

**CROCODILE
SPECIALIST
GROUP
NEWSLETTER**

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IUCN - Species Survival Commission

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COVER PHOTOGRAPH: Hatchling Gharial (*Gavialis gangeticus*) in the Babai River, Bardia National Park, Nepal. Photograph: Ashish Bashyal. See pages 10-11.

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CSG Newsletter

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

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

It has certainly been an eventful few months. The CITES, Conference of the Parties (CoP18) was held in Geneva, Switzerland, 17-18 August 2019, which included CITES Standing Committee meetings on 16 and 28 August. As usual there was a large number of CSG members present on various delegations, and great to catch up with Dietrich Jelden (former CSG Deputy Chair) and Ginette Hemley, both of whom contributed so much to the CSG in the past, when it was struggling to resolve a way forward with sustainable use. Matthew Shirley, Pablo Siroski, Matthew Brien, Dan Natusch, Christy Plott and Perran Ross were active on many issues. I made a presentation on crocodiles and sustainable use in a Sustainable Use and Livelihoods Specialist Group (SULI) side-event. The only crocodile proposal on the agenda was Mexico's transfer of *Crocodylus acutus* from Appendix I to Appendix II, which was accepted by consensus.

Against this, a serious concern at CoP18 was the degree to which the Parties fundamentally ignored the successful management of wildlife in southern Africa, based on sustainable use, and again voted on the basis of emotive animal rights ideology when it came to elephants, rhinos and giraffes. The demonstrably science-based management and livelihood benefits for local people were simply ignored. Given the UN Sustainable Development Goals, and the humanitarian umbrella and obligations implicit within them, it seems hard to justify penalising countries for demonstrating "what works" in challenging socio-economic circumstances.

The CSG was grateful to the Louisiana alligator farmers for hosting a meeting to update CSG members on the proposed reintroduction of a ban on crocodile and alligator trade in the US State of California. This ban was originally introduced in the late 1960s, before CITES came into force, and at that time it was a prudent move. Some other countries, including Australia, introduced similar bans. But to reintroduce it now, some 50 years after the problems of the 1960s have been largely solved, will impact negatively on conservation. The hardest hit will be alligator-producing states within the USA, where highly responsible and model programs operate. We

hope that common sense prevails, and that science-based rather than emotion-based decisions are made.

Following the CITES Meeting, the International Crocodile Farmers Association (ICFA) held a meeting in Paris, to which the CSG were invited as observers. Matt Shirley was able to attend. The major brands are under increasing pressure to ensure animal welfare is respected throughout their supply chains, and this means the establishment of standards, for each of the processes involved, and a certification procedure for ensuring compliance. This has been a significant pioneering venture by ICFA (www.internationalcrocodilian.com), adapting to changed circumstances in the marketplace. Extending standards and technology to the many smaller production farms remains a challenge, as does the fundamental challenge of ensuring conservation advantages accrued from sustainable use programs are not lost. Global crocodilian skin production has clearly exceeded demand, which unfortunately plagues most commodity industries.

In September, I was invited to address the "Sustainable Leather Forum" in Paris (slf-paris.com), where I presented a case history explaining the links between conservation, livelihoods, exotic leathers and the UN Sustainable Development Goals. The theme of this meeting, was a new vision for what constitutes "Responsible Leather Supply Chains". My talk stimulated a lot of discussion, as the majority of the leather trade involves the skins of domestic farm animals, and the knowledge-base about sustainable use and livelihoods was very limited indeed. While on the same trip I had the opportunity to discuss with Hermes staff the linkages between conservation, sustainable use and livelihoods, and to learn a great deal more about this remarkable company.

The CSG responded to the US Fish and Wildlife Service (USFWS) on its "amended recovery plan for the American Crocodile *Crocodylus acutus*", with input being provided from several North American and other CSG members familiar with the species and its status. The approach taken by the USFWS to species listed under its Endangered Species Act, is a model scientific one, free of many of the emotive inputs that such issues stimulate in other forums.

With Perran Ross, I attended the IUCN-SSC Leaders meeting in Abu Dhabi, UAE, on 6-9 October 2019. Here, we learned that Ansem De Silva (CSG Regional Chair, South Asia & Iran) had been awarded the Sir Peter Scott Award for Conservation Merit - the highest honour that can be awarded in the IUCN Species Survival Commission. Congratulations Ansem on his prestigious award, acknowledging decades of hard work.

Dilys Row (Chair of SULI) and I had a plenary presentation about sustainable use, and I was left with no doubt that the majority of participants (mainly other Specialist Group Chairs and Red List representatives) both appreciated and supported the CSG's approach to working with industry where species have a trade value. Where they do not, we are of course back to the same problem many Specialist Group Chairs have. Have been discussing this with Matt Shirley, because we

are basically dealing with Model 1 (commercial value) and Model 2 (no commercial value) approaches to crocodylian conservation, that ideally need separate strategies. The SSC Leader's meeting wrestled with many problems at different levels of resolution, including IUCN taking on a bigger role within CITES, given the increasing role being played by NGOs opposed to trade. A summary of the SSC Leaders meeting is on pages 5-6.

The IUCN recently provided updated details on how members can update their details on the IUCN Portal database. The transition to this new system has been a long one, and not without glitches. Although the CSG maintains its own database of members, recognition by the IUCN cannot be formalized until members have logged into the IUCN Portal. The CSG Executive Officer recently wrote to members who were not in the IUCN database, providing them with instructions on how to access the IUCN Portal and apply formally to the IUCN for membership. By the end of September, 105 members were still not registered with the IUCN as a member of the CSG. If you have any questions about this process, please contact Tom Dacey (csg@wmi.com.au).

The 4th European Croc Network Meeting (ECNM2019) was held on 4-6 October 2019, at The National Reptile Zoo, Kilkenny, Ireland. See pages 19-20 for summary of meeting.

The website for the 26th CSG Working Meeting being held in Chetmual, Quintana Roo, Mexico, on 4-7 May 2020, is up and running (<https://www.biodiversidad.gob.mx/planeta/csg2020/programa.html>).

Annual requests for donations to the CSG were sent out in July 2019. Let me once again express my thanks to all who have made donations. The support of CSG donors, big and small, is critical to the CSG's ability to operate effectively.

Our sincerest condolences are extended to the family of Joseph Fagan Sr., who passed away recently. See Obituary below.

Professor Grahame Webb, *CSG Chair*.

Obituary



Past CSG member Joseph Michael Fagan Sr. (75 y) of Dade City, Florida, USA, passed away on 30 September 2019. Born on 6 September 1944 in Dade City, he was a lifetime resident of the area. Mike was President of Fagan Alligator

Products and was an original to the nuisance alligator program when it was established in the 1970s. He was a key figure in the alligator industry, passing on his legacy for future generations. He will be missed not only by his family, but by the many people who he met daily. His contributions to the alligator industry, Florida Wildlife Commission and the citizens of Florida were greatly appreciated.

CSG Student Research Assistance Scheme

The Student Research Assistance Scheme (SRAS) provided funding to 6 students in the July-September 2019 quarter. Seven further applications are currently under review.

1. Siddhartha Regmi (Nepal): Communal nesting behaviour by Gharial (*Gavialis gangeticus*) in Chitwan National Park, Nepal.
2. Iago Ornellas (Brazil): Phylogeny of *Caiman latirostris* - from history to conservation.
3. David Ichbia (France): Study of the reproductive effort of female *Crocodylus acutus* in Banco Atoll, southeast Mexico.
4. Samantha Bock (USA): Developing molecular markers to assess sex ratios in hatchling alligators (*Alligator mississippiensis*) in conservation applications.
5. Sofia Pierini (Argentina): Influence of climatic variables and anthropization on nesting of the Broad-snouted caiman (*Caiman latirostris*).
6. Basu Dev Joshi (Nepal): Status, distribution and conservation threats of *Gavialis gangeticus* in the Narayani River of Chitwan National Park.

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

Movie Review

Crocodylian enthusiasts will enjoy the recently released movie 'Crawl'. A woman swim champion and her dad are trapped during a Florida hurricane and surrounded by ferocious alligators. What's not to like? Ominous music, a lot of sliding around in damp, muddy basements, screaming, and periodically the explosive emergence of large alligators tearing off body parts. Ok, so it's actually a B-grade, sensational, made-on-the-cheap horror thriller. But considering it was made entirely in Serbia (yes Serbia!) it is a creditable digital mash-up of genuine hurricane footage, some live alligator action shots and some very realistic alligator models - it comes off quite well.

The heroine is athletic, appropriately bedraggled but always chastely covered. The alligator biology and behaviour is, with a few exceptions, more or less realistic and the action continuous. Even with the 'Jaws-like' ominous alligator-

approaching theme music, I jumped off my seat every time and the attack sequences are realistically gory, complete with churning bloody water, realistic puncture and slash wounds and a couple of death roll dismemberments. The most glaring departures from plausibility are the unrelenting persistence of not just one, but several alligators, unable to assuage their appetite or ferocity with the half dozen or so people they devour during the movie. The alligator eyes glow gold, not orange, and a nest of alligator eggs and emerging hatchlings laid in the dark basement is atypical. Despite being seriously mauled not just once, but three times by large alligators, the heroine remains physically functional and relatively unmarked at the movies' end, and her dad philosophical about a compound leg fracture and missing arm.

Spoiler alert, the cute little dog makes it, but the rather sloppy criminal looter gang do not. There is a plot - sort of, as the young woman and her father resolve their fraught relationship in quiet moments between alligator attacks, but this does not detract from the overall satisfactory chomp and roll action. I enjoyed it and it's a quick 90 minutes on your favourite streaming service. Perhaps we have another crocodylian cult movie on our hands? If you liked 'Lake Placid' you will love 'Crawl'.

Perran Ross, *CSG Red List Authority and sometime movie critic* (pross@ufl.edu).

26th CSG Working Meeting (Chetumal, Quintana Roo, Mexico, 4-7 May 2020)

The 26th CSG Working Meeting will be held in Chetumal, Quintana Roo, Mexico, on 4-7 May 2020, and will be preceded by a Veterinary Workshop (2 May) and CSG Steering Committee meeting (3 May).

The meeting website (<https://www.biodiversidad.gob.mx/planeta/csg2020/comite.html>) has now been launched, and provides details on registration, the venue, accommodation, guidelines for authors, etc.

We encourage CSG members and others interested in crocodylian research, management and conservation to attend this working meeting, and look forward to seeing you in Chetumal, Mexico, in 2020.

Species Survival Commission Leaders Meeting (Abu Dhabi, 6-9 October 2019)

The 4th global meeting of the IUCN-SSC leaders, hosted and fully supported by the Ministry of Environment of Abu Dhabi, saw 387 people from 58 countries in Abu Dhabi, on 6-9 October 2019. They included Chairs of over 80 SSC Specialist Groups (SG), Red List coordinators, SSC and IUCN staff, partners and observers. There were daily plenary sessions, and numerous breakout and special meetings on specific SSC and IUCN themes. Significant points of discussion included:

- Growth of the network. The SSC now includes over 140 SGs, Red List Authorities, Task Forces and Conservation Committees. There has been a significant expansion of SGs focused on particular species groups of animals, plants and fungi and on general themes such as sustainable use and livelihoods, conservation planning, human-wildlife conflict and climate change. SG representation has expanded among less well known and very numerous groups such as invertebrates, grasshoppers, fungi and lichens, and ladybugs and regionally focused SGs such as SE Asian invertebrates and new world marsupials. Large and charismatic mammals (37 SGs) and reptiles (12 SGs) remain the best represented. Over 9000 individual volunteer SG members provide expert advice on species conservation through the SSC.
- Specialist Group reports. Reports on current SG activities and conservation successes and challenges, were presented throughout the meeting as both oral presentations and posters. Notable was the work of the Amphibian SG, with 8000 species and extraordinarily high real extinction rates, and the Tree SG with 60,000 species and a serious diversity of threats. Red List assessments now cover 105,000 species, with 30,000 allocated to Red List threatened categories (TH, EN, CR), and a continuing decline in species status. Up to 40% of amphibians and cycads meet Red List criteria for being threatened, but also 15% of birds, fish and gastropods. Currently, 40% of crocodylian species meet Red List criteria for being threatened.
- IUCN Strategy and SSC strategy development. SCC Chair Jon Paul Rodriguez presented the developing SSC Species Strategic plan based on an umbrella commitment to 'Assess-Plan-Act' and covering network function, assessment, planning, action and communication. The plan defines 43 "Key Species Results" adopted by IUCN in 2016 (www.iucn.org/sites/dev/files/content/documents/ssc-iucn-components-a4-digital_0.pdf). The SSC and SGs are asked to identify where their action supports and implements components of the plan. The "Assess-Plan-Act" approach is generic and aspirational and helps align SG activities with IUCN goals. However, it does not replace the need to "Implement-Assess-Adapt" when dealing with context-specific conservation problems.
- Red List training. Information was presented on updates and improvements to the Species Information Service (RL database), assessments, guidelines and interpretation, and a new process for evaluating species extinction. RL staff applauded CSG's process for generating GIS-based species maps to support Red List assessments, developed by Sergio Balaguera Reina.
- Sustainable Use as a conservation tool. SULI Chair Dr. Dilys Roe, assisted by Grahame Webb, gave a compelling presentation on sustainable use and livelihoods, noting it was a well-accepted and integral component of IUCN and SSC policy and supported by other international agreements and norms. After presenting several demonstration examples of SU in conservation action, a

'real-time' on-line survey of participants indicated a very large majority of SG's either already consider SU in their work or would consider doing so. Not a single response of the 100+ people/SGs that responded rejected SU as a conservation tool.

- Conservation success. Despite high levels of species threat, decline and conservation challenges, the meeting affirmed the need to recognize conservation success. A series of presentations on quantitative success in the conservation of Bustards, Markhor, Bighorn sheep, Seahorses, Oryx and rabbits, and a thoughtful analysis of what constitutes success, informed the group.
- Development of thematic Conservation Committees. The SSC has formed thematic committees grouping species with similar problems and challenges, to better coordinate and represent these interests within the SSC and the IUCN. Conservation committees for marine species, freshwater species, plants and invertebrates already exist. SGs representing reptiles, amphibians, birds and fungi were invited to discuss and consider the need for committees in their areas. A meeting of 19 people representing crocodile, boa and python, amphibian, freshwater turtle and iguana SGs discussed the concept of a herp committee: advantages, disadvantages, constraints and needs. A draft report circulated among reptile and amphibian SGs will allow further discussion. Birds and fungi specialists also deferred the matter for further discussion.
- Declaration on Global Species Conservation. A working group developed a draft declaration calling on the IUCN to recognize and support the need for enhanced species conservation in the face of current challenges from development, human impacts and climate change. The declaration is intended to be a catalyst for global action at the IUCN and among related international conservation interests. The declaration was adopted by acclamation and can be viewed at: www.iucn.org/news/species-survival-commission/201910/iucn-calls-halt-species-decline-2030.

Other notable events included announcement of a new conservation partnership between the SSC and Indianapolis Zoo, the CSG receiving a certificate of merit, along with 30 other SGs, presentation of the Harry Messel Award for conservation action to Pritpal 'Micky' Soorae and Ariadne Argulo, and presentation of the prestigious Peter Scott Award to Ansem Da Silva, a member of many herpetology SGs

(including the CSG), Nicole Duplaix of the Otter SG and David Mallon of the Antelope SG.



Figure 1. Participants at SSC Leaders meeting. Photograph: IUCN-SSC.

The meeting was attended by Grahame Webb and Perran Ross, who took the opportunity to renew contacts and old friendships within the SSC network.

Perran Ross, *CSG Red List Authority* (pross@ufl.edu).

Morelet's Crocodile Conservation and Management Action Plan Meeting (Placencia, Belize, 25 June 2019)

In 2010, a tri-country meeting took place between Belize, Guatemala and Mexico to discuss regional collaboration and management of Morelet's crocodile (*Crocodylus moreletii*). In response to the tri-country agreement, in collaboration with the Belize Forest Department (BFD), the Crocodile Research Coalition (CRC) led a country-wide population survey of *C. moreletii* in 2016-2018. The last thorough countrywide population survey of *C. moreletii* was conducted in the mid-1990s. The Government of Belize is interested to assess whether the population has continued to demonstrate recovery from past exploitation, and if there is a possibility of developing a small ranching program, in which crocodile products would be sold within the country.

On 25 June 2019, the CRC led a Morelet's Crocodile Conservation and Management Action Plan meeting amongst national key stakeholders, that included co-managers and NGOs who participated in the Morelet's crocodile survey, and CSG members Grahame Webb, Alejandro Larreira,



Figure 1. Participants at Morelet's Crocodile Conservation and Management Action Plan meeting.

Pablo Siroski, Alvaro Velasco and Luis Sigler (Fig. 1). Marisa Tellez, co-founder and Executive Director of the CRC, presented data from the 2-year survey, highlighting locations throughout the country that illustrated high encounter rates and possible locations that Government can protect as part of its current conservation plan of preserving habitat for crocodiles throughout the country. The meeting ended with agreement that the population of *C. moreletii* has continued to recover and grow since the last survey in the mid-1990s, and the Government of Belize should now move forward in developing further management plans to mitigate human-crocodile conflict. Additionally, the BFD, along with the CRC and Dr. Frank Mazzotti (Croc Docs), will work together on developing ranching programs in specific communities and assess the potential of ranching as a sustainable source of income for Belize.

Marisa Tellez, *CSG Vice Chair for Latin America and the Caribbean, and Executive Director, Crocodile Research Coalition, Belize* (maristellez13@gmail.com).

CSG Regional Meeting (Placencia, Belize, 25-29 June 2019)

During the week of June 25-29 2019, 80 participants representing 19 countries participated in the CSG Regional Meeting in Placencia, Belize, to discuss country status updates of conservation, management and research issues in the Central America and Caribbean region. The meeting was organised in response to discussions held at the 24th CSG Working Meeting in South Africa (2016) and the 25th Working Meeting in Argentina (2018). Central America and the Caribbean was recognized as a priority area with regard to crocodilian conservation, in view of the lack of available information about current research, conservation and management of crocodilians, and threats associated with habitat loss. Amongst CSG Steering Committee members from the Latin American and Caribbean (LAC) region, it was agreed a meeting focusing on this particular sub-region was warranted in order to identify local wildlife champions who can lead crocodilian research and management.

The Regional Meeting was hosted by Dr. Marisa Tellez, CSG Vice Chair for LAC, with responsibility for the Central America and Caribbean sub-region, and her team from the Crocodile Research Coalition (a non-profit organization based in Belize). The theme for the meeting was “Regional Conservation through Collaboration”. The meeting aimed to bring together and provide networking, collaboration and support opportunities for key stakeholders and experts in the subregion, showcasing current knowledge on topics such as crocodilian management (ie human-crocodile conflict, scientific research, population survey techniques, habitat monitoring), sustainable use and policy within the subregion that will not only be beneficial for regional crocodilian conservation, but also for long-term management of biodiversity within crocodilian habitats.

The meeting began with a traditional blessing ceremony by

Maya Elders from Toledo District (Fig. 2), followed by an official welcome by Chief Wilbur Sabido from the Belize Forest Department. Amongst the various presentations, there were four keynote speakers in the following themes: regional history of conservation and management (Alvaro Velasco, Venezuela), sustainable use programs (Dr. Pablo Siroski, Argentina), human-crocodile conflict (Juan Bolaños Monterro, Costa Rica) and history of the conservation and management programs of crocodilians in Mexico (Hesiquio Benitez, Mexico). The conference ended with a night of drumming from local indigenous Garifuna musicians from Seine Bight.



Figure 1. Signage at regional meeting.



Figure 2. Traditional blessing ceremony.



Figure 3. Crocodile workshop participants.

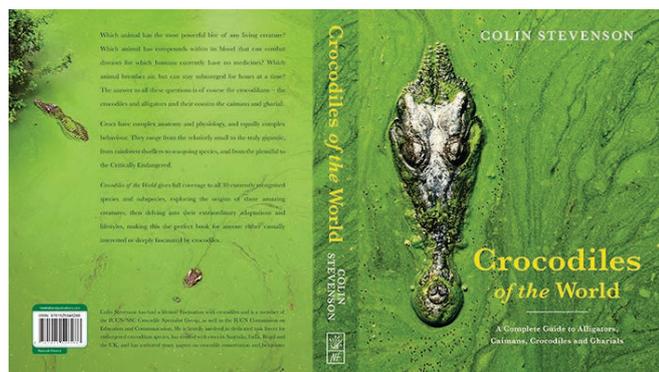
An optional crocodile workshop was held on 29 June, led by Dr. Luis Sigler (Fig. 3). This workshop, organized for relatively new crocodile researchers, included a classroom portion that discussed cultural, biological and ecological facts of crocodiles, and ended with a nocturnal eyeshine and capture survey (under the CRC research permit) on the Sittee and Monkey Rivers.

The meeting was an overall success, with many new collaborations and a greater network of crocodylian biologists established within this subregion. Discussions on holding another subregional meeting in 2021 are currently underway.

Marisa Tellez, *CSG Vice Chair for Latin America and the Caribbean, and Executive Director, Crocodile Research Coalition, Belize* (marisatellez13@gmail.com).

Crocodiles of the World

“Crocodiles of the World”, written by Colin Stevenson, has just been published by New Holland Publishers in Australia. With 288 pages and over over 300 colour and black and white images, this hardback book is pitched at the serious layperson, rather than experienced biologists. The aim was to present our current understanding of crocodylians in an accessible way.



The format and broad content conforms to the publisher’s requirements. Based on questions from both zoo visitors and those new to the world of crocodylians over the years, it also seeks to wrap some perspective around aspects of crocodylian behaviour and biology that can often be portrayed in a misleading manner, or are at least often misinterpreted.

Chapters include Evolution, Biology/Anatomy, Reproduction, Habitat, Diet and Conservation. The second section includes details on the conservation status and natural history notes for each species. All presently-recognised crocodylian species are included, although the taxonomic decisions may prove controversial! There is some unavoidable overlap with other publications, but hopefully enough in the way of a different perspective to complement these other books.

The book is available internationally through various Amazon sites, as well as Booktopia, Dymocks, etc., in Australia, and Book Depository and Abe Books in the rest of the world.

It is also available from the publisher’s website (<http://au.newhollandpublishers.com/>).

Colin wishes to thank the various CSG members who kindly contributed photographs for the Crocodiles of the World, and welcomes any comments from readers in order to make any corrections should there be any subsequent editions. Colin can be contacted at “coleosuchus@hotmail.com”.

Charlie Manolis, *Crocodile Specialist Group Newsletter compiler/editor* (cmanolis@wmi.com.au).

CITES CoP18 (Geneva, 16-28 August 2019)

CITES CoP18 was held in Geneva, Switzerland, on 17-28 August 2019. The planned Sri Lanka venue (23 May to 3 June) was changed after a terrorist attack on 21 April 2019, in which 259 people were killed and 500+ injured. The Parties extended their condolences to Sri Lanka, as did the IUCN.

In conjunction with CoP18, the 71st (16 August 2019) and 72nd (28 August 2019) meetings of the CITES Standing Committee were held. CoP18 attracted some 1700 delegates representing 170 Parties, and NGOs. There were 107 items, with 57 amendment proposals on the CoP agenda, and the details of these and deliberations of the Standing Committee are on the CITES website (www.cites.org).

The CSG was represented by the Grahame Webb (Chair), Grahame Webb), Perran Ross (Deputy Chair), a small core team (Matt Brien, Matt Shirley, Pablo Siroski), and some 15 other CSG members on country and NGO delegations. This was the first CITES CoP attended by MB and PS, implemented as part of the CSG Future Leaders initiative. Together with MS, they attended as part of the official IUCN delegation, participating in briefing and strategy sessions for IUCN’s interventions.

The single crocodile proposal was the transfer of the Mexican population of American crocodiles (*Crocodylus acutus*) from Appendix I to Appendix II. The Mexican delegation included two CSG members, and PR had been involved with the proposal, along with a team of independent CSG reviewers. In Plenary, Mexico amended its proposal to a “zero quota” of wild-caught specimens, and all interventions by Parties, NGOs and IUCN (provided by CSG members on the delegation) were positive. The proposal was accepted by consensus.

A significant crocodylian issue at CoP18 was a detailed briefing by David Wolf, the Louisiana Alligator Farmers, and Louisiana Department of Wildlife and Fisheries, on the proposed ban on trade in crocodiles, alligators and caimans in California. The problem is fundamentally the reinstatement of a ban, from 1967 (pre-CITES), that has been waived for 20 years by successive “sunset” clauses, with which Don Ashley and the CSG were intimately involved. Animal Rights activists are proudly championing the reintroduction of the ban, for ideological rather than conservation purposes. No

conservation benefits will result, and indeed, it is likely that the conservation costs will be significant. This matter has not been finally resolved.

Full details of the deliberations at CITES CoP18 are on the CITES website, but some issues of direct relevance to crocodylian trade and livelihoods at CoP18 were:

1. Guidance on making Legal Acquisition Findings (LAF). The ability to determine whether exports have been legally acquired, under national laws of source countries (a prerequisite to legal exports within CITES), is a problem in some countries. The Parties accepted that non-binding guiding LAF principles within a draft resolution would assist Parties, without becoming a significant additional burden for either exporting or importing countries.
2. Traceability. This issue has been in significant discussion as part of inter-sessional working groups, on which Dan Natusch led for the IUCN, and GW and MS facilitated [CoP18 Doc 42 (Rev. 1)]. In the interests of commonsense, the Parties adopted a simple and pragmatic definition of traceability: “Traceability is the ability to access information on specimens and events in a CITES species supply chain”. They also agreed that the implementation of traceability systems was the responsibility of individual Parties and industries, on a case-by-case basis. No fundamental obligation was placed on Parties to implement a new or overarching CITES traceability system.
3. Non-detriment findings. Parties agreed to review existing guidance on non-detriment findings (NDF), identify gaps and, subject to findings, hold an international expert workshop to better inform NDF guidelines, both globally and on a taxa-specific basis.
4. Local People and Rural Voices. The ability to get a stronger voice from rural communities within CITES, although widely acknowledged as a real need, did not get widespread traction at CoP18. The implications to widely consult with rural people and communities, although desirable, is a difficult commitment for Parties.
5. Captive-bred specimens. At CoP17, the Parties introduced a mechanism for the review of significant trade of specimens of non-wild origin (Resolution Conf. 17.7). This included decisions relating to assessment of how source codes related to captive specimens are being applied and means of verification of legally sourced founder stock, among others. Despite significant work in inter-sessional working groups, where MS led for the IUCN and received considerable support from Dan Natusch, the Parties voted to send the matter back to Standing Committee for further work in Animals and Plants Committee in the intersessional period.
6. Side events. A number of side-events on conservation, sustainable use, and livelihoods, generally and specifically with reptiles (including crocodylians and snakes), were

organised by the Sustainable Use and Livelihoods Specialist Group (SULI), the International Institute for Environment and Development (IIED), the Southeast Asian Reptile Conservation Alliance (SARCA) and the Boa and Python Specialist Group (BPSG). They were well attended, and our CSG Chair presented the Northern Territory case history with *Crocodylus porosus* and the benefits the program provides to Aboriginal people.

