CROCODILE SPECIALIST GROUP NEWSLETTER

VOLUME 40 No. 3 • JULY 2021 - SEPTEMBER 2021

IUCN • Species Survival Commission

CROCODILE

SPECIALIST

GROUP

NEWSLETTER

VOLUME 40 Number 3
JULY 2021 - SEPTEMBER 2021

IUCN - Species Survival Commission

CHAIR:
Professor Grahame Webb
PO Box 530, Karama, NT 0813, Australia

EDITORIAL AND EXECUTIVE OFFICE:
PO Box 530, Karama, NT 0813, Australia

COVER PHOTOGRAPH: Wild Mugger (*Crocodylus palustris*) in Iran. Photograph: Asghar Mobaraki. See pages 12-20.

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

CSG Newsletter

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

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

All CSG communications should be addressed to:
CSG Executive Office, P.O. Box 530, Karama, NT 0813, Australia.
Fax: +61.8.89470678. E-mail: csg@wmi.com.au.

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We thank all patrons who have donated to the CSG and its conservation program over many years, and especially to donors in 2020-2021 (listed below).

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Allan Woodward, Florida, USA.
Zoo Atlanta, Georgia, USA.
Zoological Society of Hertfordshire, UK.

Editorial

It was very sad to learn that longtime CSG member from Cuba, Manuel Alonso Tabet, passed away on 24 August 2021. Manilito contributed enormously to the conservation and management of Cuban crocodiles, and will be missed by all who knew him, and had the pleasure of working with him (see Obituary on pages 8-10).

On a brighter note, 2021 marks the 50th anniversary of the first CSG Working Meeting, which took place in New York, in 1971. This meeting established the broad protocol for the biennial working meetings that have occurred since, and in its own right, did much to collect and collate the available information on the status of different species before CITES came into being (1973). To commemorate this significant milestone, a virtual presentation is planned within the first two weeks of December. See pages 4-5.

The final draft of the "Traceability in Crocodylian Conservation and Management" was endorsed by the CSG Executive Committee and cleared by the IUCN SSC in September 2021. The CSG has long recognised the difficulties of this issue for crocodilians and has contributed to the debate in various CITES forums. The CSG Executive Committee agreed to review traceability, as it applied to crocodilians at this point in time, and to provide CSG members and others interested in the issue, with a snapshot of key points. Dr. Daniel Natusch kindly prepared an overview report on traceability in reptiles in general, which comprises Chapter 3 of "Traceability in Crocodylian Conservation and Management". The document will be available by October.

The CSG Executive Committee held a special meeting to discuss the potential impact on its annual budget of hardships within the crocodile industry, who have been important donors for many years and general financial problems caused by the COVID-19 pandemic. Fortunately, the CSG reserves are sufficient to ensure CSG can sustain its operations and support programs such as the Student Research Assistance Scheme and Newsletter production, and new ways of raising core operational funds are being investigated.

Every four years (quadrennium), the IUCN World Conservation Congress (WCC) is convened, where IUCN members set the global conservation agenda by voting on recommendations and guiding the Secretariat's work by passing resolutions and agreeing to an IUCN Program. The last WCC was held on 3-10 September 2021, in Marseille, France. The "final report" from the WCC, that contains summaries and links to major outputs, can be found at: https://civicrm.iucn.org/civicrm/mailing/view?reset=1&id=3922.

As reported previously, all memberships of IUCN SSC specialist groups lapse at the end of a quadrennium, and members will need to be reinstated. If you have not already done so, you need to access the IUCN Commission System at https://portals.iucn.org/commissions/ and confirm and/or update your details. If your name no longer appears on the IUCN Commission System then you need to be reappointed as a member by providing your details to the CSG Executive Officer at: csg@wmi.com.au.

The CSG has been registered as a charitable organisation on Amazon Smile. When you shop at Amazon, just visit Amazon Smile (smile.amazon.de/ch/27-612-03732) before going to checkout, nominate the CSG, and Amazon will donate 0.5% of the price of your purchase to the CSG - at no cost to you! This is part of Amazon's charitable initiatives, and offers the possibility to its users to choose the charitable organization they want to donate to when purchasing.

The 19th meeting of the Conference of the Parties to CITES (CoP19) is scheduled to be held on 14-25 November 2022, in Panama City, Panama (see https://cites.org/sites/default/files/notifications/E-Notif-2021-055.pdf). Draft resolutions, draft decisions or other document submitted for consideration at CoP19 should be communicated to the Secretariat at least 150 days before the meeting (by 17 June 2022). Proposals for transfers from Appendix I to Appendix II pursuant to the ranching resolution [Resolution Conf. 11.16 (Rev. CoP15)] need to be submitted 330 days in advance (ie by 12 December 2021).

The CSG Drone Working Group organised its 7th and 8th virtual workshops on 18 August (guest speaker: Clément Aubert, "Evaluation of the use of drones to monitor a diverse crocodylian assemblage in West Africa") and 15 September (guest speaker: Fabiano R. de Melo, "Drones for biodiversity conservation). Youtube links to the workshop recordings are at https://www.dropbox.com/sh/7reqmvtgb4ydd8b/AACI0eDxHm8XLx18wrcoGjaFa?dl=0 and https://www.dropbox.com/sh/72i061naizwkhp9/AAD4H1Vytnh80htUZruTiMOra?dl=0, respectively

Due to the ongoing COVID-19 pandemic, the 26th CSG Working Meeting to be held in Chetumal, Quintana Roo, Mexico, has been postponed again, tentatively to 3-9 July 2022. This situation will be reviewed again in November 2021.

As tough as these times are for everyone, annual requests for donations to the CSG have been sent out to the many individuals who value what the CSG does, and want to help sustain its activity in the future. Let me once again express my thanks to all who have made donations - big or small, cash or in-kind - because they are critical to the CSG's ability to operate effectively.

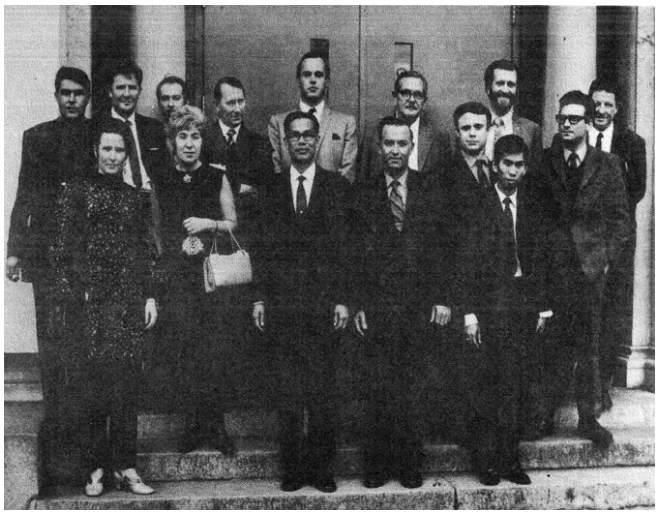
Professor Grahame Webb, *CSG Chair*.

CSG to Celebrate 50th Anniversary of First Working Meeting with a Virtual Event

The Crocodile Specialist Group (CSG) is one of the largest specialist groups within the Species Survival Commission (SSC) of the International Union for Conservation of Nature (IUCN). It is a worldwide network of experts, upon which the SSC and IUCN call, to fulfill their missions with crocodilian conservation and management.

The CSG, with 703 members from 70 countries, has diverse expertise in the science, management and industry that together conserve crocodilians. It has been pursuing crocodylian conservation for 50 years, and with its accumulated experience, provides advice, contacts and technical assistance to other organizations, government agencies and research groups. The strength of the CSG lies in its voluntary membership, many of whom are operating or contributing to national conservation and management programs for crocodilians in their home countries. When taken together, the combined conservation action being implemented by CSG members, in the field, at the coal face of conservation, is enormous.

Every two years, the CSG holds a major international Working Meeting, which in recent years has attracted 200-300 participants - CSG members and non-members. The Working Meetings mobilise people who work on crocodilians around the world to share information and experiences, and to discuss how to improve crocodilian conservation on a global scale. It is a space where the CSG Steering Committee and various CSG Working Groups hold meetings - open to everyone - to discuss conservation and management of endangered and abundant crocodylians, and technical issues in general research, veterinary aspects, taxonomy, the CSG's Student Research Assistance Scheme, the Future Leaders Program, Human-Crocodile Conflict, CITES, CBD and more. A valuable space for young and old CSG members to meet, share stories, mentor and learn.



Participants at 1st Crocodile Specialist Group meeting (New York, USA, 1971). From left; Tony Pooley (South Africa), Moira Warland (IUCN), Max Downes (PNG), Peter Brazaitis (USA), Claire Hagan (USA), Angus Bellairs (UK), Utai Youngprapakorn (Thailand), Robert Bustard (Australia & UK), Robert Chabreck (USA), Hugh Cott (UK), James Powell (USA), F. Wayne King (USA), Suphachai Yungprapakorn (Thailand), Rene Honegger (Switzerland), Federico Medem (Colombia). Photograph: New York Zoological Society.

In 1969, the IUCN established a panel of experts to investigate the status of crocodilians, but the first real product, which marks the implementation phase of the CSG, was the 1st Working Meeting held in New York, USA, in 1971 (http://www.iucncsg.org/365_docs/attachments/protarea/1st%20-0532d4ed.pdf). The Proceedings from that first meeting served as a fundamental reference for Rene Honegger to compile the first Red Data summaries for crocodilians (1975), and provided the rationale for conservation action at that time, at both national and international levels. The Proceedings also serve today, as a reference point for assessing the effectiveness of conservation action over the last 50 years. Hence the 50th anniversary of the 1st CSG Working Meeting is significant.

There have subsequently been 25 CSG Working Meetings, 11 CSG Regional Meetings and one CSG Regional Species Meeting, at various locations around the world.

- Working Meetings: Argentina (2), Australia (2), Bolivia, Brazil, Cuba, Ecuador, France, India, Papua New Guinea, Philippines, Singapore, South Africa (2), Sri Lanka, Thailand, USA (5), Venezuela, Zimbabwe, Zimbabwe/South Africa

- Regional Meetings: Argentina (2), Australia, Belize, Burkina Faso, Cambodia, Colombia, Cote d'Ivoire, Mexico, Niger, Thailand

- Regional Species Meetings: Thailand

Participants at 25th Crocodile Specialist Group Working Meeting (Santa Fe, Argentina, 2018).

The Proceedings of these meeting (most are available on the CSG website) provide an immense amount information on world crocodilians collected since the 1st Working Meeting. It was intended to celebrate the 50th anniversary at the 26th CSG Working Meeting in Chetumal, Mexico, but that eagerly awaited meeting continues to be postponed due to the COVID-19 pandemic.

Accordingly, a celebration of the 50th anniversary of the 1st CSG Working Meeting has been planned as a stand-alone virtual event. This offers a unique opportunity for CSG members to review the changes in conservation and management that have occurred over the last 50 years - the problems solved and unsolved - and acknowledge the role of the CSG and its members in the progress made. It is an opportunity for younger CSG members to reacquaint themselves with the pioneers of the CSG, and get some measure of the responsibility they will have for continuing the work of the CSG into the future.

We would like to invite everyone around the world to celebrate this 50th anniversary, and share in some special virtual moments about the history of the CSG.

It is hoped that the virtual event will held sometime during the first two weeks December 2021, with the precise date yet to be confirmed. Details will be posted as soon as they are available.

Pablo Siroski, *CSG Regional Chair for Latin America and the Caribbean and Chair of Future Leaders Program*.

Crocodile Specialist Group Chairs (1971-2021)

Crocodile Specialist Group Chairs: Top, from left: Hugh Cott (dec.) (1971-73), F. Wayne King (1973-78, 1981-89). Bottom, from left: Howard "Duke" Campbell (dec.) (1979-81), Harry Messel (dec.) (1989-2004), Grahame Webb (2004-present).

Crocodile Specialist Group Newsletter (1971-2021)

Evolution of Crocodile Specialist Group Newsletter format, from left: Volume 1(1) (1971-1986); Volume 6 (1987-1994); Volume 13(3) - WWW Edition (1994-1996); Volume 40(2) (1997-present).

The Crocodile Specialist Group Newsletter remains as one of the CSG's key forms of communication between its members, wildlife authorities, and the general public. It provides an important avenue for the publication of "grey" literature on crocodilians, and various events and activities from around the world. The "business" of the CSG is reflected through the CSG Newsletter.

The first CSG Newsletter was produced in June 1971, following the first CSG Working Meeting in March 1971 (see page 5). Up until 1987, 1-2 issues of the CSG Newsletter were produced in most years (none in 1976, 1981 and 1982), and they were relatively simple in format, largely reflecting the technology of the time.

In 1987, the current CSG Newsletter format was adopted, and it has stayed much the same since that time, with the exception of 10 issues, between mid-1994 and 1996, when a "WWW Edition" was published. With the exception of colour photographs on the cover on two issues in 2002, hard copies of the CSG Newsletter have been printed in black and white. However, since mid-2004, almost all electronic versions of the Newsletter have been available in colour.

Since 1989, four issues (quarterly) have been produced annually. Since mid-2018, hard copies of the CSG Newsletter have no longer been produced, in part to reduce the cost of production (printing, postage), but also to keep in line with changes in the way in which people now receive and store information, in electronic form.

Between 1971 and 1989, the role of CSG Newsletter editor/s was occupied by Tony Pooley (1971-73), James Powell (1973-75), Howard Campbell (1977), Rom Whitaker (1978-80), and co-editors Peter Brazaitis (1983-89) and Myrna Watanabe (1983-88), with I. Lehr Brisbin, John Polisar and F. Wayne King contributing to 1-2 issues in 1986 and 1989. Since mid-1989, the CSG Editorial Office has consisted of Wayne King (1989-2004), Perran Ross (1990-2004), John Thorbjarnarson (2002-04) and Charlie Manolis (2004-present).

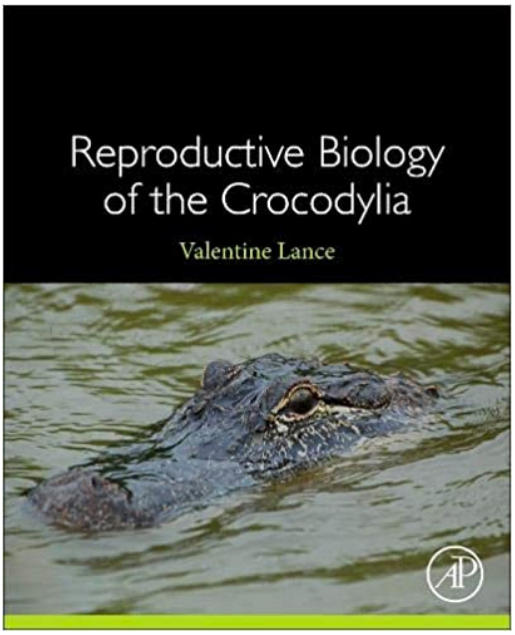
Books

Reproductive Biology of the Crocodylia

We are pleased to announce that **Reproductive Biology of the Crocodylia**, by Val Lance, will be available in November 2021 (Academic Press; 366 pages). It is based on more than 40 years of research on the world's crocodiles, alligators and caimans, and brings together data, information and knowledge on the history, ecology, physiology and anatomy of crocodilians.

The book provides a comprehensive look at the physiology, current taxonomy, ecology and sexual maturity factors of crocodilians, and delves into the anatomy and cycles of male and female reproduction systems, including nesting, incubation, temperature-dependent sex determination and sex ratios. It also focuses on conservation efforts to protect the reproductive cycle, taking factors such as pollution, climate change and human disruption into consideration. The Table of Contents is:

1. Phylogeny and fossil history
2. History and growth of knowledge
3. Life history, ecology
4. Growth, sexual maturity, senescence
5. Anatomy of the male reproductive tract
6. Male reproductive cycle
7. Anatomy of the female reproductive tract
8. Female reproductive cycle
9. Sex determination
10. Captive breeding
11. Environmental pollution
12. Conservation



There is little doubt that **Reproductive Biology of the Crocodylia** will be a valuable resource for wildlife biologists, herpetologists, veterinarians, zookeepers and crocodilian farmers.

Tratado de Crocodilianos do Brasil

Tratado de Crocodilianos do Brasil ("Treatise on Crocodilians of Brazil") was launched on 14 August 2021, at the Faculdades Integradas Espírito-Santenses, in Vitória, Espírito Santo State, Brazil. It is a realization of the Instituto Marcos Daniel (IMD), and represents an innovative and relevant academic contribution to herpetology and Brazilian society. It symbolizes a significant achievement for the study and conservation of crocodilians in Brazil.

The book represents the involvement of a multitude of professionals over a 3-year period, coordinated by editors from Projeto Caiman (André F. Barreto-Lima, Marcelo R. de Deus Santos and Yhuri C. Nóbrega).

Figure 1. Editors at the launch, during the 1st Congress on Brazilian Crocodilians (see page 24); from left, André Barreto-Lima, Yuri Nóbrega and Marcelo de D. Santos.

Sixty-nine qualified researchers from different academic and technical backgrounds, institutions, NGOs, companies, and countries (Brazil, Argentina, Ecuador, Mexico, Peru, USA, Venezuela) collaborated on the book.

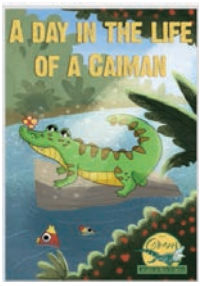
The 24 chapters are divided into 6 themes (paleontology, and taxonomy, field methods, sustainable use, veterinary medicine, cultural and traditional knowledge, research and perspectives on conservation; see pages 53-54 for chapter citations). For the first time in Brazil, fundamental, historical, and up-to-date aspects of various studies of caiman populations are presented in the one place. Tratado de Crocodilianos do Brasil has the mission of contributing to conservation in a country with around one quarter (6 species) of the current diversity of world crocodilian species.

The book is freely available in the virtual library of Projeto Caiman (https://www.imd.org.br/bibliocaiman). Further information is available on the Projeto Caiman website (www.imd.org.br/projetocaiman) and instagram (@projetocaiman), or the editors [André Barreto-Lima (afblima1@gmail.com), Marcelo de Deus Santos (marcelo@institutomarcosdaniel.org.br), Yhuri Nóbrega (yhuri@institutomarcosdaniel.org.br)].

A Children's Book Trilogy: Acknowledging Brazilian Biodiversity in Stories for Children and Their Families

A trilogy of children's books, entitled "A Day in the Life of a Caiman", "The Caiman Family" and "It's Not Easy Being a Caiman", written by Projeto Caiman-IMD (www.imd.org.br/projetocaiman; Instagram: @projetocaiman), were launched on 14 August 2021, during the first Congress on Brazilian Crocodilians (see page 24).

One of the pillars of Projeto Caiman-IMD is training of young researchers, who come from all over the country to



acquire skills during internships offered by the project. One of the challenges of the internship period is to prepare and develop a project proposal. In 2019, Fernanda Correia Silva Rochinski, an environmental education intern, together with the Environmental Education Coordinator of Projeto Caiman, Bárbara Nedelly Mello Silva, started production of the children's books. The first story was adapted from a theatre script used to teach children about the Broad-snouted caiman. Several adaptations and corrections were made over the next two years, until the final result was reached.

The books were written by Bárbara Nedelly Mello Silva and Fernanda Correia Silva Rochinski, edited by Yhuri C. Nóbrega and Leonardo Merçon, reviewed by Marcelo Renon de Deus Santos and Marcos Coutinho, and illustrated by Luiza Tanaka Paganotti. After finalizing the Portuguese versions, Fernanda Rochinski, an English major from the Federal University of Bahia, translated the three books into English.

The trilogy tells the story of Jaque, a Broad-snouted caiman (*Caiman latirostris*). Readers will learn about the biology and ecology of this species in a playful and didactic way, and also gain an understanding of the anthropogenic pressures that these animals are under, especially those living near or in large urban centres. The books are intended to stimulate the imagination and emotions, so everyone who is involved can learn from it, including adults. Children's literature is an important tool that helps children to learn and develop empathy for animals, especially those that suffer stigma by the society, as it is the case with the Broad-snouted caiman, which plays a fundamental role in the Atlantic Forest biome's balance.

The works are a realization of Projeto Caiman-IMD, with sponsorship from ArcelorMittal Tubarão, and supported by Instituto Chico Mendes de Conservação da Biodiversidade and Instituto Últimos Refúgios.

We are immensely grateful to ArcelorMittal Tubarão, our official sponsor, who has always supported the activities of Projeto Caiman-IMD, as well as the supporters and institutional partners for publicizing the books (Instituto Chico Mendes de Conservação da Biodiversidade and Instituto Ultimos Refugios).

Portuguese and English versions of the three books are freely available for download from the Projeto Caiman virtual library (https://www.imd.org.br/bibliocaiman).

Fernanda Correia Silva Rochinski[1], Bárbara Nedelly Mello Silva[2] and Yhuri Cardoso Nóbrega[2]: *[1]Universidade Federal da Bahia, Salvador, Bahia, Brazil; [2]Instituto Marcos Daniel-Projeto Caiman, Vitória, Espirito Santos, Brazil.*

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 2021 quarter, and five additional applications are under review.

1. Edison Bonilla Liberato (Colombia): Spatial ecology of crocodylia in Natural Tayrona National Park, Colombian Caribbean.

2. Asela Buenfil Rojas (Mexico): Integral analysis of environmental contamination and its impacts on *Crocodylus moreletii* in the Yucatan Peninsula, Mexico.

3. Gonzalo Pighin (Argentina): New methods of detection of *Caiman latirostris* through the use of deep learning.

4. Nishan KC (Nepal): Assessing population abundance and habitat occupancy of Mugger (*Crocodylus palustris*) in the Rapti River, Nepal.

