

CROCODILE SPECIALIST GROUP NEWSLETTER

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CROCODILE

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NEWSLETTER

VOLUME 41 Number 3
JULY 2022 - SEPTEMBER 2022

IUCN - Species Survival Commission

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COVER PHOTOGRAPH: Morelet's crocodile (*Crocodylus moreletii*). Photograph: Marco Lopez Luna.

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CSG Newsletter

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

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

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James Hennessy, The National Reptile Zoo, Ireland.

Cathy Shilton, Darwin, Australia.

Editorial

The 26th CSG Working Meeting was finally able to take place in July 2022, in Chetumal, Mexico, and although the pandemic prevented some people attending, it was clearly a great success. Some 233 participants from 34 countries did attend, either in person (186) or virtually (47). A sincere thanks to Mexico for persevering through the trials and tribulations. Summaries of the pre-meeting workshops (drones, veterinary, taxonomy), the Working Meeting and associated side meetings, are on pages 10-17, and minutes of the CSG Steering Committee on pages 4-9.

In late September, the Indianapolis Prize announced the 10 finalists for the newly created “Emerging Conservationist Award”, which is designed to recognize professional wildlife conservationists, biologists and scientists under 40 years of age, who are working to save animal species from extinction. We are very pleased to see that CSG member Sergio Balaguera-Reina, has been named one of the finalists. Reaching the short list in this highly competitive arena is a great achievement, and wish him the best in the final decision. The inaugural winner of the Emerging Conservationist Award will be announced in April 2023.

The 19th Conference of the Parties to CITES (CoP19) will be held in mid-November 2022, in Panama. The CSG is expected to be well represented at CoP19, including members of the CSG Executive Committee and participants of the CSG Future Leaders Program. There are three amendment proposals seeking transfer of crocodilians from Appendix I to Appendix II, to be considered at CoP19: Thailand (*Crocodylus siamensis*); Philippines (*Crocodylus porosus*); and, Brazil (*Caiman latirostris*). The CSG has provided feedback to the IUCN review process for CoP19 proposals.

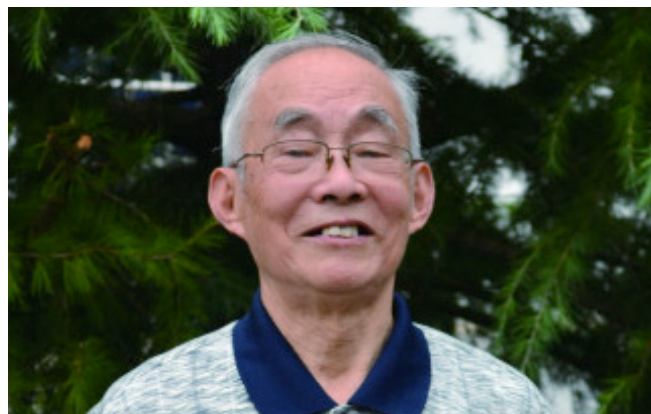
Issues of specific interest to the CSG at CoP19, which has long understood the importance of communities and livelihoods in conservation, include “Engagement of indigenous peoples and local communities” (CoP19 Doc. 13), “Livelihoods” (CoP19 Doc. 14) and “Participatory mechanisms for rural communities in CITES” (CoP19 Doc. 15) A further document (CoP19 87.1), submitted by Botswana, Cambodia, Eswatini, Namibia and Zimbabwe, propose amendments to Resolution Conf. 9.24 (Rev. CoP17) to recognise livelihoods and food security in proposals for amendment to the Appendices.

However, a potential game-changer in biodiversity conservation issue has been the publication of summary results (advice to policy makers) from the global review of sustainable use by IPBES (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services)(<https://zenodo.org/record/6810036#.Yza2GexBz2K>). The review by IUCN says it all (<https://iucnsuli.org/index.php/latest-news/>). The full report is very extensive and not yet available. Many CSG members contributed to this extensive inquiry,

that brought the world’s best experts together to evaluate sustainable use. This is a profoundly important document, and I believe will influence conservation policy globally.

CSG membership, over the decades, has included most of the notable pioneers in crocodile conservation, management, research and sustainable use. A field that really started to develop internationally in the 1970s, with huge challenges. I’m saddened to report that once again some of these iconic people have passed on.

Professor Chen Bihui passed away due to multiple organ failure in his hometown of Wuxi, China, on 28 August 2022, aged 91 years. Working at Anhui Normal University, Professor Chen worked with Chinese alligators from 1976 until his retirement in 1999. A detailed obituary covering Professor Chen’s life, written by his ex-graduate student and colleague Professor Wu Xiao Bing ([doi: 10.24272/j.issn.2095-8137.2022.338](https://doi.org/10.24272/j.issn.2095-8137.2022.338)) details the great work he did.



Professor Chen Bihui [courtesy of Wu (2022)].

George Saputra, a close friend and colleague for over 30 years, passed away on 20 July 2022 following a Covid-related illness, in Jakarta, Indonesia. Many CSG members worked closely with George, whose knowledge of reptile industry players and events in Indonesia was profoundly important and extended openly. He was a long-term supporter of the CSG and helped so many researchers interested in the varanid and python harvest programs in Indonesia.

In Newsletter 41(1), we reported that Toby Ramos, the father of crocodile research and management in Cuba, had a serious medical problem. Despite successful surgery, his health did not improve, and he passed away on 19 September 2022, aged 68 years. Since 1977, Toby actively worked with Cuban crocodiles, inspired many young biologists to follow in his footsteps, and helped so many visiting CSG members who worked with this species. See obituary (page 4) and dedication (pages 27-28).

Tran van Nga, owner of Tonphat Crocodile, in Ho Chi Minh City, Vietnam, passed away on 1 August 2022, following a long illness with cancer. He was a pioneer in the crocodile industry within Vietnam, and he helped CSG to better understand the local context.

Grahame Webb, *CSG Chair*.

Obituary

It would be impossible to write the history of crocodiles in Cuba without mentioning Roberto (“Toby”) Ramos Targarona - the Father of Crocodiles in Cuba! The loss of a friend and colleague is always painful, and although I suspected that I would have to talk and write about Toby’s passing at some stage, I am still reluctant to believe that the time has come to do so. I join many, many people in Cuba and around the world, who mourn Toby’s physical demise.



Toby’s “crocodile” story begins on 8 September 1977, when he arrived at the Zapata Crocodile Farm. Until that moment, he was unaware that his “crocodile spirit” had been activated, and would remain with him until his last breath on 19 September 2022.

One of his main contributions was to steer the Zapata Farm towards conservation of the Cuban crocodile (*Crocodylus rhombifer*) and carrying out important studies that generated valuable information that facilitated the development of captive breeding of crocodiles in Cuba. He was the first person to study in detail the wild populations of *C. rhombifer*, and generating many publications on various aspects of the biology and ecology of the species, including his PhD thesis.

He participated in many national and international events, where his lectures were always master classes of teaching, but his greatest contribution was to teach us that the only way to dedicate ourselves to conservation is to add passion to your efforts.

On each of his expeditions into Zapata Swamp, sometimes with tears in his eyes, he would say said it was the last time he would go into the swamp. However, for more than 45 years he never managed to fulfill this promise. Even during his last days, he dreamed of the countless expeditions that he had undertaken. Today his story and great passion for crocodiles embraces and urges us to follow the legend of a young man who became a symbol in the conservation of crocodiles in Cuba and Latin America.

For Toby, there was no greater pleasure than to capture a

crocodile, especially if it was a Cuban crocodile from “Zone 10”. What better place to scatter his ashes than there, at the entrance of the core distribution of *C. rhombifer*! What better place for him to be once again and forever surrounded by his crocodiles. Current and future Cuban researchers will no doubt feel comforted to know Toby’s spirit is watching over them.

Prepared by Gustavo Sosa Rodríguez, Cuba.

[Editor’s note: more details of Toby’s life and work are on pages 27-28, in an article that had been prepared well before his passing.]

CSG Student Research Assistance Scheme

The Student Research Assistance Scheme (SRAS) and Fritz Huchzermeyer Veterinary Science Student Research Assistance Scheme (FHVS-SRAS) provided funding to four students in the July-September 2022 quarter, and one application is currently under review.

1. Giovanni Herrera Pachón (Colombia): Phylogeography of *Paleosuchus palpebrosus* and *Paleosuchus trigonatus* (Crocodylia: Alligatoridae) in Colombia.
2. Leonardo Gorza (Brazil): Causes of mortality and anatomopathological changes in wild and captive *Caiman yacare*.
3. Gladys Kabaso (Zambia): Ecology and biology of the critically endangered Slender-snouted crocodile (*Mecistops cataphractus*) in Zambia.
4. Javier Moreno (Mexico): Nesting ecology of *Crocodyus acutus* in the Lake Izabal basin, Guatemala.

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

CSG Steering Committee Meeting

The CSG Steering Committee meeting was held on 4 July 2022, with participation by people in Chetumal and by Zoom. The meeting began at 1500 h (Chetumal time). Minutes of the meeting are:

Participants

SC members present in person: Alejandro Larriera, Perran Ross, Xander Combrink, Matthew Shirley, Rainier Manalo, Pablo Siroski, Hesiquio Benítez Diaz, Marisa Tellez, Luis Bassetti, Laura Porras Murillo, Carlos Piña, Alvaro Velasco, Christy Plott, Enrico Chiesa, Kent Vliet, Valentine Lance, Simone Comparini

SC members present by Zoom: Grahame Webb, Christine Lippai, Charlie Manolis, Tom Dacey, Matthew Brien,

Alfonso Llobet, Allan Woodward, Curt Harbsmeier, Nathalie Kpera, Phil Wilkinson, Ruth Elsey, Colette Adams, Thomas Rainwater, Frank Mazzotti, Gowri Mallapur

Observers present in person: Kyle Shaney, Robert Godshalk, Bruce Shwedick, Bekky Muscher-Hodges, Helen Sung, Miriam Boucher, Paul Reilly, Robinson Botero Arias, Phoebe Griffith, Alba Imhoff, Treya Picking, Saiyaad Ali, Melina Simoncini, Eduardo Mosso, Iri Gill, Shawn Helflick, Jhonathan Triminio, Gabriela Lopez Jauregui, Samuel Seashole, Sol Gutierrez

Observers present by Zoom: Mitsuko Takehara, Yoichi Takehara, Noboru Ishii, Gisela Poletta, Sukanao Iida, Jose Arturo Bocanegra Martinez, Kataoka Takayuki, Lucia Fernandez

SC member apologies: Alison Leslie, Howard Kelly, Emmanuel Amoah, Lonnie McCaskill, Wu Xiaobing, Nao Thuok, Kornvika Youngprapakorn, Yosapong Temsiripong, Luke Evans, Oswald Braken Tisen, Adrian Sugiarto, Steve Platt, Jhon Calderon, Anslem de Silva, Madhava Botejue, Maheshwar Dhakal, Raju Vyas, Abdul Aleem Choudhury, Asghar Mobaraki, S.M.A. Rashid, Thomas Ziegler, Fabian Schmidt, Jeb Linscombe, Pamela Ashley, Kevin Van Jaarsveldt, Helen Crowley, John Caldwell, Cathy Shilton, Paolo Martelli, Chris Brochu, Sally Isberg

Agenda Papers

The agenda papers can be found at: <http://www.iucncsg.org/pages/SC-Meeting%2C-Chetumal%2C-4-July-2022.html>.

1. Minutes

Interim CSG co-Chair Alejandro Larriera opened the meeting at 1500 h (Chetumal time), thanking the sponsors and organizers, including both local and national Mexican Governments, for their efforts in arranging the meeting in the face of difficulties caused by the Covid-19 pandemic, which had caused several postponements of the meeting.

One minute silence was held for 13 CSG members who had passed away since the last working meeting in May 2018: Joseph Fagan, Manuel Tabet, Effendy Sumarja, Ernesto Boede, Giam Choo Hoo, Maria Cristina Robayo, Sergio Medrano Bitar, Mario Baudoin, Mushtaq Ahmed, Wayne Sagrera, Widodo Ramono, Jerome Caraguel, Utai Youngprapakorn.

1.1. Chair's Report

The Chair Grahame Webb apologized for not being able to attend the meeting in person, and thanked Alejandro Larriera and Charlie Manolis for filling in as joint co-Chairs during his recent recovery from illness. He also thanked the hosts and organisers of this working meeting.

The Chair highlighted the following:

- The CSG, with some 710 members from 70 countries, is one of the biggest specialist groups within the Species Survival Commission, and that since the last meeting the pandemic had impacted on many of its members, including some deaths.
- Thirteen (13) members had passed away and two were expelled from the CSG since the last working meeting for breaches of the IUCN Code of Conduct.
- Since 2009, 222 students from 42 countries have been awarded SRAS and/or FHVS-SRAS grants. Some of these students are now CSG members, members of the Future Leaders Program and/or are on the CSG Steering Committee. Summary reports for completed studies are posted on the CSG website, and many have maintained their interest in crocodilians and published papers from their projects.
- Establishment of the Future Leaders Program, with Pablo Siroski as Chair, aims to enable members with demonstrated leadership abilities to strengthen their skills, become proficient in the complex world of biopolitics, and further the goals of the CSG. It is intended to get some of the Future leaders to the next CITES CoP, to be held in Panama City, on 14-25 November 2022.
- Industry Issues. Following a survey by Alan Woodward and Perran Ross, the Chair undertook to finalise a report, but this has been made more difficult because of the recent actions by animal rights activists. Matter listed for further discussion in Agenda item 3.1 Industry.
- CSG funding comes from various industry members, which is a double edge sword. However, the CSG is open and transparent and not subjected to any pressure from industry donors.
- CrocFest, headed by a small group people (Colette Adams, Flavio Morrissiey and Curt Harbsmeier), is very effective and has achieved remarkable results for crocodilian conservation.
- Case Studies document is still being developed. Delays caused by change in direction with respect to the audience for the document.
- The IUCN-SSC has established a relationship with the Indianapolis Zoo, but not sure how this will work out as many CSG members are not necessarily interested in IUCN activities. (see comments in Agenda item 3.6 Legal Affairs).
- The CSG Newsletter continues to be published ever quarter, thanks to the efforts of Charlie Manolis. It provides members with regular information about crocodilians, publications and CSG activities.

1.2. Minutes from SC Meeting, Santa Fe

Tom Dacey introduced the item. He undertook to provide a copy of the "CSG Targets for the 2021-2024 Quadrennium" to SC members (by time of writing of these Minutes this had been done). The report was noted.

1.3. Actions from SC Meeting, Santa Fe

Tom Dacey introduced the item. Actions from the previous SC meeting were also addressed:

1. African Survey Database: Christine Lippai advised “the general feeling is that the database structure is ‘old fashioned’ and requires a lot of effort and manpower to bring it up to modern standards. It remains an excellent historic source of information about surveys carried out on the continent, but is not of value to incorporate recent survey information.” No further action required at this time.
2. Incorporation of contact details of CSG members on CSG website: No actions are recommended at this time - the details of Steering Committee members will remain in the CSG Newsletter as has been the case for over 18 years now. Given information on the web, locating people is much easier now.
3. Terms of Reference for Industry Group: The Chair prepared Terms of Reference for the Industry group, which were accepted by the Executive Committee, and appointed Christy Plott as the Vice Chair of the Group.
4. Future Leaders Working Group: Following the verbal report from the working group, it was confirmed that it should now become the “Future Leaders Program”, under the leadership of Pablo Siroski and Sergio Balaguera-Reina.

The report was noted.

1.4. Executive Officer Report

Tom Dacey introduced the item. The report was noted.

1.5. CSG/IACS Financial Reports

Charlie Manolis introduced the item, advising that the Auditor’s Reports for IACS would be posted on the CSG website (by time of writing of these Minutes, this had been done). He also reported that both WMI and the Executive Officer had volunteered to take a 25% reduction in their contracts due to restrictions on travel, and as a contribution to CSG during this difficult time due to the Covid-19 pandemic.

1.6. IUCN Membership 2021-2025

Tom Dacey introduced the item, advising that of the 710 “members” currently included on the CSG’s database, only 590 were registered on the IUCN portal. People who are not on the IUCN database are not formally recognized as members of the CSG (or IUCN), and they are encouraged to register as soon as possible.

1.7. SRAS and FHVS-SRAS

Charlie Manolis introduced the item advising that there had been 222 grants awarded to date, and to date only 3 applicants had failed to complete their projects. Overall the scheme has been very successful.

Matt Shirley asked whether the outcomes had resulted in publications. Charlie Manolis advised that CSG does not monitor publications produced from funded projects, in part because of the long periods of time that may exist between completion of the project and eventual publications. Students doing their project as part of a MSc or PhD typically publish, but students undertaking projects as part of their undergraduate degree do not. Many students attend working meetings, where they present their work.

Grahame Webb suggested that it might be good to do a review of publications resulting from SRAS students. He also reminded the SC that the prime purpose and focus of the scheme was to get people involved with crocodilians, not publications.

2. Regional Reports

2.1. East and Southern Africa

Xander Combrink introduced the item, highlighting:

- Madagascar: the Madagascar Crocodile Conservation and Sustainable Use Program came to an end in 2019.
- South Africa: a) decrease in wild population; b) breeders from commercial farms provided for hunting; c) increasing number of escapes from commercial farms; and, d) research postponed due to Covid-19 pandemic, beginning again.
- Namibia: research focusing on the decrease in population, while identifying the cause of the trend.
- Zimbabwe: ranching and trophy hunting of Nile crocodiles have contributed to the increase in crocodile populations. Increased HCC in fringe communities.

The report was noted.

2.2. West and Central Africa

Matt Shirley introduced the item, highlighting:

- Emmanuel Amoah (Ghana) replaced retiring regional Vice Chair Prof. Guy Apollinaire Mensah
- An increase in regional membership
- Red List assessments and Action Plans are now progressing
- New Regional Capacity-building Program for Under-represented Species (including crocodilians) is underway
- Two documentaries have been produced on African

- Dwarf crocodiles in Gabon
- Lots of research is being undertaken

The report was noted

2.3. East and Southeast Asia

Rainier Manalo introduced the item, highlighting:

- Cambodia - FFI involvement
- Indonesia - WCS involvement
- Laos and Vietnam - Laos Zoo
- Philippines: a) involvement of CCPI and Mabuwaya Foundation; b) development of Crocodile Conservation Action Plan in the Philippines 2023-2032; and, c) a split-listing proposal for the transfer of the Philippine population of Saltwater crocodiles (*Crocodylus porosus*) on Palawan Island, from Appendix I to Appendix II, with a zero export quota for wild specimens, has been submitted to CITES.

Charlie Manolis advised that in Cambodia and the Philippines there has been increased collaboration between farmers, Government and NGOs.

The report was noted.

2.4. Latin America and the Caribbean

Pablo Siroski introduced the item, highlighting LAC Regional Office activities and the CSG's 50th Anniversary Virtual Event

- Alvaro Velasco advised on the Report on Trade in the LAC Region for 2010-2020.
- Hesiquio Diaz advised that whilst the CSG working meeting in Chetumal had been postponed three times, he was glad the meeting had eventuated as it will engage many people from the region.
- Alfonso Llobet stressed the impact being incurred on local livelihoods and the economic incentives for local conservation in Bolivia. Charlie Manolis noted that the closure of farms and programs in the region will have impacts on livelihoods.
- Marisa Tellez provided an update on the situation in El Salvador, Honduras and Trinidad & Tobago.
- Grahame Webb indicated that: a) Mexico report raises several important issues, particularly, global recognition of local communities, biodiversity and sustainable use; b) there was an oversupply of skins in trade; c) in the Philippines, *C. porosus* farmers were funding the research on *C. mindorensis*; d) Traceability (see Agenda item 5.2) - many local communities cannot meet traceability requirements (eg PNG local communities reliant on wild harvests); and, e) CSG review of sustainable use programs is not yet finalized.

The report was noted.

2.5. South Asia and Iran

The report was noted.

2.6. Australia and Oceania

Charlie Manolis introduced the item, highlighting:

- Matthew Brian is now Regional Chair for Australia & Oceania, replacing Charlie Manolis
- The Code of Practice on the Humane Treatment of Wild and Farmed Australian Crocodiles is coming up for review
- Monitoring of the population in the Northern Territory has occurred consistently since 1975
- In Queensland, detailed information is awaited on recent population surveys and there has been increasing human-crocodile conflict over the last two decades;
- In Western Australia, there is now only one commercial farm and the population monitoring program has been reduced
- Papua New Guinea: (a) due to the international market decline, there has been an impact on the wild harvest and conservation program; (b) legislation is being reviewed; and, (c) there is concern that there may be impacts on the local harvest programs and livelihoods.
- Timor-Leste: CrocFest is funding research into whether crocodiles are coming from Australia or elsewhere, with sampling being undertaken by Sebastian Brackhane, and analysis by Australian researchers. Grahame Webb indicated that the crocodile culture beliefs of the people in Timor-Leste are changing.
- Solomon Islands: Government is currently developing a national crocodile management plan, and implement training programs.
- Palau: Has a small stable population and HCC is very uncommon.

The report was noted.

2.7. Europe

The report was noted.

2.8. North America

Alan Woodward addressed this item, highlighting:

- Distribution of American alligators is extending north with climate change;
- Price declines for alligator skins is affecting the nuisance alligator program and trappers are seeking assistance funds from Government;
- There has been a decline in the harvest of alligators and eggs;
- Research projects: a) report on the effects of translocation due out soon; b) caiman removal

program by Frank Mazzotti.

Ruth Elsey thanked everyone for their contributions to the Louisiana report, and highlighted:

- Surveys
- Reduction in nesting
- Lower prices for skins and effect on trappers

The report was noted.

3. Thematic Group Reports

3.1. Industry

Christy Plott addressed this item, and highlighted:

- Conservation, sustainable use, livelihoods and the industry are intimately linked to each other for many species of crocodilian
- Luxury markets only want perfect skins. Brands have tightened quality requirements
- Wild skin markets remain bleak
- Demand for meat, globally, has eclipsed the demand for skins
- California issue - it is recommended that industry should:
 - (a) increase communication on sustainability, animal welfare, conservation, and alignment with United Nations Sustainable Development Goals industry-wide
 - (b) explore new markets for low-medium grade farmed and wild skins
 - (c) decrease raw skin production, where possible, in order to discourage a global price crash
 - (d) tanners and traders should collaborate to sell old stock of crust and finished leather
 - (e) farms should aim to sell skins as quickly as possible due to tanning issues with old skins
 - (g) implement strict policies internally (and amongst various associations) at the trapper, farm, tannery, manufacturers, and brand/retail store levels for compliance with CITES regulations.
 - (h) aim to increase education on CITES procedures amongst small artisans and cottage businesses to decrease violations globally on single item shipments.

The report was noted.

3.2. Trade Monitoring

The report was noted.

3.3. Veterinary Science

Gowri Mallapur addressed this item. The report was noted.

3.4. Zoos

Kent Vliet addressed this item and highlighted:

- Colette Adams is now a Vice Chair for the Zoo Group
- Israel asking for assistance in re-homing 700 Nile crocodiles from the Pezrael Crocodile Farm that had closed
- Cooperative project between Dr. Matt Shirley (Project Mecistops), Albuquerque BioPark Zoo, and the staff and administrators of Abidjan Zoo
- Activities in European zoos (see Agenda item 2.7)
- Zoo Animal of the Year
- Zoos funding *in-situ* projects
- St. Augustine Alligator Farm research contributions
- St. Louis Zoo Cuban crocodiles
- CrocFest fundraising events

The report was noted.

3.5. Taxonomy

Kent Vliet addressed this item and highlighted:

- Problems being experienced in moving tissue samples (eg CITES and other management authorities)
- Definition of “species”
- Sorting out caiman taxa

Hesiquio Diaz advised that there is a need to be very careful when advising CITES on taxonomic issues.

The report was noted.

3.6. Legal Affairs

Curt Harbsmeier addressed this item, and highlighted:

- CSG has not been a party to any litigation over the past 3 years
- Christy Plott’s involvement in the California issue was much appreciated
- Alligator situation in the USA: a) permits increased in Florida; and, b) extended hunting hours
- Amazon Smile as a fund-raising tool for CSG
- Renewed focus on ethical considerations
- IUCN World Commission on Environmental Law (WCEL)
- Indianapolis Zoo and IUCN-SSC create new Global Center for Species Survival

The report was noted.

3.7. IUCN Red List Authority

Perran Ross advised that Sally Isberg has taken over responsibility for the Red List Authority. To date 7 species have been submitted to the IUCN Red List Team; 3 more are pending; and, 2 others are almost ready to submit. The report was noted.

3.8. CITES

Charlie Manolis advised that three “crocodilian” proposals were submitted for consideration at CoP19 (Panama, 14-25 November 2022):

1. Brazil: Transfer of *Caiman latirostris* from Appendix I to Appendix II. This proposal was not provided to CSG for review.
2. Philippines: Transfer of Palawan population of *Crocodylus porosus* from Appendix I to Appendix II, with zero export quota for wild specimens. The draft proposal was reviewed by CSG.
3. Thailand: Transfer of *Crocodylus siamensis* from Appendix I to Appendix II, with zero quota for export of wild specimens. The draft proposal was reviewed by CSG. The proposal is similar to the previous, unsuccessful proposal at CoP16. The problem is that a very large captive population is being managed as an Appendix-I species, and the wild population is very small.

Grahame Webb advised that previously the CSG was opposed to trade in crocodilians, however, there has been a quantum shift and the CSG now assists proponents with development of proposals. CSG has been asked by IUCN/TRAFFIC to provide comments of these proposals. Any feedback would be appreciated, but there is a tight timeline.

Matt Shirley advised that CITES is organizing workshops on “non-detriment findings”, and that CSG should be represented. Grahame Webb suggested that he and Matt should have further discussions on this issue.

The report was noted.

4. Task Force/Working Groups

4.1. Future Leaders Program

Pablo Siroski addressed this item highlighting:

- Restructuring process has been implemented
- Some FLs were represented as part of official IUCN delegation at CoP18 (Geneva, Switzerland, 17-28 August 2019), and attended a number of side-events on conservation, sustainable use, and livelihoods
- FLs provided an important review and some feedback on a critical endangered species, *Tomistoma schlegelii*
- FLs involved in the development of “Traceability in Crocodylian Conservation and Management”

The report was noted.

4.2. Drone Working Group

A workshop was held prior to the Chetumal Working Meeting. The report was noted.

5. General Business

5.1. IUCN World Conservation Congress The report was noted.

5.2. Traceability

The report was noted.

5.3. Case Studies

The proposed Case Studies document is still being developed. The report was noted.

6. 27th CSG Working Meeting

The 27th Working Meeting will be held in Darwin, Northern Territory, Australia, tentatively scheduled for early June 2024.