7. General species outcomes. The most contentious issues at CoP18, which took a great deal of time to resolve, were once again trade in charismatic mega-mammals (eg elephants, rhinoceros, giraffe). Historically, there have long been polarised positions among African Parties on elephants and rhino, which spill over into other wildlife species to the detriment of positive management efficiencies and outcomes on the ground. The southern African countries, where support for science-based wildlife management is arguably most advanced, are in the minority, so many decisions made do not help their programs to succeed further. Complex politics were involved, and since that time the SADC region member states have announced their intention to submit reservations to decisions at CoP18. It will be interesting to see how this plays out and what impact it has on the western consumer versus tropical producer country power dynamics.

Some highlights were:

- a. African Elephants (*Loxodonta africana*): Parties agreed on increased scrutiny by relevant CITES scientific and management authorities on live trade, and, under exceptional circumstances or emergencies, to allow transfer of wild animals to and between *ex-situ* destinations. They proposed amendments to further close domestic ivory markets, with a view to closing all remaining legal domestic ivory markets. A proposal to down-list Zambian elephant populations from Appendix I to Appendix II was rejected. A proposal to allow Botswana, Namibia, South Africa and Zimbabwe “one-off” sales of raw ivory from Government-owned stocks was rejected. A proposal to include all African elephant populations in Appendix I, which would mean transferring Appendix II populations of Botswana, Namibia, South Africa and Zimbabwe to Appendix I, was also rejected.
- b. Great Apes: Parties established a drafting group, chaired by the USA, to review reporting obligations on great apes to the Standing Committee and Conference of Parties. Concerns were raised about trade in exotic pets advertised online.
- c. Giraffes: Parties adopted a proposal to list giraffe under Appendix II. Chad noted a 40% decline in populations over 30 years. Botswana and several other southern African countries opposed the proposal, arguing populations are stable in many countries. They proposed specific populations should be excluded from the listing.

- d. **Big Cats:** Parties agreed to establish a working group to discuss issues related to African lions and big cats in other regions. Parties adopted a proposal to map illegal trade in jaguar and assess threats such as competing land-use activities, human-jaguar conflicts, and local traditional uses. Claims of illegal trade to supply increasing international demand for jaguar teeth, skin and bones were made.
- e. **Pangolins:** Parties agreed that pangolin Range States would develop *in-situ* conservation and management programs, continue to monitor and report back on law enforcement and commercial activities involving pangolins, and that the CITES Secretariat would develop conversion parameters predicting number of pangolins from scale seizure masses/volumes.
- f. **Commercial Fish Species:** Proposals to include Shortfin and Longfin Mako sharks in Appendix II were accepted. Co-proponents Gabon, Costa Rica and the EU considered current scientific evidence justified the need for increased regulation. Parties also adopted a proposal to list guitar-fishes in Appendix II, given reported declines in largely unmanaged commercial fisheries. Parties also adopted a proposal to list wedge-fishes in Appendix II, arguing the listing would raise awareness of the species' vulnerability and facilitate greater regional cooperation to ensure sustainable use.
- g. **Glass Frogs:** Parties rejected a proposal to list Glass frogs on Appendix II. The EU argued that such a listing would not be enforceable, as there are more than 104 species, and they are morphologically indistinguishable.

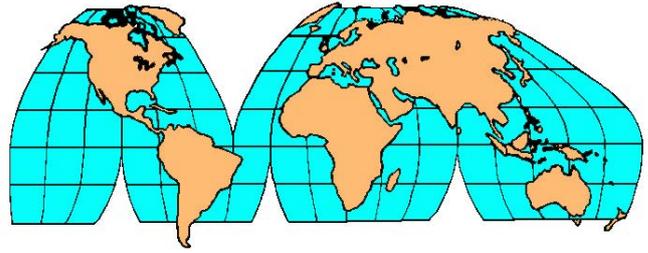
Overview

CoP18 saw the influence of anti-trade NGOs on Parties at a high level, and so relatively few of the decisions - crocodiles were an exception - helped Parties wishing to engage in trade using science-based management. Tanzania, on behalf of Southern African Development Community (SADC) countries, argued that the CITES Convention is no longer aligned with other international agreements, and is working in contradiction to principles of national sovereignty, inclusive and equitable development, and the rights of local communities living with wildlife to use their resources. This view was shared by many people who see wildlife resources as an essential source of economic development to rural people, but ideological problems tend to be cyclic within CITES. It is a complex biopolitical forum.

It was highly beneficial for CSG members attending CITES for the first or second time, to participate in the meeting and formally assist IUCN, which is arguably one of the main sources of scientific knowledge on which Parties can rely.

Matt Brien, Matt Shirley and Pablo Siroski, *Crocodile Specialist Group Future Leaders Program*,

Regional Reports



South Asia and Iran

Nepal

CONFIRMED RECORD OF GHARIAL (*GAVIALIS GANGETICUS*) HATCHLINGS IN THE BABAI RIVER, BARDIA NATIONAL PARK, NEPAL. In Nepal, Gharials (*Gavialis gangeticus*) currently occur in the Narayani and Rapti Rivers in Chitwan National Park (CNP) and the Karnali and Babai Rivers in Bardia National Park (BNP; Fig. 1). Nesting is known to occur in the Narayani-Rapti Rivers system, but there is no current confirmed evidence of Gharials nesting in the Karnali and Babai Rivers (Lang *et al.* 2019). Recent population surveys of the protected 46-km stretch of the Babai River in 2017 and 2019 documented the presence of 3-4 groups of Gharial, consisting of at least one adult male and one adult female, indicating the potential for breeding (Bashyal *et al.* 2017, unpublished data; Bashyal *et al.* 2019, unpublished data).

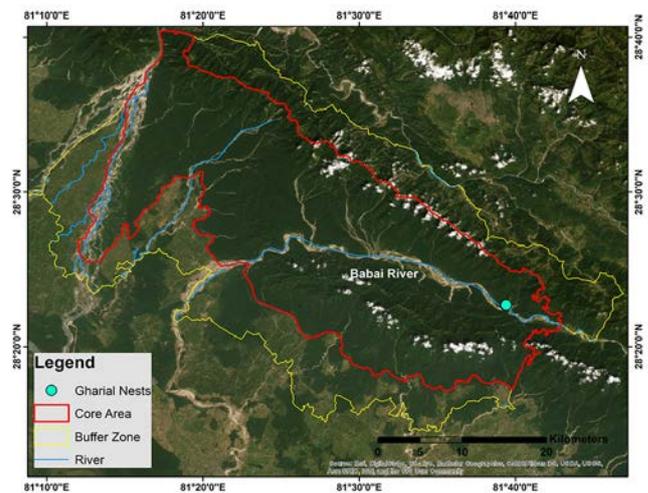


Figure 1. Location of Bardia National Park, and Gharial nests located in 2019 (green dot).

Historical records note that 25 Gharial eggs were collected from Kalinara, in the Babai River, in 1982 and taken back to the captive facilities at BNP headquarter at Thakurdwara (DNPWC 2018). In June 2016, approximately 40-50 Gharial hatchlings were sighted south of Babai bridge in Parewaodar, outside the core protected area of BNP, but none were seen post-monsoon (Rangilal Tharu, pers. comm. 2019). More recently, during the 2018 monsoon a Gharial hatchling was found by locals in Tara Taal (Babai River), outside the core protected area of BNP [it was handed to the BNP ranger post

to be eventually released back into the Babai River (Rangilal Tharu, pers. comm. 2019)].

On 19 June 2019, we opportunistically visited two localities (Dhanuse and Soth Khola) within the protected stretch of the Babai. One breeding group of Gharial had been reported from each of these localities in February-March 2019 (Bashyal *et al.* 2019, unpublished data) and we wanted to check for any evidence of nesting. We documented three Gharial nests within 50-60 m of each other in a high sand bank at Dhanuse (Figs. 1 and 2). Hatchlings were basking on the sand bank at the water's edge when first encountered (Fig. 3) and female Gharials appeared to be guarding them by staying half submerged near the water's edge. When we approached closer (maintaining a safe distance), all hatchling quickly jumped into the river and started to swim. We counted approximately 100 hatchlings, three adult female and one adult male Gharial.



Figure 2. Excavated Gharial nests at Dhanuse, on the Babai River, 2019. Photograph: Ashish Bashyal.



Figure 3. Gharial hatchlings in the Babai River, 2019. Photograph: Ashish Bashyal.

We did not find any evidence of nesting in Soth Khola. This locality does not have any high sand banks, which are generally preferred by Gharials for nesting. Similarly, on 21 June 2019, we briefly visited Parewaodar but did not find any evidence of nesting there.

Comprehensive studies on nesting and reproduction of the Gharial population in the protected stretch of the Babai River

would generate scientific information that will be crucial for designing and implementing a site-specific conservation strategy.

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STATUS OF MUGGER CROCODILES (*Crocodylus palustris*) IN THE RAPTI AND NARAYANI RIVERS OF CHITWAN NATIONAL PARK, NEPAL. The Mugger (*Crocodylus palustris*) occurs in India, Sri Lanka, Pakistan, Nepal and Iran, and its status varies between range states (Da Silva and Lenin 2010). In Nepal, Muggers (known as “Buchwa”, “Dhakarmuwa” and “Nakta” by the Tharus and Botes indigenous tribes (Kennion 1921), occupy a variety of natural freshwater habitats; including rivers, swamps, lakes, marshes, and man-made water bodies such as reservoirs and village ponds (da Silva and Lenin 2010). They are sympatric with Gharials (*Gavialis gangeticus*) in rivers (Groombridge 1982; Da Silva and Lenin 2010), and in currently occur as isolated populations, mainly in protected areas such as the Sukla Phanta, Bardia and Chitwan National Parks, and Koshi Tappu Wildlife Reserve (Whittaker and Andrews 2003).

Historically, Muggers were relatively common throughout the Terai of Nepal, and so received little attention in terms of conservation action. However, reduction of wetland areas, siltation and sedimentation, eutrophication, deterioration of water quality, mortalities in fisheries operations, modification of habitat by river disruption (dams and barrages), and other anthropogenic factors have been implicated in the decline in the Mugger's range and population in Nepal (McEachern 1994; Shrestha 2001). Each year, juveniles and hatchlings are

flushed below the barrages (low dams) during the monsoon season, cannot return during the post-monsoon and usually perish (Whitaker and Andrews 2003).

The species continues to be threatened by habitat destruction (agriculture and industrial expansion), construction of dams and barrages, entanglement and drowning in fishing nets, egg predation by humans, illegal poaching for skin and meat and use of body parts in medicines, etc. (Whitaker and Andrews 2003; Andrews and McEachern 1994; Choudhury and Da Silva 2013). The global population was estimated to comprise 5700-8700 non-hatchlings in 2013 (Choudhury and De Silva 2013).

In Nepal, crocodiles were afforded legal protection in 1973 through the *National Parks and Wildlife Conservation Act*. Conservation efforts in Nepal began in 1978 with the collection of wild Mugger and Gharial eggs for rearing and reintroduction programs (Andrews and McEachern 1994; Whitaker and Andrews 2003). A 1993 survey reported a count of 200 Muggers, which were largely restricted to isolated populations, primarily in protected habitats. This study looks in more detail at the status of the Mugger population in the Rapti and Narayani Rivers in Chitwan National Park (CNP), as assessed through annual surveys undertaken from 2011 to 2017.

Methods

The study was carried out in the mainstreams of the Rapti and Narayani Rivers of Chitwan National Park (CNP) (Fig. 1).

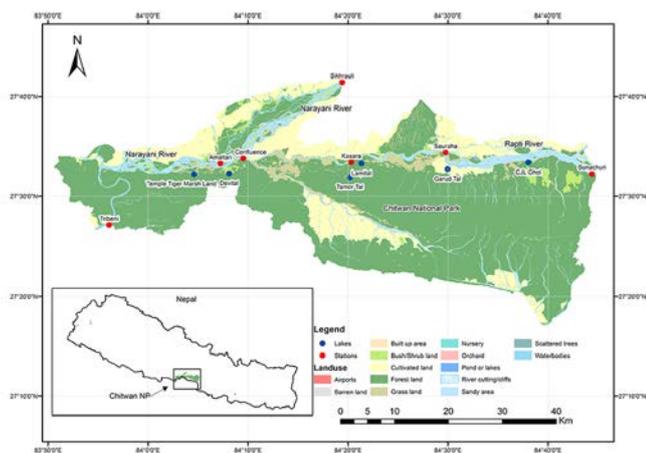


Figure 1. Location of Rapti and Narayani Rivers in Chitwan National Park, Nepal.

The Rapti River originates in the Mahabharat hills, which is a lower range of the Himalayas at 2120 m, near Chisapani Garhi in Makwanpur District. It is fed from ground water, monsoon rains and spring water from the hills. It is shallower and warmer than the Narayani River, and during winter, the water is very warm and is considered more favorable feeding habitat for waterbirds, fishes, etc. (Khadka 2010). Peak monsoon flows are around 77 m³/sec, and dry season flows are around 7 m³/sec (Acharya *et al.* 2017).

The Narayani River is formed by the confluence of the Kali Gandaki and Trisuli Rivers, which originate in the Trans Himalayas. It is very cool in the winter due to being a snow-fed (water flows from the Himalayas). Peak monsoon flows can be >4600 m³/sec, and dry season flows can be <300 m³/sec (Acharya *et al.* 2017).

The study area was divided into 6 sectors (3 in Rapti, 71.60 km; 3 in Narayani, 101.4 km; Table 1), such that each sector could be surveyed within one day. The six sectors (Fig. 1) comprised:

- Sector A (Rapti; Sunachari-Sauraha) (29.0 km): has large stretches of mudflats, shingle banks, stony feeder streams and sand banks, creeks, shallow water holes, shallow and deep water, with large areas highly threatened by human disturbance such as sand and stone mining, grazing, fish poisoning, overfishing and movement of people in the area.
- Sector B (Rapti; Sauraha-Kasara) (20.2 km): characterized by many creek confluences, tributary confluences, river confluences with shallow and deep water with less human disturbances.
- Sector C (Rapti; Kasara-Rapti/Narayani confluence) (22.4 km): characterized by many seepage waterholes, deep water, muddy flats, sand banks and stony bank, low current with high human disturbances.
- Sector D (Narayani; Sikrauli-Amaltari/western channel) (28.2 km): characterized by presence of low current channels, many tributary confluences, feeder streams in the main river, driftwood, riparian habitats such as sandy banks and forest along the river banks and lower human disturbances compared to eastern channel.
- Sector E (Narayani; Sikrauli-Amaltari/eastern branch) (30.4 km): characterized by high water current, deep water, some braided channels, fewer feeder streams mudflats, creeks with less water and microhabitat as compared to western channel.
- Sector F (Narayani; Amaltari-Tribeni) (42.8 km): main channel with slow flow deep water, with some meandering channels, seepage waterholes with deep water connecting to main branch, hide outs, stagnant water with deep water in downstream watercourses created by Gandak Barrage.

Daytime surveys were conducted annually from 2011 to 2017, during winter (Chaudhury *et al.* 2017), using a non-motorized wooden dugout canoe, with two citizen scientists and one experienced researcher searching for Muggers on either bank. The six sectors were surveyed in the same order each year over a 6-day period, typically between 1030 and 1730 h on sunny days, but during periods of foggy weather surveys were delayed until visibility was good and sufficient light available. Nonetheless, visibility during surveys of the Narayani River in 2013 and 2015 was considered sub-optimal, and those surveys were excluded from analyses. Foggy weather affects survey counts, as fewer Muggers come

Table 1. Mugger counts in the Rapti (Sectors A-C) and Narayani (Sectors D-F) Rivers, 2011-2017. Numbers in brackets indicate relative densities (ind./km). * = surveys in the Narayani River in 2013 and 2015 affected by fog.

Rapti				Narayani				Rapti+Narayani		
Date (km)	A (29.0)	B (20.2)	C (22.4)	A-C (71.6)	Date (km)	D (28.2)	E (30.4)	F (42.8)	D-F (101.4)	A-F (173.0)
4-6 February 2011	5	10	7	22 (0.30)	7-9 February 2011	8	3	17	28 (0.27)	50 (0.29)
4-6 February 2012	5	14	7	26 (0.36)	7-9 February 2012	9	3	17	29 (0.28)	55 (0.32)
6-8 February 2013	6	15	9	30 (0.41)	9-11 February 2013	4	4	13	21 (0.21) *	51 (0.29) *
19-21 January 2014	10	14	11	35 (0.48)	22-24 January 2014	7	6	17	30 (0.29)	65 (0.38)
10-12 January 2015	6	26	10	42 (0.58)	13-15 January 2015	5	3	14	22 (0.22) *	64 (0.37) *
4-6 January 2016	6	30	7	43 (0.60)	7-9 January 2016	9	9	16	34 (0.33)	77 (0.45)
9-11 January 2017	5	34	16	55 (0.77)	12-14 January 2017	7	7	23	37 (0.36)	92 (0.53)

out to bask (Khadka 2011).

Total length of Muggers sighted was estimated within four broad size classes: hatchlings (<30 cm; <1 year); yearlings (30<50 cm; 1<2 years); juveniles (50<125 cm); sub-adults (125<180 cm); and, adults (>180 cm) (Khadka *et al.* 2014). For each Mugger sighted, the GPS location and habitat parameters [river depth, river width, water current, basking site topography such as muddy/sand/grassy/gravel, stone/rock/log, position in water (midstream, on bank, shallow water on edge, etc.)] and disturbance factors were recorded. We used 7x35 Olympus DPSR and/or 10x50 DPS1 Olympus DPSR binoculars, and photographs and video were recorded using Canon Powershot 5x40 HS to confirm size classes of Muggers if required.

Results and Discussion

All Muggers sighted were basking on land - none were sighted in the midstream or in shallow water at the water's edge. Numbers of Mugger in the Rapti River have increased significantly between 2011 and 2017 (Fig. 2), with significant increases in numbers of juveniles, sub-adults and adults. Likewise, numbers of Muggers in the Narayani River have also increased significantly over time (Fig. 3), although only numbers of sub-adults and adults increased significantly.

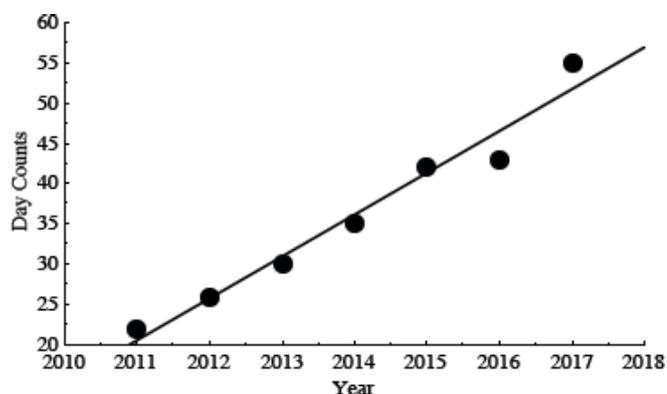


Figure 2. Mugger counts in the Rapti River, 2011-17. Line indicates significant linear regression ($r^2=0.96$, $p=0.0001$).

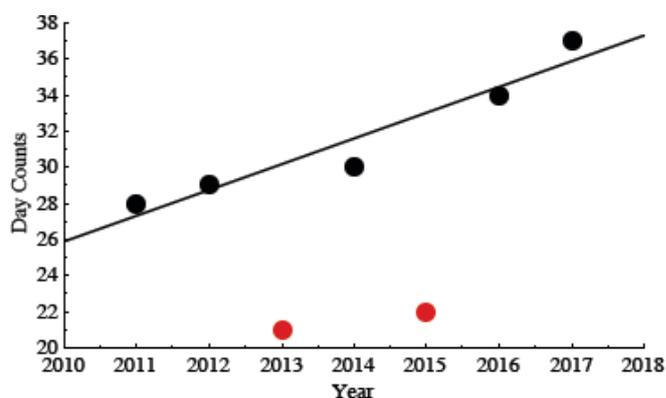


Figure 3. Mugger counts in the Narayani River, 2011-17. Line indicates significant linear regression ($r^2=0.92$, $p=0.009$) with 2013 and 2015 excluded (see text).

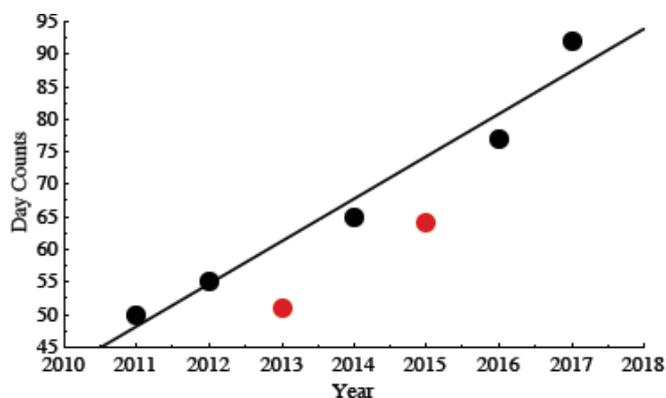


Figure 4. Mugger counts in the Rapti and Narayani Rivers combined, 2011-17. Line indicates significant linear regression ($r^2=0.96$, $p=0.004$) with 2013 and 2015 excluded (see text).

The mean rate of increase of Muggers in the Rapti River (15.7% p.a.; Fig. 2) was much higher than that in the Narayani River (4.5% p.a.; Fig. 3) - the mean rate of increase for both rivers combined was 10.1% p.a. (Fig. 4).

Mugger density varied within and between rivers (Table 1), with the Rapti River consistently reporting higher relative densities than the Narayani River. Using the most recent survey data (2017), Sector F in the Narayani River had the highest density (0.54 ind./km), and Sector B in the Rapti

River had the highest (1.68 ind./km) (see Table 1).

In terms of overall size structure, in 2017 adults comprised 76.4% and 78.4% of sightings in the Rapti and Narayani Rivers, respectively. These data suggest that the population is biased towards adults, and in the initial stages of recovery. However, the bias towards large animals may reflect that the surveys were carried out during the day.

In the Vishwamitri River (Gujarat State, India), surveys in December 2008-January 2009 recorded adults as comprising 53.0% of daytime sightings (N= 81), and in 2010 adults comprising 50.3% of night time sightings (N= 155) (Vyas 2012). Although caution must be exercised in making comparisons with CNP, as differences in size structure may exist between these two populations, it is nonetheless interesting that adults made up similar proportions of counts in both day and night surveys in the Vishwamitri River, despite significant differences in total counts.

Habitat appears to be an important factor influencing the distribution of Muggers in the Rapti and Narayani Rivers. The Rapti River experiences comparatively less human disturbance than the Narayani River, and this cannot be ruled out as a factor affecting both sightability and abundance (Maskey *et al.* 2006). Likewise, in both rivers, stringent protection of riverine habitats and subsequent reduction in human disturbances are considered factors contributing to the increases in the Mugger populations, together with natural recruitment.

In the Rapti River, Muggers were mainly sighted in the mainstream, river confluences, confluences between the river mainstems and various tributaries and creeks, and shaded forest, deep waterholes and feeder streams. Basking sites were characterized by low current, deep water, sandy and muddy islands and sloping banks with densely covered *Saccharum* sp., dead logs or flooded woody debris (Table 2).

Table 2. Mean river depth and width, main substrate and current “speed” at Mugger basking sites in 2017. Numbers in brackets indicate standard deviations and sample sizes for means.

River	Depth (m)	Width (m)	Substrate	Current
Rapti	2.1 (0.16; 25)	121.8 (10.55; 25)	mostly sand	slow
Narayani	2.4 (0.14; 45)	108.4 (8.72; 45)	mostly sand	slow

In the Narayani River, Muggers were mainly sighted in the mainstream, in braided channels, confluences of seepage waterholes with the mainstream, creeks and tributary confluences with the river, and feeder streams. Basking habitats were characterized by low current, deep water, mainstream with stagnant deep water created by Gandak Barrage, sandy and muddy stretches, and rocky and sandy

sloping areas densely covered by *Saccharum* sp. and flooded woody debris (Table 2).

Overall, there are clear signs that the *C. palustris* population in CNP is increasing, and on-going monitoring will establish the extent of this recovery.

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India

GHARIALS RELEASED INTO THE BEAS RIVER. The Punjab Wildlife Department and the World Wide Fund for Nature (WWF), with the help of the Forest Department, released 10 3-year-old Gharials (*Gavialis gangeticus*) from Chhatbir Zoo into the Beas River, at Gagrewal village, on 2 September 2019.

Gharials were not released at Harike Wetland, the largest wetland in northern India and the most favourable location for the species, due to a protest from farmers there. Farmers, concerned that the animal is dangerous for humans and damages crops, recently sent a memorandum to Punjab Chief Minister Amarinder Singh on their opposition to the release of Gharials. It is hoped that the farmers' concerns will be resolved, and that releases will be possible in Harike Wetland as well.

The departments have been working on the project for the past decade. In 2005, the Punjab State Wildlife Board recommended the reintroduction of wild Gharials in the Beas River area, as it is less polluted than the Sutlej River. The proposal was also moved to the Central Government for approval. The Beas River originates near the Rohtang Pass in Himachal and flows into Punjab - its waters are used for irrigation in more than four states, and is home to rare aquatic wildlife, including the Indus dolphin, smooth Indian otter, turtles, 500 bird species, 90 fish species and hundreds of plants.

In 2017, 47 hatchling Gharials (from Morena, Madhya Pradesh) were reintroduced in the Beas River, with one death

reported due to respiratory failure. The 46 remaining Gharials spread along the river, with one of them venturing 120 km upstream from the release site to reach Talwara in Hoshiarpur District. The latest survey by the Punjab Department of Forests and Wildlife Preservation and WWF in July 2019, confirmed that Gharials have established themselves in the Beas Conservation Reserve (notified in 2017, a 185-km stretch from Harike headworks to Talwara). During the survey, 19 Gharial were sighted in the upstream Beas River, two in Ferozpur feeder, and one in the Sutlej River, downstream of Harike headworks.

