined how crocodile oil (CO) affects the expressions of liver proteins involved in energy metabolism in rats. Twenty-one male Sprague Dawley rats were divided into three groups and underwent oral gavage of 3 mL/kg of sterile water (N), CO (CO), or palm oil (PO) for 7 weeks. Body weight, energy intake, liver weight, liver indexes, blood lipid profiles, and liver-energy intermediates were measured. Liver proteome was analyzed using shotgun proteomics, and the functions and network interactions of several candidate proteins were predicted using STITCH v.5.0 software. Body weights, energy intake, liver contents, and lipid profiles did not differ between the groups. However, hepatic oxaloacetate and malate levels were significantly higher in the CO group than in the PO group. Targeted proteomics reveals that twenty-two from 1790 unique proteins in the CO group were involved in energy-generating pathways, including the tricarboxylic acid cycle and oxidative phosphorylation (OXPHOS), and were correlated with AMP-activated protein kinase signaling pathway. Cluster analysis of 59 differentially expressed proteins showed that OXPHOS-associated proteins were upregulated in the CO group, and three glycolytic metabolism-related proteins were downregulated in the CO group. CO may enhance hepatic energy metabolism by regulating the expressions of energy expenditure-related proteins.

Guo, J., Chi, H., Zhang, L., Song, S., Rossiter, S.J. and Liu, Y. (2023). Convergent evolutionary shifts in rhodopsin retinal release explain shared opsin repertoires in monotremes and crocodylians. *Proceedings. Biological Sciences* 290(1996) (doi: 10.1098/rspb.2023.0530).

Abstract: The visual ecology of early mammals remains poorly resolved. Studies of ancestral photopigments suggest an ancient transition from nocturnal to more crepuscular conditions. By contrast, the phenotypic shifts following the split of monotremes and therians—which lost their SWS1 and SWS2 opsins, respectively—are less clear. To address this, we obtained new phenotypic data on the photopigments of extant and ancestral monotremes. We then

generated functional data for another vertebrate group that shares the same photopigment repertoire as monotremes: the crocodylians. By characterizing resurrected ancient pigments, we show that the ancestral monotreme underwent a dramatic acceleration in its rhodopsin retinal release rate. Moreover, this change was likely mediated by three residue replacements, two of which also arose on the ancestral branch of crocodylians, which exhibit similarly accelerated retinal release. Despite this parallelism in retinal release, we detected minimal to moderate changes in the spectral tuning of cone visual pigments in these groups. Our results imply that ancestral forms of monotremes and crocodylians independently underwent niche expansion to encompass quickly changing light conditions. This scenario—which accords with reported crepuscular activity in extant monotremes—may help account for their loss of the ultraviolet-sensitive SWS1 pigment but retention of the blue-sensitive SWS2.

Puértolas-Pascual, E., Kuzmin, I.T., Serrano-Martínez, A. and Mateus, O. (2023). Neuroanatomy of the crocodylomorph *Portugalosuchus azenhae* from the late cretaceous of Portugal. *Journal of Anatomy* (doi: 10.1111/joa.13836).

Abstract: We present the first detailed braincase anatomical description and neuroanatomical study of *Portugalosuchus azenhae*, from the Cenomanian (Late Cretaceous) of Portugal. This eusuchian crocodylomorph was originally described as a putative Crocodylia and one of the oldest representatives of this clade; however, its phylogenetic position remains controversial. Based on new data obtained from high resolution Computed Tomography images (by micro-CT scan), this study aims to improve the original description of this taxon and also update the scarce neuroanatomical knowledge of Eusuchia and Crocodylia from this time interval, a key period to understand the origin and evolution of these clades. The resulting three-dimensional models from the CT data allowed a detailed description of its well-preserved neurocranium and internal cavities. Therefore, it was possible to reconstruct the cavities of the olfactory region, nasopharyngeal ducts, brain, nerves, carotid arteries, blood vessels, paratympanic sinus system and inner ear, which allowed to estimate some neurosensorial capabilities. By comparison with other crocodylomorphs, these analyses showed that *Portugalosuchus*, back in the Cenomanian, already displayed an olfactory acuity, sight, hearing and cognitive skills within the range of that observed in other basal eusuchians and crocodylians, including extant species. In addition, and in order to test its disputed phylogenetic position, these new anatomical data, which helped to correct and complete some of the original observations, were included in one of the most recent morphology-based phylogenies. The position of *Portugalosuchus* differs slightly from the original publication since it is now located as a “thoracosaurid” within Gavialoidea, but still as a crocodylian. Despite all this, to better contrast these results, additional phylogenetic analyses including this new morphological character coding together with DNA data should be performed.