Grahame Webb commented that we are now good at participating in Zoom meetings, and it will no doubt become a feature of future meetings. CSG meetings give people the opportunity to meet and discuss issues with each other, apart from the formal agenda. There is a need to make it more worthwhile for people to travel and participate in face-to-face meetings.

7. Other Business

7.1. CSG Science Group

Carlos Piña suggested that consideration be given to re-establishing the Science thematic group. It was agreed that the matter be discussed out of session during the Working Meeting and a recommendation be made to the CSG Executive Committee for consideration.

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



Morelet's crocodile (*Crocodylus moreletii*). Photograph: Marco Lopez Luna.

26th CSG Working Meeting

The 26th CSG Working Meeting was held at the Centro Internacional de Negocios y Convenciones de Chetumal, Chetumal, Mexico, on 3-9 July 2022. It was attended by 233 registered participants (186 in person, 47 virtually) from 34 countries; Mexico, USA, Argentina, Brazil, Colombia, Australia, Belize, Cuba, Philippines, Japan, United Kingdom, France, Guatemala, Israel, Panama, South Africa, Cote d'Ivoire, Costa Rica, Malaysia, Germany, Benin, Bolivia, Canada, Spain, Ghana, Ireland, Italy, Jamaica, Nepal, Portugal, Czech Republic, Trinidad and Tobago, Venezuela and Zambia.

Parallel to the Working Meeting, and for the first time in the history of the CSG, a program open to the public was delivered, in which 25 presentations and 77 audiovisuals were presented. This forum was attended in person and virtually and reached more than 11,000 people through the social networks of the Comisión Nacional para el Conocimiento y Uso de la Biodiversidad (CONABIO) and the Comisión Nacional de Áreas Naturales Protegidas (CONANP).

The Working Meeting was hosted by: the Government of the State of Quintana Roo, represented by Governor Carlos Joaquín González, the Secretariat of Agricultural, Rural Development and Fisheries (Luis Torres Llanes), the Secretariat of Ecology and Environment Ministry of Environment (Efraín Villanueva Arcos); the Federal Government, represented by Hesiquio Benítez Díaz (CONABIO - CITES Scientific Authority), Roberto Aviña Carlín (General Directorate of Wildlife of the Ministry of the Environment and Natural Resources) and Carmen Pozo (ECOSUR - El Colegio de la Frontera Sur, public center of the National Council of Science and Technology); and, crocodile farm "Cocodrilia", represented by Rolando Coral Hoil.

The Organising Committee was led by representatives from SEDARPE (Secretaría de Desarrollo Agropecuario, Rural y Pesca), CONABIO, Cocodrilia Farm, ECOSUR, CONANP, higher education institutions, research institutes, and non-governmental organizations, ensured that the venue, program, sponsors, entertainment, etc., were in place. The Organizing Committee also assisted with the complex logistic arrangements required by delegates from around the world.

The official opening of the Working Meeting on 5 July, included addresses by CSG Deputy Chair Alejandro Larriera (on behalf of CSG Chair Grahame Webb), Carlos Joaquín González (Governor, State of Quintana Roo), Luis Torres Llanes (SEDARPE), Hesiquio Benítez Díaz (CONABIO), Carmen Pozo (General Director, ECOSUR), Yensunni I. Martínez Hernández (Municipal President of Othón P. Blanco), Rolando Coral Hoil (Manager, Cocodrilia Farm), Roberto Aviña Carlín (General Director, Wildlife of the Ministry of Environment and Natural Resources), Efraín Villanueva Arcos (Secretariat of Ecology and Environment Ministry of Environment), Rafael Robles de Benito (Director of Institute of Biodiversity and Natural Protected Areas of Quintana Roo) and deputy Eduardo L. Martínez



Figure 1. Opening of Working Meeting by Carlos Joaquín González, Governor of State of Quintana Roo. Photograph: José Rogelio Cedeño Vázquez.

Arcila (President of the Board of Government and Political Coordination of the H. XVI Constitutional Legislature of the State of Quintana Roo).

Considering that the theme for the Working Meeting was "Sustainable Use for Conservation", it was emphasized that the sustainable use of biodiversity, based on the best available knowledge, is one of the main ways to conserve natural capital under a scheme of co-responsibility among the various sectors of society. To this end, it is essential to strengthen integration between academia, local communities and indigenous peoples, authorities at different levels and the responsible participation of the private sector. In this context, and as an example of the industry's potential to support the sustainable, legal and traceable use of crocodiles, Grupo CUADRA organized a fashion show with more than 20 articles manufactured with skin of Morelet's crocodile. In addition, Cocodrilia Farm offered tasting of crocodile meat.



Figure 2. Fashion show Grupo Cuadra. Photograph: Gabriela López Segurajáuregui.

Three workshops preceded the Working Meeting:

a. Veterinary Workshop (reported by Luis Bassetti)

The Veterinary Workshop took place on 3 July, and was hosted by Cocodrilia Farm. This workshop was coordinated and assisted by Jonathan Nácar Muñoz, Marisa Tellez and Luis Bassetti. As in previous years, this workshop

attracted a large number of participants (30), with different professional profiles (zoo, commercial breeding, wildlife veterinarians, biologists, etc.).

Lasting 7 hours, the workshop was divided into two stages. During the morning, several topics were discussed, such as the diagnosis of the main diseases in crocodilians (signs, control measures and treatment); anesthesia in crocodilians; necropsy protocol; parasitology in crocodilians and bacterial resistance to antibiotics. In the afternoon, practical classes were held. Participants had the opportunity to work with juvenile *Crocodylus moreletii*, where they learned about blood collection techniques and the assessment of health status. Participants were divided into groups and were given dead animals for necropsy procedures. It was suggested to create a database for the results of necropsies. In this context, the findings were forwarded in a document by Jonathan Nacar.

It is important to point out that we continue with the mission of training new generations of veterinarians and, therefore, we seek to adapt the Veterinary Workshop to local realities, while presenting new perspectives and showing new diagnostic technologies.



Figure 3. Workshop at Cocodrilia Farm. Photograph: Gabriela López Segurajáuregui.

b. Drone Workshop (reported by Carlos Piña)

The inaugural Drone Workshop, held on 3 July at Crocodilia Farm, had more than 20 participants. We identified CSG members who are working with drones or interested in work with drones in the future, and set up a baseline in the understanding of this technology.

During the Working Meeting, we had live, online and recorded presentations of different capabilities of drones in the conservation/management of crocodiles and alligators. We also presented different software developed for use with these devices that allow wild population monitoring, and did a practical using a few drones during the workshop, including an autonomous flight to survey a polygon.

Finally, participants filled out a survey list of ideas about the possible use of this technology in crocodilian conservation:

- Nests: thermal images for nest, 3D models for nest, using drones to survey for nesting timing, endangered

species nests protection.

- Individuals: thermal images for individual's detection, HCC patrols, estimation of population densities, track individual over time, health surveillance, 3D models to estimate body mass of individuals without capture.
- Habitats: monitoring potential habitat, modeling dry/wet habitat, monitoring crocs movements.
- Samples: water samples, tissue samples, croc capture.
- Radio telemetry: developing VHF system to attach to a drone to locate/triangulate individuals.

There is potentially also spin-offs to other areas of science and law enforcement.

c. Taxonomy and Identification Group (prepared by Kent Vliet)

The CSG Taxonomy and Identification Group met on 4 July, at the Centro Internacional de Negocios y Convenciones de Chetumal. Sixteen people attended in person, and an additional four participated by Zoom. As Chair of the group, I led the discussion, and Perran Ross moderated the meeting. In a Zoom meeting a couple of years ago, we discussed trying to form collaborations between various research laboratories around the world that worked on crocodilian genomics and phylogenetics. A bit of discussion had occurred since that point, so we encouraged that to continue to move forward.

In all the meetings with of the group, time has been spent discussing what criteria we would use for the determination of species status. I consider these discussions, and their redundancy, to be crucial for the group to develop consensus on these issues. This is not an easy topic, every biologist probably has their own understanding of what is meant by "species". Our working group is made up of neontologists, paleontologists, genomicists and field biologists. Our goal is to have broad agreement across the group as we discuss the diversity of living crocodylians. We've agreed to use an integrative taxonomy model to differentiate species.

Early in this meeting we had two presentations to the working group. Evon Hekkala (Fordham University and the American Museum of Natural History) gave us an update on the crocodilian genomic work that she, George Amato and colleagues, have been doing with genetic samples from field collections and museum specimens, including ancient DNA techniques. Evon has gotten access to and re-analyzed all of Jacob Gratten's specimens. Veshak Gvoždík (Czech Republic) then talked to us about his work differentiating *Osteolaemus osborni* from *O. tetraspis*.

We have been working on a list of extant species, a primary objective of this group, and a goal of this meeting was to come to an agreement as to what taxa this list should include. In consideration of potential taxonomic changes in the list, we have consciously acted very conservatively, understanding that any new taxa we support may have significant consequences and ramifications to international

agreements and regulations, a point that has been made to us by Grahame Webb, Peter Paul van Dyke, and most recently by Hesiquio Benítez Díaz. A clear directive to avoid taxonomic inflation. We have not considered any changes that have not already appeared in peer-reviewed literature, though publication is certainly not the sole criterion for inclusion.

The main list is broken into Alligatoridae, Crocodylidae and Gavialidae. We list each species, its common name in English, a biogeographic description of the species' distribution, its conservation status, and all the countries in which the species are found. There's then a reference to a note section below the list in which common names are given in Spanish, Portuguese, Italian, French, and German; more information concerning taxonomic issues, and some current references are listed. Related taxa that have not been included in the list are discussed briefly.

We began with 24 species. Our draft list currently includes 27 species, including newly recognized cryptic species of African crocodiles. We are withholding judgement on the recently described *Crocodylus halli* pending further genetic support. We have not considered subspecies. In the caimans (Caimaninae), several recently published papers have revealed deep genetic structure in most species, though much less diversity morphologically. We are again being conservative and not considering any possible splitting at this time.

A secondary objective of this group, though equally important, is to provide means of physical identification of crocodylian species, for customs inspectors among others. Some of us have been working on this aspect of the work but progress is laborious and slow.

The list is being distributed to the entire Taxonomy working group for comments, which is why we are not including the list in this summary review. It will then be submitted to the CSG Executive Committee for review before we publish it.

Parallel to the Taxonomy and Identification workshop on 4 July, 35 expert members of the Crocodylian Specialist Group of Mexico (GEC-MX) met at the convention center, and reviewed several topics of interest, including: advances in the monitoring of Mexican species; steps to follow on the ranching of Morelet's crocodile; traceability of skins; S.O.S crocodile groups on human-crocodile interaction; and, planning of the next formal meeting of the group.

For some presenters, this was their first time participating in a CSG Working Meeting, and the simultaneous translation for presentations was very helpful for both English- and Spanish-speaking participants. To assist translators, the schedule of presentations was coordinated based on themes and the language of presenters.

Oral presentations in plenaries (86) and posters (72),



Figure 4. Meeting of Mexican crocodile specialists. Photograph: Gabriela López Segurajáuregui.

covered the following thematic areas: research and knowledge (natural history, systematics and evolutionary biology, population status); *ex-situ* conservation (veterinary, intensive management, zoo contribution); socio-economic issues (tourism, indigenous peoples and local communities - perceptions and culture, industry, human-crocodile interaction); and, *in-situ* conservation and sustainable use (habitat management, conservation in protected areas and other schemes, sustainable use).

On each of the four days of the meeting, a keynote speech was delivered: José Sarukhán Kermez (Sustainable use for conservation); Grahame Webb (History of crocodile management in the Northern Territory: Lessons learned); Alvaro Velasco Barbieri (Conservation and sustainable use of crocodiles); and, Bruce Swedick (CSG Tomistoma Task Force: final report). In his keynote address, CSG Chair Grahame Webb (Australia) presented lessons learned in crocodile management in northern Australia that can be useful for working with species in other countries. Similarly, Alvaro Velasco's (Venezuela) presentation emphasized that countries with good wild populations (as is the case of the Morelet's crocodile) should strive to take advantage of the potential to establish sustainable use programs.

The poster session took place in the afternoon on 7 July (before the traditional auction), where participants could speak with poster authors. To consult the general program and the abstracts, please visit: <https://www.biodiversidad.gob.mx/planeta/csg2022/programa.html>; <https://www.biodiversidad.gob.mx/planeta/csg2022/pdf/CSG26-Abstracts-Program.pdf>.

In addition to the oral presentations and the poster session, various thematic and working groups met as side-meetings, including Human-Crocodile Interaction (Paulino Ponce Campos and Simon Pooley), Zoos (Kent Vliet and Colette Adams), Industry and Fashion (Rolando Coral Hoil), IUCN Red List Assessment (Perran Ross and Sergio Balaguera-Reina).

Various side meetings were held during the Working Meeting, including:

a. Zoo Group (prepared by Kent Vliet)

Early this year, Colette Adams, Deputy Director and COO of Gladys Porter Zoo in Brownsville, Texas, was named as co-Vice Chair with me for the CSG Zoo group. This is a very welcome addition.

The Zoos group met on 6 July, with 15 attendees from 7 countries. We only had 1 hour to meet so discussions were limited. As always, I began the meeting by introducing the zoo group, its purpose and goals, to new attendees to indoctrinate them into the group. We discussed the importance of networking and capacity building by building membership in a greater diversity of countries and zoo associations. We want our group to be diverse and representative of all geographic regions and zoo associations. This takes constant effort as previous contacts drop out. We need this broad representation to share expertise to strengthen the ability of zoos to contribute meaningfully to crocodylians; to aid with equipment needs, professional assistance, finances, etc.; to provide connections with genetics, diagnostics, and other, laboratories; and, most importantly, to facilitate connections between living collections and *in-situ* crocodylian conservation projects. We also discussed means of fundraising for crocodylian conservation, including several successful models used in North America (like Crocfest, Brew at the Zoo and Croctoberfest) which can be easily replicated in zoos in other parts of the world.

Since its inception, the group has been communicating primarily through a Google Group listserv. We discussed the formation of a closed Facebook group as the primary mode of communication within the group, to increase communication, and coordinate zoos' publicity efforts for specific events - eg Tomistoma Day, World Crocodile Day, etc.

Reporting of relevant information, such as collaborative programs between zoos and *in situ* projects, zoo educational programs focused on crocodylians, new crocodylian exhibits opening at zoos, and fundraising and spending on *in-situ* conservation, needs to be collected and compiled in a systematic fashion for inclusion in the Zoos Group report presented to the CSG Executive Committee for the Steering Committee meeting at each Working Meeting. This helps demonstrate the positive impact zoos have on *in-situ* conservation of crocodylians.

Lastly, we discussed encouraging members of the zoo community to present at the CSG Working Meetings. Although there was a session nominally devoted to Zoos during the meetings, none of the presentations in that session had anything to do with zoos.

b. Red List (prepared by Perran Ross)

A side-meeting to discuss the Red List Assessments for crocodylia was convened on 8 July (1600 h). It was attended by 30 participants from 14 countries. A brief

introduction to the Red List process and current status of assessments was presented by Perran Ross, and Sergio Balaguera-Reina explained the process for Red List mapping. The role of various CSG elements were outlined:

- Red List Authority and coordinating team (Sally Isberg, Sergio Balaguera-Reina, Brandon Sideleau and Perran Ross) - overall coordination and process management.
- CSG members - assessors, expert contributors and reviewers.
- CSG Chair and Executive Committee - final review and approval.

The workshop then focused on the short list of 'Priority' assessment needs based upon: 1. the most overdue species; 2. species with assessments not currently underway or initiated; and, 3) newly recognized species.

Current assessment priority needs:

- *Osteolaemus tetraspis* (VU 1996) never assessed with current criteria and does not appear on the IUCN Red List. *O. osborni* is recently resurrected and a new clade *O. spp. nov.* is proposed
- *Melanosuchus niger* (LR 2000)
- *Crocodylus suchus*? new
- *Crocodylus halli*? new
- *Crocodylus noveaguineae* (LC 2019) needed if *C. halli* is separated

Discussion on various points followed with recommendations underlined.

The *Mecistops* assessments for both species are done, have been externally peer reviewed, and just waiting final mapping - which is also almost done.

For the *Osteolaemus* group, Matt Shirley reported that efforts were underway using regional experts to collect information but the widely dispersed nature of the species made assessments difficult. The taxonomic situation, dividing *Osteolaemus* into three species, was considered stable and had been reviewed by the CSG taxonomy workshop earlier. Given the paucity of current information, and the fact that *Osteolaemus* has never been assessed using current criteria, one strategy would be to immediately submit an assessment of *O. tetraspis* as "Data Deficient", including basic text of biology, distribution and three species status, as a holding marker that could be replaced by better assessments as information is compiled. Vaclav Gvodzdik of Czech Republic is working with the group and agreed to coordinate assessment of *O. osborni*.

For *M. niger*, Robinson Botero reported that the Brazilian Regional Red List assessment was completed 3-4 years ago, but still serves as an accurate assessment and covers most of the species' range. Adding information from Ecuador, Peru and Guyana would easily complete this assessment. Luis Bassetti would be potential assessor along with Bill Magnusson and Ronis Da Silveira.

For *C. suchus*, Matt Shirley reported that the basic status of the species is compiled, and the outline of mapping points established by regional experts dating from the meeting in Abidjan in 2015. Bringing this process to a conclusion is a priority.

C. halli and *C. noveaeguineae*: At a workshop earlier in the week, the CSG Taxonomy group considered the taxonomic status of *C. halli*. While the species is thought to be valid, and recent re-assessment of previously published genetic data by Jacob Gratten supported the split, the genetic support remains thin by currently accepted standards. The taxonomy group recommended: a) that previous samples possibly still in possession of Nancy FitzSimmons in Australia be recovered and analyzed, and b) CSG coordinate outreach to Mainland Holdings/Eric Langlet in PNG to obtain specimens that Evon Hekkala could analyze. Therefore, the Red List assessment of *C. halli* should be deferred pending further data on genetics, noting that the species remains covered under LC status of *C. noveaeguineae* and general CITES listing of all Crocodylidae in Appendix II.

In final discussions, Iri Gill of Chester Zoo (UK), James Hennessy of National Reptile Zoo (Ireland) and Jesus Reyes indicated they have student/volunteer resources that could assist with routine data entry (eg references). Perran Ross will follow up and coordinate with Sally Isberg to mobilize these resources as needed.

Shawn Heflick suggested that other groups are using closed Facebook pages as an efficient method of communication and discussion that is easier than multiple e-mails. These can be established with security and by-invitation-only access. Brandon Sideleau of The Red List Authority Group could be asked to investigate this possibility.

Meeting participants were thanked for their valuable discussion and the workshop closed at 1800 h.

Workshop participants: Marco A. Lopez Luna (Mexico), Sergio Balaguera-Reina (USA/Colombia), Hesiquio Benitez Diaz (Mexico), Robinson Botero Arias (Colombia/Brazil), Venetia Briggs Gonzalez (USA), Pierre Charruau (Mexico), Valerie Corado Garcia (Guatemala), Terri Cox (USA), Jennifer de la Fuentes Patricio (Mexico), Iri Gill (UK), Sidney Godfrey (USA), Robert Godshalk (USA), Phoebe Griffith (UK/Nepal), Vaclav Gvosdik (Czech Republic), Shawn Heflick (USA), James Hennessy (Eire), Nicole Jennings (USA), Ranier Manalo (Philippines), Jesus Manuel Reyes (USA), Sandra Marcela Hernandez (Colombia/Brazil), Alex Meurer (Germany), Gualberto Pacheco Sierra (Mexico), Andy Parks (USA), Catalina Pinzon Barrera (Colombia), Paulino Ponce (Mexico), Paul Reilly (Zambia), Perran Ross (USA), Yatzil S. Mendoza Rodriguez (Mexico), Kyle Shaney (USA), Matt Shirley (Africa), Mohamed Izwan Zulani Aboul Gani (Malaysia).

c. Human-Crocodile Conflict (prepared by Simon Pooley and Paulino Ponce)

Problematic human-crocodilian interactions have increased around the world, in many species and countries due to population recovery, often resulting from conservation interventions. This has certainly been the case in several regions across the Americas, which is the geographic focus of this report.

Commercial use of crocodilian skins began in the late 1800s in the Americas, but particularly after World War II, when demand for crocodilian skins from resurgent leather and fashion industries in Asia, Europe and the USA soared. This was facilitated by the widespread availability of guns and ammunition (and men trained to use them), along with improved technologies for accessing remote marshy regions and transporting skins out. Crocodile populations were also hit by habitat transformation, dam building and water pollution.

It was only in the early 1960s that Florida (1961) and Louisiana (1963) closed the hunting season on American alligators statewide, and in 1969 the Endangered Species Act was passed, listing alligators as endangered - ironically in the year that population recoveries, following closed seasons, was noted. Alligators were listed as Appendix I in the first CITES listings, but went onto Appendix II in 1979 due to recovered populations and detailed management plans.

In various Latin American countries, a similar decline occurred after the World War II, and the populations of various species decreased. In 1971, at the first CSG Working Meeting, it was reported that almost all crocodilian species (23 recognized at the time) were in danger, depleted or declining (Chabreck argued American alligator was not). By the 1990s, when crocodilian ranching and farming had stemmed the illegal trade in several regions, IUCN reported 11 species in danger, 7 critically. At present, some species and populations are recovering, for example in Costa Rica, Guyana, Mexico and parts of Colombia. Together with the growth of human populations and their impacts on the habitat of crocodilians, this has resulted in an increase in human-crocodile interactions in these regions, specifically attacks on humans.

For these reasons, there has been a history of meetings and collaborations within the CSG to investigate various strategies to reduce crocodilian attacks on humans. The subject has been discussed in individual papers at almost every CSG Working Meeting, and group sessions have also been held. Subsequently, a working group led by Alan Woodward and others focused on the issue, culminating in key sessions at the Louisiana CSG meeting (2014). Most recently, a group session was held in Santa Fe, Argentina (2018), led by Simon Pooley and Pablo Siroski.

Since the 2018 meeting, an informal group of CSG members has been working on HCC, including standardising data collection methods, collecting materials on handling problem animals, and conducting surveys on human-crocodilian interactions across Latin America and



Figure 5. HCC Workshop. Photographs: Pablo Siroski.

the Caribbean. In the CSG, we have identified a range of causes of HCC, and a range of possible management responses currently in use, but requiring more systematic testing, and which will vary in effectiveness according to local circumstances.

Efforts are being made around the world in order to diminish negative human-crocodilian interactions with a focus on attacks, and since 2013 there has been a strategy to improve our knowledge about crocodilian attacks worldwide (formerly on CrocBITE, collated by Brandon Sideleau), with more than 5000 records for most extant species. Published information on human-crocodilian interactions and responses to these are available in Pooley Croc Digest (2022). This issue clearly remains a priority for conservation and for crocodile specialists around the world.

For these reasons, we gathered together at the Chetumal Working Meeting, to discuss where information on HCC and/or attacks is missing and likely to be needed, where problems are increasing, what the main management challenges are, and which mitigation strategies are being applied. The aim was to prioritise research and knowledge sharing needs, and decide a shortlist of actions, to guide work on this, for sharing by the next Working Meeting. Paulino Ponce (Mexico) managed the meeting, with the assistance of Pablo Siroski (Argentina) and Simon Pooley in attendance online.

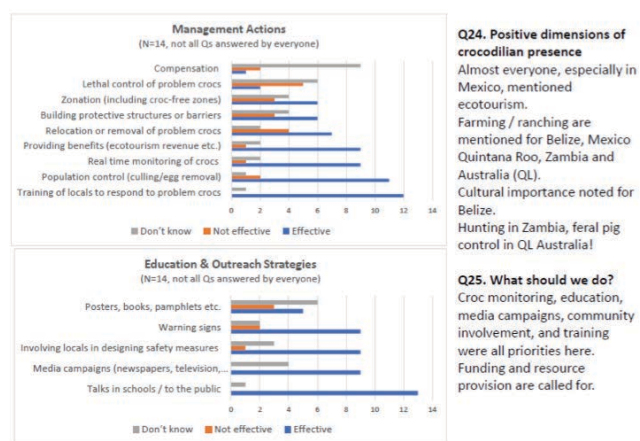


Figure 6. HCC questionnaire feedback summary.

Prior to the HCC side-meeting, a simple questionnaire was circulated to attendees (thanks to Dr. Rogelio Cedeño), and 14 were completed by participants from: Nepal, Belize, Guatemala, Mexico, Philippines, USA, Costa Rica and Guatemala. These were analyzed and a summary of results (Fig. 6) presented. At the live session, there were 50 attendees from 10 countries, with others online. Attendees discussed information based on the questionnaire in groups, and shared their conclusions at the end of the session.

The main conclusions from the side-meeting were that, when it comes to mitigation actions, the following were to be prioritised for further investigation, evaluation and sharing of results, in particular:

- Education/outreach, notably on safe fishing practices (a regional priority), and with a focus on more careful use of language.
- Community-based conservation areas, including urban areas. This involves learning from communities who manage to coexist with crocodilians, for example in some areas of Gujarat in India, and likewise in Nepal.

Other favoured strategies include working to establish refuges for crocodilians, relocating problem animals, expanding and improving monitoring and protection by government agencies, and improved reporting of attacks and other negative incidents.

We believe that a collection of case studies of situations where good outcomes have resulted from such interventions would be valuable. However, we also feel that reported good outcomes should be properly evaluated, and any new interventions designed in such a way that monitoring and evaluation are possible, and analysis can confirm causal links between interventions and outcomes, or provide clear reasons for why they don't work.

Feedback on the questionnaire included the observation that some preferred options on the questionnaire do not apply to some species or regions. Factors to take into account should include: the relevant Law, particular crocodilian species behaviour, population density and habitat.

Finally, our analysis and the discussions in the session brought out the realisation that there are both linguistic and cultural differences in how some aspects of human-crocodile interactions and efforts to mitigate attacks and other negative interactions are understood and communicated. It is obvious to us that questionnaires and similar investigations should be adapted for their regional contexts with the input of CSG members with relevant cultural and local experience and expertise.

Following the CSG Steering Committee meeting on 4 July, a dinner reception was organized by the hosts at a local restaurant (Rivero's Restaurant & Marina), overlooking Chetumal Bay. During the welcome dinner on 5 July, a folk music group performed traditional dances of the region.



Figure 7. Welcome dinner, with traditional dancers. Photograph: Gabriela López Segurajáuregui.



Figure 8. Kent Vliet, Venetia Briggs-Gonzalez and Rogelio Cedeño. Photograph: Erandi Cedeño Zacarías.



Figure 9. Auction. Photograph: Gabriela López Segurajáuregui.

The traditional auction held on the evening of 7 July aimed to raise funds for a crocodile conservation project. It was choreographed by the enthusiastic participation of Carlos Piña and Shawn Heflick. A variety of items was donated by participants, and \$US6565 was raised for the Cuban crocodile (*Crocodylus rhombifer*) Conservation Program in Cuba.