Buoyed by the success of the project, more releases are planned. This success has occurred despite threats such as increasing pollution, sand mining, habitat destruction, increasing anthropogenic pressure, a molasses spillage in 2018, restricted water flow on several occasions, and two extreme floods.

Sources: Aman Sood, "Gharials at home in Beas Conservation Reserve", *Tribune News Service*, 3 September 2019; Anil Sharma, "Wildlife department releases 10 gharials into Beas river", *Hindustan Times*, 5 September 2019.

Latin America and the Caribbean

Brazil

PROJETO CAIMAN - ENVIRONMENTAL EDUCATION. Faced with the impacts that human activities impose on Broad-snouted caiman (*Caiman latirostris*) populations in Brazil, and the growing need for technical information on the species and its ecosystem, the Marcos Daniel Institute (IMD) created the "Projeto Caiman: Caimans of the Atlantic Forest" conservation program (Projeto Caiman). IMD is a non-government organization founded in 2004 in Espírito Santo State, Brazil, focusing on biodiversity conservation, wildlife health monitoring, training courses, technical-scientific events, research and environmental education.

Projeto Caiman aims at scientific development on the natural history and ecology of the species, for its conservation and the Atlantic Forest as a whole. The project is already recognized in Brazil and abroad as an important initiative for research and conservation of Brazilian caimans. Activities are based on 6 pillars: conservation research; communication and scientific dissemination; training of young researchers; environmental education and awareness; rescue and rehabilitation of caimans; and, public policy for conservation of nature.

Environmental education is one of the strongest pillars in Projeto Caiman, as it is the direct interface with society and its social and environmental conflicts. Environmental education is the process by which individuals construct values and skills for to the conservation of nature. It is necessary to understand and share that the environment is not a private property, but a place of all living beings, breaking with the anthropocentric vision.

The conservation of crocodilians in the Atlantic Forest has been an arduous mission, especially due to the political scenario, hunting, agriculture and urbanization over the most threatened biome in Brazil. Therefore, transmitting

information about the Atlantic Forest focusing on crocodilians is a complex mission. It begins with the demystification of the animal whose image in books, films and cartoons is associated with an angry, evil and enemy of man, creature.



One of the goals of Projeto Caiman is to promote this change of perception, as many people bring with them a prejudice about caimans. Environmental education activities bring to the public knowledge about the species and its ecosystem interactions, highlighting the ecological importance of caimans for the ecological balance, especially within the “One Health” approach.

The big challenge, however, is to lead the public to a change in attitude towards the sustainable use of natural resources and the appreciation of life in all its forms. This demands specific approaches for each target audience, associated with the identification of objective problems to be addressed and solved. For this reason, Projeto Caiman’s environmental education and science dissemination program uses different formats for different audiences and objectives, such as:

- Environmental education in public and private schools
- Events and cultural manifestations
- Awareness through images
- Scientific tourism
- Training of teachers and environmental educators to use caimans as flagship species in environmental education in schools
- Publications
- Social media
- Projeto Caiman Ecological Center

Over the past 5 years, 66,369 people have been reached directly through Projeto Caiman’s environmental education and science dissemination program, developed in partnership with ArcelorMittal Tubarão (a steel producer that protects the largest caiman population in the state). Among the various actions, it is worth mentioning the environmental education activities in schools and the creation of the Projeto Caiman Ecological Center (Brazil’s first center for environmental education and scientific dissemination about caimans). The wide audience reach comes with the great challenge of measuring and evaluating the effectiveness of the program, and this is the goal we aim to achieve in order to guide efforts and the best use of resources for the most effective actions for achieving environmental education objectives.

We are aware of the challenges we face in promoting the conservation of the country’s most endangered caiman species, whose populations are under heavy economic pressure. However, learning to care and act in an environmentally sustainable manner is gradual, but when the multiplier effect occurs on a large scale, it breaks down barriers and sensitizes parents, uncles, grandparents, neighbours, friends, etc. Thus, continually, nature gains critical and ecologically oriented minds.

For video footage of Projeto Caiman activities, see:

- <https://www.youtube.com/watch?v=XZOMDYA-Zm8&t=>
- <https://www.youtube.com/watch?v=sf5eB4pV9n4>

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BRAZILIAN CROCODILIAN RESEARCHERS NETWORK ESTABLISHED. The IX Brazilian Congress of Herpetology (IX CBH) was held at Campinas University, São Paulo State, Brazil, on 22-26 July 2019. The CBH takes place every two years and is an excellent opportunity for discussion, dialogue, presentation of research results, and to learn about Brazilian and Latin American herpetology.

On 23 July, a side-meeting of an enthusiastic group of students and researchers on crocodylians was held (Fig. 1). The meeting was proposed and conducted by Dr. Luís Bassetti (CSG Regional Vice Chair for Latin America and the Caribbean), Dr. Thiago Portelinha (Federal University of Tocantins), Yhuri Nóbrega (Projeto Caiman) and Dr. Jozélia Correa (Federal Rural University of Pernambuco), and was attended by 32 people from 19 institutions (university, zoo, NGO, research center, etc.) from different Brazilian regions.



Figure 1. Students and researchers on crocodylians at side-meeting held during the IX Brazilian Congress of Herpetology.

The meeting was started by Dr. Bassetti, who explained the organizational structure and objectives of the IUCN-SSC Crocodile Specialist Group (CSG), the importance and interest of the CSG in training young researchers, as well as the possibility of support for undergraduate and post-graduate student projects through the CSG’s Student Research Assistance Scheme (SRAS). Following that, other researchers reported on their research and activities being carried out in different regions of Brazil: Dr. Portelinha commented on the importance of crocodylian research in the Amazon and Tocantins State; Yhuri Nóbrega highlighted the work in Espírito Santo State; and, Dr. Jozélia Correa commented on the research with *Caiman latirostris* in northeastern Brazil. One of the main points discussed was the creation of a group/network of researchers, which will involve institutions, researchers and collaborators interested in crocodylians. The first strategy outlined by the group was to hold a meeting of the Brazilian Crocodylian Researchers Network during 2020 in Espírito Santo State, Brazil.

Despite the high level of representation and importance of crocodylians in Latin America, and many crocodylian

researchers in Brazil, no activities on crocodilians were included during the official program of the IX CBH (ie lectures, conferences, symposia, etc.). Therefore, during the meeting, a letter was written by students and researchers interested in crocodilians and participating at IX CBH, thanking IX CBH for the space provided for the side-meeting and requesting the inclusion of crocodilians in the official program of the next CBH. The letter was handed to the president of the Brazilian Society of Herpetology, which is responsible for the CBH.

Creating a researcher group/network will be essential to discuss research strategies, management and conservation of crocodilians in Brazil. The consolidation of this group will promote and facilitate partnerships, enabling contact between students, researchers, and collaborators (ie managers, breeders, environmental agencies) from different regions, through the exchange of information, data, samples and practical experiences on the 6 crocodilian species in Brazil. It is hoped that through this group it will be possible to attract professionals and researchers from this study area, giving greater visibility to the importance of crocodilians, as well as providing tools for conservation and management practices, and discussing the future of crocodilians in our country.

Luís Bassetti, *CSG Regional Chair for Latin America and the Caribbean and University of São Paulo, Brazil.*

Cuba

CREATION OF GROUP OF CROCODILE SPECIALISTS OF CUBA. On 22-26 July 2019, the Flora and Fauna Business Group held the National Crocodile Program (PNC) meeting at the crocodile breeding centre in Manzanillo, Granma, Cuba. The main objective of this meeting was to update the status of work activities with captive and wild crocodile populations.

Following presentation of results obtained by the integral development projects, the current status of reproduction, food availability, population management, study of these topics in the wild, achievements and difficulties, were known.



By the end of the meeting, several agreements had been made, with the goal of solving the problems identified, and strengthening support for work with crocodiles of Cuba. These included: Preparation of a guide or technical manual about the handling of captive crocodiles in Cuba; and, creation of a “Group of Crocodile Specialists of Cuba” (GECC) from the PNC.

With regard to the GECC, the management structure comprises: Chair (Dr. Manuel Alonso Tabet); Executive Officer (Gustavo Sosa Rodríguez); and, Scientific Advisor (Dr. Roberto Ramos Targarona) - all of whom are also members of the IUCN-SSC Crocodile Specialist Group. Ordinary members of the GECC are Grabiél Cisneros, Yairen Alonso Jimenez, Grabiél Brul Puebla and Etiam Arturo Pérez Fleitas.

Gustavo Sosa Rodríguez (*gustavo.sosa@nauta.cu*).

French Guiana

OBSERVATION OF TAIL OUTGROWTH ON SCHNEIDER’S DWARF CAIMAN (*CAIMAN TRIGONATUS*) IN FRENCH GUIANA. Schneider’s Dwarf caiman (*Paleosuchus trigonatus*) is a forest crocodilian whose ecology remains largely unknown (Magnusson and Campos 2010). It is a discrete species that prefers dense forest, leading to rare exposure to direct UV radiation. *Paleosuchus trigonatus* lives in small streams and often uses terrestrial burrows or caves formed by rocky masses to retreat to during the day (Magnusson and Lima 1991; Lemaire *et al.* 2018).



Figure 1. Location of Nouragues Reserve in French Guiana.

Here, we report on an individual *P. trigonatus* captured in January 2018, in the “Réserve Naturelle Nationale des Nouragues”, in French Guiana (4°05’N, 52°41’W; Fig. 1). The individual was 40 cm SVL, and had an unusual 4-cm outgrowth on the left side of its tail, at the second single vertical tail scute. The outgrowth was hard, rigid and completely covered by keratin (Fig. 2).

The animal was equipped with a VHF beacon (HOLOHIL, RI-2C2, 36 months), and after 4 additional observations it did not seem to have any difficulties getting inside a burrow.



Figure 2. Tail outgrowth on *Paleosuchus trigonatus*.

Acknowledgments

This study was partly funded by the research and conservation funds of Paris Zoo, the French National Center for Scientific Research (CNRS) of French Guiana, Office de l'eau de Guyane, Agence Française pour la Biodiversité, Direction de l'Environnement, de l'Aménagement, et du Logement en Guyane. We thank the Nouragues Research Field Station (managed by CNRS) which benefits from "Investissement d'Avenir" grant managed by Agence Nationale de la Recherche (AnaEE France ANR-11-INBS-0001; Labex CEBA ANR-10-LABX-25-01). And thanks to David Oudjani for help in the field.

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Magnusson, W.E. and Lima, A.P. (1991). The ecology of a cryptic predator, *Paleosuchus trigonatus*, in a tropical rainforest. *Journal of Herpetology* 25: 41.

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Europe

4TH EUROPEAN CROC NETWORK MEETING. The 4th European Croc Network meeting (ECNM2019) was held on 4-6 October 2019, at the National Reptile Zoo in Kilkenny, Ireland. We had 52 participants from 16 countries, representing research, conservation, husbandry, fashion and industry, along with hobbyists and enthusiasts.

We started off with a workshop on alligator target training, run by James Hennessy. The talks held throughout the weekend also provided further opportunity to learn how target training is used in education and outreach (Sarah Carpentier), and in captive *Tomistoma* management (Iri Gill).

Conservation efforts were highlighted by Rikki Gumbs, who presented the current projects on critically endangered crocodilians prioritised using the EDGE metric, Flavio Morrissiey who showed successful strategies for raising money for crocodile conservation, and Marisa Tellez presenting the effects of pollution on crocodiles in Belize. We followed up with research being conducted on crocodilian cognition (Stephan Reber), crocodylomorph neuroanatomy (Mark Young), American crocodile nesting in Cuba (Roberto Rodríguez-Soberón), and the MSc on crocodile-parasite interactions in Belize conducted by Joe Patryka after attending the first ECN meeting in 2016. The keynote lecture by Jeff Lang on the Gharials in the Chambal was one of the highlights of the weekend.

The poster session provided further opportunity to learn about exciting projects conducted by participants, with the prize for best poster going to Jérémy Lemaire for his work on caimans in French Guiana.

Our traditional speed-dating session gave all participants a further opportunity to mingle and exchange ideas, and the process received a very positive feedback, particularly from prospective students. To provide further training, we also held workshops on experimental design (led by Rob Gandola) and field techniques and community outreach (led by Marisa Tellez).



Figure 1. Speed-dating session.



Figure 2. Participants of 4th ECN meeting.

Additionally, this year the European Croc Network became an official not-for-profit organization. This has allowed us to raise enough funds to offer grants for students and early career scientists based in Europe to conduct both *in-situ* and *ex-situ* work. More information can be found on our website (www.eurocrocnetwork.com).

Agata Staniewicz and Ashley Pearcy Buitenwerf.

Australia and Oceania

Australia

Surf Life Saving Queensland will deploy drones equipped with special crocodile-spotting Artificial Intelligence (AI) in north Queensland this summer to better protect swimmers. The “CrocSpotter” technology has been developed by a multi-organisation team combining drone technology, AI and cloud computing into a flying eye in the sky that can spot a crocodile in murky waters with much greater accuracy than a human.

The Little Ripper group initially developed drones to spot swimmers in trouble, and then worked with software developers to come up with a shark-spotting algorithm. Now it has adapted its system again, this time to spot crocodiles in rivers and on beaches in tourist areas of northern Queensland. However work continues to improve the system, as crocodiles live in murkier water than sharks, and can stay underwater for long periods of time.

A trial was carried out by Surf Life Saving Queensland and The Ripper Group to identify, monitor, and track the movement of crocodiles last November. The rollout of CrocSpotter is supported by the Queensland Department of Environment and Science through its CrocWise program. It will be used at some specific locations this summer (eg, Four Mile Beach, Port Douglas and some beaches in the Cairns area), with potential to roll it out across other crocodile habitats around Townsville and Mackay.

Sources: *Stuart Layt, Croc-spotting drones to patrol north Queensland skies, Brisbane Times, 26 September 2019*

(<https://www.brisbanetimes.com.au/national/queensland/croc-spotting-drones-to-patrol-north-queensland-skies-20190926-p52va0.html>); *Triple J Hack, World-first croc-spotting drones could soon be patrolling Australian beaches, ABC, 22 September 2019* (<https://www.abc.net.au/triplej/programs/hack/croc-spotting-drones-could-soon-be-patrolling-australian-beaches/11438962>).



Recent Publications

Woodward, A.R., Leone, E.H., Dutton, H.J., Waller, J.E. and Hord, L. (2019). Characteristics of American alligator bites on people in Florida. *The Journal of Wildlife Management* (<https://doi.org/10.1002/jwmg.21719>).

Abstract: Human-American alligator (*Alligator mississippiensis*) conflict in Florida, USA, has increased since the early 1970s, along with the recovery of the American alligator population. To better understand factors contributing to the risk of people being bitten by free-ranging alligators in Florida, we evaluated the trend of alligator bites during 1971-2014 and examined characteristics associated with bites on people documented during 1948-2014. We classified 372 bites as either unprovoked or unintentionally provoked and used these in further analyses. Major injuries to victims occurred in 247 bite incidents. The estimated annual number of bites resulting in major injury to the victim increased from 3.5 to 7.0 during 1971-2014. The number of bites per Florida resident did not show a significant trend during 1971-2014. No significant change occurred in the frequency of fatal attacks during 1971-2014. Monthly frequency of bites was positively correlated with both mean maximum and mean minimum air temperatures but was not significantly correlated with testosterone concentration in adult male alligators, suggesting that bites are more likely related to feeding rates associated with seasonal fluctuations in ambient temperature than to aggression by male alligators during the breeding season. A high percentage of bites (41.8%) occurred in unnamed water bodies, which were generally small or man-made. Most (93.7%) victims were Florida residents, and 58.7% resided close to the incident site. Victims were predominantly male (81.4%), and adults were more frequently victims than were adolescents or children. Most victims (93.9%) were in the water or near the shore when bitten. Victims were more likely to sustain major injuries if the bite occurred in deeper water. Male alligators were more frequently (76.9%) responsible for bites. We found only 1 instance in which a bite was associated with defense of eggs or young by an adult female alligator. Evidence of people feeding alligators before the bite was documented in 34.7% of bite incidents. Twenty-two fatalities were attributed to alligator attacks, but we could not discern a pattern in the ages of victims. Alligators responsible for severe or fatal bites were predominantly in good condition with few deformities or injuries. Most alligator bites in Florida appeared to be attempts at feeding, although 36.8% of incidents entailed a single bite followed by immediate release, suggesting that alligators were unsure about their prey or were biting in defense. The risk of alligator bites can be reduced by educating people likely to interact with alligators and by selectively removing problem alligators in human residential areas and water bodies used regularly by people for swimming, wading, and shoreline activities.

McInerney, P.J., Shackleton, M.E., Rees, G.N., Frechette, J.L., Sam, H. and Hor, L. (2019). Release of critically endangered crocodiles: Development and application of a food web approach to determine suitability of release habitat. *Aquatic Conservation: Marine Freshwater Ecosystems* 2019: 1-14.

Abstract: The Siamese Crocodile (*Crocodylus siamensis*) is a critically endangered medium-size crocodilian endemic to Southeast Asia. Extirpated from much of its natural range, conservation efforts in the Cardamom Mountains of Cambodia include the release of captive-reared juveniles and sub-adults into river reaches known to support adult *C. siamensis* populations. Despite conservation concerns, the biology of wild *C. siamensis* is not well studied and the ecology of ecosystems at release locations is poorly understood. Fish are thought to comprise a major component of the diet of *C. siamensis*. Here, the aim was to characterize fish communities within three potential *C. siamensis* release locations, focusing on community composition, density, size class structure and food web dynamics. The survey sites varied in both *C. siamensis* density and human fishing pressure, and the results are interpreted in light of these drivers. Genomic interrogation of fishes of the Cardamom Mountains distinguished 13 distinct fish species, contributing to genetic databases and adding to the documented taxon list for the region. The presence of two previously unconfirmed fish genera in the region is confirmed. The first estimates of fish density, biomass and size class distribution for three rivers in the Cardamom Mountains are provided. The three potential *C. siamensis* release reaches that were sampled showed clear differences in fish community composition, structural and trophic dynamics. Fish density and biomass were highest in the high-density *C. siamensis* survey reach and lowest in the high human fishing pressure reach. Survey reaches with food webs that were more reliant on autochthonously driven food webs supported higher densities and biomass of fish. These results have important implications for future *C. siamensis* conservation efforts in Cambodia and contribute valuable ecological information on a relatively unexplored region.

González, E.J., Martínez-López, M., Morales-Garduza, M.A., García-Morales, R., Charruau, P. and Gallardo-Cruz, J.A. (2019). The sex-determination pattern in crocodilians: A systematic review of three decades of research. *Journal of Animal Ecology* (<https://doi.org/10.1111/1365-2656.13037>).

Abstract: Sex in crocodilians is not determined by chromosomes, but by egg incubation temperature, where different temperatures produce different clutch sex ratios. Two patterns have been proposed to describe these changes in sex ratios: a 100% female proportion at low and high temperatures with male predominance at intermediate ones (FMF) or a simpler pattern with a single female-to-male transition (FM). Over the last three decades, researchers have provided empirical information to support either of these two patterns in different species; however, no consensus has been reached partly because data have not been analysed as a whole. Here, we aimed at gathering the existing data on these patterns to provide models of temperature-dependent sex determination in those crocodilians studied so far. Potentially relevant publications were searched on Web of Knowledge, Scopus, Scielo and Science Direct. Studies that reported results on the sexual identity of crocodilian hatchlings obtained from constant temperature incubation treatments were considered. Using statistical models varying in their underlying assumptions, we evaluated which sex-determination pattern was best supported for the studied crocodilians and constructed species-specific and latitude-specific models. Based on the 8458 sexed hatchlings studied throughout 31 studies, we show that the evidence supports a shared FMF pattern in all the crocodilian species for which enough data are available. We find that such pattern changes between species and at different latitudes. These results suggest a lability of the FMF crocodilian sex-determination pattern, a key feature under the present climate change scenario.

Papet, L., Grimault, N., Boyer, N. and Mathevon, N. (2019). Influence of head morphology and natural postures on sound localization cues in crocodilians. *R. Soc. open sci.* 6: 190423.

Abstract: As top predators, crocodilians have an acute sense of hearing that is useful for their social life and for probing their

environment in hunting situations. Although previous studies suggest that crocodilians are able to localize the position of a sound source, how they do this remains largely unknown. In this study, we measured the potential monaural sound localization cues (head-related transfer functions; HRTFs) on alive animals and skulls in two situations, both mimicking natural positions: basking on the land and cruising at the interface between air and water. Binaural cues were also estimated by measuring the interaural level differences (ILDs) and the interaural time differences (ITDs). In both conditions, HRTF measurements show large spectral variations (greater than 10 dB) for high frequencies, depending on the azimuthal angle. These localization cues are influenced by head size and by the internal coupling of the ears. ITDs give reliable information regarding soundsource position for low frequencies, while ILDs are more suitable for frequencies higher than 1.5 kHz. Our results support the hypothesis that crocodilian head morphology is adapted to acquire reliable localization cues from sound sources when outside the water, but also when only a small part of their head is above the air-water interface.

Chroust, M., Mazuch, M. and Luján, A.H. (2019). New crocodilian material from the Eocene-Oligocene transition of the NW Bohemia (Czech Republic): an updated fossil record in Central Europe during the Grande Coupure. *Neues Jahrbuch für Geologie und Paläontologie - Abhandlungen* 293(1): 73-82.

Abstract: The genus *Diplocynodon* was a fossil alligatoroid that inhabited Europe from the Paleocene until the Miocene. During the Eocene-Oligocene transition, circa 35 million years ago, a terrestrial faunal turnover occurred in Eurasia during the Grande Coupure. This overall climate shift is linked with the extinction of numerous European Eocene endemic mammals. The event further affected reptile assemblages, reducing the Eocene crocodilian diversity to a few taxa. Crocodilians are considered as good climate indicators since they are sensitive to fluctuations in mean annual temperatures. During the Grande Coupure, the genus *Diplocynodon* was said to have migrated southwards in Europe during the coldest intervals. However, new material presented from the Kučlín, Větruše, Kundratice and Dětaň sites (Czech Republic) does not support this theory and further provides new information on the Eocene-Oligocene cooling event in Central Europe.

Khan, N.A., Soopramanien, M. and Siddiqui, R. (2019). Crocodiles and alligators: physicians' answer to cancer? *Current Oncology* 26(3): 186. (doi: <http://dx.doi.org/10.3747/co.26.4855>).

Faulkner, P.C., Hala, D., Rahman, M.S. and Petersen, L.H. (2019). Short-term exposure to 12‰ brackish water has significant effects on the endocrine physiology of juvenile American alligator (*Alligator mississippiensis*). *Comparative Biochemistry and Physiology Part A: Molecular & Integrative Physiology* 236: (<https://doi.org/10.1016/j.cbpa.2019.110531>).

Abstract: American alligators (*Alligator mississippiensis*) mainly inhabit freshwater habitats but can be exposed to a wide range of salinities during storm surges, droughts or from alterations in freshwater flows. Although some salinization events last weeks, others only last a few days. This study assessed changes in the endocrine function of the renin-angiotensin-aldosterone system (RAAS) and steroid hormone production (steroidogenesis) in juvenile alligators exposed to brackish water (12‰) for 7 days. We quantified plasma levels of angiotensin II and the corticosteroids (aldosterone, corticosterone and 11-deoxycortisol). Various progesterones, androgens, and estrogens were further assessed. The protein expression for the RAAS enzymes, renin and angiotensin converting enzyme (ACE), was quantified immunohistochemically in kidney and lung tissue, respectively, and histology was performed on kidney, lung and gonad tissues. Finally, blood biochemistry parameters such as electrolyte levels and diagnostic indicators

for dehydration, renal, and hepatic function were measured. Corticosterone, 11-deoxycortisol, Na⁺, Cl⁻, total protein, albumin, uric acid, and cholesterol levels were all significantly elevated in alligators exposed to brackish water compared with alligators in freshwater. The levels of 17β-estradiol and estrone were significantly lowered while histology showed alterations in gonad tissue in the brackish water exposed group. In contrast, while there were no effects of exposure on aldosterone levels, angiotensin II was significantly reduced in brackish water exposed alligators. These results correlated with significantly decreased expressions for both renin and ACE in kidney and lung tissue. Overall, this study showed that short-term exposure of alligators to 12‰ brackish water has significant endocrine effects on juvenile alligators.

Pooley, S., Botha, H., Combrink, X. and Powell, G. (2019). Synthesizing Nile crocodile *Crocodylus niloticus* attack data and historical context to inform mitigation efforts in South Africa and eSwatini (Swaziland). *Oryx* (doi: <https://doi.org/10.1017/S0030605318001102>).

Abstract: Conflicts with wildlife are a major challenge for conservation across Africa, and Nile crocodiles *Crocodylus niloticus* are allegedly responsible for more attacks on people than any other species; however, there is a lack of data regarding such attacks. We analysed reported attacks on people by Nile crocodiles in South Africa and eSwatini (Swaziland) during 1949-2016, identifying spatial and temporal patterns in attack incidence, as well as victim demographics. Through a literature review and archival searches we identified records of 214 attacks. Most attacks occurred in natural water bodies, with attacks in dams increasing since 2000. Most victims were attacked while swimming or bathing, others while fishing, doing domestic chores, and crossing waterways. There was a significant relationship between gender and activity when attacked. Children (<16 years old) accounted for 51% of all attacks, with a higher fatality rate compared to adults. Most victims were male (65%), with teenage boys being the largest individual category. We make recommendations for conservation policy and management to mitigate attacks by Nile crocodiles.

Isberg, S.R., Moran, J.L., De Araujo, R., Elliott, N., Davis, S.S. and Melville, L. (2019). First evidence of Kunjin strain of West Nile virus associated with saltwater crocodile (*Crocodylus porosus*) skin lesions. *Australian Veterinary Journal* (<https://doi.org/10.1111/avj.12862>).

Abstract: Recently, the Kunjin strain of West Nile virus (WNV_{KUN}) has been detected using qRT-PCR in belly skin lesions of farmed juvenile saltwater crocodiles. This follows an established association between similar lesions and West Nile virus in American alligators. The lesions present as cutaneous lymphohistiocytic aggregates in the dermal layers of both species. While these lesion do not create an obvious defect on the live crocodile, upon tanning the lesion area collapses and does not uptake the dye evenly, thus reducing its aesthetic appeal. As a result, skins are being rejected jeopardising the economic viability of the Australian crocodile industry. Over 50 skin lesions have since been confirmed as WNV_{KUN}-positive and preliminary evidence of lesion restructuring is presented. Horizontal transmission of WNV_{KUN} by mosquitoes is well-established but other transmission routes, such as ingestion and cloacal shedding, need further evaluation. An infection trial is currently underway to ensure WNV_{KUN} is the causative agent of these skin lesions.