Arteaga, A. (2023). Brown Caiman (*Caiman fuscus*). In *Reptiles of Ecuador: Life in the Middle of the World*, ed. by A. Arteaga, L. Bustamante, J. Vieira and J.M. Guayasamin. Available from: www.reptilesfecuador.com (doi: 10.47051/DKZU8617).

Arteaga, A. (2023). Spectacled Caiman (*Caiman crocodilus*). In *Reptiles of Ecuador: Life in the Middle of the World*, ed. by A. Arteaga, L. Bustamante, J. Vieira and J.M. Guayasamin. Available from: www.reptilesfecuador.com (doi: 10.47051/EHGA5806).

Arteaga, A. (2023). Black Caiman (*Melanosuchus niger*). In *Reptiles of Ecuador: Life in the Middle of the World*, ed. by A. Arteaga, L. Bustamante, J. Vieira and J.M. Guayasamin. Available from: www.reptilesfecuador.com (doi: 10.47051/IAHJ8674).

Arteaga, A. (2023). American Crocodile (*Crocodylus acutus*). In Reptiles of Ecuador: Life in the Middle of the World, ed. by A. Arteaga, L. Bustamante, J. Vieira and J.M. Guayasamin. Available from: www.reptilesfecuador.com (doi: 10.47051/XBAZ9538).

Chávez Dagostino, R.M., Ojeda Adame, R.A., Gerritsen, P.R.W., Aguilar Olguín, S., Rivera Rodríguez, M.C. and Iñiguez Dávalos, L.I. (2023). The relationship between the fishermen and the American crocodile (*Crocodylus acutus*) in the Mexican central western Pacific: a narrative analysis. Agro Productividad (<https://doi.org/10.32854/agrop.v16i2.2361>).

Abstract: Objective: To analyze the relationship between the fishermen of central western Mexico and the river crocodiles (*Crocodylus acutus*), emphasizing the resulting conflict. The work was carried out with 22 fishermen from the Cuyutlán and Alcuzaque lagoons in Colima, Mexico. Four participative workshops were organized per community, in order to explore the positive and negative aspects of the relationship, the perception and knowledge about the ecosystem functions of the crocodile, and the management

practices and actions associated with this relationship, as well as to determine the natural participants and factors that influence the said relationship. The workshops were recorded and the resulting data was subjected to a narrative analysis and a summary. Harmonious relationships are recorded, including the creation of bonds between humans and crocodiles and recognizing the benefits to fishing and the ecosystem function of the crocodile. The conflictive relationships identified were related to fishing, the reduction of fishing resources, and accidents. The strategies used to prevent conflicts are related to the dangerous zones, the behavior of the crocodiles, and the killing of the animals to reduce their presence. Additionally, compensation schemes, a collective management of fishing resources, and the replacement of fishing by the exploitation and capture of the crocodile were taken into consideration. Besides the fishermen's, the point of view of other participants should be determined. The relationship between fishermen and crocodiles is both harmonious and conflictive. On the one hand, both receive benefits; on the other hand, fishermen suffer economic, operative, and life style impacts, which create inauspicious scenarios for the conservation of the reptile.

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