During the closing dinner, awards provided by the CSG were presented to the best student oral and poster presentations. We thank the judges who devoted their time and effort to assessing the 55 student presentations and posters.

For oral presentations, the following students were awarded prizes:

1st **Betzaida Rivera-Rivera**, Miryam Venegas-Anaya and Llewellyn Densmore III. Characterization of heavy metals found in *Crocodylus acutus* from Coiba Island and Gulf of Montijo, Panama.

2nd **José António Lemos Barão-Nóbrega**, Mauricio González-Jáuregui, Sergio Padilla-Paz and Robert Jehle. N-mixture models provide informative crocodile (*Crocodylus moreletii*) abundance estimates in the region of Calakmul (Campeche, Mexico).

3rd **Matias Bella**, Melina Simoncini, Alejandro Larriera, Carlos Piña and Pamela Leiva. Effect of temperature fluctuation during incubation on sex determination in *Caiman latirostris*.

The following students were awarded prizes for their poster presentations:

1st **Laura Kojima**, Benjamin Parrott and Tracey Tuberville. Investigating relationships between contaminant bioaccumulation and movement behavior in the American alligator (*Alligator mississippiensis*).

2nd **Everett Madsen**, Marisa Tellez, Emily Roberts and Katelyn Allen. Parasite induced metabolic bone disease in a yearling Morelet's crocodile (*Crocodylus moreletii*).

3rd **Mila Piazza**, Matías Bella, Mariela Fernández, José Vilá, Carlos Piña and Melina Simoncini. "Intracascara space" - an eggshell structure of *Caiman latirostris* eggs.

The "Castillo Award for Crocodile Conservation" was presented to Professor Jeff Lang for his more than 30 years of work with crocodiles, and more recently with Gharials in India. Phoebe Griffith accepted the Castillo Award on behalf of Professor Lang, who was unable to attend the meeting.

The Chair's Encouragement Award was presented to Gustavo Sosa Rodriguez, of Cuba.

For the second time in CSG history, the meeting website provided an option for participants to donate money for student travel grants through the registration process. This resulted in \$US1500 (\$500 Peter Ebey, \$1000 Regina Anavy)



Figure 10. Participants of 26th Working Meeting, including virtual participants on background screen. Drone photograph: Iván Alonso Aguirre Salazar and Roger Yashamir Ortiz Castro.

being raised. The Ebey family had previously provided a significant donation for student travel, which was matched by the CSG. These donations allowed financial assistance to be provided to 7 students (Catalina Pinzón, Hernán Cioacan, Jennyfer de la Fuentes, Ángel Echeverría, Jeremy Calcano, Robinson Botero Arias and Melciellyne Aguilar).

In his closing remarks, interim CSG Chair Alejandro Larriera thanked Secretary Luis Torres Llanes and his entire team from the Ministry of Agricultural, Rural Development and Fisheries of Quintana Roo, for the organization and development of all the activities in Chetumal. He also informed that the next CSG Working Meeting will be held in mid-2024, in Darwin, Australia.

On behalf of CONABIO, Hesiquio Benítez Díaz, General Director of International Cooperation and Implementation, also extended thanks to Governor Carlos Joaquín González and his team for offering the venue for this important event and for being excellent hosts, to Rolando Coral and the entire UMA Cocodrilía team for opening the doors of the farm for the workshops, to Rogelio Cedeño and ECOSUR for their support in the design and development of the academic program, and to CONANP for making the public forum possible.

Finally, the Secretary of Environment of Quintana Roo, Efraín Villanueva Arcos, thanked the CSG for choosing Mexico as the venue for its 26th Working Meeting, and for its tireless dedication and effort for the conservation and sustainable use of the world's crocodilians, thus formalizing closing the event.

As part of the Working Meeting activities, excursions were

offered to different protected natural areas in the Yucatán Peninsula (Sian Ka'an Biosphere Reserve, Calakmul Biosphere Reserve, Arrefifes de Xcalak National Park), with reservations made directly with the service providers. Sian Ka'an BR offered a nature immersion tour, including the visit to an archaeological site, then travel by boat to swim among mangroves with crystalline water and finish on an interpretative trail for nature observation. In Calakmul BR, the archaeological site stands out, where monkeys and a great diversity of birds can be seen. Xcalak NP stands out for the presence of numerous species of fish and coral reefs for those who are inclined to an aquatic adventure.

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“Crocodilian Skin in 3D” Course

A short course entitled “Crocodilian Skin in 3D” has been developed by Dr. Sally Isberg, founder and general manager of the “Crocodilian Academy”. Drawing on her 25 years in the crocodilian farming industry, Sally has designed the course to provide participants with an overview of the structure of the crocodilian skin, followed by descriptions of how defects affect skin quality, and perhaps more importantly how they may appear on the skin after it has been tanned into finished leather. Each part of the course is supported by good photographic material, including histological sections through the skin, and the information is provided in simple easy to understand manner.

Module 1 provides an overview on the global skin trade, and

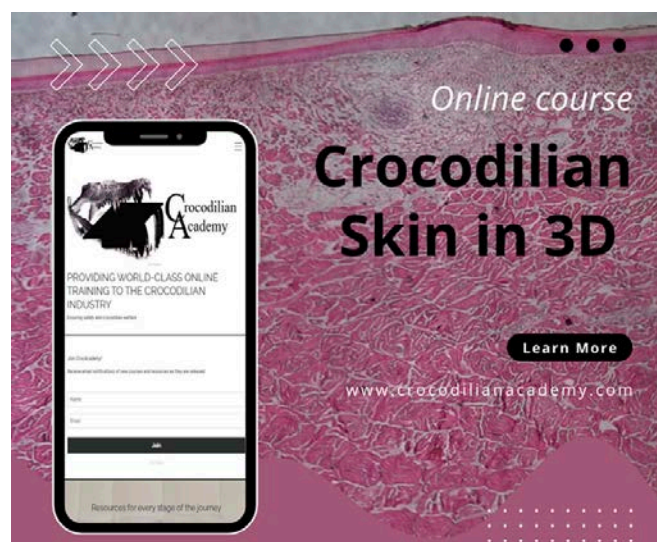
the importance of CITES in regulating trade, including the universal tagging resolution that assists with traceability of skins through supply chains. A short video on the history of management of the American alligator in Louisiana, USA, is used as a case study to demonstrate the benefits of conservation through sustainable use.

Module 2 (“Under the Scale”) sets the foundation for later modules, describing the regions of the crocodilian skin (throat, tail, belly, flanks, legs, quadrants), parts of a scale (integumentary sense organs, hinges) and histological features of a scale (epidermal layers, dermal layers, integumentary sense organs, hinge regions, capillaries and nerves, pigment cells). This section provides the basic knowledge required to understand how defects affect the different parts of the skin, which is covered in later sections of the course.

Module 3 (“Skin Grading and the Tanned Product”) describes the changes in the skin that occur during the tanning process, and why certain defects (lesions) become visible on a light table. Lesion descriptions [shape (foci, lines), keratin, contour (none, depressed, raised)] and terminology (eg pix, pitting, germ, scar, double scale and growth line, worm, erosion, wrinkles) are also covered.

Modules 4, 5, 6 and 7 deal with specific agents (West Nile Virus, poxvirus, herpesvirus, *Dermatophilus*) that may downgrade skins, with details provided on gross and histological appearance, transmission, diagnostics and prevention.

Part 8 deals with water quality implications on crocodilian skins, such as pH, dissolved gases, chlorines and chloramines, nutrients and heavy metals, water microbial profile, water quality indicators, managing water quality and assessing pen hygiene.



Additional resources are provided through short YouTube videos on:

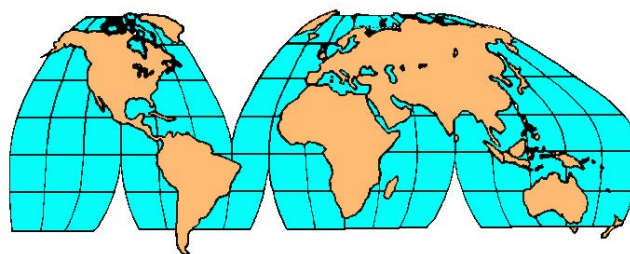
- preparing skins for histology (13.5 min).
- skin sampling to discover lesion causation (4.5 min)
- water and pen surface sampling (9.5 min)

“Crocodilian Skin in 3D” takes information on skin quality and diseases that is spread over a multitude of publications, and combines it into short course that can assist producers to understand issues of skin quality which they may be facing. Information on “Crocodilian Skin in 3D” is available at www.crocodilianacademy.com, or by contacting Sally Isberg directly (sally@crocresearch.com).

A [free](#) Masterclass titled “Histology of Scars” is also available, which describes how lesion depth determines whether a defect will show on the tanned product or not, how this changes collagen density and structure, as well as the reasons for “line pix”. Enrol in the free Masterclass at: www.crocodilianacademy.com/Histology-of-scars.

Reviewed by Charlie Manolis (cmanolis@wmi.com.au).

Regional Reports



East and Southern Africa

Morocco

WEST AFRICAN CROCODILE RETURNS TO MOROCCO! The West African crocodile (*Crocodylus suchus*) is considered to have disappeared from Morocco in the 1950s, although there is some evidence that some may have persisted in the “guelta” of Tanzida (Guelmim-Es Smara Province) until the 1970s. For the first time in over 50 years, the species is once again present in Morocco.



Figure 1. West African crocodile enclosure at Crocoparc.

With the support of the Fossa Agency (Monaco), in September 2022, Crocoparc (Agadir, Morocco) received a breeding pair of *C. suchus* from Lyon Zoo (Parc de la Tête d'Or, Lyon, France). The crocodiles are currently housed in a

specially-designed enclosure, and are now on public display. It is Crocoparc's long-term aim to reintroduce *C. suchus* back into the wild in Morocco.



Figure 2. First meal for West African crocodiles at Crocoparc.

Crocoparc was established in 2015, and already has around 300 Nile crocodiles (*C. niloticus*) on display, together with a variety of other wildlife and plant species (www.crocoparc.com).

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South Asia and Iran

India

ATTACK ON SPOTTED DEER (*AXIS AXIS*) BY A MALE ESTUARINE CROCODILE (*CROCODYLUS POROSUS*) IN BHITARKANIKA NATIONAL PARK, ODISHA, INDIA. Attacks on domestic livestock by Estuarine crocodiles (*Crocodylus porosus*) have been reported in Bhitarkanika National Park (BNP; Bustard and Kar 1981). Occasional attacks by crocodiles on Sambar deer (*Rusa unicolor*), Spotted deer (*Axis axis*), boar (*Sus scrofa*), Otter (*Lutra persipicillata*), Rhesus macaque (*Macaca mulatta*) and Indian porcupine (*Hystrix indica*) have also been reported in BNP from time to time (Kar 1982, 2021; Bustard and Kar 1981; Singh and Kar 2021).

While conducting the annual census for *C. porosus* in the river systems of BNP in January 2022 (Kar 2022), a male crocodile of approximately 4.0 m long was seen lying on the riverbank with a full-grown Spotted deer carcass (Fig. 1). It is presumed that the deer was attacked and killed by the crocodile earlier. The crocodile appears to have taken advantage of the incoming high tide to drag the deer to the upper edge of the riverbank close to the forest. As the tide receded, the grassy mud bank was then fully exposed. But the crocodile stayed at the spot with the carcass, with his body parallel to the river, appearing to be guarding its prey.

Previous sightings have been of larger (4.6+ m) crocodiles attacking Spotted and/or Sambar deer, and so this is the smallest crocodile reported preying on an adult Spotted



Figure 1. Male Estuarine crocodile with freshly killed Spotted deer. Photograph: Sudhakar Kar.

deer. The crocodile was also seen mouth gaping, possibly for thermoregulation, but also perhaps as a “threat” display towards other crocodiles that may be in the area and interested in its prey (Fig. 1). We were about 6 m from the crocodile and its prey, but the former did not appear to be too concerned by our presence.

Since implementation of the FAO/UNDP/GOI Crocodile Breeding and Management Project in Odisha in mid-1975, protection measures have been enforced rigidly in BNP, which has resulted in a significant increase in the *C. porosus* population (Kar 2022), as well as other wildlife species, including prominent mammalian fauna. In particular, the Spotted deer population has increased greatly, and currently they are seen throughout BNP. Spotted deer often come close to the water to browse on overhanging bushy mangrove plants and grasses on the banks of the river and creeks. Herds of deer will cross the river and creeks in search of food, and in such circumstance they may be attacked and killed by large crocodiles.

In the initial years of implementation of the Crocodile Project, it was observed that fresh Sambar and Spotted deer kills were being snatched away from crocodiles by local people for food (Bustard and Kar 1981). Now, attitudes have been changed, and people are aware of the rules and regulations being enforced in the Sanctuary/National Park as per the provisions of the Wildlife (Protection) Act 1972.

Acknowledgements

I am thankful to the Chief Wildlife Wardens, Odisha and Wildlife Wardens of Athagarh Forest Division as well as Wildlife Wardens of the Bhitarkanika Mangrove (Wildlife) Division, Chandabali/Rajnagar for extending support to conduct study on ecology and biology of Estuarine crocodiles in the Bhitarkanika mangrove ecosystem since July 1975.

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A CASE OF KYPHOSCOLIOSIS IN A MUGGER CROCODILE (*CROCODYLUS PALUSTRIS*) IN THE SAVITRI RIVER, MAHARASHTRA, INDIA. The Mugger (*Crocodylus palustris*) is a medium-sized crocodile found in most of the water bodies of the Indian subcontinent. Muggers are found in various habitats such as rivers, lakes, reservoirs, saltwater lagoons, estuaries, and even in highly polluted waterbodies (De Silva and Lenin 2010). Various types of deformities have been reported in crocodilians, including Muggers (Vyas 2018). Kyphoscoliosis is the combination of kyphosis, the dorsoventral curvature of the vertebral column, and scoliosis, the lateral curvature of the vertebral column (Rothschild *et al.* 2012). Such vertebral deformities have been previously reported in *C. porosus*, *Alligator mississippiensis*, *C. niloticus*, *Gavialis gangeticus* (Ferguson 1985), *C. johnstoni*, *C. siamensis* (Hibberd 1996), *Caiman yacare* (Troiano and Roman 1996), *Osteolaemus teraspis* (Olatunji-Akioye and Otuh 2015), *C. novaeguineae* (Montague 1984), and also from *C. palustris* (Singh *et al.* 2001). However, most of these reports were from captive individuals. Reports of such deformities in wild crocodiles are rare. Here we report our observation of an adult Mugger with kyphoscoliosis from the Savitri River, Maharashtra, India.

The Savitri River originates in the Western Ghats Mountain ranges of Maharashtra and flows for around 95 km west towards the Arabian Sea. The river is polluted due to industrial waste and sewage discharge, yet it is well known for its notable population of Muggers (Kulkarni 2021). On 8 January 2019, at around 1730 h, we sighted an adult Mugger of around 2.5 m total length with a hunched back basking on the river bank with other Muggers, near Mahad (73°25'35.853"E, 18°4'32.67"N; Fig.1).

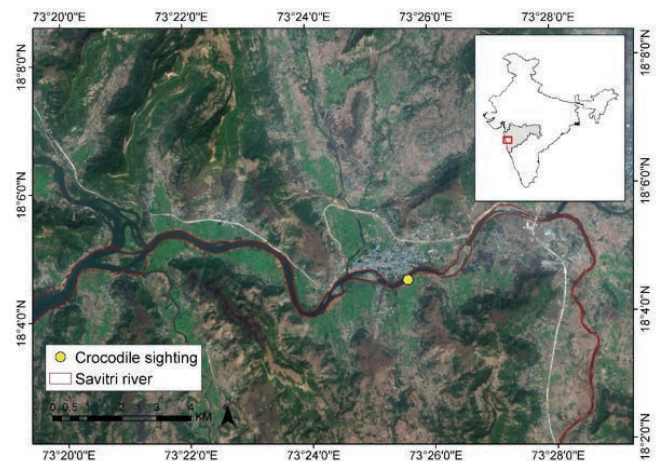


Figure 1. Location of deformed Mugger in the Savitri River. Base map made from Sentinel-2 satellite data.

Apart from a large hunch, the neck and midbody of this Mugger was bent toward its right side. Thereafter, this particular individual was frequently seen basking or swimming in the river around the location of the initial sighting. Its gait on land was unusual, but it was observed to swim without much difficulty. On 27 January 2021, at around 1640 h, we were able to photograph this individual using a drone camera - where the hunched back and lateral curvature of the trunk and neck can be seen. These features appear to reflect a case of kyphoscoliosis. Sunken muscles of the supertemporal fossae (Fig. 2) were considered by Huchzermeyer (2003) to indicate poor nutritional status.



Figure 2. Mugger with a hunchback and bent neck. Inset showing sunken muscles of supertemporal fossae. Photographs: Chirag Metha and Dharmesh Metha.

On 6 April 2022, we again sighted this individual basking on the river bank, but on this occasion, its left forelimb was missing (Fig. 3), most likely amputated during agonistic interactions with other Muggers.

Such hunch-backed condition is frequently reported in young captive Muggers due lack of dietary calcium (Tulasi Rao *et al.* 1984; Singh *et al.* 2001). A wild sub-adult Mugger with a hunched back was rescued near the Vishwamitri River in Gujrat (Vyas 2010) and an adult Mugger with a hunch back and multiple spine fractures caused due to falling from a dam was reported in Gujrat (Vyas 2020). Hatchling mortality due



Figure 3. Mugger with a hunchback and amputated left forelimb. Photograph: Yogesh Gurav.

to congenital axial deformity was also reported in wild *G. gangeticus* in National Chambal Sanctuary (Hussain 1999). Lack of calcium prevents bones from becoming hard and the contraction of long muscles of the back during walking distorts the vertebral column (Huchzermeyer 2003). Such vertebral deformities are also known to be caused due to extreme incubation temperature, desiccation of eggs, unusual egg orientation during incubation, and young or old age of egg-laying females in *G. gangeticus*, *C. porosus*, *C. johnstoni* and *A. mississippiensis* (Ferguson 1985). With the increasing global temperature, such deformities associated with unusual incubation temperature might become more frequent in the future.

Survival of this particular Mugger to adulthood in the wild is noteworthy, as most of captive crocodiles with such deformities typically die within one to two years unless treated with calcium supplementation (Tulasi Rao *et al.* 1984; Singh *et al.* 2001; Huchzermeyer 2003). The origin of the hunchbacked condition of this particular individual, whether congenital or environmental, is currently unknown.

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POSSIBLE DEATH-FEIGNING BEHAVIOUR BY MUGGER CROCODILE (*CROCODYLUS PALUSTRIS*). “Thanatosis” (meaning “putting to death” in Greek) or feigning death is a form of defensive behaviour in which an animal pretends to be dead when threatened or attacked by a predator (McFarland 1982). Thanatosis occurs in diverse groups of animals, both invertebrates and vertebrates (Edmunds 1974; Mângia and Santana 2013). There are reports of thanatosis in Asian reptiles [eg *Xenochrophis piscator* (MacDonald 1947; Vogel and Han-Yuen 2010), *Coelognathus radiatus* (Vogel and Han-Yuen 2010), *Lycodon aulicus* (Mirza *et al.* 2011), *Pseudoxenodon macrops* (Bhosale and Thite 2013), *Sphenomorphus maculatus* (Purkayastha and Das 2010), *Lygosoma guentheri* (Patel *et al.* 2016), *Lygosoma punctata* (Patel *et al.* 2016)], and here we report on possible thanatosis behaviour in the Mugger crocodile (*Crocodylus palustris*).

On 22 February 2022, we received a rescue call from the Junagadh Forest Department, about a sub-adult Mugger (130 cm TL) that had entered a water storage tank in farmland in Junagadh District, near Junagadh city. The Mugger was captured using a noose placed around its neck, and placed into a rescue cage within a minute of capture, at which time it did a single “death roll”, ending up on its back in a prone position (Fig. 1). We tried moving the crocodile with an iron pole, but it didn’t respond. After 2-3 minutes, when we started shifting the rescue cage to the transport vehicle, the crocodile turned over and returned to its normal position (Fig. 2).



Figure 1. Mugger lying on back (“death feigning” behaviour?).



Figure 2. Mugger in “normal” position after possible “death-feigning” behaviour.

We surveyed the literature, and found no records of death-feigning behaviour in any crocodilian species. Given the very large numbers on crocodilians in captivity around the world, and numerous studies that have been carried out in the wild, the absence of records suggests that it is a rare behaviour in crocodilians. Although we put forward this record as a possible case of thanatosis, we do not wish to rule out other potential causes for the behaviour.

The health status of this Mugger is unknown, although it appeared to be in good condition and apparently healthy. Following its struggling in the cage, we would have expected the animal to right itself. Loss of “righting response” is a characteristic of neurological disorders in crocodilians, such as hypoglycemia (Wallach *et al.* 1967) and thiamine deficiency (Jubb 1992).

The capture took 4-5 minutes, and most likely led to some physiological changes due to struggling. However, given the crocodile’s size, we would not consider this to have affected its ability right itself in the cage after the death roll behaviour.

Acknowledgements

We are very thankful to the volunteers of the Vasundhara Nature Club, Junagadh, for helping us during the Mugger rescues and transport. We are also grateful to the Deputy Forest Conservator and Range Forest Officer, Forest Department, Junagadh, Gujarat, for their support and encouragement. We also thank Raju Vyas for his help and motivation.

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Nepal

POPULATION ESTIMATE FOR MUGGER CROCODILES (*CROCODYLUS PALUSTRIS*) IN LOWLAND NEPAL. The Mugger crocodile (*Crocodylus palustris*), which was once widely distributed throughout Nepal's lowlands (Groombridge 1982; Da Silva and Lenin 2010), has since been reduced to isolated populations, most of are found in protected areas such as Shuklaphanta, Bardia, and Chitwan National Parks (Whitaker and Andrews 2003). Low numbers have been reported from the Saptakoshi River, and small populations were known or assumed to be present in the Mahakali, Nala, Karnali and Babai River systems (Da Silva and Lenin 2010).

Although a few studies have been carried out on the current status and distribution of the Mugger in Nepal (Andrews and McEachern 1994; Goit and Basnet 2011; Bhatt *et al.* 2012; Khatri and Baral 2012; Baral and Shah 2013; Khadka *et al.* 2014; Bhattarai *et al.* 2021; Lamichhane *et al.* 2022), it appears that the species has recovered to some degree from historical overexploitation. Despite being an apex predator species in wetlands, in Nepal the Mugger has received less attention from conservationists than other terrestrial flagship species (Khadka *et al.* 2014). This study aimed to provide data on the status of the Mugger population in the lowlands of Nepal, which could serve as a foundation for efficient planning and implementation of Mugger management activities in the area.

On the basis of historical information on Mugger presence, cases of human-crocodile conflict, and reports from local people, we divided the lowlands of Nepal into four blocks:

1. Koshi Block [Mehi River (eastern Nepal-India boundary) to Koshi River];
2. Chitwan Block (Bagmati River to Tinau River);

3. Bardia Block (Tinau River to Karnali River); and,
4. Shukla Block (Karnali to Mahakali River).

The area between the Koshi and Bagmati Rivers (~5225 km²) was not included, as there was no evidence of the species there. A total of 15 rivers and 58 fishponds, marshes, and lakes were surveyed in March 2016, mainly focusing on prime Mugger habitats such as major river systems, lakes [eg Ramsar sites (Ghodaghodi Lake, Jagadish Reservoir, Beeshazari and associated lakes, Koshi Tappu Wildlife Reserve), all lowland protected areas, fish farms and marshy areas (Fig. 1).

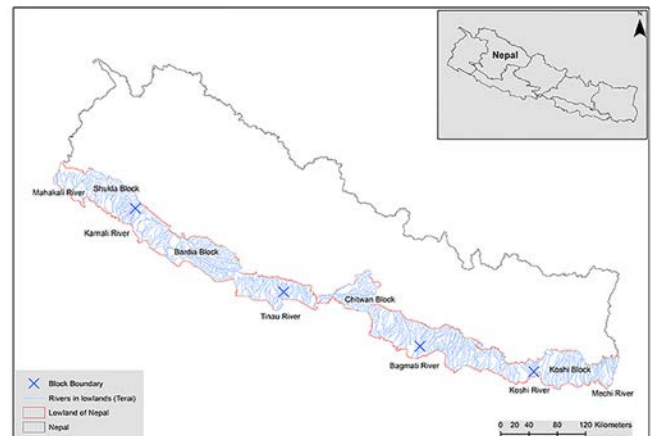


Figure 1. Study area in lowland Nepal.

We trained park staff, local youth and citizen scientists in survey methodology, and public meetings were held to learn more about the likely presence of crocodiles in specific areas. Crocodile observers were separated into groups to inspect main habitats within the different blocks.

Areas within a block were able to be surveyed completely within a single day, and repeat surveys were carried out over 3 days (that is, 3 replicate surveys). In rivers, rubber boats and dugout wooden boats were used, whilst vantage points were set up at lakes and marshy areas. Two trained observers and a boatman were deployed for each survey. Domesticated elephants (observers riding on back) were used inside protected areas to avoid tigers, rhinos and wild elephants.

Surveys were carried out during daylight hours on sunny days, when crocodiles emerge from the water to bask. Crocodiles prefer moderate sunlight to prevent sunburn (Khadka *et al.* 2014). Each observer was responsible for one side of the bank, documenting all the basking crocodiles that were sighted using binoculars.

We recorded a maximum count of 704 Muggers in the three replicate surveys, of which 367 (52%) were in rivers and 337 (48%) in fishponds, lakes and marshes (Table 1). Among the rivers, the Rapti River (Chitwan Block) reported the highest count. Shukla Block had the highest number of rivers containing Muggers.

During the fieldwork, threats such as illegal fishing, infrastructure development, exotic species, watershed encroachment and river pollution were identified. More

Table 1. Maximum counts of Muggers from three replicate daytime surveys, March 2016.

Block	River systems	Total
Koshi	Koshi	21
Koshi	-	21
Chitwan	Narayani	32
Chitwan	Rapti	57
Chitwan	Budhi Rapti and Khageri	57
Chitwan	-	146
Bardia	Karnali	12
Bardia	Babai	39
Bardia	-	51
Shukla	Gobriya Nala	8
Shukla	Bahuni Nala	50
Shukla	Chaudhar	35
Shukla	Pipraya Nala	8
Shukla	Mahakali	0
Shukla	Kataini Nala	11
Shukla	Mohana	35
Shukla	Kanda Nadi	2
Shukla	-	149
Sub-total: rivers (N= 14)		367
Block	fishponds, marshes, lakes	Totals
Koshi	N= 2	4
Chitwan	N= 33	251
Bardia	N= 1	1
Shukla	N= 22	81
Sub-total: lakes, marshes, fishponds (N=58)		337
Total		704

research into the movement of mugger crocodiles from one habitat to another during the mating season is needed.