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

Obituary

Manuel Alonso Tabet (1951-2021)

One afternoon in April 2010, in a classroom at the University of Pinar del Río, Cuba, biologist Manuel Alonso Tabet was defending his doctoral thesis on the Ethoecology of the American Crocodile (*Crocodylus acutus*) at the Monte Cabaniguán Wildlife Refuge. In hypnotic silence, the audience and members of the examining board listened in rapture as the candidate, in the relaxed way of someone who has mastered his subject matter, disclosed arcane details of the intimate life of crocodiles: their annual migrations through the wetlands;

formation of harems, courtship and mating; the females' arrival at the communal nesting areas and their dominance conflicts over nesting; the use of dens and their construction techniques; parental care of nests and offspring; the amazing synergy between these behaviours and evolution of the ecosystem as a whole; and, all illustrated with impossible photographs! A passing janitor parked the cleaning cart in the hallway and came over to listen, discreetly.

At the end, at question time, a member of the tribunal, as if to highlight the exhaustiveness of the dissertation, asked half-jokingly: "And how many crocodiles are there in Monte Cabaniguán?" And the immediate answer was: "Thirteen thousand five hundred and seventy-two, including those born last year; if anyone doubts it, let's go count them again." Then came resounding applause for an indisputable *summa cum laude*. Among many possible anecdotes, I chose this one as an instant portrait of our colleague and friend, Manolito, who had wonderful gifts as a field biologist and communicator. We lost him to Covid-19 on 20 August 2021.

Manolito was born on 1 December 1951, in Jobabo, a small sugar town in the eastern Cuban province of Las Tunas, where he completed his earlier studies. As a child, he showed a great vocation for animals, which led him to become an amateur breeder of cage birds, a hobby that absorbed him along with caring for his beloved dog and cat. Later this would lead him into teaching of biological sciences, culminating in his Bachelor's degree in Pedagogy of Biological Sciences in 1989.

We met for the first time in 1987, when I was conducting the explorations that would lead to the first phase of the Monte Cabaniguán Wildlife Refuge. By then he was working as a biology teacher and director of the high school in his municipality. When our team requested a guide, the municipal authority did not hesitate to propose Manolito. Together, we traveled a good part of that almost unaltered landscape of palm savannas, forest remnants and majestic estuaries with pristine mangroves, and visited some of the remote places where crocodiles gather to nest. Those excursions marked a before and after in Manolito's life. In 1991, he made his debut as a founding biologist in charge of the new wildlife refuge to which he would dedicate the next 30 years of his life.

Monte Cabaniguán, as an integral part of one of the largest and best-preserved coastal wetlands in the entire insular Caribbean, supports one of the largest populations of the American crocodile in its range. This 600 km^2 wetland provides a unique opportunity to study the natural history, behaviour, and ecological relationships of the species under pristine conditions. It was the ideal place to develop the pilot project to adjust and test standardized field research methods for the study of crocodiles throughout Cuba, and consequently, train the young biologists who would join the National Crocodile Program. This ambitious project was carried out simultaneously with the study of other species of principal importance concurring in the area (eg Cuban Iguana, Fernandina's Flicker, Cuban Parakeet, Rosseate Spoonbill).

Manolito had the herculean task of leading the creation of the protected area, providing it with infrastructures, managing logistics, recruiting and training personnel, implementing the management plan, and carrying out research and training projects. Over the years and overcoming countless obstacles, these goals were met. This was the melting pot, where Manolito's skills and talents as a proactive leader, scientist, educator, and a convincing communicator were put to the test and forged. Not the least of these achievements was the formation of a highly trained technical and auxiliary team in Monte Cabaniguán, young people whom he rightly described as "all-to-doologists". Some of them completed higher education and continue to work in the area.

Through my years of scientific work in Monte Cabaniguán, along with Manolito, Toby Ramos and John Thorbjarnarson, I received, first-hand, the most valuable teachings for my professional maturity and for the ethical dimension of my life. We were always impressed by Manolito's extraordinary ability to decipher the secrets of nature, his detective-like understanding of the messages contained behind each footprint, near the crocodile nests, the transformations produced in the habitat by tides, hurricanes or the activity of the crocodiles themselves, etc. From Manolito I learned the importance of a researcher's link to his work area, and his presence throughout all seasons, days and nights, storm and calm; the irreplaceable value of long-term studies, which allow us to understand the slow processes of habitat transformation, the adaptation of animal populations to these changes, and the biological cycles that occur over long periods of time.

Observing him at work I also learned that for current biological science it is essential to preserve and sometimes rescue that naturalistic spirit that, wisely supported by experimental and statistical sciences, recreates itself in the reasoned, placid and patient observation of the phenomena under our magnifying glass. And from his example and his friendship, I realized that there is nothing more sterile than jealously guarded knowledge, that the scientist only reaches his fullness as a human being and as a social entity when he is determined to share, implement, communicate and educate, and that the experience and praxis of scientific teamwork reaches its utmost effectiveness and becomes fully self-rewarding when it is seasoned by deep personal friendship among its participants.

Through his fruitful professional life, in addition to working as head of the Monte Cabaniguán Wildlife Refuge, Manolito carried out many other important tasks and responsibilities. Up until his death, he held the position of head of the National Crocodile Program of Cuba, he was a member of the IUCN SSC Iguana and Crocodile Specialist Groups, and Steering Committee representative of the latter for the Antilles sub-region.

His extensive curriculum includes numerous tutorials for undergraduate, master's and doctoral theses, participation in working meetings, national and international conventions, delivery of conferences, master's classes and workshops. The

invaluable legacy of his published works includes scientific and dissemination articles, reports, research protocols and methodologies, teaching material for environmental education, contributions to "The Crocodylia of Cuba", and even children's literature. There is a significant number of unpublished works whose completion and publication now represent an inescapable duty for us.

Manolito was a modest man with a jovial character, the owner of a fine sense humor and unshakable dignity in the face of vicissitudes and pain. He left a deep mark of sympathy, admiration and respect in all of us who had the privilege of knowing and having him in our lives. And to complete his fruitful life, he leaves us his best legacy, the most endearing gift of his efforts as a father and teacher - his daughter Yairén, who has followed in her father's footsteps as an excellent biologist and has taken the torch from her father's hands.

To Yairén, her mother, and all the family, friends and colleagues who accompanied and loved Manolito in life, our warmest hug of consolation.

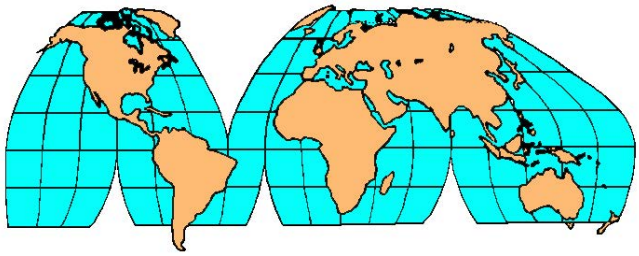
Compiled by Roberto Rodríguez Soberón.

26th CSG Working Meeting Postponed Again

The ongoing COVID-19 pandemic has forced organisors to again postpone the 26th CSG Working Meeting to be held in Chetumal, Quintana Roo, Mexico. Tentative new dates are 3-9 July 2022, but organisors will continue to track the situation and confirm these dates by November 2021.

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

Regional Reports



North America

USA

LONG-DISTANCE DISPLACEMENT OF AN AMERICAN ALLIGATOR (*ALLIGATOR MISSISSIPPIENSIS*). American alligators (*Alligator mississippiensis*) are broadly distributed and inhabit a variety of wetlands, and typically prefer fresh to intermediate salinity wetlands (Elsey and Kinler 2004; Woodward and Elsey 2019). They have also been documented well offshore, with an alligator being found some 63 km from the nearest point on mainland Louisiana (Elsey 2005). Alligators sometimes move long distances (Lance *et al*. 2011), as do other crocodilians (Read *et al*. 2007), while in other cases both juveniles and adults exhibit site fidelity (Elsey *et al*. 2008, 2011). We have documented interstate movement of alligators (Elsey and Flynt 2013), and in one extreme case, a juvenile "farm-released" alligator marked as part of a head-start component of Louisiana's egg ranching program (Elsey and Kinler 2011) was pushed some 489 km from its release site in coastal southwest Louisiana to the beach at Padre Island National Seashore (PINS) in Texas, presumably by Hurricane Ike (Elsey and Aldrich 2009).

On 24 May 2021, a juvenile alligator was found ashore, approximately 150 m south of the visitor center at PINS. The alligator was lethargic and somewhat emaciated, and for public safety concerns was captured (after consultation with Texas Parks and Wildlife Department) and taken to the Texas Sealife Center in Corpus Christi, Texas, for rehabilitation. Before capture, it was apparent the alligator had been marked by removal of two tail scutes (Fig. 1), and staff observed web tags on the rear feet. These indicated the alligator had been released from a commercial alligator farm as part of Louisiana's egg ranching program, which requires release of a portion of alligators reared from eggs collected be returned as juveniles within two years of egg collection, to ensure future recruitment (Elsey and Kinler 2011).

Figure 1. Juvenile alligator released from an alligator farm in Louisiana and recovered at Padre Island National Seashore, Texas. Photograph: Kara Rogers (National Park Service).

The alligator measured 142 cm (56") TL and had a mass of 9.1 kg. An initial health assessment included blood work, and radiographs which showed no evidence of fish hook/s in the stomach, although fishing line was present in the mouth. The alligator was given fluids to begin the rehydration process and housed in fresh water. In the first two weeks the alligator did not take food offered (rats, mice and fish), but gradually became more active. By the third week, the alligator began consuming fish, which was a significant step in its recovery. The alligator continued to increase its activity level, and plans are now underway for its release to the wild in suitable habitat.

The web tags indicated the female alligator had been marked and released on 16 April 2021, at which time it reportedly measured 119 cm (47") TL. It had been released in wetlands

in coastal Vermilion Parish (County) in Louisiana, some 529 km from the recovery site (Fig. 2). It was one of 23 juvenile alligators released at that particular property, and one of 346 alligators marked and released that day on 31 privately-owned properties. The calculated growth for this alligator [23 cm (9") in 39 days] is unlikely, and it is possible that the initial TL was recorded incorrectly. Alligators can be challenging to measure accurately as they inherently struggle during handling (Zweig *et al*. 2004; Wilkinson *et al*. 2016).

Figure 2. Release site in Vermilion Parish, Louisiana, of juvenile farm-released alligator, and straight-line distance to recovery site at Padre Island National Seashore, Texas.

It is an interesting coincidence ended up at virtually the same location at PINS as the one previously reported in 2008 (Elsey and Aldrich 2009), albeit this alligator dispersed a greater distance. Currents and prevailing winds could play a role in this movement/displacement pattern, with the juvenile alligator in 2008 moving some 489 km in 61 days, and in the case the alligator moved some 529 km in 39 days. Crocodilians have been shown to use currents in long-distance movements (Campbell *et al*. 2010). PINS is at the intersection of two longshore currents in the Gulf of Mexico, and thus receives a lot of marine debris, as well sea turtle and marine mammal strandings. Several news media outlets reported the unusual occurrence of the alligator at PINS.

Several possibilities exist that could also explain this unusual long-distance displacement. We considered the fact that numerous alligators were marked at the farm on 16 April, and destined for transportation and release on dozens of wetland properties. The burlap bags marked for each wetland could have been inadvertently confused and some alligators may not have been released into the wetlands of origin. However, the majority of alligators marked that day were to be released in Vermilion Parish and a few others in parishes slightly east of Vermilion Parish. Thus, even if bags were confused, the dispersal distance would have been nearly the same or even greater.

We also considered that perhaps the alligator could have been caught by a private citizen or fisherman and transported by vehicle closer to the recovery site. It may have been caught as a "prank" or for a pet, and ultimately a decision made to release it. This seems unlikely however, due to the moderate size of the alligator (too large for a "pet"), and if the alligator was incidentally caught with the aim of keeping the tail meat for home consumption, the alligator would probably have been immediately harvested, rather than transported live over a long distance and then released.

Much of Louisiana received an unusually large amount of rain on 17-18 May 2021, and in some areas (such as nearby Lake Charles, Louisiana) some 38 cm (15") of rain led to very high water levels, which may have led to displacement of this alligator over what would normally be natural obstacles or barriers to dispersal. The recent storm waters could have washed the alligator offshore to the longshore currents that then pushed it to PINS. We suspect this is the most likely factor responsible for this unusual observation of long-distance movement.

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Ruth Elsey *(Louisiana Department of Wildlife and Fisheries, Grand Chenier, Louisiana, USA)*, Kelly Nesvacil *(Science and Resource Management, Padre Island National Seashore, Corpus Christi, Texas, USA)* and Tim Tristan *(Texas Sealife Center, Corpus Christi, Texas, USA)*.

LAPB AWARD 2021. The Louisiana Association of Professional Biologists (LAPB) has awarded the "2021 Best Conservation Publication Award" to "The Ecological importance of crocodylians: Towards evidence-based justification for their conservation", which appeared in Biological Reviews 95: 936-959. The paper was authored by Ruchira Somaweera, and co-authors James Nifong, Adam Rosenblatt, Matthew Brien, Xander Combrink, Ruth Elsey, Gordon Grigg, William Magnusson, Frank Mazzotti, Ashley Pearcy, Steven Platt, Matthew Shirley, Marisa Tellez, Jan van der Ploeg, Grahame Webb, Rom Whitaker and Bruce Webber.

South Asia and Iran

CONSERVATION STATUS OF THE MUGGER (*CROCODYLUS PALUSTRIS*): ESTABLISHING A TASK FORCE FOR A POSTER SPECIES OF CLIMATE CHANGE. The Mugger or Marsh crocodile (*Crocodylus palustris*) was described from the Gangetic Plains in India in 1831. It is a medium-sized crocodile, with adult females reaching 2-2.5 m and males 3-3.5 m on average, and rarely reaching 5 m TL. The species is distributed from southeastern Iran to Pakistan and the Indian subcontinent, including Sri Lanka (Fig. 1). The species is considered extinct in Bhutan and Myanmar, with only transient individuals occasionally reported from Bangladesh. Fossilized remains suggest the species' existence in Pakistan for thousands of years (Sohrab Katrak 1963). Muggers inhabit freshwater habitats, including lakes, rivers, marshes, agro-wells and artificial ponds ("tanks" in Sri Lanka, and species is referred to there as 'tank crocodile'), and occasionally hypersaline waters in Sri Lanka.

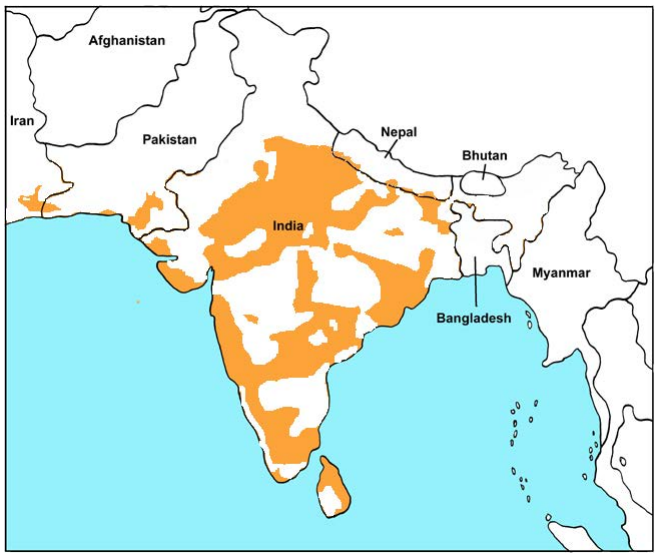

Figure 1. Distribution of the Mugger (*Crocodylus palustris*), from authors' data and data points for distribution in India from Tarun Nair. Source: Stevenson *et al*. (2021).

Muggers have the broadest snout among living members of the genus *Crocodylus*, and display adaptive behaviours, such as digging burrows to retreat from extreme temperatures and migrating over land at night to find suitable habitats during the hot, dry season (Whitaker and Whitaker 1989; Daniel 2016; Choudhury and de Silva 2013; Mobaraki 2015; De Silva 2013). In Sri Lanka, they have also been observed excavating a 'guard burrow' on the bank below their nest. One of the authors (AdS) has seen these in two contrasting areas in Sri Lanka; inside a forest, and amid a disturbed, anthropogenic habitat. These burrows serve several purposes: refuge for resting; thermoregulation; aestivation during prolonged drought; and, protection from natural predators and humans as well as nesting. Several Muggers, including hatchlings, can sometimes be found in one burrow.

Interestingly, H. Wermuth in Germany and P.E.P. Deraniyagala in Sri Lanka together lodged an appeal on the urgency of protecting crocodiles worldwide (Alice 1956). Sri Lanka and Germany, therefore, were taking a very early lead role in the conservation of crocodilians. The Mugger has been listed as "Vulnerable" on the IUCN Red List of Threatened Species since 1982, with the population trend being evaluated as stable (Choudhury and de Silva 2013). Considering the threats faced by the dwindling wild Mugger populations in range states, the species receives legal protection in the countries through national legislations. The species is listed in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

The Mugger is generally threatened by habitat destruction because of conversion of natural habitats for agricultural and industrial use, and as humans encroach into the crocodile's habitat, the incidence of conflicts increases. Climatic changes resulting in water shortage and droughts also compel Muggers to migrate from their shrinking natural niches to other suitable places, causing human-crocodile conflict (HCC). Muggers are entangled in fishing equipment and drown, and they are killed in areas where fishermen perceive them as competition.

Changes in environmental conditions also affect the species' ecology. The populations struggle to adapt to changes such as reduced water flow or water levels in habitats. Eventually, Mugger populations either migrate towards the optimum conditions or struggle to survive in their altered habitats in search for food and shelter. This increases the probability of encounters of Muggers with local communities. As Muggers migrate to more permanent water bodies, they are often victims of accidents with cars and trains (Mobaraki and Abtin 2007; Vyas 2012a; de Silva 2013), and come into villages, farms and community ponds. The opportunistic and accidental killing of Muggers is not frequent in most of wild habitats.

Periodic prolonged droughts and lack of precipitation as well as of water resulted in the habitats in Iran becoming more and more dry. This in turn, increases the temperatures. Thus the crocodiles have to tolerate hotter and drier conditions which may have effects on food availability and vegetation coverage too.

In Sri Lanka, crocodile eggs are destroyed by local people who generally fear crocodiles. In the natural habitats of the Mugger in the Gwadar District of Pakistan, the reduction in water flow due to low rainfall and droughts causes higher mortality, especially in Dasht Khor. Another threat is construction of small dams in the Saurashtra region of Gujarat State, India (Vyas and Vaghashiya 2020), which has caused mortality of crocodiles. Another example is the Mirani Dam, where the movement of Muggers has been observed from downstream of Dasht Khor/Dasht River towards Mirani Dam during increased temperatures, lack of timely rains and shortage of water in the Dasht River. During the drought period of 1999-2004, when the water level decreased in the Hingol River, many crocodiles died. Forest-clearing fires usually reduce the suitability of crocodile habitats. Habitat destruction and seasonal floods also destroy nesting areas and eggs of the Mugger in the wild (Javed *et al*. 2005; Khan 1988).

In Iran, there is no harvesting of the species, but in some countries Muggers are killed for their meat (which is sold illegally), and crocodiles are invariably killed after attacking humans. In 2006-2009, the extent of poaching in Pakistan had been reduced significantly, which perhaps contributed to an increase in the population of Muggers in Sindh Province. However, the actual extent of poaching and conflict with local communities cannot be estimated due to the lack of monitoring in the area. Unlike Muggers at Manghopir Shrine, the local communities of Gwadar District, Balochistan, do not have cultural beliefs and are unaware of the species' ecological importance, resulting in the lack of conservation measures at the local community level in the area. There is a need to locate the crocodiles' breeding and nesting areas and construct fences around these sites. The promotion of ecotourism and awareness-raising was encouraged to protect the Muggers, their eggs, and their habitats in some villages.

The crocodile became the focus of the "Zoo Species of the Year Campaign 2021", which aims to raise awareness about the threats and conservation needs of lesser-known wildlife species kept in zoos, supporting their *in-situ* conservation, and raising funds for conservation projects working directly with these species (https://www.zgap.de/index.php/en/about-us/zoo-animal-of-the-year). During the year-long "Species of the Year" campaign, German-speaking zoos are engaged in lobbying activities for crocodiles and simultaneously collect funds to support *in-situ* conservation projects. Four partners active in species conservation are joining forces to achieve as much as possible for the species in focus in public relations work and concrete species conservation measures. With the leading Zoological Society for Conservation of Species and Populations (ZGAP), the institutions and members of the German Society for Animal Parks (Deutsche Tierpark-Gesellschaft e.V., DTG), the Association of Zoological Gardens (VdZ), and the Community of German Zoo Patronisers (Gemeinschaft der Zooförderer, GdZ) work closely together and ensure professional and effective conservation work.

In light of the announcement of the campaign, Asghar Mobaraki (Iran) contacted Thomas Ziegler (Cologne Zoo, Germany) in February 2021, and they subsequently created a WhatsApp discussion group to facilitate communication and discussion of Mugger conservation efforts in Iran. Initial group members were Asghar Mobaraki, Lonnie McCaskill (USA) and Thomas Ziegler. AM further added Elham Abtin (Iran) and TZ added Cologne Zoo's Terrarium Section Keeper, Anna Rauhaus.

Asghar Mobaraki and Elham Abtin have built up a crocodile breeding facility in southeastern Iran as the first multipurpose *ex-situ* conservation centre for the species in the country. Breeding stock consists of rescued crocodiles that were in unsuitable living situations and villages and considered to be a nuisance (Fig. 2). This small captive population of Muggers is now maintained for conservation breeding purposes and future population restocking actions (Fig. 3).