Mustoe, G.E. (2019). Lower Eocene Footprints from Northwest Washington, USA. Part 1: Reptile Tracks. *Geosciences*

Abstract: Lower Eocene fluvial strata in the Chuckanut Formation preserve abundant bird and mammal tracks. Reptile trace fossils include footprints from a small turtle (ichnogenus *Chelonipus*), and several *Crocodylian* trackways that consist of irregularly

spaced footprints associated with linear tail drag marks. The latter trackways represent “punting” locomotion, where a submerged *Crocodylian* used intermittent substrate contacts to provide forward motion of their neutrally buoyant bodies. Two adjacent sandstone blocks preserve *Crocodylian* trace fossils that are named herein as a new ichnogenus and ichnospecies *Anticusuchipes amnis*. Two other *Crocodylian* trackways lack sufficient detail for ichnotaxonomic assignment.

Dridi, J. and Johnson, M.M. (2019). On a longirostrine crocodylomorph (Thalattosuchia) from the Middle Jurassic of Tunisia. *Geobis* (<https://doi.org/10.1016/j.geobios.2019.07.006>).

Abstract: The geographic origins and distributional patterns of Gondwanan teleosauroids during the Jurassic have been fiercely debated over many years. Unlike the rich thalattosuchian fossil record from Laurasia, teleosauroids described from Gondwanan ecosystems are relatively scarce. Most of the known occurrences consist of isolated and fragmentary bones collected in Madagascar, Morocco, Tunisia, India, and Ethiopia. Nevertheless, these specimens, although fragmentary, have provided substantial information for assessing the evolutionary scenarios of multiple teleosauroid lineages and have shown that certain teleosauroid taxa were widespread rather than endemic to Western Europe. Here, a partial skeleton of a teleosauroid crocodylomorph is described. It was found in the late Middle Jurassic (Callovian) deposits of southeastern Tunisia by a team of French and Tunisian paleontologists; however, it has not been thoroughly studied at both macro- and microscopic scale until now. The new specimen is composed of an incomplete symphyseal portion of a lower jaw in addition to isolated teeth, osteoderms (both dorsal and ventral), thoracic and caudal vertebrae, and several thoracic ribs. The specimen has several morphological characters that are reminiscent of longirostrine teleosauroids. Due to the total absence of other cranial bones, as well as the pectoral and pelvic girdles, the specimen is not diagnostic to the generic level. However, these new remains represent the youngest ascertained occurrence of a definitive non-machimosaurin teleosauroid in Africa, provide additional insights into the geographic distribution of Thalattosuchia, and raise once again the question whether the origins of this clade were Gondwanan or Laurasian.

Li, B., Liu, Z., Ke, C. and Hu, F. (2019). Enhancement of micro-images using feature linking model for cerebellum of *Alligator sinensis*. *IEEE Access* 17 (doi: 10.1109/ACCESS.2019.2925772).

Abstract: In order to realize the three-dimensional reconstruction of the cerebellum structure of *Alligator sinensis*, it is necessary to observe the structure by using a microscope. In the process of slice making and micro-image shooting, individual operation differences lead to good or bad quality of micro-images. To solve this problem, the feature linking model (FLM) is used to enhance the micro-image of alligator cerebellum and improve the quality of micro-image. The transverse section and longitudinal section were prepared by using the tissue of cerebellum of *A. sinensis* as a raw material, and the micro-images were obtained by the light microscopy. The different enhancement methods were used to process the transverse section microimages, and the enhancement was evaluated subjectively by direct observation. It was found that histogram equalization (HEQ) and fuzzy set method (FSM) did not enhance the darker parts well, while enhanced the brighter parts excessively. And the enhancement with pulse coupled neural network (PCNN), spiking cortical model (SCM), and FLM are better. On the basis of subjective evaluation, three objective evaluation indexes (contrast, spatial frequency, and gradient) were used to compare and analyze the image quality improvement of PCNN, SCM, and FLM, and we found that FLM had the best enhancement on transverse section micro-images. Then, FLM was used to process longitudinal section micro-images, and the objective evaluation indexes before and after processing were compared. We found FLM also had a good enhancement on longitudinal section micro-images. The results show that FLM

was effective in enhancing micro-images of the cerebellum of *A. sinensis*, and FLM improved the quality of the longitudinal section micro-images more obviously. The proposed method can improve the quality of the microscopic image of the cerebellum of *A. sinensis* so that higher quality images can be obtained, which is beneficial to improving the utilization rate of the material.

Adam, S.A.M. (2019). Impact of Some Wildlife Offenses on Wild Animals and Their Habitats in Selected States in Sudan and Dinder Biosphere Reserve during (2013-2017). MSc thesis, Sudan University of Science and Technology, Khartoum, Sudan.

Abstract: The present study was focused on shedding light of the affect Wildlife crimes in habitat and Wild animals population and habitat in the Sudan and special Dinder Biosphere Reserve (DBR) during (2013-2017). The world Wildlife is an important component of the natural system wildlife population and habitat suffer great threats that results in decreasing population sizes and damaging greater expanses of the natural habitat. In the Sudan wildlife threatened by many dangers of which we mention, poaching, trafficking, fire, over grazing. Descriptive methods have been used for data collection from record annual report wildlife law violation and distribution questionnaire of 100 personnel (wildlife officers, rangers and game scouts) to evaluate affect wild life crimes in habitat and population. Data analysis which were manipulated by simple statistics such frequency and percent and histograms. The results this study of the following data, wildlife crimes in the Sudan (poaching, bush meat, trafficking, fire wood collection, fire, leopard skin, hippopotamus skin, rhinoceros horns, spotted cat skin, crocodile skin, ivory elephant. Highest wildlife crimes in the Sudan poaching represented 59.8%, lowest wildlife crimes in the Sudan Rhinoceros horns represented 0.9%. The results of questionnaire shows 78% poaching; decline wildlife population ,shows 22% the poaching effect on environmental balance. Wildlife crimes enter the DBR represented, honey collection, fish angling, fire wood collection, entrance care, weapons, mining, charcoal production, fire, over grazing by livestock, poaching, expanded agricultural. The highest wildlife crimes in the DBR overgrazing by livestock 799 during five years (2013-2017), entrance by sheep represented 97316 (79%), lowest entrance by donkey represented 258 (0.4%) lowest wildlife crimes in the DBR fish angling, highest crimes in the DBR was in 2015, lowest crimes in the DBR in 2013. The results explained trafficking in the Khartoum airport highest rate of trafficking was in 2017, represented 30% lowest rate of trafficking was in 2016 represented 13.3%. The results explained wildlife crimes seized in the Khartoum markets, highest rate of leopard shoes and lowest rate of crocodile accessories.

Selva, N., Moleón, M., Sebastián-González, E., DeVault, T.L., Quaggiotto, M.M., Bailey, D.M., Lambertucci, S.A. and Margalida, A. (2019). Vertebrate scavenging communities. Pp. 71-99 in Carrion Ecology and Management. Wildlife Research Monographs Volume 2, ed. by P. Olea, P. Mateo-Tomás and J. Sánchez-Zapata. Springer: Cham.

Abstract: A scavenger is an animal that feeds on the carcass or remains of any dead animal which it did not participate in its killing. Scavenging is pervasive across the animal kingdom and almost all predator species use carrion to a certain extent in both terrestrial and aquatic ecosystems. There is a group of animals, the obligate scavengers, which rely (almost) entirely on carrion. Among vertebrates, only birds have evolved into obligate scavengers, namely vultures, which suggests that the costs of adaptation to obligate scavenging are high. Obligate and facultative scavengers exhibit a wide array of adaptations to locate and exploit carrion across systems, including inexpensive locomotion to find the unpredictable carrion on savannas, caching carrion in cold tundra or chemotaxis in aquatic systems. Traditionally viewed as an opportunistic process, particularly for facultative scavengers, carrion consumption by vertebrates often follows complex and structured patterns and is

crucial in maintaining the stability and structure of food webs.

Cidade, G.M., Riff, D., de Souza-Filho, J.P. and Hsiou, A.S. (2019). A reassessment of the osteology of *Mourasuchus amazonensis* Price, 1964 with comments on the taxonomy of the species. *Palaeontologia Electronica* 22.2.44A 1-23.

Abstract: This study is a thorough assessment on the morphology and taxonomy of *Mourasuchus amazonensis*, a fossil crocodylian of the Caimaninae clade from the late Miocene Solimões Formation of Brazil. A thorough redescription of the holotype of the species (DGM 562-R, a nearly complete skull with an associated incomplete left mandible) is performed together with the redescription of the specimen UFAC-1424, a posterior portion of the skull with associated mandibular remains, and the description of the specimen LACM-160157, also a posterior portion of the cranium. As such, this paper brings the most comprehensive osteological study of *M. amazonensis* to be performed to date, enabling a thorough taxonomic reassessment of the species in question. This reassessment confirmed *M. amazonensis* as a valid species, with two autapomorphies and two other distinctive characters. UFAC-1424 and LACM-160157 are assigned as *Mourasuchus* cf. *M. amazonensis*, pending further studies on the taxonomy of the species in order to clarify whether these specimens belong to the same species as DGM 526-R. Additionally, implications of the morphology observed in *M. amazonensis* for the taxonomic status of other *Mourasuchus* species are also discussed, especially with respect to *M. nativus*, which is currently a junior synonym of *M. arendsi*.

Beyrand, V., Voeten, D.F.A.E., Bureš, S., Fernandez, V., Janáček, J., Jirák, D., Rauhut, O. and Taforeau, P. (2019). Multiphase progenetic development shaped the brain of flying archosaurs. *Scientific Reports* 9: 10807.

Abstract: The growing availability of virtual cranial endocasts of extinct and extant vertebrates has fueled the quest for endocranial characters that discriminate between phylogenetic groups and resolve their neural significances. We used geometric morphometrics to compare a phylogenetically and ecologically comprehensive data set of archosaurian endocasts along the deep evolutionary history of modern birds and found that this lineage experienced progressive elevation of encephalisation through several chapters of increased endocranial doming that we demonstrate to result from progenetic developments. Elevated encephalisation associated with progressive size reduction within Maniraptoriformes was secondarily exapted for flight by stem avialans. Within Mesozoic Avialae, endocranial doming increased in at least some Ornithurae, yet remained relatively modest in early Neornithes. During the Paleogene, volant non-neoavian birds retained ancestral levels of endocast doming where a broad neoavian niche diversification experienced heterochronic brain shape radiation, as did non-volant Palaeognathae. We infer comparable developments underlying the establishment of pterosaurian brain shapes.

Brennan, C. (2019). Tropical Australia's crocodile entrepreneurs. *Arcadia* (Spring 2019), No. 4. (<https://orcid.org/0000-0002-7593-7522>).

Abstract: In the late 1940s a group of tourism entrepreneurs recognized the fascination crocodiles held for tourists and used them to promote travel to tropical Australia. The Australian Crocodile Shooters' Club proved successful in establishing safari hunting in Australia, and even after becoming a protected species, Australian saltwater crocodiles remain a significant symbol of the adventurous nature of northern Australia. Tourism promoters continue to build on the work of the early crocodile entrepreneurs by using crocodiles to draw tourists to northern Queensland and the Top End of the Northern Territory.

Poapolathep, S., Giorgi, M., Chaiyabutr, N., Klangkaew, N., Phaichoosak, N., Wongwaipairote, T. and Poapolathep, A. (2019). Pharmacokinetics of ceftriaxone in freshwater crocodiles (*Crocodylus siamensis*) after intramuscular administration at two dosages. *Journal of Veterinary Pharmacology and Therapeutics* (<https://doi.org/10.1111/jvp.12801>).

Abstract: One of the major obstacles to the successful treatment of infectious disease in freshwater crocodile species is incorrect dosing of antibiotics. There are few reports on pharmacokinetics and dosage regimens of antimicrobial drugs in crocodiles. The purpose of the present study was to clarify the pharmacokinetic characteristics of ceftriaxone (CEF) in Siamese freshwater crocodiles (*Crocodylus siamensis*). Freshwater crocodiles, *Crocodylus siamensis*, in breeding farms were treated with a single intramuscular administration of CEF at two dosages, 12.5 and 25 mg/kg body weight (b.w.). Blood samples were collected at preassigned times up to 168 hr. The plasma concentrations of CEF were measured by a validated method through liquid chromatography tandem-mass spectrometry. CEF plasma concentrations were quantified up to 72 and 96 hr after low- and high-dose administration, respectively. The C_{max} values of CEF were $24.61 \pm 5.15 \mu\text{g/ml}$ and $26.39 \pm 2.81 \mu\text{g/ml}$ at dosages of 12.5 and 25 mg/kg b.w., respectively. The AUC_{last} values increased in a dose-dependent fashion. The half-life values were not statistically different between the groups (around 20 hr). The average binding percentage of CEF to plasma protein was $53.78 \pm 2.11\%$. Based on the pharmacokinetic data, susceptibility break-point and the surrogate PK-PD index ($T > MIC$, $0.2 \mu\text{g/ml}$), i.m. administration of CEF at a dose of 12.5 mg/kg b.w. might be appropriate for initiating treatment of susceptible bacterial infections in freshwater crocodiles.

Manjunatha, V., Rout, M., Umashankar, S.N., Kshama, L.M. and Byregowda, S.M. (2019). Survey of helminth parasites in reptiles under captivity. *Journal of Immunology and Immunopathology* 21(1): 29-34.

Abstract: Parasitic infections are widespread among reptiles and may cause serious problems. Any data on its prevalence may be useful for their health management in captivity. Hence, a survey through faecal sample examination was conducted to assess the helminth fauna in captive reptiles [Caiman (*Caiman latirostris*), Bengal monitor lizard (*Varanus bengalensis*) and Star tortoise (*Geochelone elegans*)], maintained at Bannerghatta Biological Park, Bengaluru, Karnataka. A total of 23 faecal samples from apparently healthy caimans, 6 Bengal monitor lizards and 240 Star tortoises were collected over a period of 12 months during 2015-2016 and were screened using prescribed floatation and sedimentation technique followed by microscopic identification of eggs. We could detect ova of 6 (26.08%) *Physaloptera* sp. in caiman, 3 (50%) *Physaloptera* sp. in Bengal monitor lizard and 157 (65.41%) oxyurid pinworms in Star tortoise. Upon necropsy, *Physaloptera* worms were recovered from the stomach of Bengal monitor lizard and pinworms from the stomach and intestine of Star tortoise. This study contributes to our knowledge on prevalence of parasites in the said reptiles in captivity.

Mamangkey, J., Suryanto, D., Munir, E. and Mustopa, A.Z. (2019). Keratinolytic fungi isolated from Asam Kumbang Crocodile Breeding Farm, Medan, North Sumatra. *IOP Conference Series: Earth and Environmental Science*, Volume 305: 012084.

Abstract: Hydrolysis of keratin waste by fungi is an alternative biotechnology for recycling and valorization by utilizing its keratinolytic activities. The purpose of this study was to isolate the keratinolytic fungi and to test the degradation ability of chicken feather keratin. Crocodile feces and soil samples were collected from crocodile breeding farm in Asam Kumbang, North Sumatra. Casein and keratin of basal feather agar of 1% was used to isolate keratinolytic fungi. Fungal isolate was grown in feather meal broth incubated at 28°C and shake at 180 rpm using shaking orbital. Remain chicken feather was weighted after application of

keratinolytic fungi. After 4 days of incubation two fungi showed to have clear zone around their colony. THB7 was found to have relatively high hydrolysis zone in casein, while FB4 degraded more keratin in keratin agar. Most feather was degraded in 10, 12, and 16 days in THB7, FB4, and THB4 application respectively. THB4 showed to degrade feather to 1.6 g, while FB3 and FB4 remained feather to 2 and 3.4 of 10 g respectively. Further study includes molecular identification, characterization and keratinase production should be done.

Iijima, M. and Kubo, T. (2019). Allometric growth of limb and body proportions in crocodylians. *Journal of Zoology* (<https://doi.org/10.1111/jzo.12714>).

Abstract: Crocodylia is the sole extant remnant of quadrupedal archosaurs playing a pivotal role in understanding the evolution of growth allometry in the archosaur locomotor apparatus. However, among crocodylians, the postnatal growth of the postcranial skeleton has almost exclusively been examined in Alligator mississippiensis, and whether other species share the same growth pattern is unknown. Here, we tested whether the following allometric trends are conserved across Crocodylia: (1) forelimb length grows isometrically relative to hindlimb length; (2) fore- and hindlimb lengths become relatively shorter with increasing body size; and (3) long bone cross-sectional geometry becomes more robust relative to body size. We examined the relationships of limb lengths, stylopodial circumferences and presacral length (body size proxy) in extant crocodylians using reduced major axis regressions and compared the slopes among species. The result revealed non-uniform growth patterns of limb architecture among living crocodylians. Generally, the hindlimb grows with negative allometry against the forelimb in non-gavialid crocodylians, whereas two gavialids (*Gavialis gangeticus* and *Tomistoma schlegelii*) showed isometry in hind- vs. forelimb length scaling, potentially reflecting their unique locomotor ecology. Femur circumference scales negatively against humerus circumference in most of the species examined, which may be related to the anterior shift of the center of mass during growth. Stylopodial circumferences scale variously against stylopodial lengths and presacral length in crocodylians, lending little support to hypotheses that these allometries correlate with adult body size or metabolism (ie ectothermic or endothermic) in tetrapods.

Hossain, A., Huda, A.H.M.E. and Ahmed, E.U. (2019). Prospects of crocodile farming in Bangladesh. *Bangladeshi Journal*.

Abstract: Crocodile farming is a new concept for the entrepreneur, of Bangladesh as historically this industry never existed in Bangladesh. During the last decade the international demand for crocodile skin has increased tremendously which has turned this industry into a lucrative option for entrepreneurs worldwide. The major exporters of manufactured crocodile leather products are Italy, Germany, United States, Spain, France and United Kingdom. Though this crocodile farming and leather tanning industry is a new business idea but as the technology required for this industry is already available in Bangladesh, the weather and other natural factors are suitable for crocodile growth and a huge demand for crocodile leather is existing in the-world market, a great opportunity is existing in the international trade of crocodile skin for the business people of Bangladesh, who want to take the challenge of exporting these home grown products to foreign market. If this industry is given priority and if this industry becomes popular among the entrepreneurs of Bangladesh, within a very short lime, this industry will become one of the largest exporting and foreign currency earning sector of Bangladesh. Whether Bangladesh can take this opportunity to become successful in the export business of crocodile skin is a matter of further inquiry. The paper further seeks to highlight the international experience of crocodile farming and trading and suggest strategies Bangladesh may undertake in this respect.

Xie, Q., Liu, Y., Luo, F., Yi, Q., Wang, Y., Deng, L., Dai, J. and Feng, T. (2019). Antiviral activity of cathelicidin 5, a peptide from *Alligator sinensis*, against WSSV in caridean shrimp *Exopalaemon modestus*. *Fish and Shellfish Immunology* 93(Oct): 82-89.

Abstract: White spot disease caused by white spot syndrome virus (WSSV) is responsible for harming shrimp aquaculture industry and results in a pandemic throughout the world. Cathelicidin 5 treatment enhanced immune parameters including antioxidant enzyme activity and immune-related genes expression in shrimp *Exopalaemon modestus*. Shrimp treated with cathelicidin 5 and inoculated with white spot syndrome virus (WSSV) exhibited a significantly lower mortality rate and lower viral VP28 amplification and expression than control. This study addresses the role of cathelicidin 5 in immune stimulatory and antiviral activities that could protect *E. modestus* from WSSV infection.

Phillips, L. (2019). Bringing more South African game meat to dinner tables. *Farmer's Weekly* 2019(19031): 30-32.

Abstract: South Africa's Meat Safety Act, No. 40 of 2000, provides regulations for the safe handling of meat between producer and consumer for conventionally produced red meat, and for poultry, ostrich, game, crocodile and rabbit. According to Dr Tertius Bergh, an independent meat safety consultant, while these regulations are intended to guide a particular industry's activities to stay within the law, they can be difficult to understand and implement, and as such can hinder business growth. "For the 19 years since the introduction of the Meat Safety Act, and as a result of a lack of clarifying explanations from government, most of South Africa's game industry has had to interpret the relevant regulations itself," Bergh says. "Unfortunately, what we've often seen on a large scale is poorly handled and poor-quality game meat coming out of the industry. This situation needs to be corrected urgently."

Brown, J. (2019). Insights on the Translocation of a Critically Endangered Crocodylian: Diet and Body Condition of Headstart and Wild Philippine Crocodiles (*Crocodylus mindorensis*). PhD thesis, University of Oklahoma, Norman, Oklahoma, USA.

Abstract: Studies of diet are fundamental to understanding a species' ecology, and in relation to conservation translocations, dietary studies of headstart populations are particularly rare and valuable. These studies can yield insights into effects of headstarting on a population's ability to adjust and become established in the wild. With less than 150 mature individuals remaining in the wild, the critically endangered Philippine crocodile (*Crocodylus mindorensis*) is one of the most severely threatened species on the planet. We conduct the first analysis of stomach contents and characterize the diet of Philippine crocodiles from Isabela Province on the island of northern Luzon, Philippines. Additionally, we address concerns regarding captive-release programs by analyzing stomach contents of headstart crocodiles released into the wild over the last decade. Our study of diet from a resident wild population (N= 20) acts as a baseline comparison for evaluating the dietary habits of headstart crocodiles (N= 10), from which we found no evidence for dietary differences in percent occurrence, percent composition, and prey diversity. Overall, we demonstrate the use of 17 different prey species across eight prey categories (snails, fish, birds, reptiles, amphibians, mammals, crabs, and insects). Finally, we calculate the first body condition index (Relative condition factor K_n) for *C. mindorensis* and examine variation in body condition between headstart and wild crocodiles and find that wild crocodiles have significantly higher condition scores than headstart individuals. Overall, headstart crocodiles adjust well post-release and exhibit similar dietary habits compared to their wild counterparts, even within an agriculturally dominated landscape where they are likely exploiting the high abundance of the golden apple snail, an invasive species and the leading agriculture pest in the Philippines. Our focused monitoring methods reveal broader relevance for conservation,

highlighting the importance for a long-term commitment to both ecological monitoring and enhancing the capacity of in-country local communities.

Rio, J. and Turvey, S. (2018). Assessing the status, threats and future conservation action for the critically endangered Chinese alligator in Southern Anhui Province, China. 5th European Congress of Conservation Biology (doi: 10.17011/conference/eccb2018/107548).

Abstract: Chinese ecosystems are facing intense biodiversity loss. Pressure on ecosystems is particularly severe in the Yangtze basin, a 220,000 km² area supporting 300 million people in eastern China. The Chinese alligator (*Alligator sinensis*) is one of two extant species of the genus *Alligator*. Whereas the American alligator is of least concern to conservationists, the Chinese alligator is Critically Endangered, clinging on to a small stronghold in south-eastern Anhui Province within the Yangtze basin. Estimates of the number of remaining wild alligators are less than 130 individuals. They survive as isolated populations, in a 433 km² area - the National Chinese Alligator Reserve (NCAR). Despite its designation as a reserve, the NCAR is densely populated and dominated by agricultural activity, taking advantage of the fertile lowlands of the Yangtze floodplain and outcompeting the Chinese alligator. It has been estimated that half of the surviving wild alligators remain close to the main channel floodplain in marginal habitats directly adjacent to agricultural fields, where conflicts with humans occur. The remaining alligators have been displaced to even less favourable habitats at higher elevations to the south, in the valleys of tributaries draining the Huangshan mountains. Most conservation action to date has been directed towards the enlargement of captive populations, principally at the Anhui Research Centre for Chinese Alligator Reproduction. This captive population has more than 10,000 individuals. However, relatively little attention has been paid to the remaining wild population. Field data with which to assess the status and threats to the Chinese alligator, and to predict the effectiveness of management practices are limited, and therefore an alternative approach to standard ecological field techniques is needed. Here we apply local ecological knowledge to investigate the status and threats to the last remaining wild populations of Chinese alligator, using questionnaire-based surveys with inhabitants of villages throughout the NCAR. This research assesses the feasibility of strategies to support long-term coexistence of threatened megafauna, and human agricultural livelihoods in rural China. It also demonstrates the utility of novel questionnaire-based surveys, as robust sources of ecological data for informing conservation management practices.

Jakob-Hoff, R., Kingan, M., Fenemore, C., Schmid, G., Cockrem, J.F., Crackle, A., Van Bommel, E., Connor, R. and Descovich, K. (2019). Potential impact of construction noise on selected zoo animals. *Animals* 9(8): 504 (doi:10.3390/ani9080504).

Abstract: In anticipation of a major construction project in an urban New Zealand zoo, a study was initiated to assess the response to construction noise of selected animal species (elephant, giraffe, emu and alligator) previously observed to be sensitive to this kind of noise. The overall aim was to detect any signs of aversive responses to this noise to enable keepers to recognize these and take any necessary mitigating actions during the construction period. The experimental approach involved the creation of acoustic maps of each focal animal enclosure, a series of 90-min video recordings of the animals' behavior in response to ambient noise (control) and amplified broadcast of pre-recorded continuous and intermittent construction noise. Concentration of fecal corticosterone metabolites was also measured for the emu. Key findings were that giraffes, elephants and emus appeared to show an increase in behaviors that could indicate stress or agitation including vigilance and locomotion and may prefer quieter regions of their enclosure during sound exposure. Giraffes also increased close contact with conspecifics when exposed to construction noise. While alligators did not show

clear evidence of noise-related stress, our findings indicated that all focal species showed some behavioral responses to recorded construction noise.

Cidade, G.M., Fortier, D., Rincon, A.D. and Hsiou, A.S. (2019). Taxonomic review of two fossil crocodylians from the Cenozoic of South America and its implications for the crocodylian fauna of the continent. *Zootaxa* 4656(3) (<http://dx.doi.org/10.11646/zootaxa.4656.3.5>).

Abstract: The crocodylomorph fauna of the Cenozoic of South America is one of the richest and most diverse in the world. The most diverse group within that fauna is Alligatoroidea, with nearly all of its species belonging to the Caimaninae clade. Many of the fossil alligatoroid species from the Cenozoic of South America were proposed based on very incomplete remains, and as a result their validity requires revision. Two such species are *Balanerodus logimus* Langston, 1965, from the middle Miocene of Colombia and Peru, and *Caiman venezuelensis* Fortier & Rincón, 2012, from the Pliocene-Pleistocene of Venezuela. This study has performed a thorough review of the taxonomic status of these two alligatoroid species, concluding that *B. logimus* is a *nomen dubium* and that *Ca. venezuelensis* is a junior synonym of the extant species *Ca. crocodilus*. This review offers a significantly more accurate scenario for alligatoroid diversity in the Cenozoic of South America in different epochs such as the Miocene and Pleistocene. Additionally, the record of *Ca. crocodilus* from the Pleistocene of Venezuela is the first fossil record that can be assigned to this species.