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We would like to acknowledge the lead from the Department of National parks and Wildlife Conservation to conduct the study. We would also like to thank the National Trust for Nature Conservation and WWF, Nepal for supporting the study financially and technically. Further, we appreciate the cooperation of the Department of Forest, buffer zones and all forest user groups for their coordination to accomplish the study.

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Latin America and the Caribbean

Colombia

INTERINSTITUTIONAL ACTION PLAN FOR ORINOCO

CROCODILE (*CROCODYLUS INTERMEDIUS*) CONSERVATION IN COLOMBIA. The Orinoco crocodile (*Crocodylus intermedius*) is a freshwater species restricted to the Orinoco River basin, shared by Colombia and Venezuela. Like many other crocodilian species, its populations were depleted due to an intensive period of commercial hunting during the second third of the 20th century. As a result, it is now one of the most endangered crocodilians in the world. In Colombia, hunting of the Orinoco crocodile was banned in 1968, and the species was listed as Critically Endangered in 1997 by the Ministry of Environment. A year later, the National Orinoco Crocodile Conservation Program was launched.

Unfortunately, during the first years many of the actions foreseen in this plan were not implemented, and it was not until 2015 that the first reintroduction of captive-bred specimens took place. Between 2015 and 2019, 240 captive-bred crocodiles were released, most of which were monitored. This, together with recent research, field work and novel knowledge of the genetics of the species, allows us to update our knowledge of the species and to translate it into a new action plan. This document is not intended to replace the official National Program, which is still in force, but to complement it and provide inputs for better management of the species based on the most current knowledge available.

The action plan is the result of the collaborative work of the Wildlife Conservation Society (WCS-Colombia) and the Tropical Biological Station Roberto Franco from the National University of Colombia. A brief biological overview of the species, a summary of its status and the progress made in the conservation of the species over the last 10 years are presented. The main objective of this plan is to establish three wild populations in protected areas of historical distribution, with at least five breeding females in each, within the next 15 years. To achieve this, six strategies for the conservation of the Orinoco crocodile are detailed that seek to address six direct and seven indirect threats.

The Plan also proposes to implement 16 conservation actions, most of which are aligned with those contemplated in the national program: adaptation of breeding centers, ranching of hatchlings and reintroduction and monitoring of captive-bred specimens. In addition, the plan contemplates activities such as the census of wild populations, conservation agreements with local populations, mitigation of human-crocodile conflict through participative methods, and genetic studies of *ex-situ* and *in-situ* populations in order to establish appropriate management measures.

The document presents a detailed list of all the crocodiles reintroduced in Colombia until 2019, including morphometric data, coordinates of release sites, and marking information that allows the identification of the specimens if recaptured. It also shows photographs and unpublished information that has been collected in recent years, which demonstrates human-crocodile conflict, and that this species is still present in the Arauca, Meta and Orinoco Rivers and that the size of its populations has grown in the Ele-Lipa-Cravo Norte and

Guaviare-Guayabero-Duda River systems.

We hope that this plan will serve the Colombian environment authorities to guide conservation actions for the species over the next decade and provide rigorous information for researchers and others interested in the magnificent Orinoco crocodile.

Rafael Antelo, Mario Vargas-Ramírez, Germán Preciado, Carlos A. Saavedra Rodríguez and Germán Forero-Medina.

Mexico

POPULATION ESTIMATE FOR *CAIMAN CROCODYLUS* IN THE WATER BODIES OF EJIDO LA POLKA, CHIAPAS, MEXICO. *Caiman crocodilus* is an extremely adaptable species, being found in all lowland river and wetland habitats throughout its range. In Mexico, the species is distributed from the Pacific in southern Oaxaca, to Chiapas (Chiapas State), and throughout the coastal zone between 0 and 50 m asl (Álvarez del Toro 1974). The species is considered under special protection on the list of threatened species of the Official Mexican Standard (NOM-059-ECOL-2010) in Mexico.

The Ejido La Polka (15° 57'23" N-93° 39'47" W; 15° 95'63"-93° 66'30") is a town located 16.8 km southwest of the Municipality of Tonalá, in the State of Chiapas. We developed a polygon encompassing 23 water bodies that were sampled during the study (Fig. 1), however there are at least 12 other sites in the area that could not be sampled. All the water bodies were located in cultivated pastures ("cultivated grassland" on Fig. 1), and most were "jagüeyes" - small and medium-sized artificial dams used as an efficient means to store water, and which mostly contain water throughout the year.

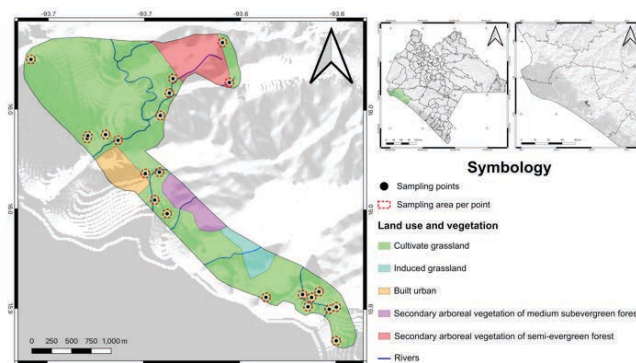


Figure 1. Polygon encompassing study area and 23 sampled water bodies (dots). Produced by Marco Vázquez Cigarroa.

The sampling area was divided into three Monitoring Units, each of which contained water bodies: SU1 (N= 9), SU2 (N= 6), and SU3 (8). Between March and November 2020, of the 23 sites, 4 were monitored once, 5 twice, 4 three times, 1 four times, 3 five times, 5 six times, and 1 seven times, due to access difficulties or environmental conditions. For monitoring, the Chabreck method (1966) was used for the quantification and subsequent classification of caimans.

Evaluation and Monitoring of the Habitat (EMH), Night Visual Detection (DVN) and Marking and Recapture of Specimens (MRE) (Fig. 2) followed established protocols (Sánchez *et al.* 2011).



Figure 2. Caimán hatchlings with their mother. Two of the specimens had black eyes, which is uncommon in the species. Photograph: Sergio Siliceo Abarca.

A maximum 187 caimans was recorded, including hatchlings, which was the sum of the maximum number of individuals sighted per site. To obtain an estimate of the visible fraction of the population in each UM, the method of King and Messel (Cerrato 1991) was adopted, using the maximum average of observations per month of each UM and the maximum number of observations in each UM (Table 1). Using an overall visible fraction of 37.6% was obtained, and maximum observation of 117 individuals, the total population in the sampled areas is estimated as 311 caimans (Table 1).

Table 1. Visible fraction (%) in each Monitoring Unit (UM).

Parameter	UM1	UM2	UM3	UM1-3
Average max. observations	14.9	7.0	22.1	44
Maximum observations	49	15	53	117
Visible fraction (%)	30.3	46.7	41.8	37.6
Estimated population size	162	32	127	311

According to the oldest and most current records on the distribution of the alligator, its distribution range reaches up to 50 m asl. However, during the present study, in UM2 (Fig. 3) the species was present up to 80 m above sea level, providing a new distributional limit with respect to altitude.

It is important to consider the implementation of a monitoring program to understand how the caiman population in the area changes over time. It is necessary to protect these sites that are affected by natural and anthropogenic factors, as they represent faunal refuges of regional importance.

Acknowledgments

To the commissary and municipal agent of La Polka, in particular to Mr. "Pepino" and the Moreno Ventura family, to COMAFFAS AC for the support provided in kindly and financially, to the CSG for a SRAS grant awarded for part of



Figure 3. Site "Adán III", with the presence of caimans at an altitude of 80 m asl. Photograph: Sergio Siliceo Abarca.

the work, and to all those who were involved in some way to take this first step to guarantee the conservation and harmony between man and caiman on the Chiapas coast.

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Cuba

TOBY RAMOS, THE GREAT CROCODILE SPECIALIST OF CUBA. In September 1977, a young man from Havana, the Cuban capital, recently graduated from the Faculty of Biology of the University of Havana, arrived at the Ciénaga de Zapata Crocodile Farm. Only 23 years of age, he was already working at the Fisheries Research Center as a specialist in fish farming, but suddenly found himself surrounded by crocodiles. The idea didn't frighten him - on the contrary, the young researcher felt challenged by destiny. His name was Roberto Ramos Targarona, affectionately known as "Toby".

It was the 1970s, and the Boca de la Laguna del Tesoro Hatchery, founded in 1959, housed an incredible and impressive population of Cuban (*Crocodylus rhombifer*) and American (*C. acutus*) crocodiles. Hybridization, inbreeding and continuous mortality were the most frequent problems encountered, together with a lack of management skills, the result of the existing pragmatism. All this was a challenge for the young man recently admitted to the center, but he quickly took hold of the reins and revealed a masterful ability to transform the hatchery into a national and international benchmark. Toby made brave and intelligent decisions, such as allocating the centre to the conservation of the endemic Cuban crocodile. He designed pens to create structures that typify captive breeding in the country and carried out important studies generating valuable information on the species and its management in captivity.

Without realizing it, Toby became one of the pioneers in the management of crocodiles in captivity in Cuba. His knowledge served as the basis for all farms in the country, which has been carried over to the present day. He was the first Cuban to study crocodile populations in the wild, identifying the core zone of the Cuban crocodile, and carrying out population estimates and morphological studies, among others. He has never used the word "aggressive" to describe the Cuban crocodile. No-one knows *C. rhombifer* better than Toby, and he knows how much this crocodile deserves respect. He is proud of the species' endemism, and of having researched the concentrations of its natural populations. Countless publications, especially his doctoral thesis, are part of his great contribution to the conservation of this important species.

Toby was a "label buster". No-one is more distant from the stereotype in which we usually pigeonhole scientists. He was frequently visited by prestigious specialists from the most remote parts of the world, who, hardly shaking off the dust of the road, come to him eager for knowledge about the Cuban crocodile. He was an open encyclopedia. These are unforgettable moments that, without a doubt, have marked their lives with his teachings and experiences.

But perhaps all these contributions are minimized by the man who has become a symbol and a legend for the crocodiles of Cuba far beyond our borders. One example that stands out, shared by Steve Gorzula, is Toby's legacy in Vietnam, which, without a doubt, caused a transcendental impact for the economy of that country. A few years after the end of the war

in that country, a significant problem was what to do with the bomb craters in the rice fields, and Cuba helped by sending some experts. Toby was part of that group, and with them went a group of Cuban crocodiles, sent as a gift from the Cuban people to the people of Vietnam. Today, Vietnam exports Siamese crocodile (*C. siamensis*) skins and meat, making an important contribution to the country's economic development.

Toby was a responsible, diligent and tireless worker who devoted his life to the conservation of the Cuban crocodile. If it had up to him, he would have still been venturing into the canals and lagoons to thoroughly study these endemic reptiles, because he always maintained his hunger for knowledge. He himself made it known that he still had many things to learn from these charismatic animals. With a casual and jovial character, like the climate of Cuba he could suddenly explode in furious, but ephemeral, storms. His everlasting beard and thick eyebrows gave him a fearsome look, which served as a defensive camouflage and combined very well with his vocation for martial arts and cultures of the Far East.



An example, which it would be unforgivable not to mention, is how Roberto Soberón fell in love with crocodiles, animals

with which he never imagined working, until in 1984 when he received a call that would change the course of his work as a biologist. The proposal was to rescue the valuable treasure of nature on his beloved island, the Cuban crocodile, and for this he could count on his friend from university. Toby unravelled for him, one by one, the precious pearls of his knowledge and experience as they walked into the huge pen of breeding crocodiles to review the nests and collect the eggs. At first, Soberón was petrified by the reactions and intense lunges of the beasts; however, surprisingly, he was also enjoying that adventure. After crossing long sections of the pen, his fear had completely disappeared, and in an emotional moment, he exclaimed – “This is for me!”

We wonder what Manolito Tabet and John Thorbjarnarson (Juan Caimán) would say when reading these notes; who better than them to talk about their great friend? The admiration, respect and affection that the eastern peasant and the yuma, his “little brother”, felt for Toby was immense. You just had to see them by his side to see how they enjoyed his company, his anecdotes and his tantrums. They exchanged jokes and were unstoppable in the field and in office work. Surely Manolito, with his mischievous smile, and Juanito, with his absolute mastery of the Cuban language, would have contributed some stories about their time together.

There is no doubt that the imprint left on each one of us who admired Toby is indelible. We would have to dedicate many pages to honor him, a man of science who has educated generations, transcending time until he became the father of Cuba’s crocodiles, and a source of inspiration for generations to come. It would be impossible to write the history of the crocodiles of Cuba without Toby.

Acknowledgements

Thanks to Berenice and Jerónimo Domínguez for information gathering and for giving us the opportunity to unite to open our hearts. They reminded us of the greatness of Toby and what he has meant to generations of crocodile specialists around the world.

Prepared by Gustavo Sosa, Roberto Soberón and Steve Gorzula. Translated from the Spanish by Regina Anavy.

[Editor’s note: this dedication had been prepared and submitted for the Newsletter well before Toby’s passing on 19 September 2022. Slight editing was done subsequently]

North America

USA

PALMETTO ALLIGATOR RESEARCH AND MANAGEMENT SYMPOSIUM RECONVENES AFTER ONE YEAR DELAY. After being postponed in 2021 due to restrictions related to the COVID-19 pandemic, the 4th Palmetto Alligator Research and Management Symposium

was held on 28-29 April 2022, at the Clemson University Baruch Institute of Coastal Ecology and Forest Science in Georgetown, South Carolina. Based on feedback from previous meetings, this year’s symposium was extended by half a day to allow for more interaction and discussion among participants.

On Day 1 (28 April), the meeting was kicked off with a working group session, during which participants separated into three focal groups to discuss issues and needs in the areas of alligator reproductive ecology, movement and space use, and conflict with humans. Following a break, the afternoon was highlighted by a keynote presentation by Phil Wilkinson entitled “Happenings in the ‘High Grass’: Reflections on a Life with Alligators” in which Phil regaled the audience with stories, knowledge gained, and lessons learned over his 80+ years living and working with alligators and other crocodilians. The keynote presentation was followed by a poster social where students, faculty, and agency biologists shared their research and refreshments in a relaxed atmosphere.

Day 2 (29 April) was packed with oral presentations, as 15 speakers from five states and a diversity of backgrounds gave talks on crocodilian management and biology, with an emphasis on American alligator populations along the US Atlantic coast. These talks included reports on alligator management and associated issues in Florida, North Carolina and South Carolina, as well as various aspects of alligator reproduction, movement and ecotoxicology. Other presentations explored movement and management of American crocodiles in Florida, conservation of American crocodiles in the Dominican Republic, and removal of invasive Spectacled caiman in south Florida.



Figure 1. Retired South Carolina Department of Natural Resources biologists Phil Wilkinson (left), Mark Bara (right), and Tom Murphy (not pictured) received special recognition for their contributions to research, management, and conservation of American alligators in South Carolina over the last four decades. Photograph: Thomas Rainwater.



Figure 2. Some of the participants of the 4th Palmetto Alligator Research and Management Symposium in Georgetown, South Carolina, USA (29 April 2022). Photograph: Katie Rainwater.

At midday, retired South Carolina Department of Natural Resources biologists Mark Bara, Tom Murphy and Phil Wilkinson received special recognition for their contributions to research, management, and conservation of American alligators in South Carolina and over four decades of educating the public and training the next generation of alligator biologists (Fig. 1).

The brief awards ceremony included a slideshow and supporting statements from CSG Chair Grahame Webb and CSG Regional Chairs for North America, Ruth Elsey and Allan “Woody” Woodward. Following another afternoon poster session, the meeting concluded with a dinner/social where speakers and attendees enjoyed the spring evening weather, no-see-ums, and a Lowcountry Boil of seasoned sausage, corn, and shrimp. Conversations about crocodilian research, management, and conservation continued deep into the night. Approximately 60 people, representing state and federal agencies, municipalities, private landowners, universities, animal parks, zoos and aquaria, and NGOs attended this year’s symposium (Fig. 2).

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Recent Publications

Iijima, M., Munteanu, V.D., Elsey, R.M. and Blob, R.W. (2022). Correction: Ontogenetic changes in limb posture, kinematics, forces and joint moments in American alligators (*Alligator mississippiensis*). *Journal of Experimental Biology* 225(14): jeb244724 (doi: [10.1242/jeb.244724](https://doi.org/10.1242/jeb.244724)).

Aswin, K., Ayyan, S.M., Ezhilkugan, G., Kumar, P. and Rajendran, G. (2022). A rare case of limb-threatening injury secondary to

extrinsic vascular compression following crocodile bite. *Wilderness & Environmental Medicine* (doi: [10.1016/j.wem.2022.05.004](https://doi.org/10.1016/j.wem.2022.05.004)).

Abstract: Crocodile bites lead to fatal and nonfatal outcomes in humans. Mugger crocodiles (*Crocodylus palustris*) and saltwater crocodiles (*Crocodylus porosus*) are common in India. Most crocodile bites can cause severe injuries, especially to the extremities, due to the substantial bite force of the crocodile, which typically leads to extensive tissue damage, fractures, amputations, and vascular injuries. We report the case of a crocodile bite victim who presented with features of acute limb ischemia, was found to have vascular thrombosis of the common femoral artery, and was experiencing complete compression of the femoral vein due to external vascular compression by a hematoma. We discuss various injury mechanisms sustained in crocodile bites and the roles of point-of-care ultrasound and continuous tomography angiography, which could help identify these injuries. After thrombectomy and hematoma evacuation the patient recovered and was discharged without any physical dysfunction.

Li, H., Staxäng, K., Hodik, M., Melkersson, K-G., Rask-Andersen, M. and Rask-Andersen, H. (2022). Regeneration in the auditory organ in Cuban and African Dwarf Crocodiles (*Crocodylus rhombifer* and *Osteolaemus tetraspis*). Can we learn from the crocodile how to restore our hearing? *Frontiers in Cell and Developmental Biology* (doi: [10.3389/fcell.2022.934571](https://doi.org/10.3389/fcell.2022.934571)).

Abstract: In several non-mammalian species, auditory receptors undergo cell renewal after damage. This has raised hope of finding new options to treat human sensorineural deafness. Uncertainty remains as to the triggering mechanisms and whether hair cells are regenerated even under normal conditions. In the present investigation, we explored the auditory organ in the crocodile to validate possible ongoing natural hair cell regeneration. Two male Cuban crocodiles (*Crocodylus rhombifer*) and an adult male African Dwarf crocodile (*Osteolaemus tetraspis*) were analyzed using transmission electron microscopy and immunohistochemistry using confocal microscopy. The crocodile ears were fixed in formaldehyde and glutaraldehyde and underwent micro-computed tomography (micro-CT) and 3D reconstruction. The temporal bones were drilled out and decalcified. The crocodile papilla basilaris contained tall (inner) and short (outer) hair cells surrounded by a mosaic of tightly connected supporting cells coupled with gap junctions. Afferent neurons with and without ribbon synapses innervated both hair cell types. Supporting cells occasionally showed signs of trans-differentiation into hair cells. They expressed the MAFA and SOX2 transcription factors. Supporting cells contained organelles that may transfer genetic information between cells, including the efferent nerve fibers during the regeneration process. The tectorial membrane showed signs of being replenished and its architecture being sculpted by extracellular exosome-like proteolysis. Crocodilians seem to produce new hair cells during their life span

from a range of supporting cells. Imposing efferent nerve fibers may play a role in regeneration and re-innervation of the auditory receptors, possibly triggered by apoptotic signals from wasted hair cells. Intercellular signaling may be accomplished by elaborate gap junction and organelle systems, including neural emperipolexis. Crocodilians seem to restore and sculpt their tectorial membranes throughout their lives.

Chen, X., Mi, J., Huang, H., Wang, J., Wu, Y., Wu, X. and Zhang, S. (2022). Ghrelin and ghrelin receptor (GHSR) in Chinese alligator, *Alligator sinensis*: Molecular characterization, tissue distribution and mRNA expression changes during the active and hibernating periods. General Comparative Endocrinology (doi: 10.1016/j.ygcen.2022.114097).

Abstract: The Chinese alligator (*Alligator sinensis*) is a freshwater crocodilian endemic to China. So far, the endocrine regulation of feeding and growth in Chinese alligator is poorly understood. In this study, the molecular structure and tissue expression profiles of ghrelin and its receptor GHSR in the Chinese alligator were characterized for the first time. The full-length cDNA of ghrelin was 1770 bp, including a 37 bp 5' -UTR (untranslated region), a 435 bp ORF (open reading frame) and a 1298 bp 3' -UTR. The ORF encodes a ghrelin precursor, which consists of 145 amino acid residues, including a signal peptide with 52 amino acid residues at the N-terminus, a mature peptide with 28 amino acid residues, and a possibly obestatin at the C-terminus. The full-length cDNA of GHSR was 3961 bp, including a 5' -UTR of 375-bp, an ORF of 1059-bp and a 3' -UTR of 2527-bp. The ORF encodes a protein of 352 amino acid residues containing seven transmembrane domains, with multiple N glycosylation modification sites and conserved cysteine residue sites. The active core "GSSF" of Chinese alligator ghrelin was identical to that of mammals and birds, and the ghrelin binding site of GHSR was similar to that of mammals. The amino acid sequences of both ghrelin and GHSR share high identity with American alligator (*Alligator mississippiensis*) and birds. Ghrelin was highly expressed in cerebrum, mesencephalon, hypothalamus and multiple peripheral tissues, including lung, stomach and intestine, suggesting that it could play functions in paracrine and/or autocrine manners in addition to endocrine manner. GHSR expression level was higher in hypothalamus, epencephalon and medulla oblongata, and moderate in multiple peripheral tissues including lung, kidney, stomach and oviduct, implicating that ghrelin/GHSR system may participate in the regulation of energy balance, food intake, water and mineral balance, gastrointestinal motility, gastric acid secretion and reproduction. During hibernation, the expression of ghrelin and GHSR in the brain was significantly increased, while ghrelin was significantly decreased in heart, liver, lung, stomach, pancreas and ovary, and GHSR was significantly decreased in heart, liver, spleen, lung, kidney, stomach, ovary and oviduct. These temporal changes in ghrelin and GHSR expression could facilitate the physiological adaption to the hibernation of Chinese alligator. Our study could provide basic data for further studies on the regulation of feeding, physiological metabolism and reproduction of Chinese alligator, which could also be useful for the improvement of artificial breeding of this endangered species.

Holliday, C.M. and Schachner, E.R. (2022). Dispatches from the age of crocodiles: New discoveries from ancient lineages. The Anatomical Record (<https://doi.org/10.1002/ar.25043>).

Abstract: Crocodilians inspire researchers and the public alike with their explosive hunting methodologies, distinct craniofacial and dental morphology, and resplendent fossil record. This special issue highlights recent advances in the biology and paleontology of this fascinating lineage of vertebrates. The authors in this volume bring crocodylians and their extinct ancestors to life using a variety of approaches including fieldwork, imaging, 3D modeling, developmental biology, physiological monitoring, dissection, and a host of other comparative methods. Our journey begins with

early crocodylomorphs from the Triassic, carries us through the radiation of crocodylians during the rest of the Mesozoic Era, and finally celebrates the diversification development and biology of extant crocodylians. Crocodylians science has grown appreciably the past few decades. New fossil species and genetic evidence continue to keep phylogenies and our understanding of relationships wavering in key places of the tree such as the relationships of the extinct marine thalattosuchians as well as still living species like gharials. The application of imaging approaches and 3D modeling to both preserved tissues as well as living specimens is now revealing patterns in brain and lung evolution and function, growth strategies, and feeding and locomotor behaviors across the lineage. Comparative anatomical studies are offering new data on genitals, cephalic venous drainage and thoracoabdominal pressures. The new discoveries found here only reveal there is far more work to be done to understand the biology and behavior responsible for the great radiation extinct suchians and their crocodylian descendants experienced during their conquest of Mesozoic and Tertiary ecosystems.

Yang, L., Xing, Y., Chen, R., Ni, H. and Li, H.H. (2022). Isolation and identification of antioxidative peptides from crocodile meat hydrolysates using silica gel chromatography. Scientific Reports 12: 13223.

Abstract: Crocodiles are cultured in large numbers in Asia and other places in order to protect wild resources and meet the needs of human life. In this study, crocodile (*Crocodylus siamensis*) meat proteins were extracted and hydrolyzed into peptides, their antioxidant peptides were isolated and purified by silica gel chromatography and identified by LC/MS. Crocodile meat proteins were optimally extracted with water and hydrolyzed by papain based on the degree of hydrolysis and antioxidant activity. The hydrolysates were fractionated by ultrafiltration into 3 kDa, 3-30 kDa, and ≥30 kDa fractions. The 3 kDa fraction showed most antioxidant activity of the hydrolysates. Its active peptides were separated by silica gel column chromatography and purified by silica gel TLC, based on TLC bioautographic assays of the activity. Four highly active peptides were identified by LC/MS as SSLTIQFVEGQFVDSYDPTIENTFTK, VPPHIY, VAPEEHPVLLTEAPLNPK, and RNLPGPIGPAG. The identified peptides were synthesized and showed 50% free radical scavenging activities at 1.0 mg/mL, equal or higher to ascorbic acid at 0.5 mg/mL, in both DPPH and ABTS assays. The results indicated that the 3 kDa hydrolyzed peptides of crocodile meat had high antioxidant activity and the active peptides can be effectively separated and purified by silica gel column chromatography and TLC.

Griffin, C.T., Botelho, J.F., Hanson, M. and Fabbri, M. (2022). The developing bird pelvis passes through ancestral dinosaurian conditions. Nature 608(7922): 346-352.

Abstract: Living birds (Aves) have bodies substantially modified from the ancestral reptilian condition. The avian pelvis in particular experienced major changes during the transition from early archosaurs to living birds. This stepwise transformation is well documented by an excellent fossil record; however, the ontogenetic alterations that underly it are less well understood. We used embryological imaging techniques to examine the morphogenesis of avian pelvic tissues in three dimensions, allowing direct comparison with the fossil record. Many ancestral dinosaurian features (for example, a forward-facing pubis, short ilium and pubic 'boot') are transiently present in the early morphogenesis of birds and arrive at their typical 'avian' form after transitioning through a prenatal developmental sequence that mirrors the phylogenetic sequence of character acquisition. We demonstrate quantitatively that avian pelvic ontogeny parallels the non-avian dinosaur-to-bird transition and provide evidence for phenotypic covariance within the pelvis that is conserved across Archosauria. The presence of ancestral states in avian embryos may stem from this conserved covariant relationship. In sum, our data

provide evidence that the avian pelvis, whose early development has been little studied, evolved through terminal addition—a mechanism whereby new apomorphic states are added to the end of a developmental sequence, resulting in expression of ancestral character states earlier in that sequence. The phenotypic integration we detected suggests a previously unrecognized mechanism for terminal addition and hints that retention of ancestral states in development is common during evolutionary transitions.