Figure 2. Muggers in conservation breeding center in Iran. Photographs: Asghar Mobaraki and Elham Abtin.

Figure 3. Mugger offspring in conservation breeding center in Iran. Photograph: Asghar Mobaraki.

To provide a better overview of the *ex-situ* conservation situation of the Mugger, populations kept in zoos and aquaria around the world were determined by AR and TZ using the Zoological Information Management Software (ZIMS: Species360, Bloomington, MN, USA; https://zims.species360.org). In total, 1986 Muggers are held globally in 14 institutions from three regions (1977 in Asia, 4 in Europe, 5 in North America), according to ZIMS (assessed in March 2021; see Table 1). However, the list may be incomplete, as some zoos do not use ZIMS. Actual numbers of Muggers in range state facilities thus might be much higher. For example, according to the official annual inventory (2019-2020) of the Central Zoo Authority of India, 2449 Muggers (175 males, 198 females, 2076 unsexed) were kept among 63 Indian zoos. The number of Muggers in the Department of National Zoological Gardens, Sri Lanka, according to the curator, was 9 (Dehiwala 4, Pinnawala 5). There is also a low number of individuals in Sindh Province: 40 in Khar Centre, Kirthar NP; 39 in Karachi Zoological Garden (Karachi); 7 in Sufi Anwar Safari Park (Ghotki); 14 in Samzu Park (Karachi); and, over 100 in Manghopir Shrine (Karachi).

As Iranian Muggers are at the extreme western range of the species, and thus at the very fringe of its distribution, this westernmost population is somewhat unique. Thus, at the national level a very small population may meet the criteria for a species at high risk and be considered nationally Critically Endangered. An estimated 500 wild Muggers remain within the southeastern part of Iran, in Sistan and Baluchestan Provinces (the Gandou Protected Area). They occupy ponds along two large rivers, namely Bahu-Kalat and Kaju, two dam reservoirs [Pishin (Fig. 4) and Zirdan], small artificial water dams, and some manmade local ponds in villages; Mobaraki 2015; Mobaraki *et al*. 2019).

In the Pakistani Balochistan Province, Muggers inhabit Hub Dam Wildlife Sanctuary, Hingol NP, and Dasht NP and Wildlife Sanctuary. In Balochistan, the numbers of Muggers in the wild are more than 100 in the Basol River/Kalmat Khor and more than 50 each in Hingol NP and the Dasht River. In Sindh Province, Muggers inhabit the Mehrano Wildlife Sanctuary, Kirthar NP, Nara Desert Wetland complex, Deh Akro II Wildlife Sanctuary, and Chotiari Wetland Complex. Based on the habitat type, the roughly estimated number of Muggers in the potential wild habitats of Sindh Province include >100 each in Chotiari Wetland Complex and Nara Canal, >150 in Deh Akro II Wildlife Sanctuary and >100 in Haleji Lake.

The WhatsApp group aimed further to discuss the

Table 1. According to zoo database ZIMS (Species 360), assessed March 2021, 1986 Muggers are held globally in 14 institutions from three regions (Asia 1977; Europe 4; North America 5).

Region/Institution	Taxon/Origin	Total
Asia: 11 institutions		
Assam State Zoo and Botanical Garden	Mugger, *C. palustris*	1
Department of National Zoological Gardens, Colombo	Sri Lankan Mugger, *C. p. kimbula*	5
Madras Crocodile Bank Trust	Indian Mugger, *C. p. palustris*	1753
National Zoological Park, New Delhi	Mugger, *C. palustris*	3
Nehru Zoological Park, Hyderabad	Mugger, *C. palustris*	65
Sakkarbaugh Zoo, Junagadh	Mugger, *C. palustris*	3
Arignar Anna Zoological Park, Chennai, Madras	Mugger, *C. palustris*	115
Sri Chamarajendra Zoo (Mysore Zoo)	Mugger, *C. palustris*	3
Nandankanan Biological Park	Mugger, *C. palustris*	19
Singapore Zoological Gardens	Mugger, *C. palustris*	4
Veermata Jijabai Bhosle Udyan & Zoo	Mugger, *C. palustris*	6
Europe: 2 institutions		
Krokodille Zoo	Mugger, *C. palustris*	2
Thrigby Hall Wildlife Gardens	Mugger, *C. palustris*	2
North America: 1 institution		
St. Augustine Alligator Farm	Mugger, *C. palustris*	1
St. Augustine Alligator Farm	Indian Mugger, *C. p. palustris*	4

development of Mugger conservation measures and continuing conservation-based research, which Asghar Mobaraki has long implemented with Elham Abtin in Iran (Abtin and Mobaraki 2016; Mobaraki 2015). As in other parts of the Mugger's range, HCC is an issue in Iran (Fig. 5). The conflict results from the proximity of villages and local people and crocodile habitat, especially during droughts and breeding seasons when crocodiles are more mobile. Most crocodile attacks are on livestock, and causes severe financial loss to local people. Also, direct attacks on people, particularly children, have been recorded (Mobaraki 2015).

Figure 4. Wild Mugger in Pishin Dam, Iran. Photograph: Asghar Mobaraki.

Figure 5. Poster highlighting the conservation status of the Marsh crocodile, prepared for public awareness and education in Iran. Photograph: Asghar Mobaraki.

The population in southeastern Iran remains severely vulnerable to extreme climatic events, such as periodic droughts and floods. Iranian Muggers are therefore directly impacted by climate change and in critical need of immediate study to evaluate this threat.

To predict the impacts of climate change on the habitat of the Mugger in Iran and Pakistan, and thus on the survival of the species itself, the necessity of species distribution modelling analyses emerged, and Dennis Rödder from the Zoologisches Forschungsmuseum Alexander Koenig (https://bonn.leibniz-lib.de/en) in Bonn, Germany, was contacted as an expert in this field to perform research on this topic. MuggerOne initial topic of discussion was of course how temperature-dependent sex determination (TSD) would be affected by potential climate change parameters across the species' range. We want to monitor how muggers across the region adapt to any local environmental variations (timing and placement of nesting, distance from water, nearer to tree cover, etc.) where such behaviour is not driven by human-led disturbance.

Then another research project came to the fore, viz. extensive DNA analysis of the Mugger across the range to determine if the population in the most western extreme range of the species is unique and distinct to the larger South Asian population. Previous genetic studies have shown a low level of genetic distinction and diversity (Mobaraki *et al*. 2014; Campos *et al*. 2018). For the new, more comprehensive approach, a molecular biologist, Minh D. Le from the Vietnam National University in Hanoi, joined the group. For compiling the required samples from across the range, Colin Stevenson (United Kingdom) joined the group, as he has many contacts with experts in South Asia. Later, Ulrich Schepp, from the German Federal Agency for Nature Conservation, joined the group to support the project. Finally, we began to develop collaboration with CSG members from South Asia directly, including colleagues from Bangladesh (SMA Rashid), India (Brinky Desai, Soham Mukherjee, Dax Pandhi, Raju Vyas), Pakistan (Rafaqat Masroor, Tahir Rasheed, Shoaib Abdul Razzaque), Sri Lanka (Anslem de Silva) and Nepal (Bed Khadka).

Besides DNA analysis, we also aim to get better insights into regionally differing threats, such as habitat degradation and loss, illegal harvest of animals and eggs, climate change effects, mortality caused by fishing activities, and agriculture development.

The Mugger originally occupied an extensive range in South Asia, with different seasonal weather conditions and a temporally variable precipitation regime, mainly subject to the influence of the monsoon. It is, therefore, assumed that *C. palustris* encounters the respective limiting climatic extremes at the fringes of its natural range, to which the populations there have had to develop particular adaptations.

Thus, we also plan to investigate the differences in ecological adaptations over the distribution range, such as potentially varying realized niches, differing reproduction and egg-laying seasons, etc., due to diverging monsoon/dry seasons/aestivation (such as in Madhya Pradesh or at the northwestern border of the range in Gujarat (India; Figs. 6-8), Iran and Pakistan). Some examples are the mangrove inhabiting population in Kerala or the populations from particular xeric regions in Iran or Gujarat. Also, in parts of Yala NP (Fig. 9) and Wilpattu NP in Sri Lanka, Dasht Wildlife Sanctuary, Kalmat, and somewhat Hingol NP, had a substantial reduction in rainfall in the last couple of years. Hypersaline areas inhabited by the Mugger in Pakistan are the artificial Chotiari Wetland Complex, Hingol NP and Manghopir (due to limited pond size and irregular water supply).

Figure 6. Wild Muggers in the Kutch/Gujarat region in India. Photograph: Dax Pandhi.

Figure 7. Muggers basking socially on small islands of a village pond in the human-dominated landscape of Deva village, Gujarat, India. Photograph: Soham Mukherjee.

Figure 8. Wild Mugger in the Kutch/Gujarat region in India. Photograph: Dax Pandhi.

Figure 9. Basking Mugger in Yala National Park, Sri Lanka. Photograph: L. Nadarajha.

Mangrove populations are probably persisting in the only habitat available to them. Muggers have had to survive in small, fragmented populations since the 1960s. With some efforts with protection since the mid-late-1970s, these populations have increased but are restricted by lack of enforcement and habitat deterioration. These factors in the past from a few decades ago need to be considered within the context of these regional populations. Physiological and genomic data could help understand better local adaptations, as far as the present. Otherwise, only realized niche shifts could be quantified, but fundamental niche differences remain hidden.

The Mugger inhabits a wide range with very different climate zones and differing rainfall and water access. If there are substantial differences, is this due to regional stenoecy and do they already have taxonomic implications? In the older literature, two subspecies were recognized, the nominate form and *Crocodylus palustris kimbula* Deraniyagala 1935, which morphologically differ by the number of the lines of dorsal scutes (4 in *palustris* vs 6 in *kimbula*) and the size and the structure of the scales in the gular region (Wermuth and Fuchs 1978). This certainly would merit re-investigation, not only based on limited numbers of skin preparations as was done by Wermuth and Fuchs (1978), but rather in the persisting sub-populations. However, it has to be taken into account that in the past, individuals from different geographic populations were probably introduced into the now persisting populations, which might weaken morphological data on its own.

Furthermore, as a consequence, should populations with potential morphological/molecular and regional behavioural differences then be considered separate management units in the context of breeding/conservation breeding programs?

The reproductive cycle lasts from December to June/July in northern India and November to June in southern India. At the beginning of the dry season, in January or February, females start building nests. According to Daniel (2016), mating was observed from mid-January in south India to March in the country's northern parts. The breeding season in Iran starts in March with mating, followed by nesting in May and hatching in July (Mobaraki 2015; Mobaraki *et al*. 2013). In Sri Lanka, egg-laying occurs from July to September, with females typically laying up to 30 eggs. The Mugger is a hole-nesting species, with egg-laying taking place during the annual dry season - February-April in southern India, about one month later in northern India, February-March in Nepal, April-May in Iran, and June-July (and as late as August) in Sri Lanka (De Silva 2013; Mobaraki 2015; Whitaker and Whitaker 1984, 1989; Andrews and McEachern 1994).

Captive females are known to lay twice in a season ('double-clutching'), as observed in Madras Crocodile Bank Trust (Whitaker 1989; Whitaker and Whitaker 1984). It probably reflects a more secure environment and steady supply of nutritional resources in captivity, high temperatures and potentially the capacity for sperm storage.

With HCC becoming a critical factor in crocodile management programs worldwide in recent decades, we also consider the HCC situation of Muggers, as already briefly mentioned for Iran before. As crocodiles are more aggressive during the breeding season, most attacks are also recorded (De Silva 2013; De Silva *et al*. 2013; Vyas and Stevenson 2017). People and wild animals compete for resources, increasing the incidence of HCC, with direct attacks by crocodiles on humans and livestock. HCC with Muggers has increased exponentially in the past decade within India; 57 attacks (33 fatal, 24 non-fatal) reported between 2001 and 2010 and 338 attacks (134 fatal, 204 non-fatal) between 2011 and 2020 (CrocBite 2020). India's human population has increased from 1.23 billion in 2010 to 1.38 billion in 2020, and the Mugger populations in many areas across India are also growing (Stevenson *et al*. 2021). This is a situation that will result in increasing contact and conflicts between humans and crocodiles.

HCC remains one of the most important subjects regarding the management of the species in Iran, especially given that most human settlements are in proximity to natural ponds. Muggers also occupy artificial ponds inside the villages (called "Hootak"). Due to shortage and lack of water pipelines or unsuitable management of water supply, most of the local people are dependent on the outdoor water bodies for daily usage like washing, bathing, and drinking water. Moreover, when the livestock of poor villagers are attacked and eaten by crocodiles, it is an economic loss. The number of attacks on humans is relatively low, 2-3 non-fatal attacks annually in recent years. However, as the victims are mostly children, losses of body parts like arms and hands are commonly the consequence. As a result, it annoys local people and weakens their traditional beliefs and respect for crocodiles. Fortunately, people of Iranian Baluchestan, based on religious and cultural beliefs, respect crocodiles, and fortunately, there is no harvest on Muggers in Iran as already pointed out above.

Figure 10. Muggers feeding on fish in Sri Lanka (top) and the Kutch/Gujarat region in India (bottom). Photographs: R. de Silva (SL) and Dax Pandhi (I).

In Sri Lanka, Muggers have long been a known threat to local people, and as far back as the 1100s, one could not pass through the deep waters of some tanks due to the 'man-eating crocodiles' (Gieger 1929). De Silva (2010, 2013) and De Silva *et al*. (2013) covered HCC in Sri Lanka comprehensively after the first island-wide survey of crocodile attacks, finding that 80% of the 177 attacks investigated were on people whilst they washed or bathed in the community tanks. Crocodile Exclusion Enclosures, traditionally used by people in the southern wet zone of the island, were erected in the northern dry zone tanks. Thirty wire mesh enclosures were installed at locations where Mugger attacks had occurred, a simple but effective way of protecting people and livestock, and reducing retaliatory killing of crocodiles (Somaweera and De Silva 2013).

In Pakistan, Mugger attacks are infrequent, yet these largely remain underreported, especially in areas in which the locals directly depend on the water resources for their daily use. In 2006, at Haleji Lake, a child was killed, and 8 other villagers sustained injuries, along with a number of attacks on livestock. In August 2020, two teenage girls, who were doing laundry at the village Allah Dino Mahar bank in Nara Canal near Salih Pat (Sukkur District), were attacked by a Mugger. Two girls, aged 8- and 4-years-old, were killed by crocodiles in 2020 and 2021 in the Nara canal, respectively. Around 16 Mugger attacks were recorded in the Sindh Province over the last 10 years. Some non-fatal attacks have been recorded from the Lodeeg Aap habitat in Gabdh village and Balochistan (CrocBITE 2021).

Our preliminary threat analyses revealed that socio-cultural differences are associated with the Mugger, and threats slightly differ regionally. Furthermore, in part, conservation measures are not sufficient and need a comprehensive overhaul.

It seems that in westernmost populations and ranges, in Iran-Pakistan, extreme weather conditions, prolonged drought, unseasonal flooding, and increasing temperatures impose considerably unfavorable conditions for the declining population of crocodiles, and cause the destruction of the species' habitats. Eventually, it needs to be addressed explicitly with science-based conservation plans and measures to mitigate the effects on the ecology and population of the crocodiles in the area.

To improve the conservation situation of this flagship species of the southwestern and southern Asian wetlands, we herein recommend:

- Modeling of effect of climate change on habitats and the species, to provide early warning for proper management measures.
- Conducting urgently needed biological and ecological studies to improve our knowledge of the species, including reproduction success and population status.
- Supporting *ex-situ* conservation programs and promoting sustainable use schemes. For example, such an approach has been known for a long time in India (since the 1970s) but has never been supported at the governmental level. This and related issues, also in several other countries, certainly require further efforts.
- Advancing close cooperation of the range states to develop conservation and research programs as well as educational plans.
- Implementing public education and awareness activities to increase the knowledge on the importance of crocodiles to reduce human-induced threats and HCC, as exemplarily executed in Gujarat (Voluntary Nature Conservancy 2021).

- Providing financial support, if possible, for *ex-situ* and *in-situ* conservation programs.
- Developing and implementing management strategies for the recovery of the Muggers in affected sites, including ranching and releasing surplus crocodiles into suitable environments and ongoing monitoring activities.
- Developing a long-term (10+ years) population monitoring program and recovery plan for the entire range of the species.
- Evaluating the success of strategies as mentioned above and conservation targets of Mugger populations regularly

Our course of action is another application of the 'One Plan Approach', which is supported by the IUCN and aims to develop integrative strategies to combine *in-situ* and *ex-situ* measures with groups of experts for improved species conservation. Moreover, even in times of the recent COVID-19 pandemic, with limited options and challenging travel logistics, the experts can build up a team to establish a global network for upscaling the conservation-based research at national and regional levels. The collaborative conservation efforts at the global level will help protect wildlife species and their natural habitats. These collective efforts will allow the threatened, endangered and protected (ETP) terrestrial wildlife species to live in harmony in their natural habitats while maintaining balanced and healthy ecosystems.

Figure 11. Mugger feeding on a pangolin in Sri Lanka. Photograph: J.M. Probst.

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Asghar Mobaraki[1], Lonnie McCaskill[2], Ulrich Schepp[3], Elham Abtin[4], Rafaqat Masroor[5], Dax Pandhi[6], Brinky Desai[7], Soham Muckerjee[8], Tahir Rasheed[9], Shoaib Abdul Razzaque[10], Anslem de Silva[11], Colin Stevenson[12], Anna Rauhaus[13], Minh D. Le[14], Dennis Rödder[15] and Thomas Ziegler[16]; *[1]Natural Environment Deputy, Wildlife Conservation and Management Bureau, Department of Environment, Tehran, Iran (amobaraki@yahoo.com), [2]Wildlife Conservation Society, Prospect Park Zoo, 450 Flatbush Ave., Brooklyn, NY 11225, USA (lmccaskill@wcs.org), [3]Federal Agency for Nature Conservation, Konstantin Straße 110, 53179 Bonn, Germany (Ulrich.Schepp@BfN.de), [4]Natural Environment Division, Department of Environment Office in Sistsan and Baluchestan Province, Zahedan, Iran (ala_saly@yahoo.co.uk), [5]Pakistan Museum of Natural History, Garden Avenue, Islamabad-44000, Pakistan (rafaqat.masroor78@gmail.com), [6]Mahim Pandhi Wildlife Foundation; dax@pandhi.org), [7]School of Arts and Sciences, Ahmedabad University, Navrangpura, Ahmedabad, Gujarat, India (brinky.d@ahduni.edu.in), [8]Vidyanagar Nature Club, Radha Darshan, Nagar, India (soham.naja@gmail.com), [9]Director of Wildlife and Regional Head Sindh and Baluchistan, WWF-Pakistan, [10]Focal person of ETP species, WWF-Pakistan, [11]15/1 Dolosbage Road, Gampola, Sri Lanka, [12]Crocodiles of the World, Oxford, UK (coleosuchus@hotmail.com), [13]Cologne Zoo, Köln, Germany (aquarium@koelnerzoo.de), [14]Faculty of Environmental Sciences, University of Science and Central Institute for Natural Resources and Environmental Studies and, Vietnam National University, Hanoi, Vietnam and Department of Herpetology, American Museum of Natural History, New York, USA, [15]Zoologisches Forschungsmuseum Alexander Koenig, Adenauerallee 160, 53113 Bonn, Germany (D.Roedder@leibniz-zfmk.de), [16]Cologne Zoo, Köln, Germany (ziegler@koelnerzoo.de).*

India

ATTACK ON RHESUS MACAQUE (*MACACA MULATTA*) BY FEMALE ESTUARINE CROCODILE (*CROCODYLUS POROSUS*) IN BHITARKANIKA NATIONAL PARK, ODISHA, INDIA. Bhitarkanika National Park (BNP) in Odisha, India, has the distinction of having the largest population of Estuarine crocodiles (*Crocodylus porosus*) in the country. The January 2021 census recorded 1768 crocodiles in various size classes in the river systems of BNP, including about 300 adults (Kar 2021). Through implementation of the FAO/UNDP, Government of India and State Forest Department Project, "Crocodile Breeding and Management" in early 1975, the mangrove habitat has been well protected, and the crocodile population, as well as other wildlife species, including prominent mammalian fauna, are increasing in abundance.

Occasional attacks by crocodiles on wild Sambar deer (*Rusa unicolor*), Spotted deer (*Axis axis*), boar (*Sus scrofa*), Otter (*Lutra perspicillata*) and Indian porcupine (*Hystrix indica*) have been recorded in BNP (Kar 1985, 1999). Here, I report on the first recorded attack on a Rhesus macaque (*Macaca mulatta*) in BNP.

Rhesus macaques are arboreal in nature, but they frequently go onto river/creek banks to eat tender shoots and tubers of grass species, especially Nalia grass (*Myriostachya wightiana*). At times, they come very close to the water in search of food, and have also been sighted crossing rivers/creeks in troupes, even during high tides.

During routine patrolling in the Bhitarkanika River in early February 2021, we observed a known female Estuarine crocodile of around 2.4 m total length suddenly emerge from a submerged position in the water with great force, and catch a full-grown Rhesus monkey by its neck (Fig. 1). The macaque had been about 0.6 m from the water's edge, feeding

on *Myriostachya* sp. tubers, at the time of the attack, and appeared to have been killed almost immediately. Following the attack, the crocodile moved further up the bank, away from the water's edge, and remained on the mud bank (Fig. 1) for over an hour. By late evening it had either taken the macaque back into the water or waited for the bank to be covered by the incoming high tide. The incident occurred on an exposed mud bank of Bhitarkanika Block, opposite Pataparia village, during low tide.

Figure 1. Estuarine crocodile with Rhesus macaque. Photograph: Bijay Kumar Das.