Souza, R.G., Figueiredo, R.G., Azevedo, S.A.K., Riff, D. and Kellner, A.W.A. (2019). Systematic revision of *Sarcosuchus hartti* (Crocodyliformes) from the Recôncavo Basin (Early Cretaceous) of Bahia, north-eastern Brazil. *Zoological Journal of the Linnean Society* (<https://doi.org/10.1093/zoolinnean/zlz057>).

Abstract: *Sarcosuchus hartii* was a top predator that inhabited the fluvial and coastal areas of north-eastern Brazil during the Early Cretaceous. Several fossil remains were recovered during the late 19th and early 20th centuries from strata that outcrop in the Recôncavo Basin in the state of Bahia. A re-analysis of this material shows that *S. hartii* is a valid species. The Brazilian taxon differs from the African *Sarcosuchus imperator* in the unique pattern of anastomosing ornamentation observed on the enamel surface. The inclusion of *S. hartii* in a novel phylogenetic analysis recovered it inside Tethysuchia, a large clade comprising South and North American pholidosaurids along Elosuchidae and Dyrosauridae. The evolutionary origin of *Sarcosuchus* is likely related to a cladogenesis event that resulted from the break-up of Gondwana.

Cidade, G.M., Fortier, D. and Hsiou, A.S. (2019). Taxonomic and phylogenetic review of *Necrosuchus ionensis* (Alligatoroidea: Caimaninae) and the early evolution and radiation of caimanines. *Zoological Journal of the Linnean Society* (<https://doi.org/10.1093/zoolinnean/zlz051>).

Abstract: Alligatoroidea is the most species-rich crocodylomorph clade of the Cenozoic of South America, with nearly all species belonging to the Caimaninae clade. However, the earliest records of Caimaninae in South America, which are from the Palaeocene, are based mostly on incomplete specimens, which increases the importance of detailed taxonomic and phylogenetic studies on these taxa. This paper offers a taxonomic and phylogenetic review of *Necrosuchus ionensis*, a caimanine species from the Salamanca Formation of the Palaeocene of Argentina. *Necrosuchus ionensis* is considered a valid species, albeit with a different diagnosis from that proposed by previous authors. The phylogenetic analysis shows, for the first time, that *N. ionensis* belongs to the derived Caimaninae clade Jacarea. However, a better understanding of the Jacarea clade is needed, and alternative placements for *N. ionensis* might be

considered. Nevertheless, the placement of *N. ionensis* as a derived caimanine raises interesting perspectives on the early evolution and radiation of caimanines, which are thoroughly discussed in this paper together with other results obtained in this study, such as the recovery of the North American caimanines *Bottosaurus* and *Tsoabichi* as a clade.

Nöthling, J.O., Nöthling, J.A. and Myburgh, J.G. (2019). The relationship between hatchling mass and egg volume in the Nile crocodile (*Crocodylus niloticus*): The productivity of eggs varies. *Suid-Afrikaanse Tydskrif vir Natuurwetenskap en Tegnologie* 38(1)

Abstract: The survival and vitality of Nile crocodile (*Crocodylus niloticus*) hatchlings is important for the success of commercial crocodile farming and the maintenance of wild populations. In this study we describe the relationship between the mass of Nile crocodile hatchlings and the estimated volume of the eggs from which they hatched and, following that, we describe the variation in the ratio between the mass of individual hatchlings and the egg volume from which each hatched (the productivity of the egg) within and among clutches. The volumes of 316 Nile crocodile eggs from 51 clutches were estimated by means of a purpose-made algorithm that uses key dimensions of eggs obtained from photos of the hatched shells. The hatchling from each egg was weighed immediately after hatching. Neither the duration of incubation prior to hatching ($P=0.88$) nor the year in which clutches were laid ($P=0.35$), nor the number of eggs per clutch ($P=0.57$) affected hatchling mass. There exists a strong, linear, positive relationship between the mass of Nile crocodile hatchlings and the estimated volume of the eggs from which they hatched ($r=0.88$, $P<0.001$, $n=316$). Without considering estimated egg volume, 86.9% of the variation in hatchling mass occurs among clutches and 13.1% within clutches. Taking estimated egg volume into account, 59% of the variation in hatchling mass occurs among clutches and 41% within clutches. Egg productivity varied from 0.57 g/ml to 0.81 g/ml, with 45.4% of the variation occurring among clutches and 54.6% within clutches. Further research is required to investigate the relationship between hatchling mass and the growth of hatchlings, as well as between egg productivity and the growth of hatchlings.

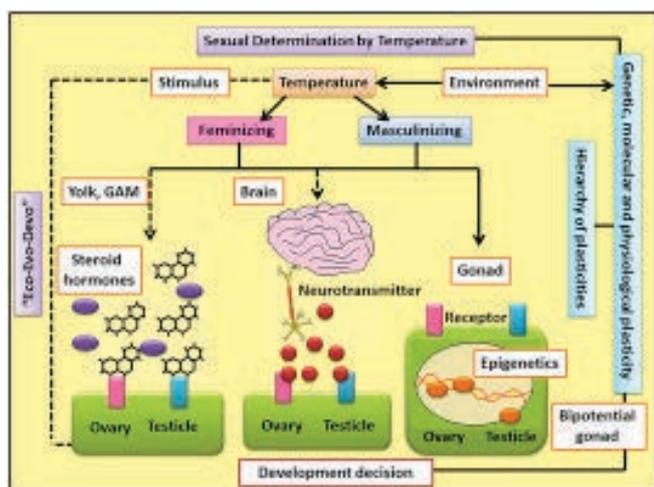
Rachlin, A., Kleinecke, M., Kaestli, M., Mayo, M., Webb, J.R., Rigas, V., Shilton, C., Benedict, S., Dyrting, K. and Currie, B.J. (2019). A cluster of melioidosis infections in hatchling saltwater crocodiles (*Crocodylus porosus*) resolved using genomewide comparison of a common north Australian strain of *Burkholderia pseudomallei*. *Microbial Genomics* (doi: 10.1099/mgen.0.000288).

Abstract: *Burkholderia pseudomallei* is a Gram-negative saprophytic bacillus and the aetiological agent of melioidosis, a disease of public health importance throughout Southeast Asia and northern Australia. Infection can occur in humans and a wide array of animal species, though zoonotic transmission and case clusters are rare. Despite its highly plastic genome and extensive strain diversity, fine-scale investigations into the population structure of *B. pseudomallei* indicate there is limited geographical dispersal amongst sequence types (STs). In the 'Top End' of northern Australia, five STs comprise 90% of the overall abundance, the most prevalent and widespread of which is ST-109. In May 2016, ST-109 was implicated in two fatal cases of melioidosis in juvenile saltwater crocodiles at a wildlife park near Darwin, Australia. To determine the probable source of infection, we sampled the crocodile enclosures and analysed the phylogenetic relatedness of crocodile and culture-positive ST-109 environmental park isolates against an additional 135 ST-109 *B. pseudomallei* isolates from the Top End. Collectively, our whole-genome sequencing (WGS) and pathology findings confirmed *B. pseudomallei* detected in the hatchling incubator as the likely source of infection, with zero SNPs identified between clinical and environmental isolates. Our results also demonstrate little variation across the ST-109 genome, with SNPs in recombinogenic regions and one suspected case of ST homoplasy accounting for nearly all

observed diversity. Collectively, this study supports the use of WGS for outbreak source attribution in highly recombinogenic pathogens, and confirms the epidemiological and phylogenetic insights that can be gained from high-resolution sequencing platforms.

Martínez-Juárez, A. and Moreno-Mendoza, N. (2019). Mechanisms related to sexual determination by temperature in reptiles. *Journal of Thermal Biology* (<https://doi.org/10.1016/j.jtherbio.2019.102400>).

Abstract: A number of strategies have emerged that appear to relate to the evolution of mechanisms for sexual determination in vertebrates, among which are genetic sex determination caused by sex chromosomes and environmental sex determination, where environmental factors influence the phenotype of the sex of an individual. Within the reptile group, some orders such as: Chelonia, Crocodylia, Squamata and Rhynchocephalia, manifest one of the most intriguing and exciting environmental sexual determination mechanisms that exists, comprising temperature-dependent sex determination (TSD), where the temperature of incubation that the embryo experiences during its development is fundamental to establishing the sex of the individual. This makes them an excellent model for the study of sexual determination at the molecular, cellular and physiological level, as well as in terms of their implications at an evolutionary and ecological level. There are different hypotheses concerning how this process is triggered and this review aims to describe any new contributions to particular TSD hypotheses, analyzing them from the “eco-evo-devo” perspective.



Graphical Abstract: Several hypotheses attempt to define how temperature influences sexual determination in reptiles. One of these suggests that steroid hormones represent an important factor in sexual determination, as well as in the differentiation of an ovary and a testicle, and that these are produced by the aromatase and 5-reductase enzymes; these enzymes can be stored in the egg yolk and produce hormones, by sending them through the bloodstream via chorion allantois; or they can be produced in the mesonephros-adrenal-gonad complex or the gonad itself. The other hypothesis states that the brain may be in charge of monitoring temperature and trigger a series of physiological responses for sexual determination, with a neurotransmitter acting as a messenger, along the hypothalamic-pituitary-gonadal axis. The last theory states that the gonad is capable of monitoring temperature, and that a receptor or epigenetic factors may be involved in sex determination in reptiles. More evidence to corroborate the latter has emerged recently. However, sexual determination by temperature is a very complex problem, in which very possibly, the genetic, molecular and physiological processes of all these hypotheses are involved, as there is evidence to show that great plasticity (hierarchy of plasticities) is required, so that during development, in response to environmental stimulus (temperature), the embryonic gonads can make a decision to differentiate into either an ovary or a testicle. Therefore TSD is a process that needs to be assessed from the perspective of the evolutionary-ecology of

development “eco-evo-devo”.

Fukuda, Y., Webb, G., Manolis, C., Lindner, G. and Banks, S. (2019). Translocation, genetic structure and homing ability confirm geographic barriers disrupt saltwater crocodile movement and dispersal. *PLoS ONE* 14(8): e0205862.

Abstract: Translocated saltwater crocodiles (*Crocodylus porosus*) in the Northern Territory (NT) of Australia often return to their original capture sites, which complicates management interventions aimed at reducing human-crocodile conflict. We examined the spatial events implicated in this homing ability, using ARGOS satellite tracking devices. Five large male *C. porosus* (3.03 m to 4.02 m TL) were shifted and released 100-320 km from their capture sites, and 3 additional ones (3.67 m to 4.23 m TL) were released at their site of capture as controls. Translocated crocodiles were more mobile than the controls, and moved at sea in the direction of their original capture site. However, they were unable or unwilling to swim around a geographic structure, Cobourg Peninsula, which prevented homing being achieved in all five cases. Two control crocodiles remained near their capture sites, but one, after the first year, made a 900-km journey for six months, before returning to its original capture and release site. Genetic analysis of tissue samples from nests across the NT coast demonstrated significant genetic structure across the coast, and confirmed that Cobourg Peninsula contributes to genetic differentiation among populations along the NT coast. These results provide new insights into *C. porosus* movements, which have management significance for the maintenance of public safety.

Patro, S. and Padhi, S.K. (2019). Saltwater crocodile and human conflict around Bhitarkanika National Park, India: A raising concern for determining conservation limits. *Ocean & Ocean Management* (<https://doi.org/10.1016/j.ocecoaman.2019.104923>).

Abstract: Recently, there has been an increase in saltwater crocodile-human interaction around Bhitarkanika National Park and the present article briefs the recent attacks of saltwater crocodiles on humans in the region. Information regarding the attacks was extracted from national newspapers and CrocBITE. It is found that in last 15 years, total of 57 persons got attacked by saltwater crocodile (*Crocodylus porosus* Schneider, 1801) in and around Bhitarkanika National Park. The trend of incidents shows that the attack on humans is increasing every year, which might be due to the increase in the density of *C. porosus* in a limited area of natural habitat. July to October was considered as the critical season when maximum attacks occur as this is the nesting and probable hatching season of *C. porosus* during which the species remain highly aggressive. In the last 42 years, since the crocodile breeding and management project implemented in India, the conservation of the species has resulted in a significant increase of their number in Bhitarkanika National Park. Existing reports suggest that the present density of *C. porosus* in Bhitarkanika National Park has surpassed the value (5 to 6 crocodiles per km length of water) which was proposed while initiating the conservation programme. The present scenario demands for development and implementation of an updated management plan for the coexistence of humans and saltwater crocodiles. The conservation and management strategy of SWCs shall include determination of carrying capacity of the sanctuary, minimizing exploitation of natural resources, relocation of the SWCs to other feasible sites, creating awareness among local people, development of alternative livelihood for the locals and construction of more number of bath huts along the water bodies.

Rice, P.M. (2019). Crocodiles, sharks, and some speculations on central Peten preclassic history. *Ancient Mesoamerica* (<https://doi.org/10.1017/S0956536119000099>).

Abstract: The first part of this two-part essay discusses the important roles crocodiles and sharks played in Preclassic (and later) political

geography and myths of cosmogenesis in Mesoamerica. They are associated with sacrifices resulting in creation of the world and births of some major gods. Crocodiles are also associated with fertility, rebirth, and renewal of seasonal and temporal/calendrical cycles. Recent investigations at Nixtun-Ch'ich' show that its gridded urban landscape, established in the Middle Preclassic period (ca. 800-400 b.c.), was likely modeled on a crocodile's back. The second part of the essay presents some speculations on the early role of this site and crocodiles in central Peten. At Tikal, archaeology and retrospective texts indicate that crocodiles appeared in early versions of the site's emblem glyph and in the namD.e of an early ruler. Nixtun-Ch'ich' might be the legendary chi place, important in the dynastic foundations of several lowland Maya centers.

Nóbrega, Y.C., da Paz, J.S., Nossa, D.N., Silva, T.T., Menezes, P.Q., Curbani, F., Silva-Soares, T., de Faria da Silva, E.L., Tobias, F.L., Tadokoro, C.E. and Santos, M.R.D. (2019). Biological hazard associated with bacteria from nests and eggs of *Caiman latirostris* (Daudin, 1802). *Herpetology Notes* 12: 905-908.

Marchetti, I., Ricardi-Branco, F., Callefo, F., Delcourt, R., Galante, D., Jurigan, I., Carvalho, I.S. and Tavares, S.A.S. (2019). Fossildiagenesis and ontogenetic insights of crocodyliform bones from the Adamantina Formation, Bauru Basin, Brazil. *Journal of South American Earth Sciences* (<https://doi.org/10.1016/j.jsames.2019.102327>).

Abstract: The histological analysis of fossil bones allows a taphonomic approach, especially to fossildiagenesis. We studied the femur, vertebra, and osteoderm of the crocodyliform *Montealtosuchus arrudacamposi* (Adamantina Formation; Late Cretaceous), understand the sequence of the diagenetic processes from buried carcasses. Cross-sections of the bones and the rock matrix that fills the medullary cavity were analysed under a scanning electron microscopy with compositional analysis (SEM/EDS) and μ -X-Ray fluorescence (μ -XRF). The microstructural pattern of the femur and vertebra was similar, with a transition from vascularised internal cortex fibrolamellar with reticular and longitudinal canals to zonal lamellar in the outer, and a medullary cavity portion filled with quartz and other mineral grains. The osteoderm, however, has a less vascularised cortex. In all samples were found the external fundamental system (EFS), secondary osteons in the internal cortex and spongy tissue, and the transition from a fibrolamellar to a lamellar tissues, indicating that the individuals might reached ontogenetic maturity (adult/senescent) before they died. The compositional results showed that the samples mainly comprised calcium and phosphorus, were homogeneously distributed. However, we inferred these elements occurred during the formation of recrystallized and authigenic minerals. Iron, vanadium, and cerium are the elements found that occurred in the composition of the fossil remains during early diagenesis, and this process was found to extend to the late diagenesis. Cerium was homogeneously distributed and incorporated to authigenic apatite. Iron and vanadium were restricted to the cortex. The presence of authigenic apatite and Rare Earth Elements (REEs) in the samples support that the diagenetic environment of the Adamantina Formation was alkaline. Furthermore, it possibly indicates an association with a groundwater environment, that have allowed and facilitated the fossilization process of the good vertebrate records in this geological formation.

Welgemoed, L. (2019). An Experimental Investigation of Interspecies Variation in Mechanical Properties of Cortical Bone. MSc thesis, University of Capetown, Capetown, South Africa. (<http://hdl.handle.net/11427/30538>).

Abstract: Cortical bone has been found to display properties that vary greatly, with most previous work focused on human or bovine bone. The main aim of this research was to investigate mechanical properties of cortical bone from various species of animal (ostrich,

baboon, crocodile and sheep) to allow for comparison of mechanical properties across species, as well as investigate the relationship of material properties to strain rate within each species. This information is valuable for use in modelling. Testing was performed quasistatically and at the high end of the intermediate strain rate regime. These higher rate tests were performed on a modified Split Hopkinson bar setup. A Cone-in-Tube striker was used to provide a near constant strain rate during testing. The use of a momentum trapping system was investigated, but was not practically useful for the scale of specimens and strain rates investigated. It was found that properties of bone from all species displayed a clear dependence on strain rate. The relationship between the properties and strain rate were very similar across all species investigated, although the ultimate values differed. The apparent modulus showed a distinct increase when testing at a higher strain rate than when testing quasistatically. The compressive strength (both yield and ultimate) displayed an increase over the quasistatic range tested and then levelled out at the higher rate. There was greater difference seen in the values of apparent modulus than in the compressive strengths for all species tested. Baboon bone consistently displayed the greatest properties for both apparent modulus and compressive strength, and crocodile the weakest. It was also found that, despite whole bones and specimens being frozen at -32°C, with the specimens frozen in normal saline, a change in the material properties of the bone occurred over time. Apparent moduli decreased, and compressive strengths stayed constant or increased slightly. Less change was seen in the strength than in the apparent modulus.

Butfiloski, J. (2019). South Carolina Private Lands Alligator Program Guide. South Carolina State Library: Columbia, South Carolina.

Abstract: This booklet was developed to provide basic information regarding the private lands alligator harvest season and what hunters will need in order to familiarize themselves with taking alligators. It includes common hunting techniques, safety tips, how to harvest an alligator, requirements for processing an alligator, and how to care for an alligator hide.

Scarpa, L.J. and Piña, C.I. (2019). The use of drones for conservation: A methodological tool to survey caimans nests density. *Biological Conservation* 238 (<https://doi.org/10.1016/j.biocon.2019.108235>).

Abstract: The use of drones, or unmanned aerial vehicles (UAVs), is a burgeoning facet of conservation biology with the potential to revolutionize the way in which animals and habitats are monitored. Recently, the location and distribution of caiman nests were mainly carried out by helicopters, paramotoring, and small plane for the identification and validation of nesting sites. The methods chosen for counting caimans are limited by interpretation difficulties when comparing densities observed in different habitats or with different visibility conditions or environmental variables. In this research, flights with drones were conducted in order to estimate the density amount of the caiman nests, quantify the nests potential in the monitored areas, and evaluate whether the current nest harvest in Corrientes Province is within the acceptable limits for a sustainable program. The use of this technology allows researchers to sample the presence of nests, their quantification, and georeferentiation, but also to find an absolute density of nests and to extrapolate it to other areas with similar habitat conditions.

Kanda, R. (2019). Reproductive impact of environmental chemicals on animals. Pp. 41-70 in *Reproductive Sciences in Animal Conservation. Advances in Experimental Medicine and Biology*, vol 1200, ed. by P. Comizzoli, J. Brown and W. Holt. Springer: Cham.

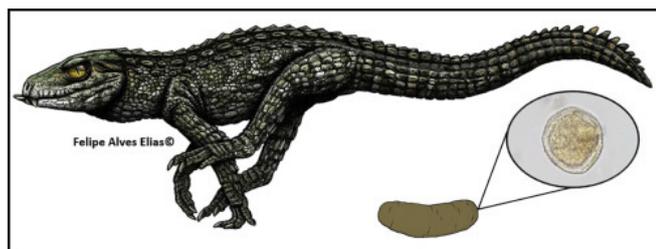
Abstract: Wildlife is exposed to a diverse range of natural and man-made chemicals. Some environmental chemicals possess specific endocrine disrupting properties, which have the potential to disrupt

reproductive and developmental process in certain animals. There is growing evidence that exposure to endocrine disrupting chemicals plays a key role in reproductive disorders in fish, amphibians, mammals, reptiles and invertebrates. This evidence comes from field-based observations and laboratory based exposure studies, which provide substantial evidence that environmental chemicals can cause adverse effects at environmentally relevant doses. There is particular concern about wildlife exposures to cocktails of biologically active chemicals, which combined with other stressors, may play an even greater role in reproductive disorders than can be reproduced in laboratory experiments. Regulation of chemicals affords some protection to animals of the adverse effects of exposure to legacy chemicals but there continues to be considerable debate on the regulation of emerging pollutants.

Lin, M., Zeng, C., Li, Z., Ma, Y. and Jia, X. (2019). Comparative analysis of the composition and function of fecal-gut bacteria in captive juvenile *Crocodylus siamensis* between healthy and anorexic individuals. *Microbiologyopen*. 2019: e929 (doi: 10.1002/mbo3.929).

Abstract: The Siamese crocodile (*Crocodylus siamensis*) is a freshwater, endangered crocodile with high economic value in the farming industry. Gut microflora plays an essential role in host physiological activity, and it contributes significantly to both the health and diseased states of animals. However, thus far, no study has focused on the correlation between diseases and intestinal bacterial communities in crocodylians. Here, we first compared the composition and function of gut microbial communities in captive juvenile *C. siamensis* suffering from anorexia and healthy crocodile controls using deep amplicon sequencing. The gut microbial diversity of anorexic crocodiles was much lower than the healthy individuals. Obvious changes in gut microbial composition were observed between sick and healthy crocodiles, except for *Cetobacterium somerae* of phylum Fusobacteria. In particular, the abundance of *Bacteroides luti*, *Clostridium disporicum*, *Plesiomonas shigelloides*, and *Odoribacter* sp. in the gut flora of healthy crocodiles was distinctly higher than the diseased group. Conversely, the species *Edwardsiella tarda* was overrepresented in the gut of anorexic crocodiles compared to the healthy group. Furthermore, in anorexic crocodiles, the predicted microbial functions that were related to amino acid metabolism, biosynthesis of other secondary metabolites, nucleotide metabolism, replication and repair, and translation were significantly reduced, while signal transduction was significantly enriched. These findings of the present study provide a reference to enrich the field of gut microorganism studies in crocodylians and suggest that alterations in the composition and function of gut bacteria in *C. siamensis* juveniles may be associated with anorexia in crocodiles.

Cardia, D.F.F., Bertini, R.J., Camossi, L.G. and Letizio, L.A. (2019). Two new species of ascaridoid nematodes in Brazilian Crocodylomorpha from the Upper Cretaceous. *Parasitol Int.* 72 (doi: 10.1016/j.parint.2019.101947).



Abstract: Two new ascaridoid species, *Bauruascaris cretacicus* n. gen. et n. sp., and *Bauruascaris adamantinensis* n. gen. et n. sp., are described based on the fossils of eggs preserved in 80-70 million year old phosphatized coprolites of Crocodyliformes, chronologically assigned to the Upper Cretaceous (Campanian/

Maastrichtian age), collected from sedimentary rocks of the Bauru Group, Adamantina Formation in the municipality of Santo Anastácio, in the southwestern region of the state of São Paulo, Brazil, South America. This paper describes the oldest ascaridoid species ever recorded in Crocodylomorpha. Hence, this article contributes to the body of knowledge about the evolutionary history of this nematode group. It also offers a clue about the composition of the parasite fauna of these reptiles from the Late Cretaceous, which is still unknown despite numerous studies about various aspects of their biology and the pioneering paleoparasitological analysis of animal coprolites by South American researchers.

Somaweera, R., Brien, M.L., Sonneman, T., Didham, R.K. and Webber, B.L. (2019). Absence of evidence is not evidence of absence: Knowledge shortfalls threaten the effective conservation of freshwater crocodiles. *Global Ecology and Conservation* (<https://doi.org/10.1016/j.gecco.2019.e00773>).

Abstract: The extensive alteration of freshwater habitat across the globe has resulted in the decline of a number of wildlife species, some of which now face extinction. Large-bodied species are frequently at greatest risk. However, identifying the direct and indirect pathways of impact on these long-lived and often cryptic predators has proven challenging. Since the cessation of commercial crocodile hunting in northern Australia in the 1970s, the assumption has been that populations of both the saltwater crocodile (*Crocodylus porosus*) and freshwater crocodile (*Crocodylus johnstoni*) would recover naturally. While extensive population monitoring of the saltwater crocodile has occurred, there has been limited ongoing monitoring of the freshwater crocodile to test this assumption. Moreover, there is growing concern that the increasing threat from global environmental change, including invasive alien species, anthropogenic landscape modification, agricultural pollutants, and other human activities, may jeopardise the recovery and long-term conservation of the freshwater crocodile. Here we summarise existing knowledge on the various direct and indirect threats this species faces and prioritise future actions to increase the likelihood of effective conservation outcomes for freshwater crocodiles. Although an in-depth understanding of the magnitude and dynamics of the majority of these emerging threats is still lacking, it is becoming clear that they are acting in previously unexpected ways, leading to novel combinations of cascading direct and indirect impacts.

Arroyo-Quiroz, I. and Wyatt, T. (2019). Wildlife trafficking between the European Union and Mexico. *International Journal for Crime, Justice and Social Democracy* 8(3): 23-37.

Abstract: Illegal wildlife trade or wildlife trafficking is a global threat to all kinds of species, not just charismatic megafauna or wildlife in Africa and Asia. This paper presents the findings of an investigation of the illegal trade in native and non-native wildlife and wildlife products between the European Union and Mexico. Using literature analysis, secondary trade data and expert interviews, this study explores the nature and extent of wildlife trafficking between these two regions, including the involvement of organised crime within an eco-global criminological framework. This is important for the regions studied and for the global community more generally, as wildlife trafficking is contributing not only to species extinction, but also to instability, violence and unhealthy physical environments for humans.

Frost, T.B. (2019). Death comes for a crocodile. *National Geographic* September 2019: 38-40.