Natsukawa, H. and Sergio, F. (2022). Top predators as biodiversity indicators: A meta-analysis. *Ecology Letters* (<https://doi.org/10.1111/ele.14077>).

Abstract: Identifying efficient biodiversity indicators is a key pillar of the global conservation strategy. Top predators have been proposed as reliable biodiversity signposts, but their role is controversial. Here, we verified their performance by a meta-analysis of published studies and found solid support for their efficacy as biodiversity indicators. As to be expected for any indicator species, efficacy was stronger for biodiversity components ‘ecologically closer’ to the predator (i.e. broad groups that include species providing key resources, such as avian and tree diversity for a bird-eating predator that nests in trees) and declined for the diversity of components more ‘ecologically remote’ from the predator (eg butterfly diversity for a fish-eating predator). This confirmed a link between the top predatory role and biodiversity and set the context for its functionality. These results show that, on average, top predators are justified candidates as biodiversity indicators and that prioritisation of conservation action based on their occurrence is likely to provide broader ecosystem benefits. However, such role should be confirmed on a case-by-case basis, acknowledging that no indicator can portray everything, checking the compatibility of the biodiversity components linked to the predator with the established conservation objectives and ideally integrating predators with other complementary indicator groups.

Deeming, D.C. and Kundrát, M. (2022). Interpretation of fossil embryos requires reasonable assessment of developmental age. *Paleobiology* ([doi: 10.1017/pab.2022.21](https://doi.org/10.1017/pab.2022.21)).

Abstract: Dinosaur embryos cause a lot of excitement in the scientific literature and are often widely reported because of the general public’s interest in dinosaur biology. Well-preserved, articulated oviraptorosaur embryos in eggs are usually interpreted as representing a stage of development close to hatching because of their large size and good level of skeletal ossification. Based on this evidence, a recent report suggested that the position of the one embryo’s head was reminiscent of an avian-like hatching position. Here we explore how the developmental stage of well-preserved oviraptorosaur embryos can be estimated, rather than assumed. This will help in our understanding of their developmental biology and its evolutionary consequences. Using quantitative methods and comparison with modern crocodilian embryos, we show that all articulated oviraptorosaur embryos are small relative to the egg and most likely at a stage of development equivalent to around 50%–60% of the developmental period, that is, not even close to hatching. This conclusion is supported by the fact that many elements of the crocodilian skeleton are well ossified many weeks before hatching and the position of oviraptorosaur embryos’ heads was also comparable to a crocodilian embryo many days before hatching. Misunderstandings about the stage of the developmental biology of these well-preserved oviraptorosaur embryos hampers our understanding of the true nature of their reproductive biology. We urge a more conservative approach to their interpretation. This is important, because misunderstandings in the minds of the public about dinosaur biology are hard to counter once poorly evidenced ideas have been reported around the world.

Brand, N.A., Heckert, A.B., Sanchez, I., Foster, J.R., Hunt-Foster, R.K. and Eberle, J.J. (2022). New Late Cretaceous microvertebrate

assemblage from the Campanian-Maastrichtian Williams Fork Formation, northwestern Colorado, USA, and its paleoenvironmental implications. *Acta Palaeontologica Polonica* 67 ([doi: https://doi.org/10.4202/app.00934.2021](https://doi.org/10.4202/app.00934.2021)).

Abstract: We describe a microvertebrate assemblage from the J&M site, of the Upper Cretaceous (Campanian-Maastrichtian) Williams Fork Formation. Breakdown of fossil bearing matrix was achieved with the use of heated dimethyl sulfoxide. Nine of the recovered taxa are new to both the J&M site and the Williams Fork Formation. The sharks *Lonchidion griffisi*, *Chiloscyllium* sp., and *Cantioscyllium markaguntensis* are the first non-batoid elasmobranchs reported from the Williams Fork Formation and are all represented by teeth. The rays *Cristomylus* and *Psuedomyledaphus* are also newly reported from teeth. The most common identifiable fossils were teeth of indeterminate amiids, most likely belonging to *Melvius*. Osteichthyan fossils new to the Williams Fork Formation include teeth of *Paralbula*, an indeterminate pycnodontid tooth plate fragment, and an indeterminate lungfish tooth fragment. A tooth of the teiid *Peneteius* is also the first reported from within the Williams Fork Formation. Alligatoroid teeth are relatively common and are extremely similar to those of the contemporaneous durophage *Brachychampsa* but are generically indeterminate. Terrestrial taxa were recovered in much smaller numbers. Theropod dinosaur fossils included isolated tooth fragments belonging to an indeterminate dromaeosaurid and, possibly, to *Richardoestesia*. We recovered both multituberculate and metatherian fossils in the form of isolated teeth. Some of these taxa are known from marine and estuarine deposits and, given that so many of these marine associated taxa have been recovered together, it seems likely that the J&M site is recording marine or estuarine influence within at least part of its depositional history. The mammalian taxa suggest a Judithian-Lancian age for the site, while records of the squamate *Peneteius* and the ray *Myledaphus*, suggest that the J&M site may be temporally transitional between other late Campanian and late Maastrichtian-aged localities.

Lindblad, K.T., Milligan, J.R. and Bamforth, E.L. (2022). Whose tooth is this tooth? An exceptionally large crocodyliform caniniform crown from the Maastrichtian Frenchman Formation of south-central Saskatchewan, Canada. Pp. 23 in 10th Annual Meeting Canadian Society of Vertebrate Palaeontology (24–25 May 2022), ed. by A.M. Murray, K. Brink and R.B. Holmes. Canadian Society of Vertebrate Palaeontology: Canada.

Abstract: Crocodyliforms were a common component of the latest Cretaceous floodplain ecosystem in north-central United States and southwestern Canada. *Borealosuchus* and *Brachychampsa* are the best represented taxa, known from numerous specimens, some of which are complete. “Thoracosauridae”, a group of gavialoid-like crocodyliforms are extremely rare from this region of North America during the latest Cretaceous to early Paleocene, only represented by a few fragmentary individuals in the Hell Creek Formation, possibly due to preferences for coastal habitats. Here we report an unusually large tooth crown collected from a microsite in the Frenchman Formation of Grasslands National Park’s East Block in southwest Saskatchewan. Its near conical form, presence of longitudinal striations, and a smooth carina preserved on the lateral-medial axis of the tooth suggest a crocodyliform. The specimen was compared to the large caniniform crowns of contemporary *Borealosuchus* and *Brachychampsa* species from other Hell Creek and Frenchman Formation localities, as well those from ‘thoracosaur’ and other gavialoidlike crocodyliforms found elsewhere in North America. This specimen surpasses the size of the caniniform teeth belonging to the two previously recognized taxa. Additionally, the crown height is much greater than it is basal width and shows a well-developed carina and distinct fine striations on the preserved enamel. This combination of features closely resemble the teeth of ‘thoracosaur’, however in the absence of cranial material we refrain from formally referring the tooth to any specific clade. The discovery of this strange tooth sparks discussion about the range of these elusive

animals and their implications relating to the extent of the receding interior seaway in Canada prior to the K-Pg extinction.

Wu, X.C., Wang, Y.C., You, H.L., Zhang, Y.Q. and Yi, L.P. (2022). A new orientalosuchine (Crocodylia, Alligatoroidea) from the Upper Cretaceous of China and its implications for the relationships of Orientalosuchina. Pp. 44-45 in 10th Annual Meeting Canadian Society of Vertebrate Palaeontology (24-25 May 2022), ed. by A.M. Murray, K. Brink and R.B. Holmes. Canadian Society of Vertebrate Palaeontology: Canada.

Abstract: In recent years, there have been several fossil reptiles discovered in the Upper Cretaceous red beds in Municipality of Ganzhou City (MGC), the southern part (Gannan) of Jiangxi Province. Most were exposed by the construction activities associated with local infrastructure development in some districts of MGC. Up to the present, the reptile fossils excavated include a few dinosaur species (Xu and Han 2010; Wang *et al.* 2013; Wei *et al.* 2013; Lü *et al.* 2013a, 2013b, 2014, 2015, 2016, 2017; Xing *et al.* 2020a), two lizards (Mo *et al.* 2010, 2012), two turtles (Tong and Mo 2010), and dinosaur eggs, including those with embryos (Sato *et al.* 2005; Cheng *et al.* 2008; Xing *et al.* 2020b, 2021). In addition to the vertebrate fossils mentioned above, there is a crocodylian reptile, *Jiangxisuchus nankangensis* described by Li *et al.* in 2019, which was soon assigned to the Orientalosuchina by Massonne *et al.* (2019) and later further confirmed by Shan *et al.* (2021). In 2021, a new fossil crocodylian was excavated from the Upper Cretaceous of MGC. The fossil locality is situated at Shahe Town of Zhanggong District, about 2 km northeast to the Ganzhou Railway Station or about 50 km northeast to the quarry of *Jiangxisuchus nankangensis* in Nankang District. The new crocodylian is represented by a well-preserved skull and some postcranial elements. It is the fifth alligatoroid known from southeastern China in addition to *Jiangxisuchus nankangensis*, *Protoalligator huiningensis* Wang *et al.*, 2016 (= *Eoalligator huiningensis* Young, 1982), *Dongnanosuchus hsui* Shan *et al.*, 2021, and *Eoalligator chunyii* Young, 1964. The new alligatoroid differs from all others mainly in the skull morphology. The most striking of the differences include: (1) the short and broad appearance of the skull, (2) the skull table is abnormally short, less than half its width, (3) the single parietal is excluded from the occipital ridge posteriorly, (4) the postdentary part of the mandible is much deeper than the anterior part dorsoventrally, (5) the splenial is excluded from the mandibular symphysis, and (6) the external mandibular fenestra is small and nearly vertical in orientation. Our preliminary study suggests that the new alligatoroid can be phylogenetically nested into the Orientalosuchina. Within the Orientalosuchina, the new orientalosuchine may further form a sub-group with other four genera from China and Vietnam. The discovery of the new orientalosuchine not only illustrates the diversity of the local crocodylian fauna but also provides a chance to test the hypotheses made by previous studies on the early history of alligatoroid crocodylians, particularly the origin of the Orientalosuchina and the dispersal route that the latter alligatoroid clades used to move between continents.

Cortés, D., Larsson, H.C.E. and De Dios Parra, J. (2022). The Early Cretaceous Paja Formation biota in Colombia reveals an exuberant predator fossil record and a complex ecological network. Pp. 11-12 in 10th Annual Meeting Canadian Society of Vertebrate Palaeontology (24-25 May 2022), ed. by A.M. Murray, K. Brink and R.B. Holmes. Canadian Society of Vertebrate Palaeontology: Canada.

Abstract: Few fossil assemblages have been used to reconstruct ecological networks of trophic interactions. Over deep time, they can be integrated with phylogenetic originations and extinctions to present larger-scale interpretations of ecological evolution. Here we present preliminary results on an ecological network for the marine Paja Formation fauna. The Paja Formation was deposited over 15 million years throughout a sequence spanning the Hauterivian through to the Aptian in central Colombia. The Early Cretaceous

was a transitional period in Earth's history and of significant importance in terms of faunistic turnovers. This time represents the recovery of the end Jurassic mass extinction, high eustatic sea levels, and high global temperatures - all factors that are expected to facilitate high levels of phyletic radiations. The Paja Formation preserves a rich marine fauna and outcrops extensively around Villa de Leyva, Boyacá. This formation is subdivided into several units, including the highly fossiliferous *Arcillolitas abigarradas* member. This unit preserves several species of marine invertebrates and vertebrates. The invertebrate fauna consists of over one hundred species of ammonites and several bivalves and crabs. The vertebrate fauna includes massive short-necked plesiosaurs, large elasmosaurs, a teleosauroid crocodylomorph, several species of ichthyosaurs, several sea turtles, and at least four morphotypes of actinopterygian fish and one shark. The ecological complexity of this palaeoecosystem hints at what this ecological network may look like. Several apex predators with ~10 m body lengths include the pliosaurs *Kronosaurus* (= *Monquirasaurus*) and *Sachicasaurus* and a teleosauroid. Mid-sized predators of >4 m include the pliosaurs *Acostasaurus* and *Stenorhynchosaurus* and the ichthyosaur *Kyhytysuka*. Another trophic level can be constructed from the large-bodied but small headed elasmosaurs and stem sea turtles *Desmatochelys*, and *Leyvachelys*. Although the Paja's biota is most famous for its large marine reptiles, little is really known about the broad ecological structure of the ecosystem. We are currently reconstructing an ecological network of the Paja Formation biota incorporating interactions between all described and undescribed taxa based on criteria such as body size, tooth guild, tooth size, jaw length, skull attributes, and postcranial attributes, which we consider as proxies for describing network linkages between species. These interactions inform us about the trophic functioning of the system, including the predator-prey interactions, the potential resources needed to maintain apex predators, potential energy flow across the chain, and estimates of ecological complexity. Although the fishes are relatively poorly known, the complex network constructed from the ammonites suggests an equally impressive network of fishes. This exercise also reveals several potential confounding factors such as taphonomic and sampling biases. Our preliminary results reveal a complex Paja ecosystem network. We explore its utility to understand the resilience of marine ecosystems after mass extinctions (ie J/K mass extinction) and the stability of the emerging Paja ecosystem that has similarities to those that dominated the remainder of the Cretaceous marine systems for the next 50 million years.

Wai Linn, T., Kobroob, A., Ngernjan, M., Amornlerdpison, D., Lailerd, N. and Wongmekiat, O. (2022). Crocodile oil disrupts mitochondrial homeostasis and exacerbates diabetic kidney injury in spontaneously diabetic Torii rats. *Biomolecules* 12: 1068.

Abstract: Diabetic nephropathy is currently the leading cause of end-stage renal disease (ESRD) in type 2 diabetes. Studies have suggested that supplementation with some fatty acids might reduce the risk and delay the progression to ESRD in patient with chronic kidney disease. Crocodile oil (CO) contains a variety of fatty acids, especially omega-3, -6 and -9, that have been reported to be beneficial to human health. This study examined the impact of long-term CO supplementation on the development of diabetic nephropathy in spontaneously diabetic Torii (SDT) rats. After diabetic verification, SDT rats were assigned to receive vehicle or CO at 500 and 1000 mg/kg BW, respectively, by oral gavage. Age-matched nondiabetic Sprague-Dawley rats were given vehicle or high-dose CO. After 28 weeks of intervention, CO failed to improve hyperglycemia and pancreatic histopathological changes in SDT rats. Unexpectedly, CO dose-dependently exacerbated the impairment of kidney and mitochondrial functions caused by diabetes. CO also disturbed the expressions of proteins involved in mitochondrial biogenesis, dynamics, and mitophagy. However, no significant alterations were observed in nondiabetic rats receiving high-dose CO. The findings reveal that CO has deleterious effects that aggravate diabetic kidney injury via disrupting mitochondrial homeostasis, possibly due to its improper omega-6: omega-3 ratio.

Joompang, A., Anwised, P., Luangpraditkun, K., Jangpromma, N., Viyoch, J., Viennet, C., and Klaynongsruang, S. (2022). Anti-melanogenesis activity of crocodile (*Crocodylus siamensis*) white blood cell extract on ultraviolet B-irradiated melanocytes. *Journal of Medicinal Food* (<https://doi.org/10.1089/jmf.2021.K.0130>).

Abstract: Ultraviolet (UV) radiation generates a range of biological effects in the skin, which includes premature skin aging, hyperpigmentation, and cancer. Therefore, the development of new effective agents for UV-related skin damage remains a challenge in the pharmaceutical industry. This study aims to test the inhibitory effect of crocodile white blood cell (cWBC) extract, a rich source of bioactive peptides, on ultraviolet B (UVB)-induced melanocyte pigmentation. The results showed that cWBC (6.25–400 µg/mL) could inhibit tyrosinase without adduct formation by $12.97 \pm 4.20\%$ on average. cWBC pretreatment (25–100 µg/mL) had no cytotoxicity and reduced intracellular melanin to $111.17 \pm 5.20\%$ compared with 124.87 ± 7.43 for UVB condition. The protective role of cWBC pretreatment against UVB was exhibited by the promotion of cell proliferation and the prevention of UVB-induced morphological change as observed from F actin staining. The decrease of microphthalmia-associated transcription factor expression levels after cWBC pretreatment might be a mechanism by which cWBC suppresses UVB-induced pigmentation. These results suggest that cWBC could be beneficial for the prevention of UVB-induced skin pigmentation.

Trivedi, K., Patel, C. and Goyani, M. (2022). Status of Mugger crocodile (*Crocodylus palustris*) and human-crocodile interaction in Surat, India. *Reptiles & Amphibians*.

Jegede, H.O., Ogunro, B.N., Hanga, A.B. and Oyerinde, S.O. (2022). Incidence of infanticide among captive wildlife in some selected zoos in Nigeria. *Journal of Research in Forestry, Wildlife & Environment* 14(2): 11–17.

Abstract: This study aimed at revealing the cause of infanticide among zoo collections and proffer strategies to mitigate its occurrence. Three zoos in Nigeria were studied using empirical data from 20-year Veterinary retrospective records and circumstances surrounding the occurrence. A total of 17 infanticide cases were reported from three zoos in Nigeria; 8 from UNILORIN Zoo, seven from UI Zoo and two from Kano Zoo. A total of 55 infants were found to have died during the 17 infanticide events. The Nile Crocodile accounted for the highest number of individual infant deaths, while the side-striped jackal accounted for the highest frequency of infanticide events. The occurrence was highest in carnivores, and major offenders were of maternal origins, accounting for 59% of all infanticides. Exploitation was observed as the major motive, either sole or combined with other motives. This study assessed scenarios surrounding maternal infanticide in different animal species and predisposing factors peri-occurrence. We also proposed possible solutions, especially in developing nations' zoo settings, where this occurrence is grossly under-reported and most often neglected. Correction of observed factors linked with infanticide led to the prevention of further occurrence of infanticide in the three zoos.

Belal, S.M., Dhakate, P.M. and Ram, J. (2022). Physicochemical assessment of wetlands and its impact on Marsh crocodiles *Crocodylus palustris* (Lesson, 1831) of Terai landscape, Uttarakhand, India. *International Journal of Ecology and Environmental Sciences* 48(4) (<http://nieindia.org/Journal/index.php/ijeec/article/view/2354>).

Abstract: Water is the basic life line of all living organism on this planet. The study revealed that the significance of water quality is good at the Terai Arc Landscape (TAL) rivers which passes through the Terai landscape of Kumaun, Uttarakhand, India. Water is essential for drinking, domestic, irrigation and industrial purposes. The Terai Landscape of Uttarakhand is rich in water resources and

which is utilizable for all purposes. Rapid industrialization has led to low quality of water due to wastewater flowing in natural wetlands of the area. Water and their ecosystems are major indicators of the strength of forest and aquatic fauna. This was achieved by analyzing 12 water quality parameters from samples collected at 13 study sites between the Kosi and Sharda river stretch of different water bodies on monthly basis for a period of 12 calendar months. The water physicochemical variables are analyzed using standard methods during May 2015 to April 2016 and its assessment is carried out. The 12 parameters included Average depth, Temperature, pH, Transparency (turbidity), Dissolved Oxygen (DO), Total Hardness, Total Alkalinity, Chloride, Nitrate, Fluoride, Total Iron, Phosphate and presence and absence of Coliforms. We observed that the range of contagion, vicinity of pollution sources and water quality of sites suggest that the species is under threatened category in Terai landscape, Uttarakhand. Amongst the 13 sites chosen for assessment, the physicochemical properties of different water bodies in reference to usage of wildlife such as Marsh crocodile, tiger, leopard, elephant, sloth bear and many species of herbivores at present is acceptable.

Devkota, A. and Joshi, B.K.S. (2022). Assessment of the water quality of Ghodaghodi lake using selected physicochemical parameters. *International Journal of Ecology and Environmental Sciences* 48(4) (<http://nieindia.org/Journal/index.php/ijeec/article/view/2494>).

Abstract: The physicochemical parameters of Ghodaghodi lake were investigated during pre-monsoon (May, 2018) and Post-monsoon season (November, 2018). Water samples for physicochemical parameters were collected and analyzed using standard methods. Four different sampling sites (I, II, III, and IV) were studied. Triplicate of water samples were collected from each site of Lake and physico-chemical characteristics, i.e. pH, temperature, depth, dissolved oxygen, total alkalinity, total hardness, conductivity, total dissolved matter, free CO₂, nitrate and inorganic phosphorous were analyzed. Random sampling method was used. Altogether, 8 quadrats (four paired quadrats) were plotted in each site of the study area per season. Altogether 32 quadrats were laid down per season. Water samples were collected from the depth of 0.5 m within the 1m×1m quadrats. CO₂, hardness, temperature and depth was also found to be high during pre-monsoon and these parameters have low values during post-monsoon. pH, conductivity, alkalinity, DO and TDS, value (±SD) was found to be high during post-monsoon with value and low during pre-monsoon. The average value of physicochemical parameters studied were water temperature (22.92°C), pH (7.69), DO (3.2 mg/L), electrical conductivity (180.71 µS/cm), TDS (91.43 ppm), Free CO₂ (128.29 mg/L), Total hardness (191.16 mg/L), Total alkalinity (177.41 mg/L), phosphate (0.33 mg/L) and nitrate (0.0095 mg/L). Very low DO concentrations in lake indicated very stressful conditions for aquatic life forms. This is of great concern especially regarding the conservation of critically endangered gharial, vulnerable marsh crocodile, and many other fish species. The limnological status of the lake estimated in this study is of critical importance to implement management actions for the conservation and better management of Ghodaghodi lake, a wetland of western terai, Nepal.

Wilkie, C. (2022). Assessing Hybridization Between Morelet's Crocodile (*Crocodylus moreletii*) and American Crocodile (*Crocodylus acutus*) in Belize Using Genome Wide Markers. MSc thesis, University of Bristol, UK.

Abstract: Within the Mesoamerican biodiversity hotspot is Belize, home to high terrestrial and marine biodiversity. Increases in human population size and ecotourism have triggered land-use change, often to the detriment of natural coastlines and forests. Two crocodilian species are present within Belize, both which have suffered past population decline due to habitat degradation and overexploitation. Morelet's crocodile (*Crocodylus moreletii*) is found primarily in

fresh waters whilst American crocodile (*Crocodylus acutus*) is more prevalent in highly saline environments. Both are historically sympatric along the brackish coastline, but it is unclear if land-use change is driving contact between the two and affecting genetic integrity of one or both crocodylians. Hybridization between the species has been identified using both mtDNA and microsatellite evidence, however the full magnitude of the process is not fully understood. This project focused on investigating the extent of hybridization across Belize using genomic variants identified by double digest restriction-site associated DNA sequencing (ddRADseq). Skin clips from 80 individuals were taken, and in total 24 were identified as admixed. Five genetically pure populations of *C. moreletii* were identified, three at inland areas, including the protected Chiquibul National Park. One genetically pure population of *C. acutus* was identified on northern offshore islands, and another on the southern mainland. Hybrids appear restricted to the central to southern coastline and in close proximity to purebreds. Inland areas and offshore islands may provide refuge for genetically pure crocodylians but confinement to small areas, particularly for offshore *C. acutus*, exposes the species to the effects of inbreeding and lowered genetic diversity. This research warrants further investigation into pure populations of both *C. moreletii* and *C. acutus* in unsurveyed areas of Belize and has potential to inform designation of management units that encompass not only the species, but their habitats and the ecosystems in which they reside.

Lessner, E.J., Elsey, R.M. and Holliday, C.M. (2022). Ontogeny of the trigeminal system and associated structures in *Alligator mississippiensis*. *Journal of Morphology* (<https://doi.org/10.1002/jmor.21498>).

Abstract: From the appearance of the vertebrate head, the trigeminal system has played a role in behavioral and ecological adaptation. The trigeminal nerve is the primary cranial somatosensory nerve, also innervating the jaw muscles. In crocodylians, the trigeminal nerve plays a role in modulating the high bite force and unique integumentary sensation. In association with these behaviors, crocodylians are known for large trigeminal nerves, a high volume of trigeminal-innervated musculature, and densely packed, specialized sensory receptors. These innovations also occurred in concert with a restructuring of the lateral braincase wall. These morphologies have previously been investigated in phylogenetic and evolutionary contexts, but an ontogenetic, whole-system investigation of trigeminal tissue and associated musculature, cartilage, and bone is lacking, as is an understanding of developmental timing of morphologies significant to hypotheses of homology. Here, we use contrast-enhanced computed tomography imaging to provide description and analysis of the trigeminal system in an ontogenetic series of *Alligator mississippiensis* from embryonic to adult form. We explore growth rates and allometric relationships of structures and discuss the significance to hypotheses of homology. We find a high growth rate and allometric trajectory of the trigeminal nerve in comparison to other cranial nerves, likely associated with the large volume of trigeminal musculature and high densities of sensory receptors. We identify a similar trend in the pterygoideus dorsalis muscle, the highest contributor to bite force. We narrow ontogenetic timing of features related to the trigeminal topological paradigm and the undeveloped epipterygoid. Overall, we provide a basis for understanding trigeminal development in crocodylians, which upon comparison across reptiles will reveal ontogenetic origins of morphological variation.

Charruau, P., Ichbia, D., González-Desales, G.A. and Platt, S.G. (2022). Reproductive dynamics of an isolated population of American crocodiles (*Crocodylus acutus*) based on long-term monitoring data. *Journal of Herpetology* 56(2): 196-202.

Abstract: The American Crocodile (*Crocodylus acutus*) is still considered Vulnerable, with some populations remaining depressed and showing little evidence of recovery. An understanding of the

reproductive dynamics and parameters of *C. acutus* is essential for its conservation and management. Although the knowledge of *C. acutus* reproductive ecology has greatly increased during recent years, some critical parameters such as breeding effort (ie proportion of adult females that nest each year in a population) remain poorly known. Herein we analyzed 14 yr of reproductive data from a *C. acutus* population in a Mexican atoll to better understand its reproductive dynamics in space and time. We estimated the number of reproductive females in the population and in each nesting area, compared nest characteristics and clutch parameters among nesting areas, and determined female breeding effort and breeding frequency (ie proportion of years that an adult female nested). We estimated that 35 reproductive female *C. acutus* inhabit the main island of the atoll, distributed among 12 nesting areas. The annual female breeding effort ranged from 27.3-60.6% and the breeding frequency of 15 selected females ranged from 57.1-92.3%. Breeding effort depends on the breeding effort in preceding years. We also found significant differences in reproductive attributes (ie number of nests, nest-water distance, nest depth, clutch size, and nesting success) among nesting areas that we explain by the quality of those habitats for crocodile nesting and by territorial behavior of females.