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

Table 1. High elevation records for Muggers in India.

No.	Location	Elevation (m)	Source
1.	Trevor's Tank (Mt. Abu, Rajasthan)	~1250	Shatrunjay Pratap, pers. comm.
2.	Sonemuda (Amarkantak, Madhya Pradesh)	~1050	Ingle (2020)
3.	Kolab Dam (Koraput, Odisha)	~850	ENS (2021)
4.	Bannerghatta National Park (Bengaluru, Karnataka)	~900	Pers. obs.
5.	Cauvery River, Dubare (Kodagu, Karnataka)	~855	Nisarg Prakash, pers. comm.
6.	Nugu River, Sulthan Bathery (Wayanad, Kerala)	~860	The Hindu (2016)
7.	Athikunna River, Pandalur (Nilgiris, Tamil Nadu)	~920	The Hindu (2021)

HIGH ELEVATION RECORDS FOR MUGGER CROCODILE (*CROCODYLUS PALUSTRIS*) IN INDIA: COMMENT ON RATHORE *ET AL*. (2021). Rathore *et al*. (2021) report on Mugger crocodiles (*Crocodylus palustris*) from Similipal Tiger Reserve (Odisha, India), and note, interestingly, that 90% of individuals were recorded above 750 m asl. Further, they report Muggers at an elevation of 822 m, and suggest this, in error, as 'the highest altitude habitat for this species in India'.

Using location records compiled for the Mugger Crocodile Action Plan (Stevenson *et al*. 2021) and a high accuracy global Digital Elevation Model (MERIT DEM; Yamazaki *et al*. 2017), records higher than 822 m were compiled (Fig. 1, Table 1).

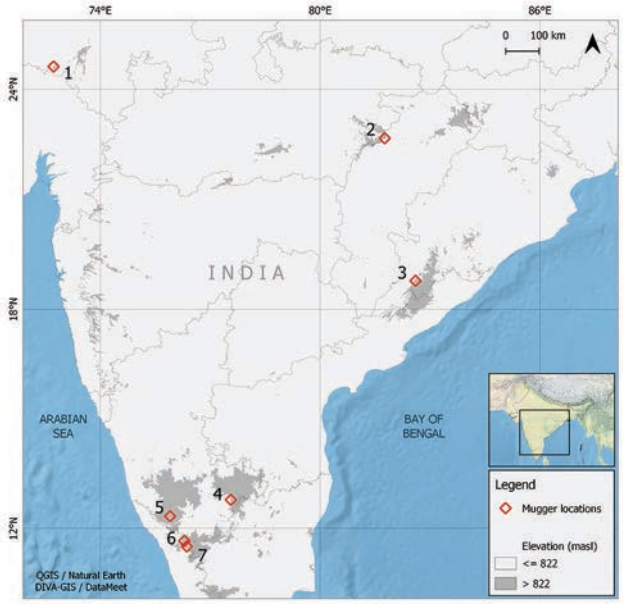

Figure 1. Mugger location records from elevations above 822 m in India. Numbers adjacent to red diamonds correspond to serial numbers in Table 1.

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Tarun Nair[1] and Colin Stevenson[2]; [1]*Bengaluru, India (tarunnair1982@gmail.com),* [2]*Crocodiles of the World, UK (coleosuchus@hotmail.com).*

East and Southeast Asia

Laos

CAMERA TRAP CONFIRMATION OF ANOTHER SIAMESE CROCODILE (*CROCODYLUS SIAMENSIS*) POPULATION IN KHAMMOUANE PROVINCE, CENTRAL LAO PDR, WITH NOTES ON CONSERVATION PLANNING. The Siamese crocodile (*Crocodylus siamensis*) was once widespread in Southeast Asia. To date, its distribution range has been diminished and fragmented, with remaining populations confined to Cambodia, Indonesia, Laos, Thailand and Vietnam, where it was reintroduced recently. It is listed as Critically Endangered on the IUCN Red List, with decreasing population trends, and is included in Appendix I of CITES (Bezuijen *et al*. 2012). In Laos, *C. siamensis* is considered "at Risk", which is the highest national ranking of extinction threat (Bezuijen *et al*. 2006). It is one of the most endangered species in Laos because many local populations are either small and isolated or have been extirpated (Salter 1993; Bezuijen *et al*. 2013). The largest remnant populations have been recorded in 8 river systems in Attapu, Salavan and Savannakhet Provinces (Bezuijen *et al*. 2006).

The Siamese crocodile was believed to be extinct in Khammouane Province in central Laos (Fig. 1) until its recent rediscovery (Ziegler *et al*. 2015) and genetic confirmation as pure *C. siamensis* (Nguyen *et al*. 2018). Besides this record from Ban Soc, another overlooked population at Nong Boua Ta Lake, near Ka Cham Village in Khammouane, was first revealed through interviews with local people and later confirmed by faecal evidence and potential resting sites (Souvannasy *et al*. 2018).

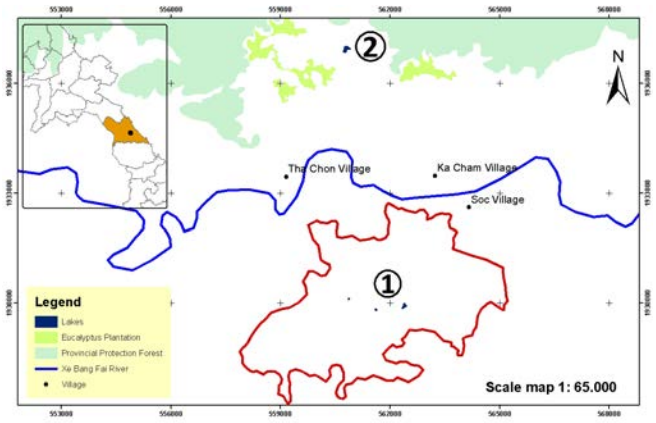

Figure 1. Khammouane Province, central Laos (inset), with Siamese crocodile location (black dot). 1= Siamese crocodile site near Ban Soc Village, within Ban Soc Crocodile Conservation Area; 2= Siamese crocodile site near Ka Cham Village, where camera traps were set up at Nong Boua Ta Lake.

To investigate the population status of *C. siamensis* at the new site in Khammouane Province, two field surveys were conducted around Ka Cham Village on 19 April-8 May and 1-20 June 2021. We detected crawling signs, resting sites and crocodile faeces (Fig. 2), but no direct observations. To improve the probability of recording crocodiles, five camera traps were set up on tree branches above a hole on the shore of Nong Boua Ta Lake (Fig. 3). The hole where the camera trap was deployed was over the water, about 3.5 m from the bank. Two photographic sequences were obtained from one of the cameras on 5 May and 9 May 2021, showing a medium-large *C. siamensis* (Fig. 4).

Figure 2. Crocodile faeces at Nong Boua Ta Lake, 1 June 2021. Photograph: Paseun Souvannasy.

Figure 3. Nong Boua Ta Lake, 25 April 2021. Photograph: Paseun Souvannasy.

Figure 4. Photographs of Siamese crocodile from camera trap at Nong Boua Ta Lake on 5 May 2021 (top) and 9 May 2021 (bottom).

We can therefore confirm the persistence of a *C. siamensis* population at Nong Boua Ta Lake, which, based on interviews with local people, Souvannasy *et al*. (2018) estimated to comprise 2-4 individuals (adults and juveniles).

The habitat at Nong Boua Ta Lake, near Ka Cham Village (17° 31'3.6" N, 105° 34'18.0" E), at elevations ranging from ca. 90 to 180 m asl, mainly contains floating grass mats, and is surrounded by secondary forest, shrubs and bamboo. In the dry season, water levels drop to about 1 m (compared to 3.5 m in the rainy season). The inaccessible wetland area, covering approximately 3 ha in the dry season and 4 ha in the rainy season, is about 0.5 km from the border with Nam In-Hou Hin Lek Phai Provincial Protection Forest and 30 km from Hin Nam No National Protected Area.

The status of Nong Boua Ta Lake as a local "holy" place (a ritual place protected by a god), benefits the protection of this crocodile population. However, protection measures are required, and there are plans to establish a conservation management committee at the local level. The lake is already very overgrown with plants, and habitat modification such as removal of grass mat at some places to restore the open water surface, are necessary. The activity will also help continued monitoring of the species at the site by providing a better population estimate. The lake can certainly serve as a site for future restocking.

In order to better protect the population of *C. siamensis* in Nong Boua Ta Lake, plans to establish up a new protected area have been developed. Ka Cham Village is approximately 4 km from the nearest population of *C. siamensis* in Ban Soc Village, for which the 2000 ha Ban Soc Crocodile Conservation Area (BSCCA) was established by the Khammouane Provincial Authority in December 2016. However, as the sites are separated by Xebangfai River, the current plans, which are currently in discussion with the Khammouane Provincial Authority, have been designed to create a new reserve instead of extending the Ban Soc Crocodile Conservation Area.

Acknowledgements

We thank the Rufford Foundation and Cologne Zoo for their support of Siamese crocodile conservation in Laos. Cologne Zoo is a partner of the World Association of Zoos and Aquariums (WAZA): Conservation Project 10007 (Siamese Crocodile Research and Conservation).

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Paseun Souvannasy[1], Vinh Quang Luu[2], Sengdeuane Wayakone[3], Bounthanh Sounivong[4], Sisomphone Soudthichak[5], Truong Quang Nguyen[6], Minh Duc Le[7] and Thomas Ziegler[8]; *[1]Ministry of Agriculture and Forestry, Vientiane, Lao PDR; [2]Vietnam National University of Forestry, Hanoi, Vietnam; [3]National University of Laos, Vientiane, Lao PDR; [4]Ministry of Agriculture and Forestry, Vientiane, Lao PDR; [5]Provincial Agriculture and Forestry Office, Khammouane, Lao PDR; [6]Institute of Ecology and Biological Resources, Vietnam Academy of Science and Technology, Hanoi, Vietnam; [7]Faculty of Environmental Sciences, University of Science and Central Institute for Natural Resources and Environmental Studies, Vietnam National University, Hanoi, Vietnam and Department of Herpetology, American Museum of Natural History, New York, USA; [8]Cologne Zoo, Köln, Germany (ziegler@koelnerzoo.de).*

Latin America and the Caribbean

Brazil

FIRST CONGRESS ON BRAZILIAN CROCODILIANS. The 1st Congress on Brazilian Crocodilians was held as a virtual event on 14-15 August 2021. Hosted by the Marcos Daniel Institute and the Federal Rural University of Pernambuco, there were some 1130 participants from 23 countries The theme of the Congress was "Scientific Plurality in the Name of Conservation", highlighting the union of research, conservation and education in favor of the conservation of crocodilians in Brazil and South America.

The opening took place with speeches by Marcelo Renan, André Felipe and Yhuri Nóbrega, which were followed by a welcome from CSG Chair Grahame Webb, and a keynote presentation by Alejandro Larriera (on world crocodilian conservation) (see https://www.youtube.com/watch?v=jDcf9plJfHM).

The first day included the launch of "Tratado de Crocodilianos do Brasil" (Treatise on Crocodilians of Brazil; see page 7) and three children's books (see pages 7-8), and was dedicated to updating information about crocodilians in Latin America and Brazil (https://www.youtube.com/watch?v=--FzzGfNiRc):

- Crocodilians from Latin America (Pablo Siroski)
- ICMBio and the crocodilians in Brazil (Marcos Coutinho)
- CSG Brasil (Luís Bassetti)
- Crocodilians from Northern Brazil (Fernanda Pereira)
- Crocodilians from the Midwest of Brazil (Thais Figueiredo)
- Crocodilians from the Northeast of Brazil (Jozélia Correia)
- Crocodilians from Southeast Brazil (Iago Ornellas)
- Crocodilians from Southern Brazil (Mariana Luchese)

The second day dealt with various themes (https://www.youtube.com/watch?v=48WhV5R_xP4):

- Paleontology (Rodrigo Giesta)
- Taxonomy of Brazilian crocodiles (Igor Joventino)
- Conservation genetics (Fabio Muniz)
- Introduction to research with crocodiles (Paulo Roberto)
- Trophic ecology (Thiago Marques)
- Sustainable use of crocodilians (Luís Bassetti)
- Sustainable use in traditional communities (Diogo Lima)
- Crocodilian anesthesia (Gianmarco Rojas)
- Necropsy techniques (Paulo Quadros)
- Ethnobiology (Rafael Barbosa)
- Environmental education (Yhuri Nóbrega)
- Scientific dissemination (Paulo Miranda)

The Organising Committee (Gabriel Gomes Dias, Fernando Paulino Alvarenga, Iago Silva Ornellas, Lucas Yu Fraga, Tamiris da Penha Chinelato, Daniel do Nascimento Santos Neves, Marcelo Renan de Deus Santos, Barbara Nedelly Mello Silva, Yhuri Cardoso Nóbrega) and the Federal Rural University of Pernambuco (Jozélia Correia, Ednilza Maranhão, Paulo Braga Mascarenhas Junior, Rafael Barbosa) assisted with the complex logistic arrangements and coordinated the program.

The quality of presentations was very high, indicating the high levels of research on crocodilians in Brazil and the region as a whole. Following the presentations, there were opportunities for discussion between researchers and participants, generating interesting interactions, especially with young researchers and students. Last but not least, the Congress attracted a large number of researchers and CSG members, who enhanced the event.

Pablo Siroski *(CSG Regional Chair for Latin America and the Caribbean)* and Luís Bassetti *(CSG Regional Vice Chair for Latin America and the Caribbean)*.

ZILCA CAMPOS AWARD FOR THE CONSERVATION OF CROCODILIANS IN BRAZIL. Instituto Marcos Daniel (IMD), through "Projeto Caiman - Jacarés da Mata Atlântica" and the Universidade Federal Rural de Pernambuco (UFRPE), through Laboratório Interdisciplinar de Répteis e Anfíbios (LIAR), presented the "Zilca Campos Award for the Conservation of Crocodilians in Brazil" at the First Congress on Brazilian Crocodilians (August 2021; see page 24).

The award aims to honour and recognize people or institutions who have performed great feats and contributions to the best conservation practices of Brazilian crocodilians. The creators named the award after Zilca Campos, who has a leading role in the conservation of crocodilians, and who has inspired and continues to inspire several generations of researchers, especially in Brazil. The pioneering spirit of women in science in Brazil has had a great contribution from Zilca Campos.

Zilca Campos is a Forestry Engineer from the Federal University of Mato Grosso, with a Master in Biology (Ecology) from the National Institute for Research in the Amazon and PhD in Ecology (wildilife conservation and management) from the Federal University of Minas Gerais. Since 1989 she has been a researcher at Embrapa - Pantanal (Brazilian Agricultural Research Corporation), and has extensive experience in ecology and wildlife management. She works mainly with the conservation, management, reproduction and ecology of all species of Brazilian caimans. She is one of the greatest references in the science of these animals and a profound expert on the Pantanal biome. Born in Corumbá, she is an authentic Pantanal woman who dedicates her life to the conservation of nature, Brazilian caimans and their habitats.

Figure 1. Zilca Campos with award named in her honour.

Therefore, the first person to receive the Zilca Campos Award for the Conservation of Crocodilians could not be anyone else, except Zilca Maria da Silva Campos herself (Fig. 1). "I just have to thank you, and in fact the focus shouldn't be on me, but on crocodilians, on caimans. We will face a very serious climate and environmental challenge and we will need a lot of efforts. We have to unite more and more, to be together ahead of this challenge", declared Zilca upon receiving the award, showing her concern with the drought in the Pantanal.

Gabriel Gomes Dias[1], Fernando Paulino Alvarenga[1], Iago Silva Ornellas[1], Lucas Yu Fraga[1], Tamiris da Penha Chinelato[1], Daniel do Nascimento Santos Neves[1], Marcelo Renan de Deus Santos[1], Bárbara Nedelly Mello Silva[1], Jozélia Maria de Sousa Correia[2], Ednilza Maranhão dos Santos[2], Paulo Braga Mascarenhas-Junior[2], Rafael Sá Leitão Barboza[2] and Yhuri Cardoso Nóbrega[1]: *[1]Instituto Marcos Daniel - Projeto Caiman, Vitória-ES, Brazil; [2]Laboratório Interdisciplinar de Répteis e Anfíbios, Universidade Federal Rural de Pernambuco, Recife-PE, Brazil.*

Australia & Oceania

Australia

The Queensland Government recently released a key findings report on the "Queensland Estuarine Crocodile Monitoring Program 2016-2019". The report summarises the results of a comprehensive monitoring program for the Saltwater crocodile (*Crocodylus porosus*) population across its range in Queensland in 2016-2019. During 2020, the Department of Environment and Science compiled and analysed data collected through this program and compared these to historic data to assess how the population had changed in size, distribution, density, and size class structure over time.

The Queensland population of *C. porosus* is currently estimated at 20,000-30,000 non-hatchlings, with an average of 1.7 crocodiles and 36 kg of crocodile biomass per kilometre of river surveyed. It is unlikely to reach the size or density of that in the Northern Territory (100,000 non-hatchlings, 5.3/km and 388 kg/km), due to a lack of suitable habitat in Queensland.

Population recovery has been relatively slow and highly variable across the state, with highest density in northern Cape York Peninsula (3.0/km), and declining southward, with 1.2/km in the Gulf of Carpentaria and the Cairns region, down to 0.2/km in the Fitzroy River, Rockhampton. The spatial distribution of crocodiles in Queensland has not changed over time, and there is no evidence of a southward expansion of the species' range.

Source: *Department of Environment and Science (2021). Queensland Estuarine Crocodile Monitoring Program 2016-2019. Key Findings Report. Queensland Government: Brisbane.*

Europe

REGIONAL COLLECTION PLAN FOR CROCODYLIA AT EUROPEAN ASSOCIATION OF ZOOS AND AQUARIA. The European Association for Zoos & Aquaria (EAZA) has re-developed the modus of its breeding programs for animals kept by its members, in order to no longer keep European StudBooks (ESB) but to give the programs more flexibility and to better tailor them to species-specific requirements. Therefore, all Taxon Advisory Groups (TAG) of EAZA were asked to develop a Regional Collection Plan (RCP) for their respective animal groups over the next years. This regional collection should follow the One Plan approach

(Byers *et al*. 2013), promoting the joint development of management strategies and conservation actions for all populations of a species by all responsible parties to produce one comprehensive conservation plan for the species. It also follows the five steps given in the IUCN SSC guidelines on the use of *ex-situ* management for species conservation. These steps include:

1. Compile a status review of the species, including a threat analysis.
2. Define the roles that *ex-situ* management will play in the overall conservation of the species.
3. Determine the characteristics and dimensions of the *ex-situ* population needed to fulfil the identified conservation role(s).
4. Define the resources and expertise needed for the *ex-situ* management program to meet its role(s) and appraise the feasibility and risks.
5. Make a decision that is informed and transparent.

After successful completion of the Chelonian RCP in 2019, the EAZA Reptile TAG, under the leadership of Ivan Rehak (Prague Zoo), was asked to conduct the RCP for Crocodylia by Spring 2020. The last EAZA RCP for crocodylians was published in 2010. Kindly invited by Thomas Ziegler and Anna Rauhaus (Cologne Zoo) to host the workshop by the end of March 2020, preparations by the EAZA animal program and conservation coordinator David Aparici Plaza, EAZA population biologists Elmar Fienig and Iva Martincova, EAZA assistant population biologist Nora Hausen, and Vice Chair Fabian Schmidt (Basel Zoo), were completed by early 2020. Unfortunately, due to the COVID-19 pandemic and the travel restrictions resulting from it, the workshop proposed for Cologne was cancelled at the last moment. Without an estimate on the duration of the pandemic, the workshop was conducted in an online format, on 21 and 22 June 2021.

Although online formats can never replace real meetings in person, we were able to include overseas guests who normally would never participate in a real meeting. There were 34 participants from 14 countries, mostly from Europe (Croatia, Czech Republic, France, Germany, Netherlands, Spain, Switzerland, United Kingdom), but also from Australia, Colombia, India, Philippines, Singapore and USA. It was really remarkable, that despite global time differences, many of the international colleagues attended most parts of the workshop, some stayed until after midnight and others started at 0300 h local time.

Participants consisted mainly of population biologists from the EAZA office, EAZA Reptile TAG chairs and vice chairs, program coordinators of existing European breeding programs for crocodylians, program coordinators of existing North American breeding program for crocodylians and representatives of other regional zoo associations such as ALPZA (Asociacion Latinoamericana de Parques Zoologicos y Acuarios), AZA (Associations of Zoos & Aquariums, North America), CZA (Central Zoo Authority, India), SEAZA (South East Asian Zoos Association) and ZAA (Zoo & Aquarium Association, Australasia). Many of the participants were also long-standing CSG members.

After some overview on the new EAZA Population Management structure and the new EAZA RCP workshop progress, there was a perfect introduction from Dr. Kent Vliet, with his lecture “How many crocodilian species are there?”. As AZA Crocodile TAG Chair, he also gave an overview on “The AZA Crocodilian Advisory Group RCP”. The main focus however was on a workshop, discussing 28 taxa for which species sheets were prepared. These data sheets included some general biological information, distribution map, IUCN Red List status, threats, *ex-situ* status with collection numbers in different global regions, trends in these collection numbers, comments of the AZA RCP, prior recommendations in the last EAZA RCP from 2010, the IUCN Red List Existing Conservation Actions and the IUCN Action Plan. The discussion mainly focussed on the roles such a species can fulfill in EAZA collections, particularly as conservation role, whether it is direct or indirect. But also non-conservation roles such as in education or roles for exhibition were considered. The benefits, feasibility and risks, were assessed for each role and checked whether EAZA Reptile TAG can recommend such a role or could contribute to deliver this role. Concluding from these roles, the recommendation on how to manage the species in EAZA collections was determined and explained. The possibilities for management included:

1. Creation or continuation of an European *ex-situ* Programme (EEP), where the taxon is proactively managed.

2. Monitor by TAG, where the TAG is monitoring the numbers of this taxon in EAZA collection without proactive management nor any recommendation.