McNabb, N.A., Bernhard, M.C., Brunell, A., Lowers, R.H., Katsu, Y., Spyropoulos, D.D. and Kohno, S. (2019). Oil dispersant Corexit 9500 is weakly estrogenic, but does not skew the sex ratio in *Alligator mississippiensis*. *Journal of Applied Toxicology* (doi:

Abstract: During the Deepwater Horizon oil spill, vast quantities of a chemical dispersant Corexit 9500 were applied in remediation efforts. In addition to the acute toxicity, it is essential to evaluate Corexit further with a broader scope of long-term sublethal endocrine endpoints. The American alligator (*Alligator mississippiensis*) is an excellent organism for such an endeavor. It exhibits temperature-dependent sex determination, in which egg incubation temperatures during a thermosensitive period (TSP) in embryonic development determine the sex of embryos. Estrogen signals play a critical role in this process. For example, a single exposure to exogenous estrogen during the TSP overrides the effects of temperature and leads to skewed sex ratios. At a concentration of 100 ppm, Corexit significantly induced transcriptional activity of both alligator nuclear estrogen receptors 1 and 2 *in vitro* in reporter gene assays. To investigate the estrogenic effects of Corexit on gonadal development, alligator eggs were exposed to Corexit at environmentally relevant concentrations (0.25, 2.5 and 25 ppm) before the TSP *in ovo*. Exposure to Corexit at 0.25 and 25 ppm significantly delayed hatching and growth. Corexit exposure at any treatment level did not affect sex ratios or testicular mRNA abundance as measured at 1-week post-hatching, suggesting that the combination of Corexit components did not synergize enough to induce ovarian development *in ovo*. These results point to a need for further investigations on individual and combined components of Corexit to understand better their long-term effects on the development and reproductive health of alligators and other coastal aquatic wildlife.

Kawai, N. (2019). Other types of studies showing that snakes hold special status in threat perception. *In* The Fear of Snakes. The Science of the Mind. Springer: Singapore.

Abstract: Abundant evidence has shown that human and nonhuman primates have perceptual biases for rapid detection of evolutionarily fear-relevant stimuli (snakes) in terms of threat perception using the visual search paradigm. There are, however, several levels at which one can criticize these paradigms. In this chapter, I summarize the problems with visual search studies. Then, I explore electroencephalogram studies using the early posterior negativity (EPN), an event-related potential (ERP) component that reflects early selective visual processing of emotionally significant information, which increases when evolutionarily relevant threat stimuli are presented. Some studies have found that EPN amplitudes in response to snake images are larger than are those for spider or crocodile images. This larger EPN for snakes is interpreted as increased source activity in visual areas, as projected from the amygdala by triggering fear circuits. Of course, this projection route confers a significant advantage for primates to rapidly respond to potential risks, helping them to evolve efficiently. These results suggest that humans are predisposed to attend rapidly to snakes through our evolutionary lineage and confirm that spiders do not appear to hold special early attentional value. Being able to avoid the sharp fangs and potentially lethal venom of attacking snakes has an obvious benefit. However, snakes use camouflage-based hunting strategies. Therefore, quick detection of snakes may not be sufficient for escape. Ancestral primates would have been equipped to recognize snakes' camouflage. We tested whether humans are better at recognizing snakes' camouflage as compared to other animals using an image manipulation tool, called the RISE technique. We showed pictures of partially obscured snakes and other animals and found that participants could identify snakes in much blurrier images as compared to other harmless animals. This study provides new evidence that humans are finely tuned to see snakes, even when they are highly camouflaged or barely visible.

Mandujano-Camacho, H., Hénaut, Y.L., Crocoft, R.B. and Vliet, K. (2019). Effect of prehatching calls of *Crocodylus moreletii* on the duration and number of hatchings. *Acta Universitaria* 29: e2211.

Abstract: Different *ex situ* nestings of *Crocodylus moreletii* underwent playbacks. These varied based on the vocalization they emit, either at the beginning or at the end of the hatching process, as well as at the repetition rate (fast or slow). Playbacks with a different rate of vocal repetition of a call for help of *Caiman crocodilus* were included. Other nestings were incubated in silence. The hatchings lasted less time and there were more group hatchings with the final vocalization playbacks of *C. moreletii* and *C. crocodilus*, both with rapid repetition rate. The nests subjected to playbacks of initial vocalization with slow repetition rate and the nests in silence took longer to hatch, and fewer group hatches occurred. The type of vocalization and the rate of vocal repetition influence on the duration of hatching and the number of individuals that hatch together.

Zajdel, J., Lance, S.L., Rainwater, T.R., Wilkinson, P.M., Hale, M.D. and Parrott, B.B. (2019). Mating dynamics and multiple paternity in a long-lived vertebrate. *Ecology and Evolution* (doi: 10.1002/ece3.5438).

Abstract: Multiple paternity is relatively common across diverse taxa; however, the drivers and implications related to paternal and maternal fitness are not well understood. Several hypotheses have been offered to explain the occurrence and frequency of multiple paternity. One set of hypotheses seeks to explain multiple paternity through direct and indirect benefits including increased genetic diversity or enhanced offspring fitness, whereas another set of hypotheses explains multiple paternity as a byproduct of sexual conflict and population-specific parameters such as density. Here, we investigate mating system dynamics in a historically studied population of the American alligator (*Alligator mississippiensis*) in coastal South Carolina. We examine parentage in 151 nests across 6 years and find that 43% of nests were sired by multiple males and that male reproductive success is strongly influenced by male size. Whereas clutch size and hatchling size did not differ between singly sired and multiply sired nests, fertility rates were observed to be lower in multiply sired clutches. Our findings suggest that multiple paternity may exert cost in regard to female fitness, and raise the possibility that sexual conflict might influence the frequency of multiple paternity in wild alligator populations.

Cohen, E. (2019). Interacting with wild animals. Pp. 220-240 *in* Tourist Behaviour, ed. by P.L. Pearce. Edward Elgar Publishing Ltd.: Cheltenham, UK.

Abstract: This chapter considers the four contexts or types of situations in which tourists interact with wild animals. Four kinds of settings are identified, from fully-natural ones, which are not framed and the wild animals are unrestrained, through increasingly framed semi-natural and semi-contrived ones, to fully-contrived settings, in which nominally wild animals are severely restrained and manipulated, mainly to attract tourists. It is argued that the neoliberalisation of these encounters has resulted in a hidden commodification of tourist-animal interaction in all types of settings in recent decades. In some of the settings discussed, specialist companies have facilitated close encounters with wild animals in natural settings, as well as in commercial establishments, so that the spectators become willing victims to an illusion of wildness. The important issue of the ethics of treating animals inappropriately and in exploitative ways is highlighted.

Schofield, G., Esteban, N., Katselidis, K.A. and Hays, G.C. (2019). Drones for research on sea turtles and other marine vertebrates - A review. *Biological Conservation* 238 (<https://doi.org/10.1016/j.biocon.2019.108214>).

Abstract: We review how unmanned aerial vehicles (UAVs), often referred to as drones, are being deployed to study the abundance and behaviour of sea turtles, identifying some of the commonalities and differences with studies on other marine vertebrates, including

marine mammals and fish. UAV studies of all three groups primarily focus on obtaining estimates of abundance, distribution and density, while some studies have provided novel insights on the body condition, movement and behaviour of individuals (including inter-specific interactions). We discuss the emerging possibilities of how UAVs can become part of the standard methodologies for sea turtle ecologists through combining information on abundance and behaviour. For instance, UAV surveys can reveal turtle densities and hence operational sex ratios of sea turtles, which could be linked to levels of multiple paternity. Furthermore, embedding UAV surveys within a mark-recapture framework will enable improved abundance estimates. The complexity of behaviours revealed by direct observations of sea turtles and animal-borne cameras can also be examined using UAV footage, complementing studies using electronic tags, such as time-depth recorders and satellite transmitters. Overall, UAVs provide a low-cost approach of quantifying the flexibility of marine animal behaviour, allowing us to integrate information on abundance to establish how individuals respond to the presence of other organisms and the immediate environment.

Atanga, R.A. (2019). Stakeholder views on sustainable community-based ecotourism: a case of the Paga Crocodile Ponds in Ghana. *GeoJournal of Tourism and Geosites* 25(2): 321-333.

Abstract: This study analysed tourism at the Paga Crocodile Ponds in the Upper East Region of Ghana as a basis to evaluate its potential for sustainable community-based ecotourism development. The study employed qualitative case study approach, using data from secondary and primary sources that involved in-depth interviews with key actors in the tourism sector of the community in Ghana. Results of the study suggest that tourism in the community is in its developing stage. The Paga Crocodile Ponds attract international and domestic tourists, and tourism influences the socio-cultural, economic, and environmental livelihood of the community. The research found that the ponds were silted and experiencing threats of drought and competition from other uses of the water. Tourism at Paga is mainly managed by the traditional community leaders with insufficient tourism infrastructure and therefore needs support from government and other stakeholders. The results suggest that a sustainable community-based ecotourism development in the community require improvement in stakeholder involvement, environmental sanitation and water level of the ponds.

Forero, Sr., M.G., Lozano, J.J. and Balaguera-Reina, S.A. (2019). Individual identification automation in Crocodylians through imagery processing: American Crocodile as a study case. *In Proceedings SPIE 11137, Applications of Digital Image Processing XLII*.

Abstract: The identification of a crocodile is a complex process. The most used method is invasive and dangerous. Recently, a new method, non-invasive, was introduced, in which the crocodile is identified by its number of post-occipital scales, nuchals, and backs. However, the scale count is done manually. In this work, we present a method based on image processing for the identification and counting of scales improving the above-mentioned method. The results obtained are reproducible and more reliable, facilitating the identification of the crocodiles for their population study.

Hoekstra, L.A., Schwartz, T.S., Sparkman, A.M., Miller, D.A.W. and Bronikowski, A.M. (2019). The untapped potential of reptile biodiversity for understanding how and why animals age. *Functional Ecology* (<https://doi.org/10.1111/1365-2435.13450>).

Abstract: The field of comparative aging biology has greatly expanded in the past 20 years. Longitudinal studies of populations of reptiles with a range of maximum lifespans have accumulated and been analyzed for evidence of mortality senescence and

reproductive decline. While not as well represented in studies of amniote senescence, reptiles have been the subjects of many recent demographic and mechanistic studies of the biology of aging. We review recent literature on reptile demographic senescence, mechanisms of senescence, and identify unanswered questions. Given the ecophysiological and demographic diversity of reptiles, what is the expected range of reptile senescence rates? Are known mechanisms of aging in reptiles consistent with canonical hallmarks of aging in model systems? What are the knowledge gaps in our understanding of reptile aging? We find ample evidence of increasing mortality with advancing age in many reptiles. Testudines stand out as slower aging than other orders, but data on crocodylians and tuatara are sparse. Sex-specific analyses are generally not available. Studies of female reproduction suggest that reptiles are less likely to have reproductive decline with advancing age than mammals. Reptiles share many physiological and molecular pathways of aging with mammals, birds, and laboratory model organisms. Adaptations related to stress physiology coupled with reptilian ectothermy suggest novel comparisons and contrasts that can be made with canonical aging phenotypes in mammals. These include stem cell and regeneration biology, homeostatic mechanisms, IIS/TOR signaling, and DNA repair. To overcome challenges to the study of reptile aging, we recommend extending and expanding long-term monitoring of reptile populations, developing reptile cell lines to aid cellular biology, conducting more comparative studies of reptile morphology and physiology sampled along relevant life-history axes, and sequencing more reptile genomes for comparative genomics. Given the diversity of reptile life histories and adaptations, achieving these directives will likely greatly benefit all aging biology.

Porcier, S.M., Berruyer, C., Pasquali, S., Ikram, S., Berthet, D. and Tafforeau, P. (2019). Wild crocodiles hunted to make mummies in Roman Egypt: Evidence from synchrotron imaging. *Journal of Archaeological Science* 110 (<https://doi.org/10.1016/j.jas.2019.105009>).

Abstract: An ancient Egyptian crocodile mummy (MHNL 90001591, Musée des Confluences, Lyon, France) dating to the Roman period and discovered at Kom Ombo (Upper Egypt) was analysed through synchrotron multiscale microtomography. Using this advanced technology, the virtual autopsy of the animal was carried out without affecting the bones, flesh, balms and linen bandages. The technique allows for the precise analysis of the specimen's bones and tissue, enabling us to establish the cause of death and the last meal(s) of the animal. From these data, we can conclude that this crocodile was hunted while living in the wild. This is the first evidence for this mode of obtaining animals to produce mummies. With this case study, it is apparent that the praxis related to the mummification of animals in ancient Egypt are more diverse than the current Egyptological reconstruction of that phenomenon.

Singh, M., Kaptchuck, T. and Henrich, J. (2019). Small gods, rituals, and cooperation: The Mentawai crocodile spirit Sikaoinan. *SocArXiv* (doi: 10.31235/osf.io/npkdy).

Abstract: Researchers focus on the powerful deities of large-scale societies, yet little work has examined punitive deities in small-scale societies. Here, in a detailed study of Mentawai's crocodile spirit Sikaoinan (Siberut Island, Indonesia), we start to fill this gap by addressing three key questions: (1) Are smaller gods believed to enforce cooperation, especially compared to bigger gods in larger-scale societies? (2) Do beliefs in these deities encourage people to incur costs? and (3) Does ritual produce beliefs in these deities? Drawing on systematic interview responses, behavioral data from healing ceremonies, and long-term ethnographic research, we show that Sikaoinan is believed to punish people who do not share meat with fellow clan members. Beliefs that Sikaoinan has attacked them motivate patients and their families to host costly healing ceremonies in which shamans remove the spirit from the

patient's house. The public nature of these ceremonies, involving prestigious individuals speaking to Sikaoinan and apologizing to it for the patient's stinginess, reinforce onlookers' beliefs about Sikaoinan. Throughout Siberut, the most widely-shared beliefs about Sikaoinan are represented in the ritual while beliefs not represented vary considerably, indicating that ritual may be a potent cultural transmission mechanism. These results suggest that moralizing supernatural punishers may be commonplace and that the important trend in the cultural evolution of religion has been the expansion of deities' scope, powers, and monitoring abilities.

Banon, G.P.R., Banon, G.J.F., Villamarín, F., Arraut, E.M., Moulatlet, G.M., Rennó, C.D., Banon, L.C., Marioni, B. and De Moraes Novo, E.M.L. (2019). Predicting suitable nesting sites for the Black caiman (*Melanosuchus niger* Spix 1825) in the Central Amazon basin. *Neotropical Biodiversity* 5(1): 47-59.

Abstract: After many years of illegal hunting and commercialization, the populations of the Black caiman (*Melanosuchus niger*) have been recovering during the last four decades due to the enforcement of a legislation that inhibits their international commercialization. Protecting nesting sites, in which vulnerable life forms (as reproductive females, eggs, and neonates) spend considerable time, is one of the most appropriate conservation actions aimed at preserving caiman populations. Thus, identifying priority areas for this activity should be the primary concern of conservationists. As caiman nesting sites are often found across the areas with difficult access, collecting nest information requires extensive and costly fieldwork efforts. In this context, species distribution modeling can be a valuable tool for predicting the locations of caiman nests in the Amazon basin. In this work, the maximum entropy method (MaxEnt) was applied to model the *M. niger* nest occurrence in the Mamirauá Sustainable Development Reserve (MSDR) using remotely sensed data. By taking into account the *M. niger* nesting habitat, the following predictor variables were considered: conditional distance to open water, distance to bare soil, expanded contributing area from drainage, flood duration, and vegetation type. The threshold-independent prediction performance and binary prediction based on the threshold value of 0.9 were evaluated by the area under the curve (AUC) and performing a binomial test, respectively. The obtained results (AUC= 0.967 ± 0.006 and a highly significant binomial test P<0:01) indicated excellent performance of the proposed model in predicting the *M. niger* nesting occurrence in the MSDR. The variables related to hydrological regimes (conditional distance to open water, expanded contributing area from drainage, and flood duration) most strongly affected the model performance. MaxEnt can be used for developing community-based sustainable management programs to provide socioeconomic benefits to local communities and promote species conservation in a much larger area within the Amazon basin.

Banon, G., Arraut, E., Villamarín, F., Marioni, B., Moulatlet, G., Rennó, C., Banon, G. and Novo, E. (2019). A review on crocodylian nesting habitats and their characterisation via remote sensing. *Amphibia-Reptilia* (doi:10.1163/15685381-20191159).

Abstract: Crocodylians usually remain inside or near their nests during most vulnerable life stages (as eggs, neonates and reproductive females). Thus, protection of nesting sites is one of the most appropriate conservation actions for these species. Nesting sites are often found across areas with difficult access, making remote sensing a valuable tool used to derive environmental variables for characterisation of nesting habitats. In this study, we (i) review crocodylian nesting habitats worldwide to identify key variables for nesting site distribution: proximity to open-water, open-water stability, vegetation, light, precipitation, salinity, soil properties, temperature, topography, and flooding status, (ii) present a summary of the relative importance of these variables for each crocodylian species, (iii) identify knowledge gaps in the use of remote sensing methods currently used to map potential crocodylian nesting sites,

and (iv) provide insight into how these remotely sensed variables can be derived to promote research on crocodylian ecology and conservation. We show that few studies have used remote sensing and that the range of images and methods used comprises a tiny fraction of what is available at little to no cost. Finally, we discuss how the combined use of remote sensing methods - optical, radar, and laser - may help overcome difficulties routinely faced in nest mapping (eg cloud cover, flooding beneath the forest canopy, or complicated relief) in a relevant way to crocodylians and to other semiaquatic vertebrates in different environments.

Ghosh, A., Johnson, M.G., Osmanski, A.B., Louha, S., Bayona-Vásquez, N.J., Glenn, T.C., Gongora, J., Green, R.E., Isberg, S., Stevens, R.D. and Ray, D.A. (2019). A high-quality reference genome assembly of the saltwater crocodile, *Crocodylus porosus*, reveals patterns of selection in Crocodylidae. *BioRxiv* (doi: <https://doi.org/10.1101/767939>).

Abstract: Crocodylians are an economically, culturally, and biologically important group. To improve researchers' ability to study genome structure, evolution, and gene regulation in the clade, we generated a high-quality de novo genome assembly of the saltwater crocodile, *Crocodylus porosus*, from Illumina short read data from genomic libraries and in vitro proximity-ligation libraries. The assembled genome is 2123.5 Mb, with N50 scaffold size of 17.7 Mb and N90 scaffold size of 3.8 Mb. We then annotated this new assembly, increasing the number of annotated genes by 74%. In total, 96% of 23,242 annotated genes were associated with a functional protein domain. Furthermore, multiple non-coding functional regions and mappable genetic markers were identified. Upon analysis and overlapping the results of branch length estimation and site selection tests for detecting potential selection, we found 16 putative genes under positive selection in crocodylians, 10 in *C. porosus* and 6 in *A. mississippiensis*. The annotated *C. porosus* genome will serve as an important platform for osmoregulatory, physiological and sex determination studies, as well as an important reference in investigating the phylogenetic relationships of crocodylians, birds, and other tetrapods.

Clarke, G.S., Hudson, C.M. and Shine, R. (2019). Encounters between freshwater crocodiles and invasive cane toads in north-western Australia: Does context determine impact? *Australian Zoologist*.

Abstract: The potent defensive chemicals of cane toads (*Rhinella marina*) protect them against predators that lack coevolved physiological tolerance to those toxins. That relative invulnerability may explain why major injuries (such as limb loss) appear to be rare in cane toads from most of their global range; however, we noted frequent predator-induced injuries (>4% of adults) in samples from within the toad's native range (in French Guiana) and from a site (Lake Argyle) in north-western Australia. Toads at Lake Argyle enter the lake at night to rehydrate, exposing them to foraging freshwater crocodiles (*Crocodylus johnstoni*). Crocodiles rarely consume toads, but the attacks often result in loss of a limb. Because limbs contain relatively little toxin, attacks to the limbs expose a crocodile to nauseating but non-lethal amounts of toxin; and hence, facilitate taste aversion learning by the predator. This may help to explain why the invasion of cane toads has not significantly impacted on crocodile populations at this site, in contrast to heavy impacts reported from nearby riverine systems.

Brown, J. (2019). American Alligator (*Alligator mississippiensis*) Populations Surveys and Nest Counts in the Big Thicket National Preserve, Texas. MSc thesis, Lamar University, Beaumont, Texas, USA.

Abstract: The American alligator (*Alligator mississippiensis*) plays a vital role in determining ecosystem integrity. An alligator population

survey has never been performed within the Big Thicket National Preserve (BTNP), and little research has been conducted on alligator populations within rivers. The preserve contains part of the Neches River, along with two major tributaries. We predicted that the BTNP would contain a low abundance and unequal distribution of alligators, with much of the population near the north and south ends of the preserve, where more suitable habitat is located near the preserve boundaries, including a large lake and coastal marshland. We conducted nighttime, spot-light surveys in October 2017, May 2018, and August 2018, and daytime nest surveys in January 2018 and September 2018. Day surveys included surveying waterbodies near the Neches River for alligator dens, nests, prints, and slide outs. During night surveys, we recorded water chemistry every 8 km and recorded the location, length, and local habitat for each alligator. Recorded data was combined with climatic factors, water chemistry, and land use type and then analyzed using a regression model to determine which factors correlate with alligator densities. Results show that alligator densities are highest in areas near open water. Developed areas and areas with woody wetland habitat had a negative correlation with alligator densities. Each survey revealed similar distributions, with alligators congregated at the north and south ends of the preserve and few alligators located within the middle of the survey area. This suggests the northernmost and southernmost edges of BTNP are near more favorable habitats. Most of the alligators near the northern boundary were subadults and, because of their proximity to Steinhagen Lake, may have been forced out of the lake by larger adults. Individuals near the southern boundary included yearlings and subadults, with very few adults. The marshlands near the south end of the survey area provide preferred habitat compared to the woody shorelines of the lower Neches River within the BTNP. Much of the southern marshes within the preserve remain unsurveyed, and these areas could be suitable habitat for larger alligators, while smaller alligators were forced into the main channels of the lower Neches River and its tributaries.

Rash, R. and Lillywhite, H.B. (2019). Drinking behaviors and water balance in marine vertebrates. *Marine Biology* 166 (<https://doi.org/10.1007/s00227-019-3567-4>).

Abstract: Acquisition of fresh water is important to animals, and is both difficult and critical for species residing in marine environments. Adaptive radiations to fully marine habitats were constrained by the need for fresh water and the capacity of various taxa to adapt physiology to reliance on sources of water other than free drinking water. Here, we review the water relations of marine vertebrates, with an emphasis on drinking and the need to procure fresh water. Numerous marine teleost fishes drink seawater, but some do not, and drinking is more variable and complex than suggested by textbooks. The mechanisms by which fishes and other vertebrates regulate water balance involve the renin-angiotensin and aldosterone endocrine systems, but plasma osmotic and ionic concentrations as well as other chemical signals can also be involved. Multiple mechanisms for stimulation of drinking are operative and diverse among species. Clearly, evolutionary adaptations to environmental salinities can alter drinking behaviors. Marine elasmobranchs do not characteristically drink seawater, but euryhaline species drink upon returning to more concentrated seawater, as with teleosts. Hagfish are osmoconformers, and there is no evidence for drinking. In general, marine reptiles and most marine mammals and seabirds do not drink seawater. Exceptions include sea turtles, cetaceans, and some pinnipeds. Some marine species (eg sea snakes) require fresh water that can be acquired from ephemeral rainwater lenses, while others are adapted to utilize dietary and metabolic water. Regardless of drinking behaviors, numerous forms have evolved varied strategies for conserving water while reducing its losses to the surrounding sea.

Zhao, J., Xu, W., Tu, G., Zhou, Y. and Wu, X. (2019). Sensitive and rapid detection of *Ortleppascaris sinensis* (Nematoda: Ascaridoidea) by loop-mediated isothermal amplification. *PeerJ* 7: e7607.

Abstract: *Ortleppascaris sinensis* is the dominant nematode species infecting the gastrointestinal tract of the captive Chinese alligator, a critically endangered species. Gastrointestinal nematode infection may cause a loss of appetite, growth, a development disorder, and even mortality in alligators, especially young ones. This research first establishment a loop-mediated isothermal amplification (LAMP) assay in rapidly identifying *O. sinensis*, upon the basis of the complete internal transcribed spacers (ITS) gene. Eight sets of primers were designed for recognition of the unique conserved ITS gene sequences, and one set was selected to be the most suitable primer for rapid detection. The specific as well as the sensitive features of the most appropriate primer in LAMP reactions for *O. sinensis*, and feces specimens of Chinese alligators suffering from *O. sinensis* were determined. Turbidity monitoring and Te Visual Reagent methods were used for determining negative and positive consequences. According to this study, amplification and visualization of the target DNA could be realized through two detection approaches during 50 min at 65°C isothermal temperature. The sensitivity of LAMP was a detecting limitation of 3.46 pg/μl DNA. No cross-reactions were found between *O. sinensis* and any other of the nine heterologous nematode parasites, which shows the outstanding specific features of the primers. The LAMP assay could also perform a detection of target DNA of *O. sinensis* in the feces samples of Chinese alligators. This LAMP assay is useful for directly detecting *O. sinensis* in the Chinese alligator breeding centers, particularly due to its rapidity, simplicity and low cost.

Murray, C.M., Russo, P., Zorrilla, A. and McMahan, C.D. (2019). Divergent morphology among populations of the New Guinea Crocodile, *Crocodylus novaeguineae* (Schmidt, 1928): Diagnosis of an independent lineage and description of a new species. *Copeia* 107(3) (doi: 10.1643/CG-19-240).

Abstract: The freshwater crocodile inhabiting Papua New Guinea, currently recognized as *Crocodylus novaeguineae*, exhibits morphological, molecular, and ecological divergence between the northern and southern versants of the Central Highlands and occupies separate evolutionary trajectories. A robust body of work has long encouraged the formal description of New Guinea crocodiles from the southern versant of the highlands as a distinct lineage with a taxonomy that reflects diagnosed relationships. Here, we use geometric morphometric techniques to assess cranial shape variation between specimens from both versants and add to the diagnostic evidence supporting a more accurate taxonomy. Further, herein, we formally describe the southern variant as a distinct lineage (Hall's New Guinea Crocodile; *Crocodylus halli*, new species).

Errickson, D. and Thompson, T.J.U (2019). Animal attacks and injuries: Anthropological findings. Pp. 143-147 in *Encyclopedia of Forensic and Legal Medicine*, 2nd edition, Vol. 1, edited by J. Payne-James and R.W. Byard. Elsevier: Oxford.