Voegelé, K.K., Boles, Z.M., Ullmann, P.V., Schroeter, E.R., Zheng, W. and Lacovara, K.J. (2022). Soft tissue and biomolecular preservation in vertebrate fossils from glauconitic, shallow marine sediments of the Hornerstown Formation, Edelman Fossil Park, New Jersey. *Biology* 11: 1161.

Abstract: Endogenous biomolecules and soft tissues are known to persist in the fossil record. To date, these discoveries derive from a limited number of preservational environments, (eg fluvial channels and floodplains), and fossils from less common depositional environments have been largely unexplored. We conducted paleomolecular analyses of shallow marine vertebrate fossils from the Cretaceous-Paleogene Hornerstown Formation, an 80–90% glauconitic greensand from Jean and Ric Edelman Fossil Park in Mantua Township, NJ. Twelve samples were demineralized and found to yield products morphologically consistent with vertebrate osteocytes, blood vessels, and bone matrix. Specimens from these deposits that are dark in color exhibit excellent histological preservation and yielded a greater recovery of cells and soft tissues, whereas lighter-colored specimens exhibit poor histology and few to no cells/soft tissues. Additionally, a well-preserved femur of the marine crocodylian *Thoracosaurus* was found to have retained endogenous collagen I by immunofluorescence and enzyme-linked immunosorbent assays. Our results thus not only corroborate previous findings that soft tissue and biomolecular recovery from fossils preserved in marine environments are possible but also expand the range of depositional environments documented to preserve endogenous biomolecules, thus broadening the suite of geologic strata that may be fruitful to examine in future paleomolecular studies.

Griffith, P., Lang, J.W., Turvey, S.T. and Gumbs, R. (2022). Using functional traits to identify conservation priorities for the world's crocodylians. *Functional Ecology* ([doi: 10.1111/1365-2435.14140](https://doi.org/10.1111/1365-2435.14140)).

Abstract: 1. Over half of all crocodylians are threatened with extinction, with many species considered to be functionally extinct throughout their historical ranges. How such losses impact crocodylian functional diversity (FD) and its conservation is poorly understood, but can be investigated using measurable traits. Where such information is unavailable, phylogenetic diversity (PD) has been proposed as an effective strategy to capture FD, but this assumption is not well tested. 2. We constructed a global trait database for 28 extant crocodylians, and quantified their FD, distinctiveness and groupings. Functionally distinctive crocodylians include the most and least evolutionarily distinct species, likely because unusual trait values and combinations can be produced by both evolutionary isolation and evolutionarily recent adaptive

radiation. We identified four functional groups of crocodylians, within which species have similar ecological roles. Highly distinctive species, such as the gharial, fit less well into functional groups. 3. We combined functional distinctiveness (FUD) and threat ranking scores to prioritise species for conservation. The metric is termed Ecologically Distinct and Globally Endangered (EcoDGE), and we tested how well it operates to preserve crocodylian FD among extant Crocodylia. Under current extinction scenarios, 32%-38% of crocodylian FD might be lost within 100 years. Losses increase to 48% if all threatened species go extinct, with Asia identified as a hotspot of threatened FD in crocodylians. Highly threatened distinctive species lead this extinction scenario, exacerbated by clusters of species sharing traits linked to high extinction risk. These traits include habitat specialism and lower reproductive investment; in contrast, species that tolerate climate extremes are more resilient. 4. Prioritising at-risk species based on FUD and threat status appears to be an effective way to conserve present-day crocodylian diversity. Conservation prioritisation based on the EcoDGE metric performed well to minimise projected losses in FD. Among extant crocodylians, FD losses are projected when high diversity overlaps with high extrinsic threats. 5. We then examined the utility of PD-based measures as surrogates for FD conservation, to better understand the advantages and drawbacks of such substitutions. A PD-based measure such as the Evolutionarily Distinct and Globally Endangered metric provided an effective tool to capture FD in our tests.

Laitman, J.T. and Smith, H.F. (2022). Teeth to the right of me, teeth to the left of me, teeth in front of me -hello to the world of crocodiles and their many relatives in a new special issue of The Anatomical Record. Anatomical Record (Hoboken) (doi: [10.1002/ar.25046](https://doi.org/10.1002/ar.25046)).

Siddiqui, R., Soopramanien, M., Alharbi, A.M., Alfahemi, H. and Khan, N.A. (2022). Novel sources of bioactive molecules: Gut microbiome of species routinely exposed to microorganisms. Veterinary Science 9(8): 380 (doi: [10.3390/vetsci9080380](https://doi.org/10.3390/vetsci9080380)).

Abstract: The development of novel bioactive molecules is urgently needed, especially with increasing fatalities occurring due to infections by bacteria and escalating numbers of multiple-drug-resistant bacteria. Several lines of evidence show that the gut microbiome of cockroaches, snakes, crocodiles, water monitor lizards, and other species may possess molecules that are bioactive. As these animals are routinely exposed to a variety of microorganisms in their natural environments, it is likely that they have developed methods to counter these microbes, which may be a contributing factor in their persistence on the planet for millions of years. In addition to the immune system, the gut microbiota of a host may thwart colonization of the gastro-intestine by pathogenic and/or foreign microorganisms through two mechanisms: (i) production of molecules with antibacterial potential targeting foreign microorganisms, or (ii) production of molecules that trigger host immunity targeting foreign microorganisms that penetrate the host. Herein, we discuss and deliberate on the current literature examining antibacterial activities that stem from the gut bacteria of animals such as crocodiles, cockroaches, and water monitor lizards, amongst other interesting species, which likely encounter a plethora of microorganisms in their natural environments. The overall aim is to unveil a potential library of novel bioactive molecules for the benefit of human health and for utilization against infectious diseases.

Rahman, M.J., Tazi, L., Haller, S.L. and Rothenburg, S. (2022). Crocodilepox virus protein 157 is an independently evolved inhibitor of Protein Kinase R. Viruses 14(7): 1564 (doi: [10.3390/v14071564](https://doi.org/10.3390/v14071564)).

Abstract: Crocodilepox virus (CRV) belongs to the Poxviridae family and mainly infects hatchling and juvenile Nile crocodiles. Most poxviruses encode inhibitors of the host antiviral protein kinase

R (PKR), which is activated by viral double-stranded (ds) RNA formed during virus replication, resulting in the phosphorylation of eIF2 α and the subsequent shutdown of general mRNA translation. Because CRV lacks orthologs of known poxviral PKR inhibitors, we experimentally characterized one candidate (CRV157), which contains a predicted dsRNA-binding domain. Bioinformatic analyses indicated that CRV157 evolved independently from other poxvirus PKR inhibitors. CRV157 bound to dsRNA, co-localized with PKR in the cytosol, and inhibited PKR from various species. To analyze whether CRV157 could inhibit PKR in the context of a poxvirus infection, we constructed recombinant vaccinia virus strains that contain either CRV157, or a mutant CRV157 deficient in dsRNA binding in a strain that lacks PKR inhibitors. The presence of wild-type CRV157 rescued vaccinia virus replication, while the CRV157 mutant did not. The ability of CRV157 to inhibit PKR correlated with virus replication and eIF2 α phosphorylation. The independent evolution of CRV157 demonstrates that poxvirus PKR inhibitors evolved from a diverse set of ancestral genes in an example of convergent evolution.

Shahaza, O., Kamini-Devi, J., Zurina, Z., Norsyuhada, M.R., Hanafi, H., Nurnadiah, H., Aina-Nazurah, M.K. and Sharina, O. (2021). Geotrichosis concurrent with bacterial infection in a captive estuarine crocodile. Malaysian Journal of Veterinary Research 12(2): 61-68.

Abstract: A male estuarine crocodile (*Crocodylus porosus*) from a private farm was necropsied. The findings revealed severe suppurative necrotizing pneumonia and pericarditis. The thymus, heart, right lung, liver, and cloacal swab were subjected to microbiology examination. *Geotrichum candidum* and *Pseudomonas aeruginosa* were isolated from the right lung, heart, and liver. The thymus and cloacal swab were positive for *Escherichia coli*. The former was also positive for *Klebsiella pneumoniae*. The cause of death was most likely due to circulatory and respiratory failure that resulted from geotrichosis with concurrent mixed bacterial infection. This paper describes the laboratory findings and possible route of infection that leads to the infection. This organism has a zoonotic potential especially in immunocompromised individuals particularly those that had close contact with the infected animal.

Corvera, M.D. and Manalo, R.I. (2022). Additional records on the altitudinal range of Philippine crocodile (*Crocodylus mindorensis*) in Abra Province, Luzon Island, Philippines. Southeast Asia Vertebrate Records 2022: 007-008.

Sideleau, B., Staniewicz, A., Syah, M. and Shaney, K. (2022). An analysis of Tomistoma (*Tomistoma schlegelii*) attacks on humans. Marine and Freshwater Research (<https://doi.org/10.1071/MF22015>).

Abstract: Increasing human-crocodile conflict (HCC) is a major conservation and management issue. While three species are responsible for most attacks, on occasion, some slender-snouted species, such as Tomistoma (*Tomistoma schlegelii*), are also implicated. Aims: To analyze reports of confirmed and suspected attacks on humans by Tomistoma and explore potential causes and solutions. Reports of attacks were collected for the CrocBITE project from January 2010 to December 2019, utilizing media reports and communication with local authorities. Attack trends, including outcome, victim demographics and activities, geographic location, and other details were analyzed. We recorded 31 attacks, including 10 deaths, where the culprit species was confirmed or strongly suspected to be a Tomistoma. The Jambi Province of Sumatra was the site of most attacks and most victims were male and fishing at the time. In addition, most attacks were reported during the 3-year period from 2016 to 2018. On rare occasions, Tomistoma prey upon humans. Certain anthropogenic factors may be altering Tomistoma behavior and contributing to increased conflict. Tomistoma were

recently up listed from Vulnerable to Endangered on the IUCN Red List and this conflict is yet another threat facing the species, alongside the destruction habitat.

Young, B.A., Grondel, B., Preston, P. and Cramberg, M. (2022). The orbitalauricular chord of *Alligator*: The unusual functional linkage between the earflap and eyelid of Crocodylians. *Journal of Anatomy* (doi: [10.1111/joa.13752](https://doi.org/10.1111/joa.13752)).

Abstract: One of the distinctive features of the Crocodylia is the presence of a superficial meatal chamber the aperture of which is regulated by two earflaps. The movements of the upper earflap have been detailed by multiple workers, however, the mechanics of the lower earflap remain unresolved. The present study was undertaken to document the mechanics of the lower earflap in the American alligator, *Alligator mississippiensis*, and to explore the functional bases of coordinated movements between the lower earflap and lower eyelid in this species. This anatomical system was examined using a combination of fresh dissection, histology, and micro-CT analyses applied to postembryonic specimens. The rostral margin of the lower earflap is tightly bound to a block of dense connective tissue herein termed the orbitalauricular chord. The orbitalauricular chord is anatomically distinct from both a ligament and a tendon. The dorsal surface of the orbitalauricular chord is attached to a slip of the levator palpebra, while the ventral surface is attached to a slip of the depressor palpebra. These attachments produce a simple mechanism for the elevation and depression of the lower earflap, and thus the opening and closing of the meatal aperture. The caudal surface of the orbitalauricular chord has connective tissue links to the rostral margin of the lower earflap. The morphology of the orbitalauricular chord appears to explain both the mechanics of the lower earflap and the functional coupling between the lower eyelid and lower earflap.

Rowe, A.J. and Rayfield, E.J. (2022). The efficacy of computed tomography scanning versus surface scanning in 3D finite element analysis. *PeerJ* 10: e13760.

Abstract: Finite element analysis (FEA) is a commonly used application in biomechanical studies of both extant and fossil taxa to assess stress and strain in solid structures such as bone. FEA can be performed on 3D structures that are generated using various methods, including computed tomography (CT) scans and surface scans. While previous palaeobiological studies have used both CT scanned models and surface scanned models, little research has evaluated to what degree FE results may vary when CT scans and surface scans of the same object are compared. Surface scans do not preserve the internal geometries of 3D structures, which are typically preserved in CT scans. Here, we created 3D models from CT scans and surface scans of the same specimens (crania and mandibles of a Nile crocodile, a green sea turtle, and a monitor lizard) and performed FEA under identical loading parameters. It was found that once surface scanned models are solidified, they output stress and strain distributions and model deformations comparable to their CT scanned counterparts, though differing by notable stress and strain magnitudes in some cases, depending on morphology of the specimen and the degree of reconstruction applied. Despite similarities in overall mechanical behaviour, surface scanned models can differ in exterior shape compared to CT scanned models due to inaccuracies that can occur during scanning and reconstruction, resulting in local differences in stress distribution. Solid-fill surface scanned models generally output lower stresses compared to CT scanned models due to their compact interiors, which must be accounted for in studies that use both types of scans.

Lensink, M.J., Li, Y. and Lequime, S. (2022). Aquatic flaviviruses. *Journal of Virology* (doi: <https://doi.org/10.1128/jvi.00439-22>).

Thévenet, J., Papet, L., Campos, Z., Greenfield, M., Boyer, N., Grimault, N. and Mathevon, N. (2022). Spatial release from masking in crocodilians. *Communications Biology* 5: 869.

Abstract: Ambient noise is a major constraint on acoustic communication in both animals and humans. One mechanism to overcome this problem is Spatial Release from Masking (SRM), the ability to distinguish a target sound signal from masking noise when both sources are spatially separated. SRM is well described in humans but has been poorly explored in animals. Although laboratory tests with trained individuals have suggested that SRM may be a widespread ability in vertebrates, it may play a limited role in natural environments. Here we combine field experiments with investigations in captivity to test whether crocodilians experience SRM. We show that 2 species of crocodilians are able to use SRM in their natural habitat and that it quickly becomes effective for small angles between the target signal source and the noise source, becoming maximal when the angle exceeds 15°. Crocodiles can therefore take advantage of SRM to improve sound scene analysis and the detection of biologically relevant signals.

Yang, S., Lan, T., Zhang, Y., Wang, Q., Li, H., Dussex, N., Sahu, S.K., Shi, M., Hu, M., Zhu, Y., Cao, J., Liu, L., Lin, J., Wan, Q.-H., Liu, H. and Sheng-Guo Fang, S.-G. (2022). Genomic investigation of the Chinese alligator reveals wild-extinct genetic diversity and genomic consequences of their continuous decline. *Molecular Ecology Resources* (<https://doi.org/10.1111/1755-0998.13702>).

Abstract: Critically endangered species are usually restricted to small and isolated populations. High inbreeding without gene flow among populations further aggravates their threatened condition and reduces the likelihood of their long-term survival. Chinese alligator (*Alligator sinensis*) is one of the most endangered crocodiles in the world and has experienced a continuous decline over the past ca. 1 million years. In order to identify the genetic status of the remaining populations and aid conservation efforts, we assembled the first high-quality chromosome-level genome of Chinese alligator and explored the genomic characteristics of three extant breeding populations. Our analyses revealed the existence of at least three genetically distinct populations, comprising two breeding populations in China (Changxing and Xuancheng) and one breeding population in an American wildlife refuge. The American population does not belong to the last two populations of its native range (Xuancheng and Changxing), thus representing genetic diversity extinct in the wild and provides future opportunities for genetic rescue. Moreover, the effective population size of these three populations has been continuously declining over the past 20 ka. Consistent with this decline, the species shows extremely low genetic diversity, a large proportion of long runs of homozygous fragments, and mutational load across the genome. Finally, to provide genomic insights for future breeding management and conservation, we assessed the feasibility of mixing extant populations based on the likelihood of introducing new deleterious alleles and signatures of local adaptation. Overall, this study provides a valuable genomic resource and important genomic insights into the ecology, evolution, and conservation of critically endangered alligators.

Paiva, A.L.S., Godoya, P.L., Souza, R.B.B., Klein, W. and Hsiou, A.S. (2022). Body size estimation of Caimaninae specimens from the Miocene of South America. *Journal of South American Earth Sciences* 118 (<https://doi.org/10.1016/j.jsames.2022.103970>).

Abstract: Living crocodylians are frequently regarded as morphologically and ecologically conservative, contrasting with the group's rich fossil record, which reveals a much higher diversity. In particular, Caimaninae is a striking example of such diversity, with only six extant species but a myriad of extinct taxa, exhibiting remarkable morphological variation. Their skulls vary substantially, with robust and flattened shapes, ranging from short to long snouts, and serve as a basis for many evolutionary studies

in the group. Previous works have demonstrated that the skull is a good proxy to estimate the body size of extinct crocodylians. In this study, we estimate the body size of large Caimaninae specimens from the Miocene of South America, including *Purussaurus* and *Mourasuchus*. For that, we elaborated a comprehensive dataset of body size data collected from living crocodylians to generate regression equations. We performed regression analyses both including and excluding juvenile/subadult specimens, to account for the possible influence of ontogeny on the relationship between cranial measurements and body size. Furthermore, we also employed two different approaches (phylogenetic and non-phylogenetic) for estimating the body size of these Miocene caimanines. Our results indicate a significant influence of ontogeny on the body proportions of crocodylians, suggesting that datasets used for estimating the body size of extinct taxa should not include juvenile specimens. Moreover, the phylogenetic approach provided more conservative estimates, possibly as a result of the phylogenetic position of the analyzed taxa, given that the body size metrics are strongly phylogenetically structured in crocodylians. This is the first study to infer the body size of fossil caimanines using different methods and skeletal measurements, as well as a dataset comprised of solely adult crocodylians. In the light of our results, we also discuss the paleobiological implications of the large size of these Miocene caimanines.

Ristevski, J., Weisbecker, V., Scanlon, J.D., Price, G.J. and Salisbury, S.W. (2022). Cranial anatomy of the mekosuchine crocodylian *Trilophosuchus rackhami* Willis, 1993. The Anatomical Record (<https://doi.org/10.1002/ar.25050>).

Abstract: One of the best-preserved crocodylian fossil specimens from the Cenozoic of Australia is the holotype of the mekosuchine *Trilophosuchus rackhami*, from the middle Miocene (13.56±0.67 Ma) Ringtail Site at Riversleigh, northwestern Queensland. Although lacking most of the snout, the holotype skull of *T. rackhami* (QMF16856) has an exceptionally well-preserved cranium. Micro-CT scanning of the holotype has allowed for all the preserved cranial bones to be digitally disarticulated, facilitating an unprecedented insight into the cranial anatomy of not just *T. rackhami*, but any mekosuchine. *Trilophosuchus rackhami* was a small-bodied crocodylian and one of the most morphologically distinct mekosuchines, characterized by a unique combination of cranial characteristics several of which are exclusive to the species. Fossil material that is definitively referable to the species *T. rackhami* is currently known solely from the middle Miocene Ringtail Site. However, an isolated parietal from Hiatus Site at Riversleigh demonstrates that *Trilophosuchus* also occurred during the late Oligocene (~25 Ma), extending the range of the genus by more than 10 million years. The new description of *T. rackhami* also allowed for a reevaluation of its phylogenetic relationships. Our results reaffirm the placement of *T. rackhami* as a member of Mekosuchinae within the subclade Mekosuchini. In all analyses, Mekosuchinae was consistently found to be monophyletic and part of the larger crocodylian clade Longirostres. However, the assignment of Mekosuchinae as a subset of Crocodylidae is brought into question, suggesting that the status of Mekosuchinae as a subfamily should be reconsidered.

Ristevski, J. (2022). Neuroanatomy of the mekosuchine crocodylian *Trilophosuchus rackhami* Willis, 1993. Journal of Anatomy (doi: [10.1111/joa.13732](https://doi.org/10.1111/joa.13732)).

Abstract: Although our knowledge on crocodylomorph palaeoneurology has experienced considerable growth in recent years, the neuroanatomy of many crocodylomorph taxa has yet to be studied. This is true for Australian taxa, where thus far only two crocodylian crocodylomorphs have had aspects of their neuroanatomy explored. Here, the neuroanatomy of the Australian mekosuchine crocodylian *Trilophosuchus rackhami* is described for the first time, which significantly increases our understanding on the

palaeoneurology of Australian crocodylians. The palaeoneurological description is based on the taxon's holotype specimen (QMF16856), which was subjected to a μ CT scan. Because of the exceptional preservation of QMF16856, most neuroanatomical elements could be digitally reconstructed and described in detail. Therefore, the palaeoneurological assessment presented here is hitherto the most in-depth study of this kind for an extinct Australian crocodylomorph. *Trilophosuchus rackhami* has a brain endocast with a distinctive morphology that is characterized by an acute dural peak over the hindbrain region. While the overall morphology of the brain endocast is unique to *T. rackhami*, it does share certain similarities with the notosuchian crocodyliforms *Araripesuchus wegeneri* and *Sebecus icaeorhinus*. The endosseous labyrinth displays a morphology that is typical for crocodylians, although a stand-out feature is the unusually tall common crus. Indeed, the common crus of *T. rackhami* has one of the greatest height ratios among crocodylomorphs with currently known endosseous labyrinths. The paratympanic pneumatic system of *T. rackhami* is greatly developed and most similar to those of the extant crocodylians *Osteolaemus tetraspis* and *Paleosuchus palpebrosus*. The observations on the neuroanatomy of *T. rackhami* are also discussed in the context of Crocodylomorpha. The comparative palaeoneurology reinforces previous evaluations that the neuroanatomy of crocodylomorphs is complex and diverse among species, and *T. rackhami* has a peculiar neuromorphology, particularly among eusuchian crocodyliforms.

Hilevski, S., Cordero, T. and Siroski, P. (2022). Do crocodilians eat plant material? A review of plant nutrients consumed by captive crocodilians. South American Journal of Herpetology 24(1): 19-25.

Abstract: Several species of crocodilians consume, digest, and benefit from plant nutrients, and the animal food industry has made important efforts to use different plant materials in the development of new pellets for these animals. This information is very important within the ambit of captive breeding and crocodilian nutrition. The search for plants to supplement the diets of crocodilians is important because it may help to satisfy the nutritional demand of captive crocodilians and reduce the costs of their feeding and production. These initiatives have been mainly focused on animals such as fish and poultry, although some research has also been carried out with crocodilians. The demand for crocodilian skin and meat spiked during the 1990s. Since then, efforts have been amplified to investigate the use of different plants in the development of artificial diets to replace or complement the diet of different crocodile species, without interfering with product quality, health, and animal development while keeping production cost low. To achieve this, the existing information about the main and new sources of plant raw materials used to feed crocodilians must be known.

Viotto, E.V., Simoncini, M.S., Verdade, L.M., Navarro, J.L. and Piña, C.I. (2022). Winter survivorship of hatchling broad-snouted caimans (*Caiman latirostris*) in Argentina. Ethnobiology and Conservation 11: 18.

Abstract: The first life stage of crocodilians is considered the most critical in terms of survival, particularly in regions that have well-defined cold seasons. To estimate this parameter for hatchling broad-snouted caimans, Class I (snout-vent length <25 cm), we released 36 caimans (18 in 2018, and 18 in 2019) born in captivity that were equipped with VHF radio-transmitters, and we monitored them during each first winter season. We actively searched for the animals during field trips and registered their status as alive, dead, lost transmitter (LT), or radio signal ceased (SC). Due to the occurrence of LT and SC, we proposed eight possible survival scenarios, assuming different combinations of “alive” and “dead” caimans. We analyzed each scenario and compared it between years. In 2018 we found 55.5% dead and 44.5% LT, resulting in survival estimates from 0 to 0.38 according to the scenario. In 2019 we found 50% alive, 33% LT, and 17% SC, with survival varying from 0.5 to 1. Survival in 2019 was higher than in 2018 in all scenarios.

Assuming predation was the most plausible cause of LT, with the most likely scenarios estimated 0% survival in 2018 (although the minimum detectable by this methodology is 5%) and 67% in 2019. This information can be helpful for ranching with release programs, as it allows for a better adjustment of the reintroduction rate and opens up the possibility of earlier releases when resources to keep animals in enclosures are scarce.

Custodio, L.R.A., Valente-Aguiar, M.S., Ramos, R.P., Rossato, G. and Espicalsky, T.L.D.C. (2022). Identifying a victim of alligator attack and scavenger fish in the Brazilian Amazon rainforest using smile photographs: a case report. *The Journal of Forensic Odontostomatology* 2(40): 31-37.

Abstract: Reports of deaths caused by alligators or crocodiles are rare in the literature. These deaths may be related to sharp force trauma caused by the teeth of these animals, with or without mutilation, or even drowning after seizure and submersion of the victim. It is difficult to forensically identify bodies in cases of mutilation of the upper limbs during the attack or when the corpse is in an advanced stage of skeletonization. Smile photographs are an important source of ante-mortem references for comparison. We report a human identification based on a photograph of a victim, with the absence of limbs caused by an alligator attack and the advanced skeletonization stage due to scavenger fish action in the Amazon within only 36 hours after his disappearance. The description of alligator attacks and the marks observed on the victim's body are essential to help medical and forensic professionals diagnose the injuries found and, consequently, define the cause of death.

Bhattarai, D., Lamichhane, S., Pandeya, P., Bhattarai, S., Gautam, J., Kandel, R.C. and Pokheral, C.P. (2022). Status, distribution and habitat use by Mugger crocodile (*Crocodylus palustris*) in and around Koshi Tappu Wildlife Reserve, Nepal. *Heliyon* 8(8): e10235.

Abstract: Mugger crocodile is found in various locations of Nepal, ranging from Eastern to Western lowlands, and is also a resident crocodilian of the Koshi Tappu Wildlife Reserve (KTWR). Fewer studies have been carried out on the status and distribution of this crocodilian with limited information on its habitat characteristics. This study sets forth to highlight the population status, distribution and habitat use by Mugger crocodile in and around KTWR. Detailed surveys were conducted in the rivers, natural and private ponds of the KTWR in December 2020. Every 500 m along the survey transects, habitat characteristics were recorded in each habitat station as part of the habitat survey. The dependent variables were presence or absence of Mugger crocodile in each habitat station. Meanwhile, the independent variables included habitat predictors such as; water depth, slope, elevation, distance to roads, distance to settlements, bank substrate, and human disturbance. Generalized Linear Model under binary logistic regression was employed to test variables associated with presence and absence of Muggers for statistical significance. The population survey of the Muggers was assessed by day counts either using dugout canoe or walking along transects. During the research period, 35 individuals of Muggers were recorded. The probability of Mugger sighting augmented with increased slope and depth. 34 Muggers (97.14%) were basking, while 1 (2.85%) were seen swimming out of the total Muggers detected. In private and public ponds, 22 Muggers were sighted, while 13 were sighted in the main Koshi river, its branches, and the Moriya River. Sixteen Muggers (45.71%) were sighted within the reserve, while the remaining 19 Muggers (54.28%) were sighted in the buffer-zone areas. The probability of Mugger sighting varied considerably with regard to slope and water depth among the seven habitat predictors examined. In lieu of prevailing fishing pressure in the river systems of the KTWR and easy availability of prey species for Muggers in private fishponds; the muggers are likely use private fishponds more frequently. In order to subdue the Muggers inside the KTWR, the reserve authority has a vital role for proper habitat management decisions and regulation of fishing activities.