3. Do not obtain (DNO), when the taxon is currently not present in EAZA collections and it is not recommended to be obtained.

4. Phase out, when it is recommended that the taxon disappears from EAZA collections.

5. Replace with, when it is recommended that a taxon is replaced with one or more other taxa in EAZA collections.

Already during the discussion about each single taxon, some more general topics raised, which were also broadly discussed

at the end of the workshop. These general topics included:

1. Inclusion of non-EAZA members into programs, which in Europe can be split in mainly three different categories: Specialized reptile or even crocodile zoos, which are not and are unlikely to become EAZA members, small zoos and animal parks, which are not EAZA members, and private keepers. All parties acknowledged that cooperation between EAZA institutional and non-EAZA members must take place, but it is strongly dependent on single cases and maybe differs from species to species.

2. Rearing of juveniles with their parents, which is considered as favourable in most cases, as animals learn a more naturalistic social behaviour than when reared in large groups with other juveniles but without parents guarding them.

3. Breed and cull policy. While a breed and cull policy is already in place for many taxa kept in European collections, the discussions in crocodylians were very controversial. While some members think that especially sustainable use of crocodiles and selling crocodylian products to support conservation projects may become an important conservation contribution in the future, other strictly refuse such a policy for ethical reasons and refer to zoo visitors who wouldn't understand and support such a policy in our modern times. For many countries also national legislation prohibits such a policy.

As a result, programs which were developed for species in need of conservation were either confirmed or upgraded from a studbook to an EEP. The only EEP we had before - for the Chinese alligator (*Alligator sinensis*) - was confirmed as EEP also in the new EAZA Population Management structure. Existing studbooks for the Critically Endangered species Indian Gharial (*Gavialis gangeticus*), Philippine crocodile (*Crocodylus mindorensis*), Siamese crocodile (*C. siamensis*), Cuban crocodile (*C. rhombifer*) as well as for the Vulnerable Tomistoma (*Tomistoma schlegelii*) were upgraded to new EEPs. For the African genera of slender-snouted crocodiles (*Mecistops*) and dwarf crocodiles (*Osteolaemus*), generic EEPs are established. The focus of active management should be for the West African slender-snouted crocodiles (*M. cataphractus*), whereas Central African slender-snouted crocodiles (*M. leptorhynchus*) should not be obtained. Similarly, the not yet described new species of West African Dwarf crocodile (*Osteolaemus* sp. nov. cf. *tetraspis*) should be actively managed, whereas for the remaining taxa hybridization should be avoided. For the West African crocodiles (*C. suchus*), active monitoring is recommended, and genetic samples of possible West African crocodiles in EAZA should be collected and analysed. Depending on the results and depending on the Red List assessment for this species, it still can be upgraded to an EEP.

In order to use the space in EAZA collections more effectively for species in need of conservation recommendations were issued not to obtain the following species, or if already present to replace them with species which are in more urgent need of conservation; American alligator (*A. mississippiensis*), Spectacled caiman (*Caiman crocodilus*), Schneider's Smooth-fronted caiman (*Paleosuchus trigonatus*), Broad-snouted caiman (*Ca. latirostris*), Yacare caiman (*Ca. yacare*), American crocodile (*C. acutus*), Morelet's crocodile (*C. moreletii*), Saltwater crocodile (*C. porosus*), New Guinea freshwater crocodiles (*C. novaeguineae* and *C. halli*) and Nile crocodile (*C. niloticus*).

If you are interested in more details on the RCP, please contact the author.

Fabian Schmidt, *EAZA Reptile Tag Vice Chair with special responsibilities for Crocodylian Programmes and Curator, Zoo Basel, Switzerland (Fabian.schmidt@zoobasel.ch).*

Recent Publications

Najmuddin, M.F., Nurhizatul Safikah Mohd Hauri, N.S.M., Haris, H., Zahari, F., Othman, N., Hassem, S.H. and Abdul-Latiff, M.A.B. (2021). Agonistic behavior of captive Saltwater crocodile, *Crocodylus porosus* in Kota Tinggi, Johor. Journal of Sustainable Resources 2(1): 31-37.

Abstract: Agonistic behavior in *Crocodylus porosus* is well known in the wild, but the available data regarding this behavior among the captive individuals especially in a farm setting is rather limited. Studying the aggressive behavior of *C. porosus* in captivity is important because the data obtained may contribute for conservation and the safety for handlers and visitors. Thus, this study focuses on *C. porosus* in captivity to describe systematically the agonistic behaviour of *C. porosus* in relation to feeding time, daytime or night and density per pool. This study was carried out for 35 days in two different ponds. The data was analysed using Pearson's chi-square analysis to see the relationship between categorical factors. The study shows that *C. porosus* was more aggressive during daylight, feeding time and non-feeding time in breeding enclosure (Pond C, stock density= 0.0369 crocodiles/m^2) as compared to non-breeding pond (Pond B, stock density= 0.3317 crocodiles/m^2) where it is only aggressive during the nighttime. Pond C shows the higher domination in the value of aggression in feeding and non-feeding time where it is related to its function as breeding ground. Chi-square analysis shows that there is no significant difference between ponds ($p= 0.47$, $\chi^2= 2.541$, $df= 3$), thus, there is no relationship between categorical factors. The aggressive behaviour of *C. porosus* is important for the farm management to evaluate the risk in future for the translocation process and conservation of *C. porosus* generally.

DeNardo, D.F. (2021). Behavioral Biology of Reptiles. CRC Press: Boca Raton.

Abstract: Reptiles represent an immense group of organisms that are morphologically, ecologically, and behaviorally diverse. However, one commonality among all reptiles is that none are domesticated. Each is adapted to its natural habitat, and its behaviors are the means by which the organism enables itself to use the biotic and abiotic resources available to it or to cope with resource limitations. Providing a reptile with each of its resource needs does not ensure that the reptile will use them, if it cannot use its typical behaviors to do so. Accordingly, this chapter focuses on behaviors related to the critical needs of thermoregulation, acquisition of food and water, social interactions, and reproduction, to include considerations for

promoting natural behaviors in a captive environment.

Faudzir, N.M., Hassem, S.H., Hauri, N.S.M., Zahari, F., Othman, N., Haris, H. and Bakar, M.A.L.A. (2021). Feeding regime and management of captive saltwater crocodile, *Crocodylus porosus* in Kota Tinggi, Johor. Journal of Sustainable Natural Resources 2(1): 26-30.

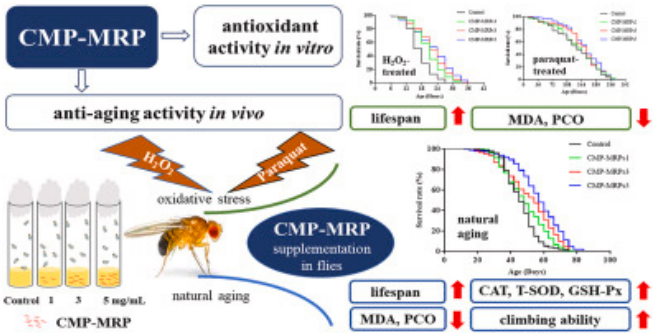
Abstract: *Crocodylus porosus* is the largest species of crocodile and can be found in estuarine and riverine area in Malaysia. Crocodile in captivity can be found in Malaysia for various purposes such as tourism, conservation and leather industry. However, the management practice in established crocodile farm varies across park for example in terms of feeding regime. Thus, this study focusses on the feeding regime of *C. porosus* in captivity and evaluation of management of crocodile of Teluk Sengat Crocodile Farm. This study was carried out for 35 days in two different ponds of Teluk Sengat Crocodile Farm, Kota Tinggi, Johor. The results show majority of the food given to crocodile were chicken (64%), followed by fish (28%) and prawn (8%). Prawn was only given to juvenile crocodile every day, while fish and whole chicken were given to adult crocodile once a week. The feeding frequency are adequate for the juvenile crocodile however, the feeding quantity for adult pond are worrying. Future research should be conducted on other captive population of *C. porosus* in other areas in Malaysia as well to better understand the overall management practices in Malaysia.

Velit, A., Piperis, R.E., Iturrizaga, D.M. and Saldarriaga, F. (2021). Hematological values of American crocodile *Crocodylus acutus* (Cuvier, 1807) kept in captivity in Puerto Pizarro, Tumbes, Peru. Salud y Tecnología Veterinaria 8(2): 35-39.

Abstract: The objective was to determine the hematological values of the Tumbes crocodile (*Crocodylus acutus*), a species categorized as in critical endangered of extinction by the Peruvian Government. Blood samples were collected by puncture of the venous sinus located in the postoccipital cervical region of male individuals separated into two age groups (15 juveniles and 15 sub-adult individuals) apparently healthy from the Tuna Carranza Aquaculture Center, Puerto Pizarro in Tumbes, Peru. After collecting the blood in tubes with lithium heparin, hemogram smears were made and microcapillaries were filled for the determination of hematocrit. The samples were sent and processed in the Laboratory of Clinical Pathology of the Faculty of Veterinary Medicine and Zootechnics of the Universidad Peruana Cayetano Heredia. The average values found were: 23.56% ± 3.23 of hematocrit, 8.48 g/dL ± 2.13 of hemoglobine, 0.988 106/μL ± 4.54 of red blood cells y 5.90 ± 4.27 103/μL of white blood cells: 2.68 103/μL ± 1.51 of heterophils, 1.58 103/μL ± 1.4 of lymphocytes, , 2.35 103/μL ± 2.4 of eosinophils, 1.45 103/μL ± 1.71 of basophils and 0.50 103/μL ± 0.85 of monocytes. No statistically significant differences were observed between age groups.

Li, Y., Hu, D., Huang, J. and Wang, S. (2021). Glycated peptides obtained from cultured crocodile meat hydrolysates via Maillard reaction and the anti-aging effects on *Drosophila in vivo*. Food and Chemical Toxicology 155 (https://doi.org/10.1016/j.fct.2021.112376).

Abstract: With the aging problems increasing, the discovery of anti-aging compounds has become a popular research direction. Accumulation of free radicals and the consequent oxidative stress are the chief culprit of aging. Given this, cultured crocodile meat peptides-Maillard reaction product (CMP-MRP) with remarkable antioxidant activity was obtained via Maillard reaction of cultured crocodile meat hydrolysates and xylose. The antioxidant activity *in vitro* and anti-aging activity *in vivo* of CMP-MRP were investigated. Results indicated that the lifespan and the athletic ability of *Drosophila* were significantly improved after the administration of CMP-MRP in natural aging, H_2O_2 and paraquat-induced models. Furthermore, the antioxidant enzyme activities of *Drosophila* treated with CMP-MRP were enhanced while the levels of malondialdehyde (MDA) and protein carbonyl (PCO) were reduced in three Drosophila models. With the supplement of 5 mg/mL CMP-MRP in natural aging *Drosophila* model, the maximum lifespan increased from 61 days to 73 days, athletic ability raised by 95.45%, MDA and PCO reduced by 52.72% and 47.43%, respectively. Taken together, CMP-MRP exhibited outstanding antioxidant and anti-aging capacities in *Drosophila* models, suggesting that CMP-MRP possesses great potential in the health food and biomedicine fields as a food-derived anti-aging agent.



Simora, R.M.C., Wang, W., Coogan, M., El Husseini, N., Terhune, J.S. and Dunham, R.A. (2021). Effectiveness of cathelicidin antimicrobial peptide against Ictalurid Catfish bacterial pathogens. Journal of Aquatic Animal Health (https://doi.org/10.1002/aah.10131).

Abstract: One of the major goals in aquaculture is to protect fish against infectious diseases as disease outbreaks could lead to economic losses if not controlled. Antimicrobial peptides (AMPs), a class of highly conserved peptides known to possess direct antimicrobial activities against invading pathogens, were evaluated for their ability to protect Channel Catfish *Ictalurus punctatus* and hybrid catfish (female Channel Catfish × male Blue Catfish *I. furcatus*) against infection caused by the fish pathogen *Aeromonas hydrophila* ML09-119. To identify effective peptides, the minimum inhibitory concentrations against bacterial pathogens *Edwardsiella ictaluri* S97-773, *Edwardsiella piscicida* E22-10, *A. hydrophila* ML09-119, *Aeromonas veronii* 03X03876, and *Flavobacterium columnare* GL-001 were determined *in vitro*. In general and overall, cathelicidins derived from alligator and sea snake exhibited more potent and rapid antimicrobial activities against the tested catfish pathogens as compared to cecropin and pleurocidin AMPs and ampicillin, the antibiotic control. When the peptides (2.5 μg of peptide/g of fish) were injected into fish and simultaneously challenged with *A. hydrophila* through immersion, increased survival rates in Channel Catfish and hybrid catfish were observed in both cathelicidin (alligator and sea snake) treatments as compared to other peptides and the infected control ($P<0.001$) with alligator cathelicidin being the overall best treatment. Bacterial numbers in the kidney and liver of Channel Catfish and hybrid catfish also decreased ($P<0.05$) for cathelicidin-injected groups at 24 and 48 h after challenge infection. These results show the potential of cathelicidin to protect catfish against bacterial infections and suggest that an approach overexpressing the peptide in transgenic fish, which is the long-term goal of this research program, may provide a method of decreasing bacterial disease problems in catfish as delivering the peptides via individual injection or feeding would not be economically feasible.

Kuczumow, A., Chałas, R., Nowak, J., Lekki, J., Sarna-Boś, K., Smułek, W. and Jarzębski, M. (2021). Novel approach to tooth chemistry: Quantification of the dental-enamel junction. International Journal of Molecular Science 22(11) (doi: 10.3390/ijms22116003).

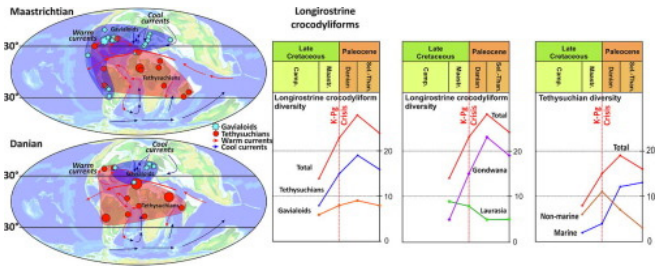
Abstract: The dentin-enamel junction (DEJ) is known for its special role in teeth. Several techniques were applied for the investigation of the DEJ in human sound molar teeth. The electron (EPMA) and proton (PIXE) microprobes gave consistent indications about the variability of elemental concentrations on this boundary. The locally increased and oscillating concentrations of Mg and Na were observed in the junction, in the layer adhering to the enamel and covering roughly half of the DEJ width. The chemical results were compared with the optical profiles of the junction. Our chemical and optical results were next compared with the micromechanical results (hardness, elastic modulus, friction coefficient) available in the world literature. A strong correlation of both result sets was proven, which testifies to the self-affinity of the junction structures for different locations and even for different kinds of teeth and techniques applied for studies. Energetic changes in tooth strictly connected with crystallographic transformations were calculated, and the minimum energetic status was discovered for DEJ zone. Modeling of both walls of the DEJ from optical data was demonstrated. Comparing the DEJ in human teeth with the same structure found in dinosaur, shark, and alligator teeth evidences the universality of dentin enamel junction in animal world. The paper makes a contribution to better understanding the joining of the different hard tissues.

Sabau, I., Venczel, M., Codrea, V.A. and Bordeianu, M. (2021). *Diplocynodon*: a salt water eocene crocodile from Transylvania? North-Western Journal of Zoology 17(1): 117-121.

Abstract. Crocodiles are a conservative group of reptiles regarding their morphology and behaviour. Fossil representatives are hence important to be studied. In the Paleogene sedimentary area of Gilău, from the former Mănăștur limestone quarry in ClujNapoca, a fossil fragmentary crocodile skull was found in Priabonian rocks. This 19th century discovery documents a new species of *Diplocynodon*. From the Leghia-Tabără limestone quarry, another crocodile fossil was unearthed a decade ago. The latter specimen, representing a crocodile mandible, may be associated to the same new species. The new discovery provides new characters enhancing our knowledge on that species and on the whole group. Unusual is the Eocene marine environment where the crocodile fossil originated from. As a consequence, the following questions are raising: had it been a marine taxon or a terrestrial representative that managed to get in marine environments during incursions for food, or had it been transported postmortem in the marine basin by fluvial streams? The mentioned genus probably had limited osmoregulatory capabilities, in a similar way to recent alligators, which do not possess osmoregulatory salt glands, which would keep their homeostatic equilibrium under control.

Jouve, S. (2021). Differential diversification through the K-Pg boundary, and post-crisis opportunism in longirostrine crocodyliforms. Gondwana Research (https://doi.org/10.1016/j.gr.2021.06.020).

Abstract: The evolution of the crocodyliforms through the K-Pg crisis has often been evaluated, but each time, the crocodyliforms were considered as forming a homogeneous group. I considered here, the evolution of two longirostrine taxa from the Campanian to the Thanetian: tethysuchians and gavialoids. The gavialoids are almost restricted to Laurasian continents, where tethysuchians form most of the Gondwanan fauna. This segregation can be compared with climatic distribution: tethysuchians are restricted to hot climatic areas, where gavialoids are restricted to a northern, warm temperate climatic belt from where tethysuchians were almost excluded. This suggests that gavialoids were more tolerant of cooler climates than tethysuchians. The tethysuchians could have been excluded from the European continent by the existence of a cool European oceanic current, whilst on the contrary, the presence of a proto-gulfstream along north-east American coast could have allowed the presence of some tethysuchians in marine realm in this area. Both gavialoids and tethysuchians strongly diversified after the K-Pg crisis, particularly on Gondwanan continents, and mostly with tethysuchian species. Most of these tethysuchians were non-marine during the Maastrichtian, and the number of marine species strongly increases after the K-Pg crisis, whilst the number of non-marine ones remains nearly constant. This rise of marine diversity compared to non-marine forms is congruent with previous hypotheses suggesting that the crocodyliforms did not suffer from the K-Pg crisis, but on the contrary, benefited from the extinction of large marine reptiles to diversify after the crisis mainly in this environment. So, if the history of the crocodyliforms on the whole is important, the evolution of each group should be considered separately, as their evolution could be influenced by regional environmental conditions and factors.



Mdhluvu, R.M., Mlambo, V., Madibana, M.J., Mwanza, M. and O'Brien, G. (2021). Crocodile meat meal as a fishmeal substitute in juvenile dusky kob (*Argyrosomus japonicus*) diets: Feed utilization, growth performance, blood parameters, and tissue nutrient composition. Aquaculture Reports 21 (https://doi.org/10.1016/j.aqrep.2021.100779).

Abstract: Overreliance on fishmeal (FM) as an aquafeed ingredient has become economically and ecologically unsustainable because wild stocks of forage fish are declining causing disruptions in aquatic food webs. On the other hand, the crocodile skin business generates substantial quantities of crocodile meat whose demand for human consumption is extremely low. The potential value of crocodile meat meal (CMM) as a FM alternative in fish diets is unknown. Therefore, this short-term, preliminary study investigated the effect of replacing FM with raw or cooked CMM on feed utilization, growth performance, haemato-biochemical parameters, and tissue nutrient composition in juvenile dusky kob (*Argyrosomus japonicus*, Temminck and Schlegel, 1843). Diets were formulated by replacing FM in a commercial diet (control) with 1. cooked CMM at 50% (CCR50), 2. raw CMM at 50% (RCR50), 3. raw CMM at 100% (RCR100), and 4. cooked CMM at 100% (CCR100). Fingerlings (7.55 ± 0.87 g) were offered diets at 2.8% body weight, twice daily, in a recirculating aquaculture system (20 tanks; 110 fish/tank) for 5 weeks. Weight was measured weekly while blood and fillet samples were collected in week 5. Complete replacement of FM with CMM significantly reduced feed intake, weight gain, specific growth rate (SGR), and protein efficiency ratio (PER) while increasing FCR over the 5-week period. The RCR100 and CCR100 diets also resulted in higher levels of urea, alkaline phosphatase, and lower triglycerides in the serum of fish. Complete replacement of FM with CMM increased palmitoleic and oleic acids in fish muscle compared to the control. Regardless of level of FM substitution, CMM had an adverse impact on linoleic acid, linolenic acid, eicosapentaenoic acid, and docosahexaenoic acid concentration of the dusky kob fillet. A supplementation strategy using oils rich in n-3 fatty acids could mitigate the negative impact of dietary CMM on feed utilization, growth performance, and polyunsaturated fatty acid levels in dusky kob fillet without raising economic and ecological costs.

Woodborne, S., Botha, H., Huchzermeyer, D., Myburgh, J., Hall, G. and Myburgh, A. (2021). Ontogenetic dependence of Nile crocodile (*Crocodylus niloticus*) isotope diet-to-tissue discrimination factors. Rapid Communications in Mass Spectrometry (doi: 10.1002/rcm.9159).