Abstract: Human and animal interaction can lead to conflict. Animal attacks taken place for many reasons including means of self-defence, hunger, protection, and scavenging. Most animals under specific conditions will attack a corpse. Further, most animals have been reported as having bitten and attacked living humans. In these attacks, morphological characteristics are often left behind on the bone. These features can help identify the species of animal involved, and the wider context of the interaction. This chapter describes the recognizable characteristics that different species of animals leave on the bone and the different imaging methods available to help describe and identify the specific trauma.

Hearn, L. and Williams, A.C. de C. (2019). Pain in dinosaurs: What is the evidence? *Philosophical Transactions of the Royal Society B* (<https://doi.org/10.1098/rstb.2019.0370>).

Abstract: How far back can we trace behaviour associated with

pain? Behaviour is not preserved in the palaeontological record, so, for dinosaurs, we are restricted to what we can deduce from fossilized bones and tracks. This review is a thought experiment using circumstantial evidence from dinosaur fossils and from the behaviour of their extant relatives to describe probable responses of dinosaurs to serious injuries. Searches yielded 196 papers and chapters with: reports of healed serious injuries, and limping gait and injured feet in trackways; information about physiology and behaviour relevant to healing; evidence of evolutionary connections with birds and crocodylians, and their behaviour; and information about relevant aspects of evolution. Clearly, many dinosaurs survived injuries that would have seriously hampered mobility, impairing hunting or escape from predators, and affecting social interactions. Recovery from severe injuries implies pain-mediated responses. Rates of healing seem faster than for other reptiles, possibly aided by warm-bloodedness. Nesting was often communal, raising the possibility of parental and group protection for injured young. The existence of family groups, packs or herds raises the possibility of protection or feeding from pack kills. This is the first study, to our knowledge, of possible pain behaviour and responses to injury in dinosaurs.

Smith, B., Crossley, J.L., Elsey, R.M., Hicks, J.W. and Crossley II, D.A. (2019). Embryonic developmental oxygen preconditions cardiovascular function response to acute hypoxic exposure and maximal β -adrenergic stimulation of anesthetized juvenile American alligators (*Alligator mississippiensis*). *Journal of Experimental Biology* (doi: 10.1242/jeb.205419).

Abstract: The effects of the embryonic environment on juvenile phenotypes are widely recognized. We investigated the effect of embryonic hypoxia on the cardiovascular phenotype of 4-year-old American alligators (*Alligator mississippiensis*). We hypothesized that embryonic 10% oxygen preconditions cardiac function, decreasing the reduction in cardiac contractility associated with acute 5% oxygen exposure in juvenile alligators. Our findings indicate that dobutamine injections caused a 90% increase in systolic pressure in juveniles that were incubated in 21% and 10% O₂ with the 10% O₂ group responding with a greater rate of ventricular relaxation and greater left ventricle output compared the 21% O₂ group. Further our findings indicate that juvenile alligators that experienced embryonic hypoxia have a faster rate of ventricular relaxation, greater left ventricle stroke volume, and greater cardiac power following beta-adrenergic stimulation, compared to juvenile alligators that did not experience embryonic hypoxia. When juveniles were exposed to 5% oxygen for 20 minutes, normoxic-incubated juveniles had a 50% decline in left ventricle maximal rate of pressure development and maximal pressure; however, these parameters were unaffected and decreased less in the hypoxic-incubated juveniles. These data indicate that embryonic hypoxia in crocodylians alters the cardiovascular phenotype, changing the juvenile response to acute hypoxia and beta-adrenergic stimulation.

Roy, A., Pittman, M., Saitta, E.T., Kaye, T.G. and Xu, X. (2019). Recent advances in amniote palaeocolour reconstruction and a framework for future research. *Biological Reviews* (doi: 10.1111/brv.12552).

Abstract: Preserved melanin pigments have been discovered in fossilised integumentary appendages of several amniote lineages (fishes, frogs, snakes, marine reptiles, non-avian dinosaurs, birds, and mammals) excavated from lagerstätten across the globe. Melanisation is a leading factor in organic integument preservation in these fossils. Melanin in extant vertebrates is typically stored in rod- to sphere-shaped, lysosome-derived, membrane-bound vesicles called melanosomes. Black, dark brown, and grey colours are produced by eumelanin, and reddish-brown colours are produced by pheomelanin. Specific morphotypes and nanostructural arrangements of melanosomes and their relation to the keratin matrix in integumentary appendages create the so-called 'structural

colours'. Reconstruction of colour patterns in ancient animals has opened an exciting new avenue for studying their life, behaviour and ecology. Modern relationships between the shape, arrangement, and size of avian melanosomes, melanin chemistry, and feather colour have been applied to reconstruct the hues and colour patterns of isolated feathers and plumages of the dinosaurs *Anchiornis*, *Sinosauropteryx* and *Microraptor* in seminal papers that initiated the field of palaeocolour reconstruction. Since then, further research has identified countershading camouflage patterns, and informed subsequent predictions on the ecology and behaviour of these extinct animals. However, palaeocolour reconstruction remains a nascent field, and current approaches have considerable potential for further refinement, standardisation, and expansion. This includes detailed study of non-melanin pigments that might be preserved in fossilised integuments. A common issue among existing palaeocolour studies is the lack of contextualisation of different lines of evidence and the wide variety of techniques currently employed. To that end, this review focused on fossil amniotes: (i) produces an overarching framework that appropriately reconstructs palaeocolour by accounting for the chemical signatures of various pigments, morphology and local arrangement of pigment-bearing vesicles, pigment concentration, macroscopic colour patterns, and taphonomy; (ii) provides background context for the evolution of colour-producing mechanisms; and (iii) encourages future efforts in palaeocolour reconstructions particularly of less-studied groups such as non-dinosaur archosaurs and non-archosaur amniotes.

Rodriguez-Cordero, A.L. Balaguera-Reina, S.A. and Densmore III, L.D. (2019). Regional conservation priorities for crocodylians in Bolivia. *Journal for Nature Conservation* (<https://doi.org/10.1016/j.jnc.2019.125753>).

Abstract: Crocodylians are large predators and ecological keystone species in wetland ecosystems. In Bolivia a total of five species occur, all of which are members of the family Alligatoridae: *Caiman yacare*, *C. latirostris*, *Melanosuchus niger*, *Paleosuchus palpebrosus*, and *P. trigonatus*. Beginning in the mid-1800s, wild populations were reduced and threatened by unsustainable exploitation, commercial hunting, lack of wildlife law enforcement, and poor management strategies. Economic incentives that can be generated through the management of crocodylians and sustainable use of wildlife (SUW) programs have become key elements for conservation of the species and their habitats. Nevertheless, these programs must be designed based on solid scientific strategies to guarantee efficiency and sustainability. Adapted from successful conservation strategies for other species, we present the first country-wide range assessment of crocodylians in Bolivia. We evaluated the current state of knowledge and propose regional conservation priorities, integrating distribution and biological information available for Bolivian crocodylians. We carried out a literature search and review, and spatial data compilation to estimate the distribution range (Extent of Occurrence - EOO), characterize ecoregions (Crocodylian Geographic Regions - CGRs), and delineate areas with species occurrence and population surveys (Crocodylian Study Units - CSUs). Finally, ecoregions inside CSUs were defined as Crocodylian Conservation Units (CCUs), for which we developed a geographic priority setting. We categorized them as Regional Habitat Priority (RHP) areas with sufficient biological information to implement management and sustainable use programs aimed at species and habitat conservation, or as Regional Research Priority (RRP) areas with the absence or insufficiency of biological information to prioritize research and monitoring programs. We reviewed 105 documents written from 1977 to 2017 and used spatial data from 44 documents. We estimated an EOO of 654,930 km², defined 17 CGRs, 98 CSUs, and 167 CCUs, out of which 29 were categorized as RHP and 138 as RRP. This study is the first effort to develop a regional conservation plan as a scientific baseline that can facilitate decision-makers to prioritize future research, encourage habitat protection, and promote management and sustainable use programs to achieve effective long-term survival of crocodylians in Bolivia.

Drumheller, S.K. and Wilberg, E.W. (2019). A synthetic approach for assessing the interplay of form and function in the crocodyliform snout. *Zoological Journal of the Linnean Society* (<https://doi.org/10.1093/zoolinnean/zlz081>).

Abstract: Existing classifications of snout shape within Crocodylia are supported by functional studies, but ecological surveys often reveal a higher than expected diversity of prey items within putatively specialist groups, and research into bite force and predation behaviour does not always reveal significant differences between snout shape groups. The addition of more distantly related crocodyliforms complicates the ecomorphological signal, because these groups often occupy a larger area of morphospace than the crown group alone. Here, we present an expanded classification of snout shapes and diets across Crocodyliformes, bringing together geometric morphometrics, non-hierarchical cluster analyses, phylogenetic analyses, ancestral state reconstructions, ecological surveys of diet, and feeding traces from the fossil record to build and test predictive models for linking snout shape and function across the clade. When applied to living members of the group, these new classifications partition out based on differences in predator body mass and maximal prey size. When applied to fossils, these classifications predict potential prey items and identify possible examples of scavenging. In a phylogenetic context, these ecomorphs reveal differences in dietary strategies and diversity within major crocodyliform clades. Taken together, these patterns suggest that crocodyliform diversity, in terms of both morphology and diet, has been underestimated.

Conover, M.R. (2019). Numbers of human fatalities, injuries, and illnesses in the United States due to wildlife. *Human-Wildlife Interactions* 13(2): 264-276.

Abstract: I reviewed published and unpublished papers, government reports, and websites to estimate how many people are injured or killed each year by wildlife or stricken by a zoonotic disease. Over 47,000 people annually in the United States sought medical attention after being attacked or bitten by wildlife, and approximately 8 people died annually. Most bites were by snakes, birds, rodents, and raccoons (*Procyon lotor*). Each year, wildlife-vehicle collisions resulted in >59,000 human injuries and >440 human fatalities, while wildlife-aircraft collisions added 16 more injuries and 10 fatalities. I also found that >68,000 people each year sought medical assistance for a zoonotic disease, and 243 of these cases were fatal. When wildlife-related casualties and fatalities are summed, >174,000 people were injured or sickened and >700 were killed by wildlife annually. These figures do not mean that wildlife populations should be reduced; they do indicate, however, that wildlife biologists have an opportunity to serve society by preventing human injuries, morbidities, and fatalities resulting from wildlife. In doing so, wildlife biologists will also be protecting the future of wildlife.

Stefanic, C.M. and Nesbitt, S.J. (2019). The evolution and role of the hyosphene-hypantrum articulation in Archosauria: phylogeny, size and/or mechanics? *R. Soc. open sci.* 6: 190258.

Abstract: Living members of Archosauria, the reptile clade containing Crocodylia and Aves, have a wide range of skeletal morphologies, ecologies and body size. The range of body size greatly increases when extinct archosaurs are included, because extinct Archosauria includes the largest members of any terrestrial vertebrate group (eg 70-tonne titanosaurs, 20-tonne theropods). Archosaurs evolved various skeletal adaptations for large body size, but these adaptations varied among clades and did not always appear consistently with body size or ecology. Modification of intervertebral articulations, specifically the presence of a hyosphene-hypantrum articulation between trunk vertebrae, occurs in a variety of extinct archosaurs (eg non-avian dinosaurs, pseudosuchians). We surveyed the phylogenetic distribution of the hyosphene-hypantrum to test its relationship with body size. We found convergent evolution among

large-bodied clades, except when the clade evolved an alternative mechanism for vertebral bracing. For example, some extinct lineages that lack the hyosphene-hypantrum articulation (eg ornithischians) have ossified tendons that braced their vertebral column. Ossified tendons are present even in small taxa and in small-bodied juveniles, but large-bodied taxa with ossified tendons reached those body sizes without evolving the hyosphene-hypantrum articulation. The hyosphene-hypantrum was permanently lost in extinct crownward members of both major archosaur lineages (ie Crocodylia and Aves) as they underwent phyletic size decrease, changes in vertebral morphology and shifts in ecology.

Lueangsakulthai, J., Michael, N., Temsiripong, T., Khunkitti, W., Klaynongsruang, S. and Jangpromma, N. (2019). Antioxidant and anti-inflammatory activities of the Siamese crocodile (*Crocodylus siamensis*) hemoglobin hydrolysate derived from trypsin and papain hydrolysis. *Chiang Mai Journal of Science* 46(5): 915-929.

Abstract: *Crocodylus siamensis* hemoglobin hydrolysates (CHHs) were obtained by trypsin and papain digestion at different incubation times (2, 4, 6 and 8 h) at 37°C and subjected to antioxidant and anti-inflammatory activity assessment. DPPH scavenging activity of CHH derived from trypsin was similar to intact Hb. CHH derived from papain hydrolysis by 8-h hydrolysis (8h-CHHp) showed the highest DPPH scavenging activity at 56.86% antioxidant inhibition with IC50 value of 31 µg/ml. CHH derived from papain hydrolysis by 2-h hydrolysis (2h-CHHp) showed the highest reducing power activity at 0.99 mM Trolox equivalent and 4h-CHHt showed reducing activity at 0.16 mM Trolox equivalent (at concentration of 500 µg/ml). The linoleic peroxidation activity of CHH derived from papain hydrolysis by 6-h hydrolysis (6h-CHHp) and CHH derived from trypsin hydrolysis by 8-h hydrolysis (8h-CHHt) was increased in a dose-dependent manner with IC50 value of 5 µg/ml. The strongest anti-inflammatory activity was found for 2h-CHHp, which displayed a high efficacy in decreasing NO production of macrophage RAW 264.7 cells (46.86%) with no toxicity and significantly reduced pro-inflammatory cytokines interleukin-6 (IL-6) production to about 25.73 pg/ml. Taken collectively, the results of this work demonstrate that CHHs derived from papain hydrolysis possesses antioxidant and anti-inflammatory activities, which provides support for the application against inflammation and oxidative stress-related disorders.

Rizac, R.I., Soare, T., Ciobotaru-Pîrvu, E. and Militaru, M. (2019). Systemic granulomatous pathology in two captive *Alligator mississippiensis*. *Acta Veterinaria-Beograd* 69(3): 348-359

Abstract: The literature in this field cites various ubiquitous fungal and bacterial microorganisms as etiologic agents in severely stressed captive alligators and crocodiles. This study reports two cases of *Alligator mississippiensis* with bacterial and fungal disease. Two adult American alligators have been submitted for post-mortem investigations. Necropsy, cytology (MGG), and histopathology investigations (HE, HEA, PAS, Gram, Giemsa, Ziehl Neelsen) were carried out. Pleural and pericardial swabs were subjected to microbiological examination. The main lesions detected involved the lower respiratory system and were characterized by thoracic serosanguineous effusions, pleural and pulmonary nodules (1-80 mm), accompanied by edema. Similar nodules observed also in the liver, spleen and myocardium, suggested a systemic disease. Additionally, cutaneous, gingival and gastrointestinal erosions and ulcers were found. Cytoarchitecture findings in the major organs revealed lymphoid depletion, multifocal to coalescing necrotic areas with coccoid aggregates and rod shaped bacteria intermixing fungal structures, boarded by heterogeneous inflammatory infiltrates, composed by epithelioid macrophages, lymphocytes and heterophils. The microbiological examination revealed the presence of *Aeromonas hydrophila*, *A. caviae*, *Serratia marcescens*, *Pantoea agglomerans*, *Proteus vulgaris*, haemolytic and non-haemolytic *E. coli*, *Citrobacter freundii*, *Rhizopus/Abisidia* from pleural and

pericardial cavities, concluding that death occurred following a bacterial and fungal pneumonia, with secondary spreading of microorganisms. Along with the low immune response, severe stress was the main possible cause, as a result of environmental temperature changes during the winter, as well as other husbandry issues.

Hlaing, M.M. (2019). Crocodile conservation and breeding management - issues and constraints: Experience of Myanmar. *Fish for the People* 17(2): 26-34.

Abstract: Crocodiles play a vital ecological role as key predators in wetland environments where they thrive, and have always been part of human culture, even co-existing with people, and found in the form of leather as their skin is used to make boots, handbags, jackets, belts, and more. While some regions worship the crocodiles as holy creatures by honoring them to please the god or goddess associated with them (eg in some Egyptian towns), these reptiles are also being hunted elsewhere for their skin as well as meat for food, and other body parts for medical, religious or decorative purposes. Crocodiles belong to the Order Crocodylia or Crocodilia, comprising three families and nine genera. All 23 species of crocodilians are listed under the Appendix I or II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). While crocodilians were reported many years ago to be “slated for rapid extermination at the hands of man” because of overhunting and loss of habitat, currently the populations of many crocodilian species are known to have recovered or restored. Myanmar has been breeding crocodiles since the 70s, but issues and constraints relevant to the conservation and management of crocodile breeding had been encountered, as reported in this article.

De Oliveira Ferronato, B. (2019). An assessment of funding and publication rates in Herpetology. *Herpetological Journal* 29: 264-273.

Abstract: Currently, herpetofauna worldwide is facing enormous threats; the number of threatened species is increasing at an alarming rate and many species have gone extinct. Despite efforts of institutions and researchers to understand and address the causes of declines and raise awareness of herpetofauna conservation, there has been no systematic study to evaluate the allocation of funding for basic and applied research relevant to conservation, relative publication rates, and the relationship of these measures to a degree of threat among herpetological groups. This study addresses this gap and identifies strengths and weaknesses of herpetological research and conservation over the last 10 years (2008-2018). Frogs had the highest grant-publication index (1384), followed by lizards (695), turtles (678), snakes (461.5), salamanders (366.5), crocodiles (164), caecilians (25.5), worm lizards (23) and tuatara (10). Nonetheless, when the grant-publication index is divided by the number of threatened and data-deficient species within each group, it demonstrates that, proportionally and in ascending order, salamanders, snakes, lizards, worm lizards, frogs and caecilians are in most need of knowledge and on-going funding for their conservation and survival. I was able to document a continued shift in attention in herpetological research owing to the emergence of chytridiomycosis and the global decline of amphibians. Despite some caveats, these findings should represent a proxy for the allocation of research and conservation effort on herpetofauna worldwide. I suggest priorities for research and how to better direct efforts to herpetofauna conservation.

Tang, K.-Y., Wang, Z.-W., Wan, Q.-H. and Fang, S.-G. (2019). Metagenomics reveals seasonal functional adaptation of the gut microbiome to host feeding and fasting in the Chinese alligator. *Frontiers in Microbiology* (doi: 10.3389/fmicb.2019.02409).

Abstract: Hibernator gut microbiomes vary seasonally with host

physiology and food availability, but their functional potential and host-microbial interactions have not been well characterized. As a natural hibernator, the Chinese alligator (*Alligator sinensis*) is an ideal and intriguing model to investigate changes in microbial community structure and function caused by hibernation. In this study, we used 16S rRNA profiling and metagenomic analysis to compare the microbiome composition, diversity, and functional capacity in the gut of hibernating versus active Chinese alligators. Our results show that gut microbial communities undergo seasonal restructuring in response to seasonal cycles of feeding and fasting in the Chinese alligator, but this animal harbors a core gut microbial community primarily dominated by Proteobacteria, Fusobacteria, Bacteroidetes and Firmicutes across the gut regions. During hibernation, there is an increase in the abundance of bacterial taxa (eg Bacteroidetes) that can degrade and utilize host mucin glycans, which allows adaptation to winter fasting. This is accompanied by the enrichment of mucin oligosaccharide-degrading enzyme and carbohydrate-active enzyme families. In contrast, during the active phase (feeding), active Chinese alligators exhibit a carnivore gut microbiome dominated by Fusobacteria, and there is an increase in the relative abundance of bacteria (eg *Cetobacterium somerae*) with known proteolytic and amino acids-fermentating functions that improve host protein-rich food digestion efficiency. In addition, seasonal variations in the expression of β -defensins play a protective role in intestinal immunity. These findings provide insights into the functional adaptations of host-gut microbe symbioses to seasonal dietary shifts to maintain gut homeostasis and health, especially in extreme physiological states.

Jensen, B., Joyce, W., Gregorovicova, M., Sedmera, D., Wang, T. and Christoffels, V.M. (2019). Low incidence of atrial septal defects in nonmammalian vertebrates. *Evolution & Development* 2019: e12322.

Abstract: The atrial septum enables efficient oxygen transport by separating the systemic and pulmonary venous blood returning to the heart. Only in placental mammals will the atrial septum form by the coming-together of the septum primum and the septum secundum. In up to one of four placental mammals, this complex morphogenesis is incomplete and yields patent foramen ovale. The incidence of incomplete atrial septum is unknown for groups with the septum primum only, such as birds and reptiles. We found a low incidence of incomplete atrial septum in 11 species of bird (0% of specimens) and 13 species of reptiles (3% of specimens). In reptiles, there was a trabecular interface between the atrial septum and the atrial epicardium which was without a clear boundary between left and right atrial cavities. In developing reptiles (four squamates and one crocodylian), the septum primum initiated as a sheet that acquired perforations and the trabecular interface developed late. We conclude that atrial septation from the septum primum only results in a low incidence of incompleteness. In reptiles, the atrial septum and atrial wall develop a trabecular interface, but previous studies on atrial hemodynamics suggest this interface has a very limited capacity for shunting.

Sudrajat and Saleh, H.A. (2019). The potential of Mesangat Lake, East Kutai, Indonesia as an essential ecological area for habitat conservation of critically endangered *Crocodylus siamensis*. *Biodiversitas* 20: 3126-3133.

Abstract: The Siamese crocodile, *Crocodylus siamensis*, is one of the most threatened reptile species in the world with IUCN Red List status of Critically Endangered. This study aims to investigate and assess the biogeophysical conditions of Mesangat Lake area, Indonesia as an essential ecological area for *C. siamensis* conservation outside biodiversity conservation areas. Data was collected through direct survey using spotlight technique at night, tracking, observation and interviews with local fishermen. The results showed that the biogeophysical conditions of Mesangat Lake habitat in Long Balau, Loah Toh and Abang areas still support *C. siamensis* population

which was marked by the presence of its nests and the occurrence of 17 individuals with sizes between 30 and 50 cm in length. Habitat conditions in the form of lake waters had depths between 30-110 cm, low currents, and covered with aquatic plant species for resting, nesting and basking, as well as contained sufficient diversity of fish and other prey. A nest was also found in the form of mound of plants measuring ± 45 cm high and ± 75 cm wide which contained 20 eggs with an average length of ± 8.45 cm, an average width of ± 4.9 cm. Potential factors that threaten *C. siamensis* habitat included siltation of water bodies caused by invasive weeds, over-exploitation of fishes and conversion of lake land into plantations and/or agriculture lands. Based on the results of this study, it can be stated that Mesangat Lake has the potential to be designated as an essential ecological area of *C. siamensis* habitat. Through this strategy, it is hoped that there will be good collaboration between local government and concession rights holders, NGOs and local communities to participate in the conservation of *C. siamensis*. In the area of the lake, zoning can be classified into areas of nesting, closed areas, playing and sunbathing, limited fishing, recreation.

Gabel, W., Frederick, P. and Zabala, J. (2019). Nestling carcasses from colonially breeding wading birds: patterns of access and energetic relevance for a vertebrate scavenger community. *Scientific Reports* 9: 14512.

Abstract: Energy transfer is fundamental to ecosystem processes, affecting productivity and community structure. Large aggregations of colonially breeding birds are known as nutrient sources through deposition of feces, but also may deposit large quantities of energy in the form of dead nestlings. The magnitude and ecological relevance of this process to the scavenger community is poorly understood. We used trail cameras to monitor the fates of size-appropriate chicken carcasses in heron colonies in order to quantify the proportion of available fallen nestlings that were consumed by scavengers in the Everglades of Florida, USA. Overall, 85% of 160 carcasses were consumed, with Turkey Vultures (*Cathartes aura*, 47%) and American Alligators (*Alligator mississippiensis*, 29%) being the primary consumers. Probability of consumption by alligators or vultures was related to distance from nest to water, local nesting density, and colony type. Consumption probabilities of both scavengers in relation to habitat covariates suggested clear resource partitioning promoting coexistence. We estimate fallen nestlings throughout this ecosystem could support 16% of the alligator population and 147 adult Turkey Vultures during a nesting season. This work indicates that fallen nestlings can serve as an important source of energy for scavengers at colonial breeding aggregations, particularly in oligotrophic systems.

Billings, B.K. (2019). Crocodile Cognition: Tracing the Roots of Cognition. PhD thesis, University of the Witwatersrand, Johannesburg, South Africa.

Abstract: For millennia the reptiles have been considered inferior animals, saddled with a poor reputation, to be scorned and shunned. Similarly, the reptilian brain has been characterized as simple, in no way capable of matching the intellectual heights achieved by mammals, and more recently birds. Reptiles, including crocodiles, have been thought to exhibit behaviours solely in response to specific stimuli, unable to think, plan ahead, and consider their actions. Fortunately, our understanding of reptilian behaviour is undergoing a renaissance, due to the accommodation of their life history and physiology in the analysis of their behaviour. Reptiles have been shown to be capable of complex behaviours such as play, long term parental care, complex social structures and courtships, communication and tool use. With this evolving view of reptilian behaviour comes an evolving view of the reptilian brain. The crocodilian brain in particular, due to their phylogenetic proximity to birds, has garnered significant recent attention, but mostly due to the desire to understand how the bird brain evolved. This thesis takes the view that the crocodilian brain should be understood in its

own right, prior to aligning it with either avian, or other reptilian, brains. Given this, the current thesis presents a series of studies, focused on the functional neuroanatomy of the Nile crocodile brain, with a specific focus on the telencephalon - that part of the brain known to generate complex behaviours. The studies begin with a classical architectural analysis of the telencephalon, supplemented with immunohistochemical staining methods, to provide a baseline regarding the organizational complexity of the Nile crocodile telencephalon. This is followed by a study of the catecholaminergic system throughout the crocodile brain to reveal whether this neural system, that plays a major role in the modulation of neural processing networks, evinces features homologous or analogous to those observed in mammalian and avian brains. Using state of the art magnetic resonance (MR) imaging, a three dimensional atlas of the Nile crocodile telencephalon has been produced, and this atlas played a critical role in the subsequent functional MR imaging study that follows. Without going into exhaustive detail, the findings of the current series of studies, while providing many answers, has generated more questions than answers. What is patently clear is that the brain of the Nile crocodile, especially the telencephalon, is far more complexly organized than previously thought, exhibiting clear hierarchical neural processing networks that are central to the production of complex behaviours. This hierarchical processing demonstrates one of the most significant findings of this study, namely that birds, mammals and reptiles share a conserved system of sensory processing. At present we are only scratching the surface when it comes to our understanding of the interaction of the reptile brain with their environment and their behaviours (both overt and covert), but what the studies contained in this thesis clearly show is that with more work we will continue to unravel the complex inner workings of the reptile brain. This future work will lead us on a path that will change our preconceived and historical notions of this important and interesting class of amniote vertebrates, and allow us to regard them with the esteem they deserve.