Kvasilova, A., Gregorovicova, M., Olejnickova, V., Kolesova, H. and Sedmera, D. (2022). Myocardial development in crocodylians. *Developmental Dynamics* (doi: 10.1002/dvdy.527).

Abstract: Recent reports confirmed the notion that there exists a rudimentary cardiac conduction system (CCS) in the crocodylian heart, and development of its ventricular part is linked to septation. We thus analyzed myocardial development with the emphasis on the CCS components and vascularization in two different crocodylian species. Using optical mapping and HNK-1 immunostaining pacemaker activity was localized to the right-sided sinus venosus. The atrioventricular conduction was restricted to dorsal part of the atrioventricular canal. Within the ventricle, the impulse was propagated from base-to-apex initially by the trabeculae, later by the ventricular septum, in which strands of HNK-1 positivity were temporarily observed. Completion of ventricular septation correlated with transition of ventricular epicardial activation pattern to mature apex-to-base direction from two peri-apical foci. Despite a gradual thickening of the ventricular wall, no morphological differentiation of the Purkinje network was observed. Thin-walled coronary vessels with endothelium positive for QH1 obtained a smooth muscle coat after septation. Intramyocardial vessels were abundant especially in the rapidly thickening left ventricular wall. Most of the CCS components present in the homeotherm hearts can be identified in the developing crocodylian heart, with a notable exception of the Purkinje network distinct from the trabeculae carneae.

Bock, S.L., Smaga, C.R., McCoy, J.A. and Parrott, B.B. (2022). Genome-wide DNA methylation patterns harbour signatures of hatchling sex and past incubation temperature in a species with environmental sex determination. *Molecular Ecology* (doi: 10.1111/mec.16670).

Abstract: Conservation of thermally sensitive species depends on monitoring organismal and population-level responses to environmental change in real time. Epigenetic processes are increasingly recognized as key integrators of environmental conditions into developmentally plastic responses, and attendant epigenomic data sets hold potential for revealing cryptic phenotypes relevant to conservation efforts. Here, we demonstrate the utility of genome-wide DNA methylation (DNAm) patterns in the face of climate change for a group of especially vulnerable species, those with temperature-dependent sex determination (TSD). Due to their reliance on thermal cues during development to determine sexual fate, contemporary shifts in temperature are predicted to skew offspring sex ratios and ultimately destabilize sensitive populations. Using reduced-representation bisulphite sequencing, we profiled the DNA methylome in blood cells of hatchling American alligators (*Alligator mississippiensis*), a TSD species lacking reliable markers of sexual dimorphism in early life stages. We identified 120 sex-associated differentially methylated cytosines (DMCs; FDR<0.1) in hatchlings incubated under a range of temperatures, as well as 707 unique temperature-associated DMCs. We further developed DNAm-based models capable of predicting hatchling sex with 100% accuracy (in 20 training samples and four test samples) and past incubation temperature with a mean absolute error of 1.2°C (in four test samples) based on the methylation status of 20 and 24 loci, respectively. Though largely independent of epigenomic patterning occurring in the embryonic gonad during TSD, DNAm patterns in blood cells may serve as nonlethal markers of hatchling sex and past incubation conditions in conservation applications. These findings also raise intriguing questions regarding tissue-specific epigenomic patterning in the context of developmental plasticity.

Linn, T.W., Kobroob, A., Ngernjan, M., Amornlerdpison, D., Lailerd, N. and Wongmekiat, O. (2022). Crocodile oil disrupts mitochondrial homeostasis and exacerbates diabetic kidney injury in spontaneously diabetic Torii Rats. *Biomolecules* 12(8): 1068 (doi: 10.3390/biom12081068).

Abstract: Diabetic nephropathy is currently the leading cause of end-stage renal disease (ESRD) in type 2 diabetes. Studies have suggested that supplementation with some fatty acids might reduce the risk and delay the progression to ESRD in patient with chronic kidney disease. Crocodile oil (CO) contains a variety of fatty acids, especially omega-3, -6 and -9, that have been reported to be beneficial to human health. This study examined the impact of long-term CO supplementation on the development of diabetic nephropathy in spontaneously diabetic Torii (SDT) rats. After diabetic verification, SDT rats were assigned to receive vehicle or CO at 500 and 1000 mg/kg BW, respectively, by oral gavage. Age-matched nondiabetic Sprague-Dawley rats were given vehicle or high-dose CO. After 28 weeks of intervention, CO failed to improve hyperglycemia and pancreatic histopathological changes in SDT rats. Unexpectedly, CO dose-dependently exacerbated the impairment of kidney and mitochondrial functions caused by diabetes. CO also disturbed the expressions of proteins involved in mitochondrial biogenesis, dynamics, and mitophagy. However, no significant alterations were observed in nondiabetic rats receiving high-dose CO. The findings reveal that CO has deleterious effects that aggravate diabetic kidney injury via disrupting mitochondrial homeostasis, possibly due to its improper omega-6: omega-3 ratio.

Voegele, K.K., Boles, Z.M., Ullmann, P.V., Schroeter, E.R., Zheng, W. and Lacovara, K.J. (2022). Soft tissue and biomolecular preservation in vertebrate fossils from glauconitic, shallow marine sediments of the Hornerstown Formation, Edelman Fossil Park, New Jersey. *Biology (Basel)* 11(8):1161 (doi: [10.3390/biology11081161](https://doi.org/10.3390/biology11081161)).

Abstract: Endogenous biomolecules and soft tissues are known to persist in the fossil record. To date, these discoveries derive from a limited number of preservational environments, (eg fluvial channels and floodplains), and fossils from less common depositional environments have been largely unexplored. We conducted paleomolecular analyses of shallow marine vertebrate fossils from the Cretaceous-Paleogene Hornerstown Formation, an 80-90% glauconitic greensand from Jean and Ric Edelman Fossil Park in Mantua Township, NJ. Twelve samples were demineralized and found to yield products morphologically consistent with vertebrate osteocytes, blood vessels, and bone matrix. Specimens from these deposits that are dark in color exhibit excellent histological preservation and yielded a greater recovery of cells and soft tissues, whereas lighter-colored specimens exhibit poor histology and few to no cells/soft tissues. Additionally, a well-preserved femur of the marine crocodilian *Thoracosaurus* was found to have retained endogenous collagen I by immunofluorescence and enzyme-linked immunosorbent assays. Our results thus not only corroborate previous findings that soft tissue and biomolecular recovery from fossils preserved in marine environments are possible but also expand the range of depositional environments documented to preserve endogenous biomolecules, thus broadening the suite of geologic strata that may be fruitful to examine in future paleomolecular studies.

Hale, M.D., Koal, T., Pham, T.H., Bowden, J.A. and Parrott, B.B. (2022). Transcriptional networks underlying a primary ovarian insufficiency disorder in alligators naturally exposed to EDCs. *Molecular and Cellular Endocrinology* 557: 111751 (doi: [10.1016/j.mce.2022.111751](https://doi.org/10.1016/j.mce.2022.111751)).

Abstract: Interactions between the endocrine system and environmental contaminants are responsible for impairing reproductive development and function. Despite the taxonomic diversity of affected species and attendant complexity inherent to natural systems, the underlying signaling pathways and cellular consequences are mostly studied in lab models. To resolve the genetic and endocrine pathways that mediate affected ovarian function in organisms exposed to endocrine disrupting contaminants in their natural environments, we assessed broad-scale transcriptional and steroidogenic responses to exogenous gonadotropin stimulation in

juvenile alligators (*Alligator mississippiensis*) originating from a lake with well-documented pollution (Lake Apopka, FL) and a nearby reference site (Lake Woodruff, FL). We found that individuals from Lake Apopka are characterized by hyperandrogenism and display hyper-sensitive transcriptional responses to gonadotropin stimulation when compared to individuals from Lake Woodruff. Site-specific transcriptomic divergence appears to be driven by wholly distinct subsets of transcriptional regulators, indicating alterations to fundamental genetic pathways governing ovarian function. Consistent with broad-scale transcriptional differences, ovaries of Lake Apopka alligators displayed impediments to folliculogenesis, with larger germinal beds and decreased numbers of late-stage follicles. After resolving the ovarian transcriptome into clusters of co-expressed genes, most site-associated modules were correlated to ovarian follicle phenotypes across individuals. However, expression of two site-specific clusters were independent of ovarian cellular architecture and are hypothesized to represent alterations to cell-autonomous transcriptional programs. Collectively, our findings provide high resolution mapping of transcriptional patterns to specific reproductive function and advance our mechanistic understanding regarding impaired reproductive health in an established model of environmental endocrine disruption.

Colmant, A.M.G., Warrilow, D., Hall-Mendelin, S., Onn, M., Hobson-Peters, J., Huang, B., Kurucz, N., Warchot, A., Primmer, B.R., Isberg, S., Bielefeldt-Ohmann, H. and Hall, R.A. (2022). Arthropod-borne virus surveillance as a tool to study the Australian mosquito virome. *Viruses* 14: 1882.

Abstract: Mosquitoes (n= 4381 in 198 pools) were collected in March and April 2018 to survey the presence of West Nile virus Kunjin strain in mosquito populations around crocodile farms in the Darwin region of the Northern Territory (NT) of Australia. While no Kunjin virus was detected in these mosquitoes, we applied our viral replicative intermediates screening system termed monoclonal antibodies to viral RNA intermediates in cells or MAVRIC to this set of samples. This resulted in the detection of 28 pools with virus replicating in C6/36 mosquito cells and the identification of three insect viruses from three distinct virus classes. We demonstrate the persistence of the insect-specific flavivirus Palm Creek virus in *Coquillettidia xanthogaster* mosquitoes from Darwin over almost a decade, with limited genetic drift. We also detected a novel Hubei macula-like virus 3 strain in samples from two mosquito genera, suggesting the virus, for which the sequence was originally detected in spiders and soybean thrips, might be involved in a horizontal transmission cycle between arthropods and plants. Overall, these data demonstrate the strength of the optimized MAVRIC system and contribute to our general knowledge of the mosquito virome and insect viruses.

Khan, R.A., Sabir, B., Sarwar, A., Liu, H-D. and Lin, C-H. (2022). Reptile search algorithm (RSA)-based Selective Harmonic Elimination Technique in Packed E-Cell (PEC-9) inverter. *Processes* 10(8): 1615.

Abstract: The multilevel inverters (MLIs) are capable of handling large quantities of power and generating high-quality output voltages. Consequently, the size of the filters is reduced, and the circuitry is simplified. As a result, they have a diverse range of uses in the industrial sector, especially in smart grids. The input voltage boosting feature is required to utilize the MLI with renewable energy. In addition, a large number of components are required to attain higher output voltage levels, which increases the cost of the circuit and weight. A variety of MLI topologies have been identified to reduce losses, device quantity, and device ratings. The selective harmonic elimination (SHE) approaches reduce distinct lower order harmonics by computing the ideal switching angles. This research presents a nine-level Packed E-Cell (PEC-9) inverter that uses selective harmonic elimination to eliminate total harmonic distortion. In order to calculate the best switching angle, the reptile

search algorithm (RSA) is implemented in this paper, a nature-inspired metaheuristic algorithm inspired by the hunting behavior of the crocodile. The hunting behavior of crocodiles is implemented in two main steps: the first is encircling, which is accomplished by belly walking or high walking, and the second is hunting, which is accomplished by hunting cooperation or hunting coordination. In this technique, nonlinear transcendental equations have been solved. The simulation was run in the MATLAB R2021b software environment. The simulation results suggest that the RSA outperforms the other metaheuristic algorithms. Furthermore, the simulation result was validated on a hardware setup using DSP-TMS320F28379D in the laboratory.

Arega, T., Ayano, A.A. and Tintaku, T. (2022). Assessment of major health problem and constraints of crocodile skin production at Arba Minch Crocodile Ranch. Research Square (doi: <https://doi.org/10.21203/rs.3.rs-1913103/v1>).

Abstract: A cross-sectional study was conducted in Arba Minch crocodile ranch (AMCR) with the objective to identify major health problems and constraints of crocodile skin production. For this purpose, data were obtained from 105 purposively selected respondents using structured questionnaire and by field observation and secondary data from record files. During the study period major infectious and noninfectious diseases, main source of health problem, health problem intervening habit, background of intervening individuals, frequency of skin production and average price of single skin were assessed. According to data obtained from the respondents bacterial infections were found with higher prevalence (34.3%) among the infectious diseases whereas trauma (40%) and poisoning (37.1%) were most frequently occurred noninfectious diseases. Contaminated feed and water and lack of enough sanitation were reported as the main source of health problems. Most frequently practiced intervening habits in the ranch were combination of prophylaxis, treatment and management. According to the data obtained from the respondents background of intervening individuals in disease intervention process in AMCR was dominated by layman (34.3%) rather than veterinarian and veterinary technician. Based on the respondents reply, fungal disease is the most frequently occurred skin disease in the ranch. Based on the findings, recommendations were forwarded to amend clear policy on crocodile management and apply the code of practices on crocodile management and further expansion of the industry.

Romanenko, S.A., Proskuryakova, A.A., Yu Prokopov, D., Davletshina, G.I., Pereira, J.C., Ferguson-Smith, M.A. and Trifonov, V.A. (2022). The cytogenetic map of the Nile Crocodile (*Crocodylus niloticus*, Crocodylidae, Reptilia) with *in situ* localization of major tandemly arranged repetitive DNAs. Bioinformatics of Genome Regulation and Structure/Systems Biology (doi: [10.18699/SBB-2022-089](https://doi.org/10.18699/SBB-2022-089)). Abstracts of the Thirteenth International Multiconference. Novosibirsk, 2022. Page 167.

Abstract: Among other reptiles, crocodilians demonstrate small diploid chromosome numbers (30-42), little interspecific variation of the chromosome arm number, and the absence of dot-shaped microchromosomes. The Nile crocodile (*Crocodylus niloticus*, 2n= 32) karyotype described in 1967 is composed of 20 meta-, six submeta-, and six telocentric chromosome and has a pair of NOR-bearing chromosomes. Since then, no study of the karyotype of this species has been carried out. We applied cytogenetic approaches (CBG-, GTG-, and CDAG-banding) for detailed *C. niloticus* karyotype description. Using low-coverage whole-genome sequencing data and graph-based clustering approach we identified nine prevailing tandemly arranged repetitive elements in the genome of *C. niloticus* and together with 18S/28S-rDNA and telomeric DNA probe applied

Mikos, E. (2022). Alligators in the sewers: Urban

legends about terrifying animals and frightening places. *Ethnographica et Folkloristica Carpathica* 24 (doi: [10.47516/ethnographica/24/2022/10928](https://doi.org/10.47516/ethnographica/24/2022/10928)).

Abstract: The aim of the present study is to provide an overall picture of the nature of urban folklore using the “Alligators in the Sewers” urban legend type circulated in both the Hungarian and international press and by word of mouth. While contemporary legends have attracted only sporadic attention in Hungarian research to date, by illustrating the historical development of this legend type the aim of the present case study is to demonstrate how the phenomenon has existed in the Hungarian press for almost 200 years. The present study attempts to identify the kind of opportunities for interpretation offered by these stories in the field of folkloristics; the extent to which they are relevant beyond their literal meaning; and the ways in which they shed light on modern-day understandings of the world. Giant reptiles that are not indigenous to Europe are terrifying to the average individual, while at the same time they evoke a yearning for the natural world in city dwellers trapped amid concrete walls. Urban sewers and storm drains hold similar terrors: on the one hand, they are there to remove filth and symbolize the more unsavory aspects of urban life, while on the other hand their hidden presence beneath the ground offers ample opportunity for the projection of numerous fantasies. Animals that lurk in the sewers, from where they emerge to attack people, are manifestations, contained within simple, traditional narrative frameworks, of the murkiness of highly structured societies and of the sense of danger that this opacity engenders in us. The emergence and persistence of such stories can be attributed to a number of social practices, such as circuses, sideshows, and the keeping of reptiles as pets, along with the respective press reports and rumors.

Aucar, B., Rocha, E. and Boeschstein, L. (2022). Monstrous animals: Some images of reptiles in Hollywood cinema. *International Journal of Human Sciences Research* 2(25) (doi: [10.22533/at.ed.5582252210085](https://doi.org/10.22533/at.ed.5582252210085)).

Abstract: The present work aims to relate the media representation of animals, more specifically that of reptiles. The study considers that many contemporary meanings given by the media to animals such as snakes and crocodiles come from traditional religions or sacred narratives. The proposition is illustrated from the narratives of American films of great repercussion. Therefore, this investigation highlights cinema as a device that promotes bricolage, in the anthropological sense of Claude Lévi-Strauss, insofar as it uses the elements it has at its disposal and reorganizes them into new discursive appropriations or new combinations whose origin is in classical beliefs. The feature films that exemplify the proposal are: *Alligator* (1980), *Anaconda* (1997) and *Anaconda 2* (2004).

Mobaraki, A., Abtin, E., Erfani, M. and Stevenson, C. (2021). Total length and head length relationship in Mugger Crocodiles *Crocodylus palustris* in Iran. *Journal of Threatened Taxa* 13(8): 19162-19164.

Shil, P.K., Wawegama, N.K., Browning, G.F., Noormohammadi, A.H. and Marendia, M.S. (2022). Mycoplasmas. Chapter 31 in *Pathogenesis of Bacterial Infections in Animals*, Fifth Edition, ed. by J.F. Prescott, A.N. Rycroft, J.D. Boyce, J.I. MacInnes, F. Van Immerseel and J.A. Vázquez-Boland. John Wiley & Sons: New York.

Abstract: All members of the class Mollicutes are commonly referred to as mycoplasmas. Each of the major domestic animal species is host to several different species of pathogenic mycoplasmas. They are divided into four phylogenetic groups, *Pneumoniae*, *Hominis*, *Anaeroplasmata* and *Spiroplasma*, but exhibit considerable genetic plasticity, with massive horizontal genetic transfer events between species in different phylogenetic groups shaping the evolution of a number of important pathogenic species. This chapter lists the

important pathogenic mycoplasmas of the major domestic animal species. It also provides a list of mycoplasma diseases of animals characterized by invasive blood-borne infection and localized extension of infection. Several mycoplasma species can cause mastitis in cattle, but *Mycoplasma bovis* is the most common and causes the most severe disease. *M. bovis* can cause exudative otitis media in calves. Within 48 hours of attachment to respiratory epithelia, mycoplasmas induce ciliostasis.

Fa, J.E., Funk, S.M. and Nasi, R. (2022). Hunting Wildlife in the Tropics and Subtropics. Cambridge University Press: UK.

Abstract: The hunting of wild animals for their meat has been a crucial activity in the evolution of humans. It continues to be an essential source of food and a generator of income for millions of Indigenous and rural communities worldwide. Conservationists rightly fear that excessive hunting of many animal species will cause their demise, as has already happened throughout the Anthropocene. Many species of large mammals and birds have been decimated or annihilated due to overhunting by humans. If such pressures continue, many other species will meet the same fate. Equally, if the use of wildlife resources is to continue by those who depend on it, sustainable practices must be implemented. These communities need to remain or become custodians of the wildlife resources within their lands, for their own well-being as well as for biodiversity in general.

Pooley, S. (2022). The challenge of compassion in predator conservation. *Frontiers in Psychology* (doi: [10.3389/fpsyg.2022.977703](https://doi.org/10.3389/fpsyg.2022.977703)).

Abstract: This paper argues that compassion for wild animals and the humans living alongside them should be integral to wildlife conservation. Nowhere is this more apparent than in predator conservation, and case studies are used to explore the consequences of wild animal attacks for human victims. Some arguments for extending compassionate consideration to animals seen as individuals are considered, along with the challenges these pose for predator conservation. A way forward from this apparent impasse is suggested, drawing on the capacity approach to embrace human with animal actors. The paper concludes with implications for predator conservation and recommendations, including incident responses sensitive to the traumatic impacts of attacks, and more collaborative approaches to handling human-wildlife interactions taking account of the capacities of local humans and wildlife.

Inatimi, S.A., Popoola, O.M., Yarkwan, B., Iyiola, A.O. and Izah, S.C. (2022). Therapeutic potentials of wildlife resources and options for conservation. *In Biodiversity in Africa: Potentials, Threats and Conservation. Sustainable Development and Biodiversity*, Vol. 29, ed. by S. Chibueze Izah. Springer: Singapore.

Abstract: Therapeutic practices for the treatment of ailments is a global practice in the world. Indigenous groups in Africa and some continents have used the approach of the ethno-zoological process to cure various defects and have reported quick recovery. In countries like China, Brazil, India, Vietnam, South Africa, Sudan and Nigeria, mammals can be used for several therapeutic purposes. The leg, skin, skull, head, eggs and various parts of the body of birds can be used for various therapeutic processes. Amphibians such as frog and toads can be used for curing diverse ailments in Chinese medicine. Reptiles such as snakes, lizards, turtles, crocodiles and geckos have been used for treating cancers, sores, rashes and diabetes in Mexico and India. Fishes have both therapeutic and medicinal functions and it contains n-3 polysaturated fatty acids as well as fat-soluble vitamins, all of which are important for human health. The population of wildlife resources is affected by various factors. Bush burning can destroy natural habitats, cause release of emissions and public disturbances, and displace animals and the slow ones are more vulnerable. Bush trade is expected along the roads and

open markets and involves the sale of these animals for economic gains. In countries like Nigeria, South Africa and Zimbabwe, the sale of bushmeat is on the rise because they are used in religious, cultural celebrations and traditional rites. There is, therefore, need for conservation as described by the International Union for the Conservation of Nature (IUCN) Red list criteria. This review therefore presents the various wildlife resources that can serve therapeutic purposes, the factors that impact their presence and the management procedures for conservation of these resources.

Benansio, J.S., Demaya, G.S., Dendi, D. and Luiselli, L. (2022). Attacks by Nile Crocodiles (*Crocodylus niloticus*) on humans and livestock in the Sudd Wetlands, South Sudan. *Russian Journal of Herpetology* 29(4): 199-205.

Abstract: Nile Crocodiles, *Crocodylus niloticus*, are widespread along the riverine systems and wetlands of East Africa, and may locally be involved into serious conflicts with local human communities. A research study was conducted to investigate Human-Crocodiles Conflicts (HCC) and its impacts on lives and livelihoods of local communities in the Sudd Wetlands in South Sudan (East Africa). The methodology involved face-to-face interviews and structured questionnaire to fishers and other persons from riverine communities. The questionnaire focused on (i) numbers of attacks by Nile Crocodiles on humans and livestock, (ii) months of attacks, (iii) locations of attacks, and (iv) activity of victims at the time of attacks, from 2018 to 2020. The majority of the interviewees responded that Nile Crocodiles do represent a serious threat to their lives: a total of 23 persons were attacked and killed by crocodiles between 2018 and 2020, with 100% of the attacks to humans being fatal. In addition, 166 heads of livestock were killed during the same period, and a total of 355 livestock were attacked (most of them escaped the attack). The present study revealed that the peak season of attacks by crocodiles was the dry season (October-March), and that there is urgent need of environmental education and awareness for local riverine communities in order to minimize the intensity of the HCC in South Sudan.

Perez-Marron, J., Sanders, C., Gomez, E., Escopete, S., Owerkowicz, T. and Orwin, P.M. (2022). Community and shotgun metagenomic analysis of *Alligator mississippiensis* oral cavity and GI tracts reveal complex ecosystems and potential reservoirs of antibiotic resistance. *Comparative Biochemistry and Physiology Part A: Molecular & Integrative Physiology* (<https://doi.org/10.1016/j.cbpa.2022.111319>).

Abstract: We report here the community structure and functional analysis of the microbiome of the *Alligator mississippiensis* GI tract from the oral cavity through the entirety of the digestive tract. Although many vertebrate microbiomes have been studied in recent years, the archosaur microbiome has only been given cursory attention. In the oral cavity we used amplicon-based community analysis to examine the structure of the oral microbiome during alligator development. We found a community that diversified over time and showed many of the hallmarks we would expect of a stable oral community. This is a bit surprising given the rapid turnover of alligator teeth but suggests that the stable gumline microbes are able to rapidly colonize the emerging teeth. As we move down the digestive tract, we were able to use both long and short read sequencing approaches to evaluate the community using a shotgun metagenomics approach. Long read sequencing was applied to samples from the stomach/duodenum, and the colorectal region, revealing a fairly uniform and low complexity community made up primarily of proteobacteria at the top of the gut and much more diversity in the colon. We used deep short read sequencing to further interrogate this colorectal community. The two sequencing approaches were concordant with respect to community structure but substantially more detail was available in the short read data, in spite of high levels of host DNA contamination. Using both approaches we were able to show that the colorectal community is a

potential reservoir for antibiotic resistance, human pathogens such as *Clostridiodes difficile* and a possible source of novel antimicrobials or other useful secondary metabolites.

Garcia Marsa, J.A., Martinelli, A.G., Lio, G., Nava, W. and Novas, F.E. (2022). Bone microstructure in terrestrial Mesozoic Crocodylomorpha: *Neuquensuchus* and notosuchians. *Lethaia* (<https://doi.org/10.18261/let.55.3.6>).

Abstract: The bone histology of different taxa of terrestrial Crocodylomorpha, specifically the Cretaceous non-mesoeucrocodylian *Neuquensuchus universitas* and three mesoeucrocodylian notosuchians, were studied. In order to better understand their growth pattern, we analysed the bone histology of the femora and humerus of *Neuquensuchus universitas*, two specimens of *Notosuchus terrestris*, one specimen of *Mariliasuchus amarali*, and one specimen of *Adamantinasuchus navae*. *Neuquensuchus* exhibits an important inter-elemental histovariability (the humerus constituted by crossed parallel-fibred bone tissue and without growth marks, while the femur possesses fibrolamellar bone tissue and growth marks). The *Mariliasuchus* cortex presents a parallel-fibred bone tissue, as well as a moderate density of longitudinal vascular canals and 4 LAGs (lines of arrested growth). *Adamantinasuchus* exhibits in its cortex a parallel-fibred bone tissue, and a moderate density of longitudinal vascular canals. The specimens of *Notosuchus* present a cortex with parallel-fibred bone tissue, with vascularization densities from moderate to dense, and from longitudinal to reticular vascular patterns. The evidence presented here does not support an endothermic metabolism for the analysed specimens; it reinforces the previous hypothesis about the uncoupling between terrestrial life habits and a high growth rate; and the environmental influence on growth patterns is remarkable. This study suggests that the high growth tissues described in some specimens could be related to a plesiomorphic condition shared with other early archosaurs.