Abstract: The diet of wild Nile crocodiles (*Crocodylus niloticus*) is difficult to assess because they are cryptic, nocturnal predators that are extremely sensitive to disturbance by observers, and stomach content analysis is challenging, especially in large specimens. Stable light isotope analysis provides a means of assessing their diet but diet-to-tissue discrimination factors have yet to be established for the species. Isotope ratio ($^{15}N/^{14}N$ and $^{13}C/^{12}C$ expressed as $\delta^{15}N$ and $\delta^{13}C$) analyses of scutes, claws and blood of farmed crocodile of a range of sizes were compared with the isotope values of their lifelong diet, which comprises chickens from a single supplier. Systematic size dependence in the diet-to-tissue discrimination factors for scute collagen, scute keratin, and claw keratin, is described in regression relationships against the snout to vent length. Fixed values are presented for erythrocytes and blood plasma because blood was not sampled from juveniles. The diet-to-tissue discrimination factors allow an assessment of the diet of wild crocodiles. The diet of crocodiles from Lake Flag Boshielo shows a clear ontogenic shift, as has been seen in other studies, and the results strongly indicate a dependence on the terrestrial food web rather than a fish diet. That this population may exploit a terrestrial diet highlights potential conflicts for conserving Nile crocodiles outside of protected areas.

Bouyoucos, I.A., Schoen, A.N., Wahl, R. and Anderson, W.G. (2021). Ancient fishes and the functional evolution of the corticosteroid stress response in vertebrates. Comparative Biochemistry and Physiology Part A: Molecular & Integrative Physiology (https://doi.org/10.1016/j.cbpa.2021.111024).

Abstract: The neuroendocrine mechanism underlying stress responses in vertebrates is hypothesized to be highly conserved and evolutionarily ancient. Indeed, elements of this mechanism, from the brain to steroidogenic tissue, are present in all vertebrate groups; yet, evidence of the function and even identity of some elements of the hypothalamus-pituitary-adrenal/interrenal (HPA/I) axis is equivocal among the most basal vertebrates. The purpose of this review is to discuss the functional evolution of the HPA/I axis in vertebrates with a focus on our understanding of this neuroendocrine mechanism in the most ancient vertebrates: the agnathan (ie hagfish and lamprey) and chondrichthyan fishes (ie sharks, rays, and chimaeras). A review of the current literature presents evidence of a conserved HPA/I axis in jawed vertebrates (ie gnathostomes); yet, available data in jawless (ie agnathan) and chondrichthyan fishes are limited. Neuroendocrine regulation of corticosteroidogenesis in agnathans and chondrichthyans appears to function through similar pathways as in bony fishes and tetrapods; however, key elements have yet to be identified and the involvement of melanotropins and gonadotropin-releasing hormone in the stress axis in these ancient fishes warrants further investigation. Further, the identities of physiological glucocorticoids are uncertain in hagfishes, chondrichthyans, and even coelacanths. Resolving these and other knowledge gaps in the stress response of ancient fishes will be significant for advancing knowledge of the evolutionary origins of the vertebrate stress response.

Suharno, Kadir, A., Sembiring, E., Masiki, A.D., Mubarak, T., Lessil, N., Ratnawati, L.D., Idris, D. and Imbenai, J.G. (2021). Population estimation of freshwater crocodiles (*Crocodylus novaeguineae*) and tree vegetation diversity at wildlife reserve of Mamberamo Foja, Papua, Indonesia. Biodiversitas 22(7): 2928-2936.

Abstract: The structure and composition of vegetation in the conservation area have a major influence on the existence of other flora and fauna, including freshwater crocodiles (*C. novaeguineae*). Wildlife Reserve of Mamberamo Foja (WRMF) is a conservation area in Papua that aims to protect the habitat and existence of freshwater crocodiles. The purpose of this study was to estimate the number of freshwater crocodile populations and tree species diversity in the WRMF, Papua. The method used was a field survey. The crocodile survey was carried out using the spotlight night count method. Tree species diversity was assessed using the line-transect plot method in 6 different locations representing the Upper, Central, and Lower Mamberamo. The results of the investigation showed that the freshwater crocodile population in the WRMF wasaround 0.3-19.7 individuals per kilometre. The population of this freshwater crocodile was very high, with an average of 4.5 individuals per kilometre. The highest population numbers were found in the upstream Mamberamo River area (6.22 ind./km), followed by the central Mamberamo (2.21 ind./km) and downstream Mamberamo area (2.05 ind./km). Crocodiles were found in the Mamberamo River and other river systems, such as swamps and lakes. The tree vegetation in this area is still relatively good, and there are 112 species, dominated by the Moraceae, Burseraceae, Myrtaceae, Rubiaceae, Lauraceae, Dipterocarpaceae, and Euphorbiaceae families. The results of this study are important as a basis for determining the conservation policy for freshwater crocodiles that have limited distribution.

Paratthakonkun, C., Vimuttipong, V., Nana, A., Chaijenkij, K., Soonthornworasiri, N. and Arthan, D. (2021). The effects of crocodile blood supplementation on delayed-onset muscle soreness. Nutrients 13 (https://doi.org/10.3390/nu13072312).

Abstract: Delayed-onset muscle soreness (DOMS) is associated with increases in acute inflammatory and biochemical markers, muscle swelling, pain, and reduced functional performance. This study aimed to investigate the preventative effects of crocodile blood supplementation on DOMS induced by eccentric exercise. Sixteen healthy males were randomly allocated to either a crocodile blood (CB, n= 8) or a placebo (PL, n= 8) treatment. Participants receiving the CB treatment consumed four capsules of freeze-dried CB powder (1 g day^{-1}) over 18 days. Participants receiving the other treatment were administered a placebo over the same period. An eccentric exercise protocol was performed, and functional performance, visual analogue scale(VAS)-measured pain, knee range of movement (ROM), thigh circumference (swelling), and cytokines, enzymes, and biochemical parameters were assessed immediately after exercise as well as after 24 h, 48 h, and 72 h. CB supplementation could significantly maintain maximum voluntary isometric contraction (MVIC) at 24 h (p= 0.001) and 48 h after exercise (p= 0.001) when comparing values at different times for the CB group. In the CB group, thigh circumference decreased only immediately after eccentric exercise (p= 0.031) in comparison with pre-eccentric exercise values. An 18-day supplementation (1 g day^{-1}) of crocodile blood does aid in the maintenance of functional performance and muscle swelling after eccentric exercise. Our data indicate that 1 g day^{-1} of crocodile blood supplementation should be safe for human consumption.

Watanabe, A., Balanoff, A.M., Gignac, P.M., Gold, M.E.L. and Norell, M.A. (2021). Novel neuroanatomical integration and scaling define avian brain shape evolution and development. Elife 10: e68809 (doi: 10.7554/eLife.68809).

Abstract: How do large and unique brains evolve? Historically, comparative neuroanatomical studies have attributed the evolutionary genesis of highly encephalized brains to deviations along, as well as from, conserved scaling relationships among brain regions. However, the relative contributions of these concerted (integrated) and mosaic (modular) processes as drivers of brain evolution remain unclear, especially in non-mammalian groups. While proportional brain sizes have been the predominant metric used to characterize brain morphology to date, we perform a high-density geometric morphometric analysis on the encephalized brains of crown birds (Neornithes or Aves) compared to their stem taxa-the non-avialan coelurosaurian dinosaurs and *Archaeopteryx*. When analyzed together with developmental neuroanatomical data of model archosaurs (*Gallus*, *Alligator*), crown birds exhibit a distinct allometric relationship that dictates their brain evolution and development. Furthermore, analyses by neuroanatomical regions reveal that the acquisition of this derived shape-to-size scaling

relationship occurred in a mosaic pattern, where the avian-grade optic lobe and cerebellum evolved first among non-avialan dinosaurs, followed by major changes to the evolutionary and developmental dynamics of cerebrum shape after the origin of Avialae. Notably, the brain of crown birds is a more integrated structure than non-avialan archosaurs, implying that diversification of brain morphologies within Neornithes proceeded in a more coordinated manner, perhaps due to spatial constraints and abbreviated growth period. Collectively, these patterns demonstrate a plurality in evolutionary processes that generate encephalized brains in archosaurs and across vertebrates.

Neto, V.D.P., Desojo, J.B., Brust, A.C.B., Ribeiro, A.M., Schultz, C.L. and Soares, M.B. (2021). The first braincase of the basal aetosaur *Aetosauroides scagliai* (Archosauria: Pseudosuchia) from the Upper Triassic of Brazil. Journal of Vertebrate Paleontology (https://doi.org/10.1080/02724634.2021.1928681).

Abstract: The phylogenetic relationships of Pseudosuchia, the crocodile-line of Archosauria, are still poorly resolved, in part, due to the lack of crucial braincase information for several key taxa. Recently, erpetosuchids and ornithosuchids have been recovered as close relatives to Aetosauria, sharing several braincase features. Here we provide the description of the first braincase of the basal aetosaur *Aetosauroides* based on specimens from the Upper Triassic Candelária Sequence of Brazil. Our study revealed the presence of an exoccipital lateral ridge and a medial ridge on the supraoccipital (both shared with all aetosaurs and erpetosuchids, but absent in ornithosuchids) and an anterolateral exit for the internal carotids (shared with all aetosaurs and ornithosuchids, but not with erpetosuchids). *Aetosauroides* lacks a medial contact between the exoccipitals (shared with the aetosaurs *Desmatosuchus smalli* and *Tecovasuchus*) and possesses a single hypoglossal foramen (contrasting with *Stagonolepis robertsoni* and *Desmatosuchus spurensis*). It also differs from the putative Argentinian *Aetosauroides* (PVSJ 326) by the presence of a ridge connecting the basal tubera medially (contrasting also with all stagonolepidoideans) and by a bulbous and ventrolaterally recurved basipterygoid process (contrasting with *Paratypothorax*). These features show that the braincase of aetosaurs is suitable for providing further phylogenetic information and may contribute to resolving controversies within Pseudosuchia relationships.

Barragán-Contreras, L.A., Antelo, R. and Amézquita, A. (2021). Not only big bulls - Correlation between morphometry, reproductive success, and testosterone level in a flooded savannah population of the Spectacled Caiman (*Caiman crocodilus*). Canadian Journal of Zoology 99: 580-587.

Abstract: Testosterone is a steroid hormone involved in the expression of many morphological, physiological, and behavioral traits that arguably affect reproductive success. The evidence for that link is, however, incomplete or absent in the research on crocodilian species. Testosterone levels are also known to change throughout the breeding season, often on an hourly basis, which may further complicate studying their relationship with breeding success. We tested here whether baseline testosterone levels, measured out of the breeding season, are correlated with morphometry and reproductive success in Spectacled Caiman (*Caiman crocodilus* Linnaeus, 1758). Paternity tests, based on the amplification and genotyping of eight fluorochrome labeled microsatellites, failed to support a continuous relationship between these variables. Although adult males of all sizes contribute to reproduction, paternity was overrepresented in a few males with high values of maleness index (bigger males), supporting a despotic or pyramidal hierarchy among males. Maternity assignments supported the existence of multiple paternity, a phenomenon previously attributed in this species to the lack of large males caused by human hunting. The idea of larger males having more offspring is widespread in crocodilians, but to our knowledge, this is the first investigation that prove this dogma.

Steele, Z.T. and Pienaar, E.F. (2021). Knowledge, reason and emotion: Using behavioral theories to understand people's support for invasive animal management. Biological Invasions (https://doi.org/10.1007/s10530-021-02594-5).

Abstract: Species invasions contribute to global environmental change and cause declines in populations of threatened and endangered species. Significant government funds are expended on invasive species management (ISM) actions each year. Public support and compliance are critical to the success of these actions. We conducted a study to assess determinants of the general public's support for ISM actions to identify potential barriers to ISM. We administered an online questionnaire to the general public (n = 1561) in Florida, a state severely affected by species invasions. We presented respondents with 12 different non-native animals from 4 different taxa (birds, rodents, herpetofauna, fish) to test whether their support for ISM actions depended on the animals to be managed or their perceptions of risk. We utilized structural equation models to explore how different variables directly and indirectly influenced support for management actions. Respondents tended to oppose management actions targeted towards birds and charismatic species. Respondents' support for government-implemented ISM actions was positively correlated with their awareness of the risks associated with different animals and species invasions in general, their awareness of the consequences of species invasions, and their recognition of the importance of taking actions to mitigate invasion threats. Efforts to promote public support for ISM actions should emphasize the different risks associated with invasive species and the consequences of species invasions to offset opposition to ISM actions that target charismatic species.

Wang, L-H., Chen, L-R. and Chen, K-H. (2021). *In vitro* and *vivo* identification, metabolism and action of xenoestrogens: An overview. Journal of Molecular Science 22 (https://doi.org/10.3390/ijms22084013).

Abstract: Xenoestrogens (XEs) are substances that imitate endogenous estrogens to affect the physiologic functions of humans or other animals. As endocrine disruptors, they can be either synthetic or natural chemical compounds derived from diet, pesticides, cosmetics, plastics, plants, industrial byproducts, metals, and medications. By mimicking the chemical structure that is naturally occurring estrogen compounds, synthetic XEs, such as polychlorinated biphenyls (PCBs), bisphenol A (BPA), and diethylstilbestrol (DES), are considered the focus of a group of exogenous chemical. On the other hand, nature phytoestrogens in soybeans can also serve as XEs to exert estrogenic activities. In contrast, some XEs are not similar to estrogens in structure and can affect the physiologic functions in ways other than ER-ERE ligand routes. Studies have confirmed that even the weakly active compounds could interfere with the hormonal balance with persistency or high concentrations of XEs, thus possibly being associated with the occurrence of the reproductive tract or neuroendocrine disorders and congenital malformations. However, XEs are most likely to exert tissue-specific and non-genomic actions when estrogen concentrations are relatively low. Current research has reported that there is not only one factor affected by XEs, but opposite directions are also found on several occasions, or even different components stem from the identical endocrine pathway; thus, it is more challenging and unpredictable of the physical health. This review provides a summary of the identification, detection, metabolism, and action of XEs. However, many details of the underlying mechanisms remain unknown and warrant further investigation.

Rathore, H.S., Pati, J., Das, A. and Pandav, B. (2021). Population status and distribution of mugger crocodile *Crocodylus palustris* in the Similipal Tiger Reserve, Odisha, India. The Herpetological Bulletin 156: 28-30.

Sandmaier, S., Shepard, T., Reeves, A., Bohr, K., Krebs, J. and Herrick, J. (2021). Characterization of spermatozoa production and morphology in the male Philippine crocodile (*Crocodylus mindorensis*) via voluntary behavioral training. Reproduction, Fertility and Development (https://www.publish.csiro.au/RD/justaccepted/RD21016).

Abstract: Philippine crocodiles (*Crocodylus mindorensis*) are critically endangered due to agricultural and fishing threats that have severely fragmented their habitat and population in the Philippines. Captive management plans are important to safeguard against their extinction, but the current population in U.S. zoos is small and breeding is hampered by the slow growth of this species and the danger of introducing differently sized animals for breeding. There is little information regarding the sperm characteristics of crocodilians, and none for Philippine crocodiles. In this study, we sought to characterize sperm production in the male Philippine crocodile (n= 1) by performing voluntary (without sedation or restraint) collections (n= 181) over a 3.5-year period. Peak sperm production in this individual occurs from January to July, when the total number of recovered spermatozoa was 10.2 million ± 3.8 million (n= 104) compared to 0.3 million ± 0.2 million (n= 71) for all other months of the year. Analysis of sperm morphology indicated 15.9% of spermatozoa exhibited normal morphology. A bent tail was the most common abnormality (48.2%) observed. Understanding the basic reproductive biology of the male Philippine crocodile will facilitate the development of artificial reproductive technologies to improve captive propagation and genetic management of this species.

Bashyal, A., Shrestha, S., Luitel, K.P., Yadav, B.P., Khadka, B., Lang, J.W. and Densmore, L.D. (2021). Gharials (*Gavialis gangeticus*) in Bardiya National Park, Nepal: Population, habitat and threats. Aquatic Conservation: Marine and Freshwater Ecosystems (https://doi.org/10.1002/aqc.3649).

Abstract: The Critically Endangered gharial (*Gavialis gangeticus*) residing within Bardiya National Park (BNP) in Nepal constitutes the sixth major sub-population of this unique lineage; however, this population is not well studied. A 46-km protected stretch of the Babai River and a 60-km stretch of the Karnali River in and around BNP were surveyed for gharials in early 2017 and in 2019. Gharial counts in 2017 - 17 from the Babai and one from the Karnali Rivers - consisted of 10 adults, five sub-adults and three juveniles. In 2019, 19 gharials were counted - 18 for the Babai and one for the Karnali - comprising 11 adults, six sub-adults and two juveniles. In the Babai River within BNP, four breeding groups were identified. Gharials in BNP prefer sandy versus rocky banks for basking and completely avoid sand-grass and clay banks. Habitat preference did not vary with size class. Protected stretches of both rivers inside BNP (76 km) have resident gharial, intact habitats and few human threats. In contrast, the unprotected stretch of the Karnali (30 km) is threatened by boulder quarrying, sand mining and unlicensed fishing, and is avoided by gharials despite the availability of habitat. This study established baseline data, including indices of population size, distribution and habitat preferences, and documented resident gharials that are breeding in the Babai River in BNP. The conservation of this Babai population is crucial for the species' survival in BNP. Based on this study, we recommend the following conservation actions on the Babai stretch: (a) determine hatching success; (b) assess juvenile recruitment; (c) consider supplementation by releasing captives; (d) study riverine features important as baselines; (e) accommodate upstream movements on the protected Babai stretch; and, (f) protect the downstream Babai outside the boundary of the BNP.

He, Q., Gui, Z., Mao, L., Huang, J., Xing, L., Chen, Y. and Zhang, W. (2021). Element and isotope compositions of newly discovered dinosaur eggs and geochemical environmental instructions from the early Late Cretaceous of Xiuning Basin, China. Historical Biology (https://doi.org/10.1080/08912963.2021.1952195).

Abstract: New umbellaoolithid and faveoloolithid eggs were discovered from the early Late Cretaceous deposit in the Xiuning Basin, Anhui Province, China, and the samples were examined for elemental and isotopic compositions to reconstruct the geochemical environment. The results show that the trace elements consist of Sr, Mn, Ti, Ba, As, La, Cr, Ni, Pb, Cu, Zn, Co and Ir. The abnormal Sr and Mn were deposited in the eggshell mainly through material exchange of dinosaurs, and the high Ir concentration of surrounding rocks in the Xiuning Basin is conformed to the early Late Cretaceous Ir anomaly. The $\delta^{13}C$ compositions of eggshells suggest that the palaeovegetations are supposed to be -20.191‰ and -21.156‰ showing C3 plant and high CO_2 concentration, as well as low mean annual precipitation. The $\delta^{18}O$ compositions of eggshells indicate that the drinking water was mainly composed of meteoric water and plant leaf water, and the mean palaeotemperature was approximately 19°C. Based on the geochemical compositions of eggshells, the Ni content, the Sr/Ba ratio and the palaeoclimate index of surrounding rocks, the palaeoenvironment in the Xiuning Basin were dominated by alluvial fans and river systems with semi-arid climate in the early Late Cretaceous.

Felice, R.N., Pol, D. and Goswami, A. (2021). Complex macroevolutionary dynamics underly the evolution of the crocodyliform skull. Proceedings of the Royal Society B 288 (https://doi.org/10.1098/rspb.2021.0919).

Abstract: All modern crocodyliforms (alligators, crocodiles and the gharial) are semi-aquatic generalist carnivores that are relatively similar in cranial form and function. However, this homogeneity represents just a fraction of the variation that once existed in the clade, which includes extinct herbivorous and marine forms with divergent skull structure and function. Here, we use high-dimensional three-dimensional geometric morphometrics to quantify whole-skull morphology across modern and fossil crocodyliforms to untangle the factors that shaped the macroevolutionary history and relatively low phenotypic variation of this clade through time. Evolutionary modelling demonstrates that the pace of crocodyliform cranial evolution is initially high, particularly in the extinct Notosuchia, but slows near the base of Neosuchia, with a late burst of rapid evolution in crown-group crocodiles. Surprisingly, modern crocodiles, especially Australian, southeast Asian, Indo-Pacific species, have high rates of evolution, despite exhibiting low variation. Thus, extant lineages are not in evolutionary stasis but rather have rapidly fluctuated within a limited region of morphospace, resulting in significant convergence. The structures related to jaw closing and bite force production (eg pterygoid flange and quadrate) are highly variable, reinforcing the importance of function in driving phenotypic variation. Together, these findings illustrate that the apparent conservativeness of crocodyliform skulls betrays unappreciated complexity in their macroevolutionary dynamics.

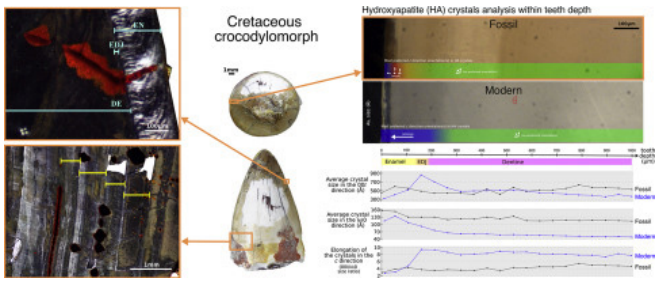
Schucht, P.J., Klein, N. and Lambertz, M. (2021). What's my age again? On the ambiguity of histology-based skeletochronology. Proceedings of the Royal Society B (https://doi.org/10.1098/rspb.2021.1166).

Abstract: Histology-based skeletochronology is a widely used approach to determine the age of an individual, and is based on the assumption that temporal cessations or decelerations of bone growth lead to incremental growth marks (GM), reflecting annual cycles. We studied the reliability of histology-based skeletochronology in a variety of extant tetrapods by comparing two different approaches: petrographic ground sections versus stained microtomized sections. Each bone was cut into two corresponding halves at its growth centre in order to apply both approaches to one and the same sample. None of the samples unequivocally revealed the actual age of the specimens, but truly concerning is the fact that the majority of samples even led to conflicting age estimates between the two approaches. Although the

microtomized sections tended to yield more GM and thus indicated an older age than the ground sections, the contrary also occurred. Such a pronounced ambiguity in skeletochronological data strongly challenges the value of the respective age determinations for both extant and extinct animals. We conclude that much more research on the fundamental methodological side of skeletochronology - especially regarding the general nature and microscopic recognition of GM - is required.