Moore, B.C., Holliday, C.M., McMurry, S.T., Platt, S.G. and Rainwater, T.R. (2019). Correlation between increased postpubertal phallic growth and the initiation of cranial sexual dimorphisms in male Morelet's crocodile. *Journal of Experimental Zoology A. Ecology and Integrated Physiology* (doi: 10.1002/jez.2325).

Abstract: While puberty is an animal commonality, little is known of its timing or process in crocodylians. Males copulate with an intromittent phallus that has a distinct glans morphology which directly interacts with the female cloaca, putatively effecting effective semen transfer and ultimately increased fecundity. Here we present, during the Morelet's crocodile lifecycle, a well-defined body length (65 cm snout-vent length) inflection point that marks a subsequent increase of phallic glans growth rates. Putatively, this postpubescent growth produces a copulatory-effective phallus. While not as robust of a trend as snout-vent length, this growth inflection concomitantly begins with a body condition index ($CI = BM/SVL^3$) between 2.0 and 2.5 and is most distinct above a CI of 2.5. Also, in males, this 65 cm size threshold also aligns with the initiation of more robust growth in caniniform alveoli associated with prominent maxillary and mandibular teeth. This inflection was not observed in females, thus marking a sexual dimorphism that begins to present with the onset of puberty. This bodily manifestation of puberty other than those changes observed in the reproductive tracts is a novel observation for crocodylians and lays a foundation for further study among species of how changing endocrine signaling within sexually maturing males may also influence a broader range of secondary sex characteristics.

Simoncini, M.S., Lábaque, M.C., Perlo, F., Fernandez, M.E., Leiva, P.M.L., Paez, A.R., Teira, G., Larriera, A. and Piña, C.I. (2019). *Caiman latirostris* meat characterization: Evaluation of the nutritional, physical and chemical properties of meat from sustainable ranching program in Argentina. *Aquaculture* (<https://doi.org/10.1016/j.aquaculture.2019.734570>).

Abstract: The scientific community has made considerable efforts to improve the production of protein from traditional sources. Currently it has also been focused on non-conventional protein sources, such as those produced in conservation and sustainable use programs, which would contribute to the improvement of local and national economies. In Argentina, the meat of *Caiman latirostris* (the Broad-snouted caiman) is consumed; since commercial breeding of *C. latirostris* in the country has been incorporated relatively recently compared to other species of crocodiles and is growing, the qualities of the products that can be marketed have still been scarcely determined. Knowledge of caiman meat and its physical and chemical characteristics are necessary to promote its consumption. Thus, physical and chemical characteristics, including pH, cooking loss, color, tenderness, moisture, protein and fat content were determined in the meat of *C. latirostris*. Fifteen caimans ($n= 15$; $X \pm SD$; 97.4 ± 1.2 cm of length and 4.2 ± 0.15 kg of weight) raised in captivity by Proyecto Yacaré (program for conservation and sustainable use of caiman) were slaughtered; meat samples were taken from the tail muscle ischio-caudalis. Caiman meat was found to be luminous and tender, with a low amount of intramuscular fat (0.8%), usual proportion of protein in animal tissues (20.5%) and a high proportion of moisture (77.2%). Fatty acid content in caiman meat consisted of 30.2% of saturated fatty acids (SFA), 69.9% of unsaturated fatty acids (UFA), 36.8% of polyunsaturated fatty acids (PUFA), and 1.25 of PUFA/SFA ratio. Caiman meat (produced in management and conservation program in Argentina) might be marketed as a healthy meat given its very favorable lipid profile for human health, characterized by its low total lipid content, balanced fatty acids, tenderness and luminosity attributes, as well as characteristics similar to those of other usually marketed meats. The results may help to introduce an alternative source of protein and energy for human consumption, and to propose the meat of this caiman species as a healthy food. In addition, by involving local people, the activity improves the local economy and the economic return to the program, thereby supporting the conservation of this caiman species.

Iijima, M., Tsubamoto, T., Tsogtbaatar, K., Chinzorig, T. and Baasankhuu, S. (2019). Discovery of a crocodyliform tooth from the upper Eocene Ergilin Dzo Formation, Mongolia. *Acta Palaeontologica Polonica* (doi:<https://doi.org/10.4202/acta.006633.2019>).

Abstract: Although the distribution of Asian crocodyliforms was extended northwards during the Paleocene-Eocene greenhouse world, the fossil record in northern Asia becomes scarce towards the end of the Eocene. We here report the first crocodyliform (an isolated tooth) from the upper Eocene Ergilin Dzo Formation of southeastern Mongolia, the mammalian fauna of which defines the Ergilian Asian Land Mammal Age. The conical non-recurved crown, the near complete root with the central resorption facet, and its late Eocene age suggest the crocodyliform affinity of the tooth. The current finding represents one of the northernmost occurrences of crocodyliforms in the upper Eocene of Asia (paleolatitude ca. $49^{\circ}30' N$), and demonstrates that SE Mongolia probably met thermal requirements of crocodyliforms during the late Eocene.

Castelblanco-Martinez, D.N., Blanco-Parra, M.P., Charruau, P., Prezas, B., Zamora-Vilchis, I. and Niño-Torres, C.A. (2019). Detecting, counting and following the giants of the sea: a review of monitoring methods for aquatic megavertebrates in the Caribbean. *Wildlife Research* (<https://doi.org/10.1071/WR19008>).

Abstract: The Caribbean is a mega-diverse and bio-geographically important region that consists of the Caribbean Sea, its islands, and surrounding coastlines. Among the billions of aquatic species inhabiting this region, the mega-vertebrates stand out for their social, economic and ecologic relevance. However, the Caribbean has been threatened by climate change, poverty, pollution, environmental degradation and intense growth of the tourism industry, affecting

megafauna species directly and indirectly. Population monitoring plays a critical role in an informed conservation process and helps guide management decisions at several scales. The aim of the present review was to critically examine the methods employed for monitoring marine megafauna in the Caribbean, so as to create a framework for future monitoring efforts. In total, 235 documents describing protocols for the monitoring of sirenians, cetaceans, elasmobranchs, sea turtles and crocodylians in the Caribbean region, were reviewed. The methods included community-based monitoring (interviews, citizen science and fisheries monitoring), aerial surveys (by manned and unmanned aerial vehicles), boat-based surveys (including manta tow, and side-scan sonars), land-based surveys, acoustic monitoring, underwater surveys, baited remote underwater video, mark-recapture, photo-identification and telemetry. Monitoring efforts invested on aquatic megafauna in the Caribbean have been highly different, with some species and/or groups being prioritised over others. The present critical review provides a country-based overview of the current and emerging methods for monitoring marine megafauna and a critical evaluation of their known advantages, disadvantages and biases.

Black, J. (2019). Assessment of Crocodile Abundance and Seasonal Effects of Salinity on Distribution using both Boat and Aerial Drone Surveys. MSc thesis, Purdue University, Fort Wayne, Indiana, USA.

Abstract: The American crocodile (*Crocodylus acutus*) is a common resident of Central American waterways, with one of the largest ranges of all crocodylians. It is very salt-tolerant, with only Nile crocodiles and Saltwater crocodiles superseding it in terms of being the most saline tolerant. Globally it has lost 9% of its range, with habitat destruction and fragmentation as the leading threat to this species. Overall there is a great need to understand the habitat uses by this species in order to mitigate consequences of further anthropogenic incursions along its range. Thus, this study aims to investigate seasonal effects of salinity on habitat selection of American crocodiles in a natural mangrove habitat, and to validate use of a commercial drone as a surveying tool for crocodylians in such habitats. This study found that as the seasons shift from wet to dry there was an associated increase in salinity of the estuarine waterway that resulted in an increase in the halocline of the estuary waters the greater the distance from the ocean. When broken down into the following groups: Hatchlings and juveniles (HJ) vs subadults and adults (SbA) it was found that salinity as well as season both had a correlation with the presence of crocodiles from the HJ group ($p<.05$) and there was no correlation in regard to SbA crocodiles. Further, HJ size classes predominantly were found in the further reaches of the estuary, regardless of season. Surveys taken via drone were as efficacious as surveys taken diurnally via boat, with a survey encounter rate of 0.40 km^{-1} , but still less efficacious than nocturnal eyeshine surveys, which had an encounter rate between $1.2\text{-}2.9 \text{ km}^{-1}$. The drone was able to identify animals that were submerged under water, but was unable to ID animals resting on banks in thick mangroves. However, the drone was able to identify crocodiles as small as 0.7 m. Further, the drone showed encounter rates for sharks and rays that were much higher than crocodiles, 0.84 km^{-1} and 0.64 km^{-1} respectively.

Grajal-Puche, A. (2019). Microbial Assemblage Dynamics within the American Alligator Nesting Ecosystem: A Comparative Approach Across Ecological Scales. MSc thesis, Middle Tennessee State University, Murfreesboro, Tennessee, USA.

Abstract: Understanding the ecological processes that shape species assemblage patterns is central to community ecology. The effects of ecological processes on assemblage patterns are scale-dependent. Research that addresses community patterns at different focal scales may discern distinct conclusions about ecological processes that structure communities. Ideally, studies conducted across focal scales may reflect relevant process-shaping assemblage patterns. Here, I use metabarcoding and shotgun sequencing to determine bacterial

assemblage patterns among defined focal scales (micro-, meso-, macro-) within the American alligator (*Alligator mississippiensis*) nesting microbiome. I correlate bacterial assemblage patterns among eight defined compartments within and proximal to alligator nests (microscale), among 27 nests (mesoscale), and across three geographic sampling sites (macroscale), to discern among four main ecological processes (ie drift, speciation, selection/filtering, dispersal) that drive bacterial pattern-process dynamics. I hypothesized variation in taxonomic diversity but functional redundancy among defined compartments within alligator nests and between geographic sites. Among all focal scales, bacterial richness (α -diversity) did not statistically differ. In contrast, bacterial composition was unique (β -diversity), with whole nests predicting the largest degree of assemblage variation. Interestingly, functional pathways were redundant within nests. Considering these observed scale-based patterns, alligator nest bacterial assemblages are likely sourced from site-specific reservoirs whose dispersal limitations drive taxonomic differences but are under redundant selection. Critically, the alligator eggshell microbiome is comparably distinct from within-nest assemblages. Bacteria that are found only on the alligator eggshell, are not likely sourced from surrounding environmental reservoirs and are possibly transferred from the mother's cloaca. I speculate that bacteria found only on the alligator eggshell, with the functional potential to degrade the eggshell surface, are an integrated part of hatching ecology. These findings advance pattern-process dynamics within the field of microbial community ecology and describe processes influencing the American alligator nest microbiome.

Lambert, H., Carder, G. and D'Cruze, N. (2019). Given the cold shoulder: A review of the scientific literature for evidence of reptile sentience. *Animals* 9: 821.

Simple Summary: Reptiles are popular pets around the world, although their welfare requirements in captivity are not always met, due in part to an apparent lack of awareness of their needs. Herein, we searched a selection of the scientific literature for evidence of, and explorations into, reptile sentience. We used these findings to highlight: (1) how reptiles are recognised as being capable of a range of feelings; (2) what implications this has for the pet trade; and (3) what future research is needed to help maximise their captive welfare. We found 37 studies that assumed reptiles to be capable of the following emotions and states; anxiety, stress, distress, excitement, fear, frustration, pain, and suffering. We also found four articles that explored and found evidence for the capacity of reptiles to feel pleasure, emotion, and anxiety. These findings have direct implications for how reptiles are treated in captivity, as a better understanding of their sentience is critical in providing them with the best quality of life possible.

Abstract: We searched a selection of the scientific literature to document evidence for, and explorations into reptile sentience. The intention of this review was to highlight: (1) to what extent reptile capability for emotions have been documented in the scientific literature; (2) to discuss the implications this evidence has for the trade in reptiles; and (3) to outline what future research is needed to maximise their captive welfare needs. We used 168 keywords associated with sentience, to search through four journal databases and one open-access journal. We recorded studies that explored sentience in reptiles and those that recognised reptile sentience in their experiments. We found that reptiles were assumed to be capable of the following emotions and states; anxiety, distress, excitement, fear, frustration, pain, stress, and suffering, in 37 articles. We also found four articles that explored and found evidence for the capacity of reptiles to feel pleasure, emotion, and anxiety. These findings show that reptiles are considered to be capable of experiencing a range of emotions and states. This has implications for how reptiles are treated in captivity, as a better understanding could help to inform a range of different operational initiatives aimed at reducing negative animal welfare impacts, including improved husbandry and consumer behaviour change programmes.

Willson, N.-L., Van, T.T.H., Lever, J., Moore, R.J. and Stanley, D. (2019). Characterisation of the intestinal microbiota of commercially farmed saltwater crocodiles, *Crocodylus porosus*. *Applied Microbiology and Biotechnology* (<https://doi.org/10.1007/s00253-019-10143-3>).

Abstract: The Australian saltwater crocodile (*Crocodylus porosus*) industry began commercially in the 1980s, producing skins for export and crocodile meat as a by-product. Industry research has thus far focused on strategies to improve production efficiency. In the current study, we utilised 16S rRNA sequencing to characterise the intestinal microbiome of Australian saltwater crocodiles. Samples were collected from 13 commercially farmed crocodiles from six sample sites along the length of the intestinal tract. The results indicate a similar microbiome composition to that found in the freshwater alligator, with the dominate phyla represented by Firmicutes, primarily Clostridia, and Fusobacteria, which appears to be distinct from mammalian, fish, and other reptile phyla which are generally dominated by Firmicutes and Bacteroidetes. The high abundance of 'pathogenic' bacteria, with no apparent consequence to the host's health, is of great interest and warrants further additional investigation. This will enable expansion of the current understanding of host immune function and how it is modified by host and intestinal microbiome interactions.

Mazingi, D., Mbanje, C., Muguti, G.I. and Chitiyo, S.T. (2019). A case report of a bite from the Nile Crocodile (*Crocodylus niloticus*) managed with regional anesthesia. *Wilderness & Environmental Medicine* (<https://doi.org/10.1016/j.wem.2019.06.013>).

Abstract: Crocodile attack injuries plague communities near bodies of water and continue to be an infrequent but significant form of trauma encountered in our medical facility. Regional anesthesia techniques are a novel adjunct to treatment and may facilitate simplified definitive management and better utilization of constrained operating room resources. We report a case of an adult male who presented with a large lower extremity wound after a crocodile bite. The patient was managed with initial debridement and irrigation and serial wound care entirely under regional anesthesia at the bedside. The patient did not develop wound infection, eventually receiving a skin graft with good functional outcomes. Regional anesthesia techniques are increasingly being used in the trauma setting, and their versatility allows for their use in multiple settings, by practitioners with limited experience and in resource-limited environments. No specific guidelines exist for performance of neuraxial techniques in the setting of animal bite injuries, but concerns about infectious complications have been raised. Regional anesthesia techniques may be useful in the management of extremity trauma due to crocodile attacks without infectious complications. They may reduce utilization of theatre resources and reduce opioid requirements.

Kiladze, A.B. and Chernova, O.F. (2019). Lateral osteoderms of the Nile crocodile *Crocodylus niloticus*. *Ukrainian Journal of Ecology* 9(3): 99-102.

Abstract: The article shows morphometry of large and small lateral osteoderms on the Nile crocodile body, which forms into arclike lines. Length of large lateral osteoderms is 2.52 times greater than small lateral osteoderms, width of large lateral osteoderms is 2.20 times greater than small lateral osteoderms, and area of large lateral osteoderms is 5.59 times greater than small lateral osteoderms. Configuration index (length to width ratio) is similar in large (2.03 ± 0.06) and small (1.92 ± 0.17) lateral osteoderms, but scale range of this factor is less significant in large lateral osteoderms (1.67-2.50), than in small lateral osteoderms (1.003-.00).

Brunner, N., Kühleitner, M., Nowak, W.G., Renner-Martin, K. and Scheicher, K. (2019). Comparing growth patterns of three species:

Similarities and differences. PLoS One 14(10): e0224168.

Abstract: Quantitative studies of the growth of dinosaurs have made comparisons with modern animals possible. Therefore, it is meaningful to ask, if extinct dinosaurs grew faster than modern animals, e.g. birds (modern dinosaurs) and reptiles. However, past studies relied on only a few growth models. If these models were false, what about the conclusions? This paper fits growth data to a more comprehensive class of models, defined by the von Bertalanffy-Pütter (BP) differential equation. Applied to data about *Tenontosaurus tilletti*, *Alligator mississippiensis* and the Athens Canadian Random Bred strain of *Gallus gallus domesticus* the best fitting growth curves did barely differ, if they were rescaled for size and lifespan. A difference could be discerned, if time was rescaled for the age at the inception point (maximal growth) or if the percentual growth was compared.

Palei, N.C., Rath, B.P. and Bimal Prasanna Acharya, B.P. (2019). An observation of the White-bellied Sea Eagle *Haliaeetus leucogaster* preying on Saltwater Crocodile hatchlings *Crocodylus porosus* in Bhitarkanika Wildlife Sanctuary, India. Journal of Threatened Taxa 11(13): 14767-14769.

Abstract: During our regular monitoring of Saltwater Crocodile in Bhitarkanika National Park in Odisha, eastern India, we for the first time photographed the predation of a hatchling Saltwater Crocodile by a White-bellied Sea Eagle. This information is very crucial as it aids in understanding the natural history of the species.

Bemis, M.F. (2018). We Eat What? A Cultural Encyclopedia of Unusual Foods in the United States, ed. by J. Deutsch. Greenwood: Santa Barbara.

Abstract: Fried crickets. Boiled pig intestines. Sautéed bull testicles. And that's just the sampler plate. Bon appetite! All joking aside, these and other - ahem - interesting food items are discussed and illustrated within the pages of this well-written reference work. Approximately 114 alphabetically arranged entries, each signed by its writer, cover mostly regional specialties, from alligator meat served in Florida restaurants to Whoopie pie, a sweet treat made in bakeries throughout New England.

Bustard, H.R. and Kar, S. (2019). Highly accurate measurement technique for large crocodiles in Bhitarkanika. Cheetal 56(1).

Abstract: Very accurate ocular estimation of crocodile length is described. These results were cross-checked using a measurement of the hind foot pugmark multiplied by a factor of 14. The results of the two techniques matched closely.

Bustard, H.R. and Kar, S. (2019). The leucistic Estuarine crocodiles of Bhitarkanika. Cheetal 56(1).

Abstract: Leucism is defined and its occurrence in this population is discussed. Only two leucistic hatchlings emerged from 3000 captive-hatched wild-laid eggs. Despite this, three of the 12 territory-holding huge males are leucistic. It appears, therefore, that leucism may confer advantages on those crocodiles which survive to 1 metre or more.

Puértolas-Pascual, E. and Mateus, O. (2019). A three-dimensional skeleton of Goniopholididae from the Late Jurassic of Portugal: implications for the Crocodylomorpha bracing system. Zoological Journal of the Linnean Society (<https://doi.org/10.1093/zoolinnean/zl1202>).

Abstract: We here describe an articulated partial skeleton of a small

neosuchian crocodylomorph from the Lourinhã Formation (Late Jurassic, Portugal). The skeleton corresponds to the posterior region of the trunk and consists of dorsal, ventral and limb osteoderms, dorsal vertebrae, thoracic ribs and part of the left hindlimb. The paravertebral armour is composed of two rows of paired osteoderms with the lateral margins ventrally deflected and an anterior process for a 'peg and groove' articulation. We also compare its dermal armour with that of several Jurassic and Cretaceous neosuchian crocodylomorphs, establishing a detailed description of this type of osteoderms. These features are present in crocodylomorphs with a closed paravertebral armour bracing system. The exceptional 3D conservation of the specimen, and the performance of a micro-CT scan, allowed us to interpret the bracing system of this organism to assess if previous models were accurate. The characters observed in this specimen are congruent with Goniopholididae, a clade of large neosuchians abundant in most semi-aquatic ecosystems from the Jurassic and Early Cretaceous of Laurasia. However, its small size, contrasted with the sizes observed in goniopholidids, left indeterminate whether it could have been a dwarf or juvenile individual. Future histological analyses could shed light on this.

Raubaba, H.S., Octavia, S., Simorangkir, Y.V. and Sumardi (2019). Timor street study as a center for sales of crocodile leather crafts in the City of Merauke based on the city design elements criteria. IOP Conf. Series: Earth and Environmental Science (doi:10.1088/1755-1315/343/1/012232).

Abstract: Timor Street is one of the roads in the city of Merauke and has become a phenomenon of gathering places for alligator craftsmen in the center of Merauke City. Timor Street is the main attraction for businessmen and craftsmen of crocodile skin to become a place of business in the form of workshops and displays of their handicrafts. This has become an interest of researchers to identify Timor Street as a center for selling crocodile skin in Merauke City which, if viewed in macro terms, can be linked to the rapid development and development of Merauke City, which is micro-increasing public activity on Timor Street. For this reason, a study of the existing conditions of Timor Street is needed according to the 8 (eight) criteria of the city design according to Hamid Shirvani. This research is a quantitative descriptive study that departs from a survey and collection of primary data taken directly in the field and supported by interviews and questionnaires from various groups of respondents. The data is then compiled, grouped and analyzed according to the elements of the city design delivered by Hamid Shirvani. The results showed that the strategic location in accordance with its use, building form and massing, circulation and parking, open space, pedestrian ways, activity support in the form of public spaces, signage, conservation, and preservation have strong attachments to the function of Timor Street as a center for craft sales crocodile skin in Merauke City.

De Valais, S., Díaz-Martínez, I., Citton, P., Maniel, I. and De la Fuente, M. (2019). A predation attempt in a Late Cretaceous pleurodire turtle from Patagonia. Cretaceous Research (<https://doi.org/10.1016/j.cretres.2019.104290>).

Abstract: In the present contribution, we report the evidence of a predation attempt against a semi-aquatic pleurodire turtle who survived the attack. The almost complete specimen of this adult turtle, the holotype of *Rionegrochelys caldieroi*, was found in the Upper Cretaceous Plottier Formation, El Anfiteatro area, Río Negro Province, Patagonia. The shell displays two distinct but synchronously produced trace fossils in the anterior right portion of the plastron. One of the trace fossils is semicircular and indicates where the bone has been broken during the attack, as a consequence of a bite. The other one reflects the predator's teeth morphology, and suggests a crocodyliform as the best candidate. Computed tomography analysis reveals regenerated tissue associated with both trace fossils, indicating healing of the wound. No vital organ was seriously injured during the attack, and the turtle survived, lacking

a fragment of the shell. Taking into account the evidence in the fossil record, the unambiguous predator-prey relationship between crocodyliforms and turtles is present from at least the Late Jurassic, and the *Rionegrochelys caldieiroi* holotype and their trace fossils is a new evidence of this interaction.

Tsai, H.P., Turner, M.L., Manafzadeh, A.R. and Gatesy, S.M. (2019). Contrast-enhanced XROMM reveals *in vivo* soft tissue interactions in the hip of *Alligator mississippiensis*. *Journal of Anatomy* (doi: 10.1111/joa.13101).

Abstract: Extant archosaurs exhibit highly divergent articular soft tissue anatomies between avian and crocodylian lineages. However, the general lack of understanding of the dynamic interactions among archosaur joint soft tissues has hampered further inferences about the function and evolution of these joints. Here we use contrast-enhanced computed tomography to generate 3D surface models of the pelvis, femora, and hip joint soft tissues in an extant archosaur, the American alligator. The hip joints were then animated using marker-based X-Ray Reconstruction of Moving Morphology (XROMM) to visualize soft tissue articulation during forward terrestrial locomotion. We found that the anatomical femoral head of the alligator travels beyond the cranial extent of the bony acetabulum and does not act as a central pivot, as has been suggested for some extinct archosaurs. Additionally, the fibrocartilaginous surfaces of the alligator's antitrochanter and femoral neck remain engaged during hip flexion and extension, similar to the articulation between homologous structures in birds. Moreover, the femoral insertion of the ligamentum capitis moves dorsoventrally against the membrane-bound portion of the medial acetabular wall, suggesting that the inner acetabular foramen constrains the excursion of this ligament as it undergoes cyclical stretching during the step cycle. Finally, the articular surface of the femoral cartilage model interpenetrates with those of the acetabular labrum and antitrochanter menisci; we interpret such interpenetration as evidence of compressive deformation of the labrum and of sliding movement of the menisci.

Our data illustrate the utility of XROMM for studying *in vivo* articular soft tissue interactions. These results also allow us to propose functional hypotheses for crocodylian hip joint soft tissues, expanding our knowledge of vertebrate connective tissue biology and the role of joint soft tissues in locomotor behavior.

Lennard, D. (2019). *Brute Force: Animal Horror Stories*. State University of New York Press: Albany, NY, USA.

Paz, L.N., Hamond, C., Dias, C.S., Curvelo, V.P., Medeiros, M.A., Oriá, A.P. and Pinna, M.H. (2019). Detection of *Leptospira* spp. in captive Broad-snouted caiman (*Caiman latirostris*). *EcoHealth* (<https://doi.org/10.1007/s10393-019-01452-0>).

Abstract: *Leptospira* sp. is an important waterborne zoonotic bacterium, known to cause infection in animals and humans worldwide. The role of reptiles in the transmission of this microorganism is poorly understood and historically neglected. This study aimed to investigate the presence of anti-*Leptospira* spp. antibodies and leptospiral DNA in captive *Caiman latirostris* (broad-snouted caiman). Of the 23 reptiles studied by microscopic agglutination test (MAT), 22/23 (95.65%) were considered reactive (titers ≥ 100) and 1/23 (4.35%) non-reactive (titer < 100). The serogroup with highest occurrence was Grippotyphosa (68.18%, n=15/22) followed by serogroup Djasiman (18.18%, n=4/22). Specific amplification of *Leptospira* spp. gene *lipL32* was observed in six (26.09%, n=6/23) blood samples. Five of six samples, previously detected as pathogenic leptospira by PCR, were amplified and sequenced. All the samples corresponded to the pathogenic species *Leptospira interrogans* (presented 100% of identity) using the PCR targeting to *secY* gene. We demonstrated high detection of DNA of *L. interrogans* in crocodylians, and the authors suggest that further research is needed to elucidate the impact of *Leptospira* spp. infection in healthy Broad-snouted caimans as well as the pathophysiology of leptospirosis in crocodylians.

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