Ardiantiono, Alfarisi, A.M., Ishaq, Y., Wijaya, R., Septian, R., Hadi, A.N., Surya, R.A. and Rahmi, T. (2022). Media content analysis of human-predator interaction in Indonesia. *Jurnal Belantara* 5(2): 153-168.

Abstract: Media reports on human-predator interaction can influence public attitudes and supports toward wildlife conservation. Negative interactions between humans and wildlife in Indonesia are dominated by two predator species: Sumatran tiger (*Panthera tigris sumatrae*) and saltwater crocodile (*Crocodylus porosus*). This research aims to characterize the patterns of media reporting on human-predator interaction and compare the reporting between tiger and crocodile. Media reports published between 2017-2019 were collected from online mass media using Google News searching tool. Four parameters were used to evaluate the media content: tone, framing, illustration, and objectivity. Reports on human-tiger interaction (HTI; 356 articles) and human-crocodile interaction (HCI; 430 articles) showed similar patterns including dominant negative headline tone, neutral reporting focusing on interaction events, use of neutral-safe illustrations, and objective reporting. Further investigation showed that some aspects of media reporting on HCI differed with HTI. Reporting on HTI incidents used more negative contents and illustrations; and not as comprehensive as HTI reporting. To promote balanced reporting, this research recommends collaboration between practitioners, scientists, and media to increase the media awareness on human-predator interactions and wildlife conservation; to write engaging content; and to increase the roles of practitioners and scientists as writers and sources in mass media.

Crossley, J.L., Lawrence, T., Tull, M., Elsey, R.M., Wang, T. and Crossley II, D.A. (2022). Development oxygen preadapts ventricular function of juvenile American alligators, *Alligator mississippiensis*. *The American Journal of Physiology - Regulatory, Integrative and*

Comparative Physiology (doi: 10.1152/ajpregu.00059.2022).

Abstract: Developmental oxygen is a powerful stressor that can induce morphological and functional changes in the cardiovascular systems of embryonic and juvenile vertebrates. This plasticity has been ascribed, at least in part, to the unique status of the developing cardiovascular system, which undergoes organogenesis while meeting the tissue oxygen demands of the embryo. We have previously reported an array of functional and morphological changes in embryonic American alligators that persist into juvenile life. Most notably, cardiac enlargement as well as functional parameters of anesthetized juvenile alligators remain after embryonic hypoxic exposure. Because the effects of developmental oxygen in crocodilians have only been investigated in anesthetized animals, we explored the pressure dynamics of both ventricles as well as systemic pressure in response to stressors of acute hypoxia and swimming. Our current findings demonstrate that developmental programming of cardiac function (intraventricular pressure and heart rate) does persist into juvenile life, but it is chamber-specific and depends on the experimental manipulation. Acute hypoxic exposure revealed that juvenile alligators that had experienced 10% O₂ as embryos maintain right ventricle function and increase left ventricle function during exposure. Finally, the data indicate blood flow in the left aorta must originate from the left ventricle during acute hypoxia and swimming.

Matanzima, J., Marowa, I. and Nthiatiwa, T. (2022). Negative human-crocodile interactions in Kariba, Zimbabwe: data to support potential mitigation strategies. *Oryx* (doi:10.1017/S003060532200014X).

Abstract: Interactions between people and wild animals often result in negative impacts, and different views on the management of such interactions can lead to conflicts. Both intentional and unintentional negative human-wildlife interactions are increasing problems in many places where people share space with wild animals. Here we focus on negative interactions between people and Nile crocodiles *Crocodylus niloticus* in and around Lake Kariba in Zimbabwe. In the study area, crocodile attacks on people occur frequently, leading to people being injured or killed, which in turn prompts retaliatory actions against crocodiles. However, despite the negative impact of such interactions on both people and crocodiles, little is known about the spatio-temporal patterns of crocodile attacks or environmental conditions under which attacks occur. We collected information about crocodile attacks on people that occurred during 2000-2020, including the date, time, season and location of attacks, the age of victims and the activities they were carrying out when attacks occurred, and water conditions during attacks. We analysed these data to discern patterns and trends of crocodile attacks on people. Attacks occurred in clear as well as turbid water, and nearly half of all reported attacks were at night or in the early morning. The locations with the highest number of recorded attacks were Nyanyana and Charara lakeside, and the fewest attacks occurred at Andora harbour. Most victims were 26-40 years old, and most were attacked in the dry-hot season, while they were fishing. Our findings can be used to design area-specific mitigation strategies to reduce negative human-crocodile interactions.

Chowdhury, A.H. (2022). Impacts of industrialization and infrastructure developments on the flora, fauna and ecosystems of the Sundarbans and surrounding areas. *African Journal of Biological Sciences* 4(3): 22-40.

Abstract: The impacts of rapid industrialization in the periphery of the Sundarbans on the flora and fauna (tiger, deer, crocodile, dolphin, fishes, etc.) and ecosystem of the Sundarbans, surrounding areas and on the other components like river banks erosion, livelihoods of the people, etc. of the Sundarbans and surroundings areas were studied to develop a guideline for future conservation and restoration. The study area is 20 km inside and outside (Periphery) of the

Sundarbans under Mongla and Rampal upazilas of Bagerhat district, Bangladesh. Fortnight sampling was carried out and air, water, soil and biological samples were studied in the field and laboratory. The recorded data indicate that the present condition of Sundarbans and its surrounding area has reflected a sign of threatened environment. The Sundarbans has lost both floral and faunal diversity by the years. Tigers are disappeared, fishes lost their habitat, trees are affected with unknown diseases, other faunal diversity are also disappeared, erosion is concentrated along the Pashur River, people are being helpless and migrated their occupation. The industries have also brought the curse for natural environment of this area by discharging waste, gases, hot water recklessly into river and surrounding water bodies. As a result the world largest mangrove forest-Sundarbans may can lose its recognition as world heritage site.

Douti, N.B., Amuah, E.E.Y., Imoro, A-W.M. and Abanyie, S.K. (2022). Assessing the water quality and ecological sustainability of the Paga crocodile pond and the associated socio-economic implications. *Environment, Development and Sustainability* (<https://doi.org/10.1007/s10668-022-02619-6>).

Abstract: Tourism has become a major socio-economic activity and one of the fastest-growing sectors of Ghana. However, this rapid expansion has contributed to detrimental effects environmentally and socio-culturally. This study was conducted to assess the impacts of human activities on the water quality and the plant species in and around the Paga crocodile pond and their implications for the sustainability of tourism in the area. The pond was divided into five grids, and five samples (20 cm depth) were collected from each grid for bacteriological and physicochemical analyses. The woody plant and low herbaceous species were assessed using visual appraisal and 1 m² quadrat, respectively. The results showed that except for the chemical parameters (pH, Cl⁻, SO₄²⁻, PO₄³⁻, NO₃⁻, total hardness, Ca²⁺ and DO) and TDS, the enteric bacteria load and physical parameters (colour, turbidity and EC) were above standards. This was majorly attributed to anthropogenic activities. The tree species identified on the banks were mainly *Azadirachta indica* (neem), *Diospyros mespiliformis* (Ebony), *Acacia nilotica* (Acacia), *Taminaliacatapa* (Indian Almond) and *Ficus* sp. The study recommends that proper sanitation and hygiene practices are implemented and enforced, and ensure periodic assessment of the pond's quality. Also, the protection of the vegetation within the catchment area of the pond should be integral in the management of the tourist site.

Voiculescu-Holvad, C. (2022). Historical material of cf. *Thoracosaurus* from the Maastrichtian of Denmark provides new insight into the K/Pg distribution of Crocodylia. *Cretaceous Research* 139 (<https://doi.org/10.1016/j.cretres.2022.105309>).

Abstract: Crocodylia are one of the distinctive groups that survived the K/Pg mass extinction event. New material from Upper Cretaceous-lower Palaeogene deposits is therefore important to understanding shifts in crocodylian distribution and ecology. This paper describes a fragmentary mandible of a marine crocodylian, from the lower Maastrichtian (Upper Cretaceous) of Møns Klint (Denmark). The specimen is referred to cf. *Thoracosaurus* (Gavialoidea). Although the material was collected in 1968, it has not yet been formally described. However, the specimen warrants further attention, given its palaeoecological and palaeobiogeographical significance. For instance, the Møns Klint "*Thoracosaurus*" is an indication of increased competition between large piscivores, and of added predation pressure on fish and cephalopod communities. This gavialoid therefore provides new insight into predator-prey interactions in the Danish Chalk palaeoenvironment. Regarding crocodylian distribution, the Møns Klint specimen represents the oldest European gavialoid record, with all other material deriving from uppermost Maastrichtian and Danian deposits. This indicates that Gavialoidea were present in the European "Chalk Sea" throughout the Maastrichtian, rather than being latest Maastrichtian

arrivals. Furthermore, the Møns Klint "*Thoracosaurus*" represents one of few lower Maastrichtian gavialoids worldwide, the other two being from Mississippi and New Jersey (USA). The specimen thus extends the palaeogeographical range of lower Maastrichtian gavialoids across the proto-Atlantic. This reveals transatlantic distribution of Gavialoidea dating back to the earliest Maastrichtian, providing further evidence for distributional communication between marine vertebrate faunas of North America and Europe. These factors make the Møns Klint "*Thoracosaurus*" particularly valuable to understanding the distribution of K/Pg Crocodylia.

Humphries, M., Benitez-Nelson, N. and Combrink, X. (2022). Trace metal accumulation in eggs of wild Nile crocodiles (*Crocodylus niloticus*) from Lake St Lucia, South Africa: Implications for biomonitoring in a global biodiversity hotspot. *Arch Environ Contam Toxicol* ([doi: 10.1007/s00244-022-00960-5](https://doi.org/10.1007/s00244-022-00960-5))

Abstract: Nile crocodiles (*Crocodylus niloticus*) at Lake St Lucia, South Africa, have some of the highest blood lead (Pb) concentrations ever recorded in wildlife globally. Although exposure to Pb is known to pose major risks to wildlife reproductive success, potential impacts on crocodile reproduction at Lake St Lucia have yet to be examined. In this study, we investigated the accumulation of Pb and other trace metals (Al, V, Cr, Co, Cu, Ni, Zn and Cd) in eggs (n= 20) collected from five wild crocodile nests at Lake St Lucia. All metals analysed in this study were detected in egg contents, although concentrations varied considerably among nests and within clutches. Lead was detected in the contents of all eggs, but only at relatively low concentrations (43 ± 26 ng g⁻¹ dry weight). Although sampling limitations commonly associated with wild population surveys prevent a complete assessment of exposure variability, our findings suggest maternal transfer may not be a significant depuration pathway for Pb and females possibly clear Pb through other mechanisms (eg sequestration into claws, bone and osteoderms). Metal concentrations in eggshells and shell membranes were poorly correlated with concentrations measured in egg content and thus do not provide viable non-lethal indicators for monitoring metal exposure in Nile crocodiles. Intra-clutch variability accounted for a considerable proportion of the total variance in egg content metal concentrations, suggesting the "one egg" sampling strategy often applied in reptile studies may not be an effective biomonitoring tool for wild crocodylian populations. Although maternally derived Pb does not appear to present widespread toxicological concern at Lake St Lucia, adverse effects of Pb exposure on other reproductive functions (eg spermatogenesis) cannot be discounted and warrant further investigation.

O'Dea, A., Flantua, S.G.A., Leray, M., Lueders-Dumont, J.A. and Titcomb, M.C. (2022). Pleistocene sea level changes and crocodile population histories on the Isthmus of Panama: A comment on Avila-Cervantes *et al.* (2020). *Evolution* ([doi: 10.1111/evo.14610](https://doi.org/10.1111/evo.14610)).

Abstract: Avila-Cervantes *et al.* (2020 *Evolution* 75: 245-259) proposed that glacial-interglacial sea level changes played an important role in the evolutionary and demographic histories of the crocodile *Crocodylus acutus* on the Isthmus of Panama. However, the study used erroneous sea level proxy data that produced flawed paleogeographic reconstructions. We present new paleogeographic reconstructions and review the timing of, and proposed mechanisms behind, the demographic events estimated by Avila-Cervantes *et al.* (2020). With the data currently available, we find little evidence to support the hypothesis that sea level changes drove population demographic events in crocodiles on the Isthmus. Alternative hypotheses, including changing climate and habitat suitability, are equally valid and should be considered along with well-supported sea level models.

Murphy, K.M., Watkins, M.M., Finger Jr., J.W., Kelley, M.D., Elsey, R.M., Warner, D.A. and Mendonça, M.T. (2022). Xenobiotic

estradiol-17 β alters gut microbiota of hatchling American alligators (*Alligator mississippiensis*). *Environmental Microbiology* (doi:10.1111/1462-2920.16222).

Abstract: Environmental estrogens pose serious concerns for ecosystems through their effects on organismal survival and physiology. The gut microbiome is highly vulnerable to environmental influence, yet the effects of estrogens on gut homeostasis are unknown because they are poorly studied in wildlife populations. To determine the influence of environmental estrogens (ie xenoestrogens) on the diversity and abundance of gut microbiota, we randomly assigned 23 hatchling American alligators (*Alligator mississippiensis*) to three ecologically relevant treatments (control, low, and high estrogen concentrations) for 10 weeks. We predicted that xenoestrogen exposure would decrease microbial diversity and abundance within the digestive tract and that this effect would be dose-dependent. Microbial samples were collected following diet treatments and microbial diversity was determined using 16S rRNA gene-sequencing. Individuals in estrogen-treatment groups had decreased microbial diversity, but a greater relative abundance of operational taxonomic units than those in the control group. Additionally, this effect was dose-dependent; as individuals were exposed to more estrogen, their microbiota became less diverse, less rich, and less even. Findings from this study suggest that estrogen contamination can influence wildlife populations at the internal microbial-level, which may lead to future deleterious health effects.

Fachini, T.S., Godoy, P.L., Marsola, J.C.A., Montefeltro, F.C. and Langer, M.C. (2022). A large-sized mesoeucrocodylian from the Late Cretaceous of Brazil with possible neosuchian affinities. *Historical Biology* (<https://doi.org/10.1080/08912963.2022.2122822>).

Abstract: Most crocodyliforms of the Bauru Group were found in rocks of the Adamantina Formation, whereas the younger Marília Formation is almost devoid of such fossils. Here, we provide a detailed comparative description of MPMA 02-0005/87, a large skull roof found in Marília Formation deposits of the Monte Alto area, assigning it to a new crocodyliform. Despite its fragmentary nature and puzzling suit of characters, the new taxon possesses enough characters to reject its placement within Notosuchia, which is so far the only crocodyliform clade known from the Bauru Group. We tested its phylogenetic position with twodata matrices, both of which recovered the new taxon within Neosuchia and Eusuchia. Although the material does not preserve any eusuchian synapomorphy, a neosuchian affinity is supported by: anterior extension of the meatal chamber covered by the squamosal; constricted flange of the posterior process of the postorbital; poorly developed posterolateral process of squamosal. Finally, the large size estimated for the specimen, ranging from 2.98 to 5.88 metres, coupled with its possible neosuchian affinity, suggests a possible semiaquatic behaviour, an ecology rarely explored by the predominantly terrestrial crocodyliforms of the Bauru Group.

Suwannaphan, S. (2021). Isolation and characterization and of protease with collagenolytic activity produced by bacteria from different sources found in Phra Nakhon Si Ayutthaya Province. *Asian Journal of Microbiology, Biotechnology and Environmental Sciences* 23(4): 517-523.

Abstract: Collagen is generally extracted by non-environmentally friendly chemical methods, with occurrence restricted to several proteases due to its complex structure with hydrogen bond binding. Discovery of an enzyme with the potential to extract collagen would be beneficial. This research isolated and characterized 52 proteases with bacterial collagenolytic activity, which produced a clear zone surrounding colonies on Basal medium skim milk agar and Davis minimal gelatin agar. Two potential isolates as BS25 and BS44 showed maximum protease production in Basal medium gelatin broth, with specific activities of 158.30 and 167.25 Umg⁻¹,

respectively. They were identified as *Chryseobacterium* sp. BS25 and *Pseudomonas aeruginosa* BS44. The optimum pH of crude enzyme from BS25 and BS44 isolates was 7.0, while optimum temperatures were 50 and 60°C, respectively. The BS25 enzyme was stable in pH range 5.5 to 8.0, whereas the BS44 enzyme showed higher stability in a wider pH range (5.5 to 11.0). The BS25 enzyme was stable at 30°C, while the BS44 enzyme retained activity over a wider range of 30 to 50°C. Both the BS25 and BS44 isolates showed high potential to produce protease with collagenolytic activity and enabled efficient extraction of collagen from protein waste or crocodile cartilage for commercial production.

Seghetti, S.M., Georgalis, G.L., Tschopp, E. and Delfino, M. (2022). A historical overview of the reptile fauna from the Eocene Bolca Fossil-Lagerstätte (Italy). *Bollettino della Società Paleontologica Italiana* 61(2): 119-143.

Abstract: The Eocene fossil reptiles from the Bolca Fossil-Lagerstätte (Verona, Italy) have been known in the literature since at least the 1850' and were the subject of many studies during the second half of the XIX century and the first decades of the XX century. However, with the exception of a few papers, only rare works have been published on the Monte Bolca herpetofauna in recent years, and in many cases knowledge of the anatomy, taxonomy, and proper nomenclature of the Bolca reptiles still remains uncertain. Herein, we reassess the history of the discoveries, the earlier taxonomy and revisions of the crocodilians, turtles, and snakes from Bolca. To date, a total of 13 crocodilian specimens have been described in the literature or are housed in museum collections and remain unpublished. Two of the crocodilian specimens formerly cited and/or described are currently lost. All the fossil crocodilian specimens had originally been referred to two species, *Crocodylus vicetinus* Liouy, 1865, and *Crocodylus bolcensis* Sacco, 1895. In this study these identifications are considered invalid, and some specimens are referred to the genera *Asiatosuchus*, *Boverisuchus*, *Diplocynodon* and *Hassiacosuchus* while assignment at species level is still debatable. The turtles are represented by multiple specimens, which had been referred in the past to several different taxa of pleurodires and trionychids. However, only two species of turtles from Monte Bolca are currently accepted as being valid, both with species epithets dedicated to the renowned Italian palaeontologist Giovanni Capellini (1833-1922): the pleurodire *Neochelys capellini* (de Zigno, 1890), which is the type species of its genus, and the trionychid "*Trionyx*" *capellini* Negri, 1892. Both the crocodilians and the turtles had been collected at the Purga di Bolca locality. Only three snake specimens have been described from the Bolca area, representing also the oldest Cenozoic snakes from Italy: *Coluber ombonii* de Zigno, 1889 from Purga, and the archaeophiine *Archaeophis proavus* Massalongo, 1859 and anomalophiid *Anomalophis bolcensis* (Massalongo, 1859) from the Pesciara locality. The affinities of *C. ombonii* are still not clear, whereas *A. proavus* and *A. bolcensis* are considered valid and represent the type species of their genera but also are among the very few representatives of Archaeophiinae and Anomalophiidae respectively. The fossil reptiles from Bolca are housed in public collections in Italy (Turin, Verona, Padua, Rome, Pavia), the United Kingdom (London), USA (Pittsburgh, Cambridge), Germany (Darmstadt, Berlin) and Austria (Vienna).

Campos, Z., Muniz, F., Mourão, G., Magnusson, W.E., Farias, I.P. and Hrbek, T. (2022). Geographic variation in colour and spot patterns in Dwarf Caiman, *Paleosuchus palpebrosus* (Cuvier, 1807) in Brazil. *Amphibia-Reptilia* (doi:10.1163/15685381-bja10104).

Abstract: Colour variation in crocodilians is associated with size, environment and genetic structure, but little is known about colour variation in the genus *Paleosuchus* (Alligatoridae). Different genetic lineages of *Paleosuchus palpebrosus* (Dwarf caiman) occupy different environments throughout the species extensive distribution, and all are cryptically coloured. We captured 187 *P. palpebrosus* and recorded their head colour from four genetically distinct geographic

clades between 2008 and 2019. Additionally, we determined the jaw and belly spot pattern of a subsample of 95 individuals (22-109 cm snout-vent length). PERMANCOVA was used to investigate the relationships between head colour and spot patterns, to the caiman size, sex, and geographic lineage, as well as ambient temperature. Variation in head colour, and jaw and belly spot patterns, were related to genetic lineage, snout-vent length and temperature, but the model explained only ~45.4% of the variance in the data. Sex was not significantly related to the head colour, or jaw and belly spot patterns. Dwarf caimans inhabiting cooler climates tend to be darker than individuals from warmer areas, and individuals from the “Cerrado-Pantanal” and “Bolivia” lineages generally darker than the “Amazon” and “Madeira” lineages. However, individuals of a given size in different lineages overlap greatly in colour patterns and colour alone could not be used to distinguish lineages. The Natterer’s hypothesis of head-colour as diagnose from “Cerrado-Pantanal” lineage, cannot be completely accepted according our quantitative analysis, although there are a variation in the geographic distribution of these phenotypic traits, and the “Cerrado-Pantanal” lineage had been the most distinct among the lineages.

Ligtermoet, E., Gumurdul, J.N., Nayinggul, C. and Baker, R. (2022). The return of the kinga (saltwater crocodile): Population ‘bust then boom’ shapes shifting baselines in Indigenous biocultural knowledge in northern Australia. Biological Conservation

Abstract: The saltwater crocodile (*Crocodylus porosus*) can be regarded as a cultural keystone species for many Indigenous societies around the world, including for many Aboriginal clans in northern Australia. Here the regional population of *Crocodylus porosus* suffered a decline, almost to extinction, with unregulated commercial hunting between the 1940s to the early 1970s. Following protected status, saltwater crocodile populations made a rapid recovery. This research documents the perceptions and experiences of this rapid (within living memory) ‘bust then boom’ saltwater crocodile population change, among a regional group of Indigenous Australians (comprising several clans) from the Alligator Rivers Region of western Arnhem Land and Kakadu National Park in the Northern Territory. Using semi-structured interviews, archival work and on-Country (place-based) learning, significant influences on the continuity of Aboriginal people’s contemporary engagement with freshwater Country were identified. In particular, the loss of access to freshwater customary harvesting sites and to key harvested species, and as a driver of adaptive changes in harvesting methods and consumption preferences for saltwater crocodile meat and eggs. Importantly, the experiential losses from restricted access to waterbodies were found to have significant impact on opportunities for inter-generational knowledge transmission, according with more recent applications of the Shifting Baseline Syndrome to Indigenous Ecological Knowledge. Findings demonstrate the need for monitoring and management programs of cultural keystone species, like the saltwater crocodile, to include co-produced biocultural knowledge programs to provide practical means for supporting ongoing engagement with Indigenous Knowledge. This is particularly critical in cross-cultural, First Nations, and joint-management contexts.

Boerman, S.A., Perrichon, G., Yang, J., Li, C-S., Martin, J.E., Speijer, R.P. and Smith, T. (2022). A juvenile skull from the early Palaeocene of China extends the appearance of crocodyloids in Asia back by 15-20 million years. Zoological Journal of the Linnean Society (<https://doi.org/10.1093/zoolinnean/zlac067>).

Abstract: The earliest Crocodylia from Asia have been represented so far only by alligatoroids and planocraniids. Although definitive crocodyloids are not known until the late Eocene, it has been hypothesized that *Asiatosuchus*-like basal crocodyloids originated in Asia before the late Palaeocene. In this paper, we describe a new fossil crocodyloid from the lower Palaeocene of Qianshan Basin, Anhui Province, China. The skull and lower jaw fragment

exhibit several characteristics typical of juvenile crocodylians. They also display a combination of features not seen in any other taxon, warranting the erection of a new species and genus, *Qianshanosuchus youngi* gen. & sp. nov. Its affinities are tested in phylogenetic analyses based on two recent character matrices of Eusuchia. To assess the effect of juvenile characteristics on the outcome of the phylogenetic analyses, juvenile specimens of extant crocodylian taxa are analysed in the same way, showing that the effect of their ontogenetic stage on their placement in the tree is minimal. Our analyses point to a basal crocodyloid position for *Q. youngi*. With these findings, the presence of Crocodyloidea in Asia is extended to the early Palaeocene, 15-20 Myr earlier than formerly thought. Furthermore, our results corroborate previous hypotheses of a Palaeocene dispersal route of *Asiatosuchus*-like crocodyloids from Asia into Europe.

Horgan, M.D., Alexander, A.B., Innis, C., Stacy, B.A., Gai, J.J., Pesavento, P.A., Highland, M.A., Liguori, B.L., Norton, T.M., Wellehan Jr, J.F.X. and Ossiboff, R.J. (2022). Pulmonary and coelomic mycoses due to *Metarhizium* and *Beauveria* species in reptiles. Journal of Zoo and Wildlife Medicine 53(3): 605-612.

Abstract: This report documents cases of fatal pulmonary mycosis caused by entomopathogenic fungi in the genera *Metarhizium* and *Beauveria* (Order Hypocreales) in a loggerhead sea turtle (*Caretta caretta*), a Chinese alligator (*Alligator sinensis*), two gopher tortoises (*Gopherus polyphemus*), a Cuvier’s dwarf caiman (*Paleosuchus palpebrosus*), a false gharial (*Tomistoma schlegelii*), a green sea turtle (*Chelonia mydas*), and a Kemp’s ridley sea turtle (*Lepidochelys kempii*), and a case of granulomatous coelomitis in a hawksbill sea turtle (*Eretmochelys imbricata*). Fungi identified in these cases included *Beauveria bassiana*, *Beauveria brongniartii*, *Metarhizium anisopliae*, *Metarhizium robertsii*, and one case of infection by a novel *Metarhizium* species. The animals were either housed at zoos or brought into rehabilitation from the wild. Although the majority of animals had comorbidities, the fungal infections were believed to be the primary cause of death. Fungal susceptibility testing was performed on two *Beauveria* spp. isolates, and revealed lower minimum inhibitory concentrations for itraconazole and voriconazole when compared to terbinafine and fluconazole. This case series demonstrates that a variety of reptile species from different orders are vulnerable to infection with *Metarhizium*, and multiple species of sea turtle are susceptible to infection with *Beauveria*.

Pritz, M.B., Elsey, R.M., Thompson, T.N. and Hsu, E.W. (2022). A rare case of partial skull and brain duplication in a hatchling *Alligator mississippiensis*. Anatomical Record (Hoboken) ([doi: 10.1002/ar.25087](https://doi.org/10.1002/ar.25087)).

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

Kuzmin, I.T. (2022). Anatomy, Development and Evolution of Braincase in Crocodylomorpha (Diapsida: Archosauria). BSc thesis, Saint-Petersburg State University, Saint-Petersburg, Russia.

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