Vallcorba, O., Canillas, M., Audije-Gil, J., Barroso-Barcenilla, F., González-Martín, A., Molera, J., Rodríguez, M.A. and Cambra-Moo, O. (2021). Synchrotron X-ray microdiffraction to study dental structures in Cretaceous crocodylomorphs. Cretaceous Research (https://doi.org/10.1016/j.cretres.2021.104960).

Abstract: Synchrotron radiation X-ray microdiffraction (SR-μXRD) has been applied for the first time as a fundamental method of analysis to unveil crocodilian teeth growth and development. Teeth from a fossil crocodylomorph from the Upper Cretaceous site of Lo Hueco (Spain) and a modern crocodylian from the living species *Crocodylus niloticus* have been analysed. Both samples have been studied through Polarized Light Microscopy, Scanning Electron Microscopy coupled with Energy Dispersive X-Ray Spectroscopy, Confocal Raman Spectroscopy, and SR-μXRD. Significant differences have been found in hydroxyapatite (HA) crystallite sizes and texture, and the evolution of these two features along teeth depth. The main differences observed in crystallite size are related to postdepositional processes and/or the environmental and functional pressures of teeth during crocodylomorph life, very different from that of the modern specimen. Regarding the crystalline texture in the tooth enamel, it can be linked to teeth functionality during crocodilian life, causing the directed growth of HA crystallites due to the mechanical stress to which they are subjected.



Novas, F.E., Agnolin, F.L., Lio, G.L., Rozadilla, S., Suárez, M., de la Cruz, R., de Souza Carvalho, I., Rubilar-Rogers, D. and Isasi, M.P. (2021). New transitional fossil from late Jurassic of Chile sheds light on the origin of modern crocodiles. Scientifc Reports 11: 14960.

Abstract: We describe the basal mesoeucrocodylian *Burkesuchus mallingrandensis* nov. gen. et sp., from the Upper Jurassic (Tithonian) Toqui Formation of southern Chile. The new taxon constitutes one of the few records of non-pelagic Jurassic crocodyliforms for the entire South American continent. *Burkesuchus* was found on the same levels that yielded titanosauriform and diplodocoid sauropods and the herbivore theropod *Chilesaurus diegosuarezi*, thus expanding the taxonomic composition of currently poorly known Jurassic reptilian faunas from Patagonia. *Burkesuchus* was a small-sized crocodyliform (estimated length 70 cm), with a cranium that is dorsoventrally depressed and transversely wide posteriorly and distinguished by a posteroventrally fexed wing-like squamosal. A well-defned longitudinal groove runs along the lateral edge of the postorbital and squamosal, indicative of a anteroposteriorly extensive upper earlid. Phylogenetic analysis supports *Burkesuchus* as a basal member of Mesoeucrocodylia. This new discovery expands the meagre record of non-pelagic representatives of this clade for the Jurassic Period, and together with *Batrachomimus*, from Upper Jurassic beds of Brazil, supports the idea that South America represented a cradle for the evolution of derived crocodyliforms during the Late Jurassic.

Lima dos Santos, R., de Sousa Correia, J.M. and Maranhão dos Santos, E. (2021). Freshwater aquatic reptiles (Testudines and Crocodylia) as biomonitor models in assessing environmental contamination by inorganic elements and the main analytical techniques used: A review. Environmental Monitoring and Assessment 193 (https://doi.org/10.1007/s10661-021-09212-w).

Abstract: Despite the general lack of studies that use reptiles as bioindicators, the value of freshwater turtles and crocodilians in ecotoxicology has been proven, due to their importance as sentinel species. The aim of this study was to compile information on the use of freshwater turtles and crocodilians as environmental biomonitors of inorganic element contamination. We searched for articles in databases using specific keywords. A total of 104 studies published between the years 1970 and 2020 were collected. We noted a general increase in the number of studies involving turtles and crocodilians during the study time period. The Order Testudines were the subjects of 46% of the analysed publications, and the Order Crocodylia accounted for 54%. Within these studies, we counted 39 species (turtles n= 29 and crocodilians n= 10). Forty chemical elements were evaluated in the analysed articles, of which the majority represented non-essential elements (Hg, Cd, Pb). Although internal organs constituted the main biological matrix chosen for each group (37%), we observed an increase in the use of non-destructive matrices in both groups (scale, blood, tail muscle, carapace). The majority of analysed studies used HNO_3 for the sample decomposition, with the majority of analyses being performed using atomic absorption spectroscopy (53%). Mainly blank controls (19%), analyte recovery (18%) and replicates (18%) were used as methods of validating analytical procedures. Furthermore, the studies used certified reference materials, which measure the accuracy of the methods used. We conclude that the increase in the use of aquatic reptiles in environmental monitoring research is mainly due to their ability to reveal integrated changes in ecosystems, aiding in environmental public policy decision-making and effective management plans.

Balaguera-Reina, S.A., Konvalina, J.D., Mohammed, R.S., Gross, B., Vazquez, R., Moncada, J.F., Ali, S., Hoffman, E.A. and Densmore III, L.D. (2021). From the river to the ocean: Mitochondrial DNA analyses provide evidence of spectacled caimans (*Caiman crocodilus* Linnaeus 1758) mainland-insular dispersal. Biological Journal of the Linnean Society (https://doi.org/10.1093/biolinnean/blab094).

Abstract: There are few studies that have investigated the evolutionary history of large vertebrates on islands off the Caribbean coast of South America. Here we use the spectacled caiman (*Caiman crocodilus*) to investigate among- and within-population patterns of genetic diversity to understand connectivity between island and mainland populations. The spectacled caiman is naturally distributed across Central and South America including the islands of Trinidad and Tobago, which are considered to have the only natural insular populations of the species. Because of this apparent isolation, we sought to determine whether caimans on Trinidad and Tobago comprise a unique lineage and have reduced genetic diversity compared to mainland caimans. We test these hypotheses by using mitochondrial DNA variation to assess the phylogenetic and phylogeographical relationships of the *C. crocodilus* populations inhabiting these islands within the evolutionary context of the entire spectacled caiman complex. Phylogenetic analyses placed the Trinidad and Tobago samples together with samples from Colombia, Venezuela and Brazil into one well-supported clade, which corresponds to the defined Orinoco/upper Negro lineage. Interestingly, the majority of sequences from Trinidad and Tobago are similar or identical to haplotypes reported from Venezuela and Colombia, supporting the idea of a dispersal process from the Orinoco River to these islands. We discuss the implications of our findings for systematics and the conservation of the species and how these

dispersal movements could shape the current phylogeographical structure depicted for *C. crocodilus*.

Vargas Ferreira de Rezende, M., Arcanjo Lima, P.P. and Reis Junior, L.L. (2021). Pathology as a tool for identification of West Nile Fever in crocodilians and its impact on public health. Archives of Health, Curitiba 2(4): 1303-1306.

Abstract: West Nile Fever (WNF) is a zoonotic arbovirosis that affects several species, including crocodilians that can act as amplifiers of the disease, therefore, utilizing pathology can be strategic to reduce public health impacts.

Sharma, R.K., Jangid, A.K. and Das, A. (2021). Blood on the track: A case of Mugger (*Crocodylus palustris*) mortality in Jawai, Rajasthan, India. Reptiles & Amphibians 28(2): 320-321.

Kengpol, A. (2021). The future of green industry from luxury niche market of crococdile leather to major industry using AI deep learning and virtual reality: An empirical study in Thailand during Covid-19 era. Applied Science and Engineering Progress (doi: 10.14416/j.asep.2021.01.001).

Rose, K.A.R., Tickle, P.G., Elsey, R.M., Sellers, W.I., Crossley II, D.A. and Codd, J.R. (2021). Scaling of axial muscle architecture in juvenile *Alligator mississippiensis* reveals an enhanced performance capacity of accessory breathing mechanisms. Journal of Anatomy (https://doi.org/10.1111/joa.13523).

Abstract: Quantitative functional anatomy of amniote thoracic and abdominal regions is crucial to understanding constraints on and adaptations for facilitating simultaneous breathing and locomotion. Crocodilians have diverse locomotor modes and variable breathing mechanics facilitated by basal and derived (accessory) muscles. However, the inherent flexibility of these systems is not well studied, and the functional specialisation of the crocodilian trunk is yet to be investigated. Increases in body size and trunk stiffness would be expected to cause a disproportionate increase in muscle force demands and therefore constrain the basal costal aspiration mechanism, necessitating changes in respiratory mechanics. Here, we describe the anatomy of the trunk muscles, their properties that determine muscle performance (mass, length and physiological cross-sectional area [PCSA]) and investigate their scaling in juvenile *Alligator mississippiensis* spanning an order of magnitude in body mass (359 g-5.5 kg). Comparatively, the expiratory muscles (*transversus abdominis*, *rectus abdominis*, *iliocostalis*), which compress the trunk, have greater relative PCSA being specialised for greater force-generating capacity, while the inspiratory muscles (*diaphragmaticus*, *truncocaudalis ischiotruncus*, *ischiopubis*), which create negative internal pressure, have greater relative fascicle lengths, being adapted for greater working range and contraction velocity. Fascicle lengths of the accessory *diaphragmaticus* scaled with positive allometry in the alligators examined, enhancing contractile capacity, in line with this muscle's ability to modulate both tidal volume and breathing frequency in response to energetic demand during terrestrial locomotion. The *iliocostalis*, an accessory expiratory muscle, also demonstrated positive allometry in fascicle lengths and mass. All accessory muscles of the infrapubic abdominal wall demonstrated positive allometry in PCSA, which would enhance their force-generating capacity. Conversely, the basal tetrapod expiratory pump (*transversus abdominis*) scaled isometrically, which may indicate a decreased reliance on this muscle with ontogeny. Collectively, these findings would support existing anecdotal evidence that crocodilians shift their breathing mechanics as they increase in size. Furthermore, the functional specialisation of the *diaphragmaticus* and compliance of the body wall in the lumbar region against which it works may contribute to low-cost breathing in crocodilians.

Suzuki, D., Yamakawa, S., Iijima, M. and Fujie, H. (2021). Function of the crocodilian anterior cruciate ligaments. Journal of Morphology (doi: 10.1002/jmor.21401).

Abstract: The anterior cruciate ligament (ACL) is an important knee stabilizer that prevents the anterior subluxation of the tibia. Extant crocodiles have two ACLs, the ACL major and minor, yet their functional roles are unclear. We here examined *in-situ* forces within the ACL major and minor in saltwater crocodiles (*Crocodylus porosus*) with a 6-degree-of-freedom robotic testing system under the following loading conditions: 1) 30 N anterior tibial load at 150°, 120°, and 90° knee extension; 2) 1 Nm internal/external torque at 150° and 120° knee extension; 3) 30 N anterior tibial load +1 Nm internal/external torque at 150° and 120° knee extension. The *In-situ* force in the ACL minor was significantly higher than that of the ACL major in response to anterior tibial load at 90° knee extension, and anterior tibial load + external torque at both 150° and 120° knee extension. Meanwhile, the force in the ACL major was significantly higher than that of the ACL minor in response to internal torque at 120° knee extension, and anterior tibial load + internal torque at 150° knee extension. The present results showed that the ACL minor and major of saltwater crocodiles have different functions. In response to anterior tibial load + internal/external torques, either of two ACLs reacted to opposing directions of knee rotation. These suggest that two ACLs are essential for walking with long axis rotation of the knee in crocodiles.

Chacón, C.F., López González, E.C. and Poletta, G.L. (2021). Biomarkers of geno- and cytotoxicity in the native broad-snouted caiman (*Caiman latirostris*): Chromosomal aberrations and mitotic index. Mutation Research (doi: 10.1016/j.mrgentox.2021.503353).

Abstract: We evaluated the sensitivity of the chromosomal aberration (CA) and mitotic index (MI) assays on peripheral blood lymphocytes (PBLs) of *Caiman latirostris*, following *ex-vivo* exposure to the alkylating agent, MMS. Two concentrations of MMS were tested in cultured peripheral blood. Relative to controls, MMS exposure reduced the number of metaphases observed, but both the numbers of cells with MN and the percentages of aberrant metaphases increased. The types of CA identified were chromosome and chromatid breaks, chromosomal rearrangements, monosomies, and nullisomies, with significantly higher values in the MMS-exposed groups. The incorporation of the MI and CA tests in *C. latirostris* can provide information on damage caused by xenobiotic exposures.

Hedrick, B.P., Schachner, E.R. and Dodson, P. (2021). Alligator appendicular architecture across an ontogenetic niche shift. Anatomical Record (Hoboken) (doi: 10.1002/ar.24717).

Abstract: A variety of species undergo ontogenetic niche shifts in either diet, habitat, or both. As a result, multiple ontogenetic stages are able to take advantage of different resources and live in sympatry without competing with one another. The American alligator (*Alligator mississippiensis*) begins to undergo an ontogenetic niche shift in both diet and habitat at a length of 1.2 m. They transition from a terrestrial wetland environment to a riverine environment and take advantage of different dietary resources. At 1.8 m, *A. mississippiensis* reaches sexual maturity. Ontogenetic shifts in habitat have the capacity to alter morphology, especially limb morphology, as different age classes traverse different ecological systems. We evaluated shape trends in the scapulae, humeri, ilia, and femora using geometric morphometrics to test whether there were punctuated changes in limb shape, shape disparity, and integration corresponding to either the ontogenetic habitat shift or onset of sexual maturity. We found size to strongly correlate with limb shape but found a continuous size gradient rather than punctuated changes in size. Furthermore, we found that adults (total length >1.8 m) had significantly higher limb shape disparity than juveniles or subadults, likely related to ontogenetic decreases in limb use and a reduction in

limb constraints. Finally, we found that the forelimb and hindlimb acted as a single integrated unit and that neither the forelimb nor hindlimb was significantly more integrated than the other. Therefore, the ontogenetic niche shift itself did not impact limb morphology in *A. mississippiensis*.

Faulkner, P.C., Elsey, R.M., Hala, D. and Petersen, L.H. (2021). Correlations between environmental salinity levels, blood biochemistry parameters, and steroid hormones in wild juvenile American alligators (*Alligator mississippiensis*). Scientific Reports 11(1): 15168 (doi: 10.1038/s41598-021-94557-y).

Abstract: American alligators (*Alligator mississippiensis*) inhabit freshwater wetlands that are vulnerable to salinization caused by anthropogenic alterations to freshwater flow, in addition to storm surges, sea level rise, and droughts. Salinization of coastal freshwater habitats is a growing concern in a changing climate due to increased frequency and intensity of storm surges and drought conditions. This study opportunistically sampled juvenile male and female wild alligators in various salinities each month excluding November, December, and January for one year at Rockefeller Wildlife Refuge in coastal Louisiana. Blood plasma biochemistry parameters including electrolyte levels were subsequently measured. In addition, levels of various renin-angiotensin-aldosterone system hormones, glucocorticoids, androgens, estrogens, and progestogens were analyzed using liquid chromatography and tandem mass spectrometry. Only males were sampled in hyperosmotic environments (>10‰) during dry conditions in late summer 2018. In juvenile males, plasma Na^+, Cl^-, and the progestogen 17α,20β-dihydroxypregnenone were significantly and positively correlated with environmental salinity. However, variation in glucocorticoids, androgens, and estrogens were not associated with hypersaline water while sex steroids showed significant seasonal variation. This study demonstrated significant correlation of environmental salinity with electrolyte levels and a sex steroid in wild juvenile alligators, and to our knowledge represents the first measurement of 17α,20β-dihydroxypregnenone in alligators.

Hawkeswood, T.J. (2021). Time to end taxonomic vandalism by Wolfgang Wuster *et al*.: The Snakeman, Raymond Hoser's publications are validly published and his names available according to the ICZN: Objective investigation finds Hoser's taxonomic works as scientific best practice and in every relevant case identifies valid entities. Calodema 860: 1-51.

Abstract: In light of statements by a cohort generally known as Wuster *et al*. (see Wuster, 2012), including Wuster (2012), rebadged as Kaiser *et al*. (2013), and Rhodin *et al*. (2015) to the effect that the scientific papers of Raymond T. Hoser involving reptile and amphibian taxonomy and nomenclature were "evidence free" and "unscientific", a forensic analysis of Hoser's works was undertaken by 10 herpetologists. This included reviewing all Hoser papers naming taxa from 1998 to the end of 2020. Without exception, it was found that Hoser's taxonomic works were methodical, scientific, best practice and in every relevant case, identified valid biological entities as per the relevant descriptions. Far from being "evidence free" and "unscientific", the evidence behind Hoser's taxonomic judgements and nomenclature is properly presented and self-evident in every paper. With the ICZN Ruling on 30 April 2021 (Case 3601), that Hoser's works and nomenclature are available according to the rules of the International Code of Zoological Nomenclature, it is recommended that all Hoser's taxonomy and nomenclature be used in preference to any other unsupported and invalid taxonomies. It is noted that Section 29 of the Code does not allow in any situation for names post 1899 to be over-written. In the wake of the ICZN ruling which took a strong and decisive stand against taxonomic vandalism, it is likely that Wuster *et al*. will ignore the ICZN, continue to act dishonestly and illegally and seek the ultimate destruction of the ICZN rules and even the ICZN itself. The scientific community must resist these attacks as best they can.

Crane, M., Silva, I., Marshall, B.M. and Strine, C.T. (2021). Lots of movement, little progress: A review of reptile home range literature. Peer J 9: e11742.

Abstract: Reptiles are the most species-rich terrestrial vertebrate group with a broad diversity of life history traits. Biotelemetry is an essential methodology for studying reptiles as it compensates for several limitations when studying their natural history. We evaluated trends in terrestrial reptile spatial ecology studies focusing upon quantifying home ranges for the past 20 years. We assessed 290 English-language reptile home range studies published from 2000-2019 via a structured literature review investigating publications' study location, taxonomic group, methodology, reporting, and analytical techniques. Substantial biases remain in both location and taxonomic groups in the literature, with nearly half of all studies (45%) originating from the USA. Snakes were most often studied, and crocodiles were least often studied, while testudines tended to have the greatest within study sample sizes. More than half of all studies lacked critical methodological details, limiting the number of studies for inclusion in future meta-analyses (55% of studies lacked information on individual tracking durations, and 51% lacked sufficient information on the number of times researchers recorded positions). Studies continue to rely on outdated methods to quantify space-use (including Minimum Convex Polygons and Kernel Density Estimators), often failing to report subtleties regarding decisions that have substantial impact on home range area estimates. Moving forward researchers can select a suite of appropriate analytical techniques tailored to their research question (dynamic Brownian Bridge Movement Models for within sample interpolation, and autocorrelated Kernel Density Estimators for beyond sample extrapolation). Only 1.4% of all evaluated studies linked to available and usable telemetry data, further hindering scientific consensus. We ultimately implore herpetologists to adopt transparent reporting practices and make liberal use of open data platforms to maximize progress in the field of reptile spatial ecology.

Paungpin, W., Thongdee, M., Chaiwattanarungruengpaisan, S., Sariya, L., Sirimanapong, W., Kasantikul, T., Phonarknguen, R., Darakamas, P. and Arya, N. (2021). Coinfection of *Chlamydia* spp. and herpesvirus in juvenile farmed Siamese crocodiles (*Crocodylus siamensis*) in Thailand. Veterinary World 14(7): 1908-1914.

Abstract: For a decade, chlamydial and herpesvirus infections have caused significant morbidity and mortality in farmed crocodiles. In September 2017, a total of 160 juvenile freshwater Siamese crocodiles (*Crocodylus siamensis*) with conjunctivitis/pharyngitis lesions were admitted at the Veterinary Aquatic Animal Research Health Care Unit, Faculty of Veterinary Science, Mahidol University. All crocodiles did not respond well to antibiotics or supportive treatments and died. This study aimed to detect and identify the causative agents associated with conjunctivitis/pharyngitis and fatal outcomes in juvenile farmed Siamese crocodiles. A total of 138 pharyngeal and conjunctival swabs and conjunctival scrapes were collected from live crocodiles. All swab and scrape samples were DNA-extracted and amplified by polymerase chain reaction (PCR) using Chlamydiaceae- and herpesvirus-specific primers. Tissue samples (brain, lung, liver, heart, spleen, and intestine) were collected from two representative postmortem animals. All tissue samples were processed for molecular and pathological analyses. PCR examinations identified chlamydial and herpesvirus DNA in 92% (126/138) and 100% (138/138), respectively, of the tested swab and scrape samples. Of those positive samples, 79% (26/33), 67% (4/6), and 98% (97/99) of the pharyngeal swabs, conjunctival swabs, and conjunctival scrapes, respectively, were positive for both chlamydial and herpesvirus DNA. Histopathological examination indicated necrosis and mononuclear cell infiltration in the liver, kidney, and intestine of the affected animals. The intracytoplasmic accumulation of *Chlamydia* was randomly observed in the examined tissue sample. Moreover, the presence of chlamydial and herpesvirus DNA was also detected in the tissue samples, including the heart, intestine, brain, lung, liver, and spleen,

of the affected animals by PCR. Phylogenetic analyses revealed that *Chlamydia* spp. detected in the juvenile Siamese crocodiles was notably different from other known species in the *Chlamydia* genus, while the herpesvirus detected in the crocodiles was closely related to crocodyline herpesvirus 1. Based on histopathological and molecular examinations, this report provided the first evidence of coinfection of *Chlamydia* spp. and crocodyline herpesvirus 1 in juvenile Siamese crocodiles in Thailand.

Kratochvíl, L., Gamble, T. and Rovatsos, M. (2021). Sex chromosome evolution among amniotes: is the origin of sex chromosomes non-random? Philosophical Transactions of the Royal Society B 376: 20200108.

Abstract: Sex chromosomes are a great example of a convergent evolution at the genomic level, having evolved dozens of times just within amniotes. An intriguing question is whether this repeated evolution was random, or whether some ancestral syntenic blocks have significantly higher chance to be co-opted for the role of sex chromosomes owing to their gene content related to gonad development. Here, we summarize current knowledge on the evolutionary history of sex determination and sex chromosomes in amniotes and evaluate the hypothesis of non-random emergence of sex chromosomes. The current data on the origin of sex chromosomes in amniotes suggest that their evolution is indeed non-random. However, this non-random pattern is not very strong, and many syntenic blocks representing putatively independently evolved sex chromosomes are unique. Still, repeatedly co-opted chromosomes are an excellent model system, as independent co-option of the same genomic region for the role of sex chromosome offers a great opportunity for testing evolutionary scenarios on the sex chromosome evolution under the explicit control for the genomic background and gene identity. Future studies should use these systems more to explore the convergent/divergent evolution of sex chromosomes. This article is part of the theme issue 'Challenging the paradigm in sex chromosome evolution: empirical and theoretical insights with a focus on vertebrates (Part II)'.

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

Jenkins, M., Ahmed, S. and Barnes, A.N. (2021) A systematic review of waterborne and water-related disease in animal populations of Florida from 1999-2019. PLoS ONE 16(7): e0255025.

Abstract: Florida's waters are a reservoir for a host of pathogens and toxins. Many of these microorganisms cause water-related diseases in people that are reportable to the Florida Department of Health. Our objective in this review was to ascertain which water-related pathogens and toxins of public health importance have been found in animal populations in Florida over the last 20 years. Nineteen databases were searched, including PubMed and Web of Science Core Collection, using keywords and search terms for the waterborne diseases, water-related vector-borne diseases, and water-based toxins reportable to the Florida Department of Health. For inclusion, peer-reviewed journal articles were to be written in English, published between 1 January 1999 and 31 December 2019, and contain primary research findings documenting at least one of the water-related pathogens or toxins of interest in an animal population within Florida during this same time frame. Of over 8000 initial search results, 65 studies were included for final analysis. The most common animal types implicated in the diseases of interest included marine mammals, fish and shellfish, wild birds, and livestock. Toxins or pathogens most often associated with these animals included toxin-producer *Karenia brevis*, vibriosis, *Escherichia coli*, and Salmonellosis. Findings from this review elucidate the water-related disease-causing pathogens and toxins which have been reported within animal populations in recent Florida history. As most of these diseases are zoonotic, our results suggest a One Health approach is necessary to support and maintain healthy water systems throughout the state of Florida for the protection of both human and animal populations.

Bautista, N.M., Malte, H., Natarajan, C., Wang, T., Storz, J.F. and Fago, A. (2021). New insights into the allosteric effects of CO_2 and bicarbonate on crocodilian hemoglobin. Journal of Experimental Biology 224(15) (doi: 10.1242/jeb.242615).

Abstract: Crocodilians are unique among vertebrates in that their hemoglobin (Hb) O_2 binding is allosterically regulated by bicarbonate, which forms in red blood cells upon hydration of CO_2. Although known for decades, this remarkable mode of allosteric control has not yet been experimentally verified with direct evidence of bicarbonate binding to crocodilian Hb, probably because of confounding CO_2-mediated effects. Here, we provide the first quantitative analysis of the separate allosteric effects of CO_2 and bicarbonate on purified Hb of the spectacled caiman (*Caiman crocodilus*). Using thin-layer gas diffusion chamber and Tucker chamber techniques, we demonstrate that both CO_2 and bicarbonate bind to Hb with high affinity and strongly decrease O_2 saturation of Hb. We propose that both effectors bind to an unidentified positively charged site containing a reactive amino group in the low-O_2 affinity T conformation of Hb. These results provide the first experimental evidence that bicarbonate binds directly to crocodilian Hb and promotes O_2 delivery independently of CO_2. Using the gas diffusion chamber, we observed similar effects in Hbs of a phylogenetically diverse set of other caiman, alligator and crocodile species, suggesting that the unique mode of allosteric regulation by CO_2 and bicarbonate evolved >80-100 million years ago in the common ancestor of crocodilians. Our results show a tight and unusual linkage between O_2 and CO_2 transport in the blood of crocodilians, where the build-up of erytrocytic CO_2 and bicarbonate ions during breath-hold diving or digestion facilitates O_2 delivery, while Hb desaturation facilitates CO_2 transport as protein-bound CO_2 and bicarbonate.

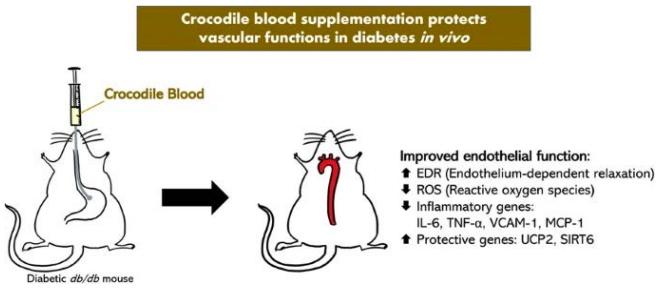
Steger, C., Klein, J.A., Reid, R.S., Lavorel, S., Tucker, C., Hopping, K.A., Marchant, R., Teel, T., Cuni-Sanchez, A., Dorji, T., Greenwood, G., Huber, R., Kassam, K-A., Kreuer, D., Nolin, A., Russell, A., Sharp, J.L., Hribar, M.S., Thorn, J.P.R., Grant, G., Mahdi, M., Moreno, M. and Waiswa, D. (2021). Science with society: Evidence-based guidance for best practices in environmental transdisciplinary work. Global Environmental Change (https://doi.org/10.1016/j.gloenvcha.2021.102240).

Abstract: Transdisciplinary research is a promising approach to address sustainability challenges arising from global environmental change, as it is characterized by an iterative process that brings together actors from multiple academic fields and diverse sectors of society to engage in mutual learning with the intent to co-produce new knowledge. We present a conceptual model to guide the implementation of environmental transdisciplinary work, which we consider a "science with society" (SWS) approach, providing suggested activities to conduct throughout a seven-step process. We used a survey with 168 respondents involved in environmental transdisciplinary work worldwide to evaluate the relative importance of these activities and the skills and characteristics required to implement them successfully, with attention to how responses differed according to the gender, geographic location, and positionality of the respondents. Flexibility and collaborative spirit were the most frequently valued skills in SWS, though non-researchers tended to prioritize attributes like humility, trust, and patience over flexibility. We also explored the relative significance of barriers to successful SWS, finding insufficient time and unequal power dynamics were the two most significant barriers to successful SWS. Together with case studies of respondents' most successful SWS projects, we create a toolbox of 20 best practices that can be

used to overcome barriers and increase the societal and scientific impacts of SWS projects. Project success was perceived to be significantly higher where there was medium to high policy impact, and projects initiated by practitioners/other stakeholders had a larger proportion of high policy impact compared to projects initiated by researchers only. Communicating project results to academic audiences occurred more frequently than communicating results to practitioners or the public, despite this being ranked less important overall. We discuss how these results point to three recommendations for future SWS: 1) balancing diverse perspectives through careful partnership formation and design; 2) promoting communication, learning, and reflexivity (ie questioning assumptions, beliefs, and practices) to overcome conflict and power asymmetries; and, 3) increasing policy impact for joint science and society benefits. Our study highlights the benefits of diversity in SWS - both in the types of people and knowledge included as well as the methods used - and the potential benefits of this approach for addressing the increasingly complex challenges arising from global environmental change.

Chook, C.Y.B., Chen, F.M., Tse, G., Leung, F.P. and Wong, W.T. (2021). Crocodile blood supplementation protects vascular function in diabetic mice. Food Production, Processing and Nutrition 3(19) (https://doi.org/10.1186/s43014-021-00066-w).

Abstract: Cardiovascular disease is a major cause of mortality in diabetic patients due to the heightened oxidative stress and pro-inflammatory state in vascular tissues. Effective approaches targeting cardiovascular health for diabetic patients are urgently needed. Crocodile blood, an emerging dietary supplement, was suggested to have anti-oxidative and anti-inflammatory effects in vitro, which have yet to be proven in animal models. This study thereby aimed to evaluate whether crocodile blood can protect vascular function in diabetic mice against oxidation and inflammation. Diabetic db/db mice and their counterparts db/m+ mice were treated daily with crocodile blood soluble fraction (CBSF) or vehicle via oral gavage for 4 weeks before their aortae were harvested for endothelium-dependent relaxation (EDR) quantification using wire myograph, which is a well-established functional study for vascular function indication. Organ culture experiments culturing mouse aortae from C57BL/6J mice with or without IL-1β and CBSF were done to evaluate the direct effect of CBSF on endothelial function. Reactive oxygen species (ROS) levels in mouse aortae were assessed by dihydroethidium (DHE) staining with inflammatory markers in endothelial cells quantified by quantitative polymerase chain reaction (qPCR). CBSF significantly improved deteriorated EDR in db/db diabetic mice through both diet supplementation and direct culture, with suppression of ROS level in mouse aortae. CBSF also maintained EDR and reduced ROS levels in mouse aortae against the presence of pro-inflammatory IL-1β. Under the pro-inflammatory state induced by IL-1β, gene expressions of inflammatory cytokines were downregulated, while the protective transcripts UCP2 and SIRT6 were upregulated in endothelial cells. Our study suggests a novel beneficial effect of crocodile blood on vascular function in diabetic mice and that supplementation of diet with crocodile blood may act as a complementary approach to protect against vascular diseases through anti-oxidation and anti-inflammation in diabetic patients.



Cavalier, R., Pratt, E.N., Serenari, C. and Rubino, E.C. (2021). Human dimensions of crocodilians: A review of the drivers of coexistence. Human Dimensions of Wildlife (https://doi.org/10.1080/10871209.2021.1953195).

Abstract: Crocodilians are socially and ecological important apex predators. Yet, many societies struggle to share space with crocodilians, especially in urban and coastal regions. The literature provides fragmented insights into human-crocodilian coexistence and conflict across the urban-rural gradient. We conducted an exploratory review of the literature to identify trends in research and opportunities for researchers to unearth potential principles of human coexistence with crocodilian species within cognitive, spatial, and governance domains. Our results follow two lines of inquiry: (a) interactions in increasingly urbanizing areas, and (b) interactions in natural resource dependent rural communities. In both instances, our review revealed the influential role of cognitions in human defense of symbolic and material livelihoods and negotiating human-crocodilian interactions. Our findings also demonstrated that studies insufficiently attend to larger forces (eg rural-urban drift, land use change, societal adaptive capacity) influencing interactions. Understanding social-ecological connections between humans and apex predators are necessary to rethink coexistence.

Assumpção, T.I., Silva Lopes, A.J., Fromme, L. and Quagliatto Santos, A.L. (2021). Histological study of the male internal genital tract of Dwarf caiman (*Paleosuchus palpebrosus* Cuvier, 1807). Journal of Zoological Research 3(3): 28-32.

Abstract: Brazil has six species of crocodiles belonging to the subfamily Caimaninae, one of them being *Paleosuchus palpebrosus* (Cuvier, 1807) (Dwarf caiman). It is considered one of the smallest crocodilian species, and is sensitive to environmental changes. The anatomical and histological descriptions of the reproductive tract of reptiles are scarce, so it is important to study the morphology of the genital tract of caimans for a better understanding of the reproduction of these species. We performed the histological analysis of the testis, epididymis, and deferent duct of the dwarf caiman *P. palpebrosus*. Structures of the genital tract were collected from euthanized animals. Testes, epididymis, and deferent ducts were separated and prepared according to routine histological techniques for morphological characterization. The testis is covered by a capsule of fibromuscular connective tissue. Spermatogonia are observed as spherical cells with round nuclei and loose chromatin, and primary spermatocytes show dark cytoplasm, round nuclei, and pale chromatin. Spermatids are seen as cylindrical or filamentous cells with nuclei that may be highly condensed, ranging from round to oval. The epididymis is observed as a coiled duct lined by a tall cuboidal epithelium with stereocilia; the deferent duct shows ciliated pseudostratified cylindrical epithelium. The adrenal gland is found in the dorsomedial portion of the testis. The histological structure of the reproductive tract of *P. palpebrosus* is similar to that of other reptiles' species.

Marowa, I., Matanzima, J. and Nhiwatiwa, T. (2021). Interactions between humans, crocodiles, and hippos at Lake Kariba, Zimbabwe. Human-Wildlife Interactions 15(1) (digitalcommons.usu.edu/hwi).

Abstract: Human-wildlife conflicts (HWCs) are on the increase due to shrinking space that results in increased competition for land, water, and other natural resources between humans and wildlife. Investigating the occurrence of HWCs is important in that the results can be used to formulate better management policies and strategies. In this paper, we describe the nature of HWCs emerging between humans and the Nile crocodile (*Crocodylus niloticus*) and between humans and the African hippopotamus (*Hippopotamus amphibius*; hippo) on Lake Kariba, Zimbabwe. Lake Kariba is the second largest manmade lake by volume in the world. Conflicts involving humans and these species are readily noticeable and played out around water bodies, which are sources of daily human sustenance and important habitats for aquatic wildlife. We used a mixed-methods approach to

gather data on these conflicts, including questionnaires, face-to-face interviews, focus group discussions, and participant observation. The research participants involved national parks officials, fishing camp residents, and HWC victims. Our research confirmed that crocodiles and hippos have negatively affected humans through deaths, injuries, instilling fear, and destruction of sources of livelihood for fishermen such as fishing nets and boats. In retaliation, humans have implemented lethal methods to remove problem animals. The results of this research can inform the conservation community about the severity of the conflicts, which have been exacerbated by current economic hardships, to better inform conservation policies.

Utete, B. (2021). A review of the conservation status ofthe Nile crocodile (*Crocodylus niloticus* Laurenti, 1768) in aquatic systems of Zimbabwe. Global Ecology and Conservation (doi:https://doi.org/10.1016/j.gecco.2021.e01743).

Abstract: Nile crocodile survival is threatened by water pollution, habitat loss, extensive water abstraction for irrigation, domestic use and industrial development and overexploitation of fisheries resources in water systems in Zimbabwe. This review assessed the abundance, distribution and population trends of Nile crocodiles (*Crocodylus niloticus* Laurent, 1768), and explored the effects of ranching, trophy hunting and human-crocodile conflicts (HCC) on its conservation status in water systems of Zimbabwe. Scoping reviews of available literature and analysis of recurrent themes indicated that crocodile censuses were concentrated in the warmer northern and southern parts of the country. Ranching and trophy hunting have contributed to the increases in crocodile populations. Human encroachment and wetland degradation have increased HCC in fringe communities proximate to protected areas consequently inducing negative perceptions and hurt-rage which threatens crocodile populations. Overall, there is an increase in crocodile populations in sampled areas. Nonetheless, there is a need to assess the abundance, distribution and population trends, and delineate hotspots of suitable habitats and contextual challenges in less sampled areas before stating the national crocodile population estimate. Implementing astute crocodile conservation efforts involving locals is key in HCC mitigation. However, it implores the need for development of pro human-crocodile co-existence and circumstantial HCC resolution policies. For posterity, the conservation status of crocodiles in Zimbabwe should be ascribed as Vulnerable or Near Threatened rather than the current Least Concern or Low Risk status.

Poelmann, R., Gittenberger-de Groot, A.C., Goerdajal, C., Grewal, N., de Bakker, M.A. and Richardson, M.K. (2021). Ventricular septation and outflow tract development in crocodilians result in two aortas with bicuspid semilunar valves. Preprints 2021 (doi:10.20944/preprints202108.0157.v1).

Abstract: The outflow tract of crocodilians resembles that of birds and mammals as ventricular septation is complete. The arterial anatomy however, presents with a pulmonary trunk originating from the right ventricular cavum, and two aortae originating from either the right or left ventricular cavum. Mixing of blood in crocodilians cannot occur at ventricular level as in other reptiles, but instead takes place at aortic root level by a shunt, the Foramen of Panizza, the opening of which is guarded by two facing semilunar leaflets of both bicuspid aortic valves. Developmental stages of *Alligator mississipiensis*, *Crocodylus niloticus* and *Caiman latirostris*, have been studied. The outflow tract septation complex can be divided into 2 components. The aorto-pulmonary septum divides the pulmonary trunk from both aortae, whereas the interaortic septum divides the systemic from the visceral aorta. Neural crest cells are most likely involved in the formation of both components. Remodeling of the endocardial cushions and both septa results in the formation of bicuspid valves in all three arterial trunks. The foramen of Panizza originates intracardially as a channel in the septal endocardial cushion.

Timurovic, K.I. (2021). Anatomy and evolution of the braincase of crocodylians (Archosauria: Crocodylia). Thesis, Saint Petersburg State University, Russia. (In Russian).

Cronin, M.R., Alonzo, S.H., Adamczak, S.K., Baker, D.N., Beltran, R.S., Borker, A.L., Favilla, A.B., Gatins, R., Goetz, L.C., Hack, N., Harenčár, J.G., Howard, E.A., Kustra, M.C., Maguiña, R., Martinez-Estevez, L., Mehta, R.S., Parker, I.M., Reid, K., Roberts, M.B., Shirazi, S.B., Tatom-Naecker, T.M., Voss, K.M., Willis-Norton, E., Vadakan, B., Valenzuela-Toro, A.M. and Zavaleta, E.S. (2021). Anti-racist interventions to transform ecology, evolution and conservation biology departments. Nature Ecology & Evolution (https://doi.org/10.1038/s41559-021-01522-z).

Abstract: Racial and ethnic discrimination persist in science, technology, engineering and mathematics fields, including ecology, evolu-tion and conservation biology (EECB) and related disciplines. Marginalization and oppression as a result of institutional and structural racism continue to create barriers to inclusion for Black people, Indigenous people and people of colour (BIPOC), and remnants of historic racist policies and pseudoscientific theories continue to plague these fields. Many academic EECB departments seek concrete ways to improve the climate and implement anti-racist policies in their teaching, training and research activities. We present a toolkit of evidence-based interventions for academic EECB departments to foster anti-racism in three areas: in the classroom; within research laboratories; and department wide. To spark restorative discussion and action in these areas, we summarize EECB's racist and ethnocentric histories, as well as current systemic problems that marginalize non-white groups. Finally, we present ways that EECB departments can collectively address shortcomings in equity and inclusion by imple-menting anti-racism, and provide a positive model for other departments and disciplines.

Lockley, M.G., Plint, A.G., Helm, C.W., Sharman, K.J. and Vannelli, K.M. (2021). Crocodylian swim tracks from the Gates Formation (Albian), British Columbia, Canada: comparisons with Cretaceous crocodylian ichnology in western USA. Cretaceous Research (https://doi.org/10.1016/j.cretres.2021.104967).

Abstract: Numerous crocodylian swim tracks occur in the late Early Cretaceous and earliest Late Cretaceous of western North America, in coastal plain deposits marginal to the Cretaceous interior seaways. New assemblages from the lower Albian Gates Formation, within the Tumbler Ridge UNESCO Global Geopark Quintette site (TRUGG-Q) in British Columbia, Canada, resemble those from Albian-Cenomanian Dakota Sandstone sites in Colorado, Kansas and Utah, and facilitate comparative analysis of how such assemblages are registered and preserved. The Gates Formation track assemblage formed on the southwest margin of the 'Moosebar Sea' that filled the foredeep of the Western Canada Foreland Basin in the Early Albian. Northeast-prograding sandy deltas were backed by low-lying and heavily-vegetated coastal plains, inhabited by track-making dinosaurs, birds, and crocodylians. The base of a tidal channel-fill at the TRUGG-Q site preserves crocodylian swim traces indicating progression largely parallel to the channel axis, as also inferred for some USA sites. Swim track lengths can be categorized on a short-long spectrum which reflects swimming behavior, with short, wide toe tip traces indicating firm digging-in of toes ('punting' or 'poling' behavior), and elongate scrape marks indicating light touch-down (or substrate 'raking') by buoyant animals making intermittent contact with a subaqueous substrate. The body lengths size of crocodylian trackmakers can be calculated from rare complete 'walking' track footprints or from the widths, not lengths, in the case of 'swim' traces. The mean size of the Canadian tracks indicates individuals with body lengths in the range of ~1.0 m, with larger trackmakers up to ~4.0 m more common at the USA sites.

Gonwouo, N.L., Tchassem, A.M.F., Doherty-Bone, T.M. and Rödel,

M.O. (2021). Amphibians and reptiles of a proposed iron ore mining concession in southern Cameroon. Herpetology Notes 14: 1051-1065.

Abstract: We present a checklist of amphibian and reptile species that occur in the Ntem Iron ore mining concession in southern Cameroon, compiled as part of a broader biodiversity impact survey during a two-week herpetofaunal survey. Visual and acoustic encounter surveys were carried out during day and night, covering the entire area of mining exploration. We document the presence of 38 amphibian and 28 reptile species. The most notable observation was a 150-km southward range extension of *Didynamipus sjostedti*. Other species of conservation concern include *Conraua goliath*, *Leptodactylodon albiventris*, *L. ventrimarmoratus*, *Osteolaemus tetraspis*, *Varanus niloticus*, and *Kinixys erosa*. These and numerous other forest-dwelling species indicate the intact nature of herpetofauna forest assemblages at the study sites. Efforts to conserve the herpetofauna at these sites should focus on protecting and monitoring the intact forest corridors linking the concession to a neighbouring forest reserve, as well as plans for restoration once extraction is completed.

Yong, Z. (2021). Research on sustainable community-based conservation of the last 150 wild Yangtze alligators. International Journal of Business Anthropology 11(1): 79-86.

Abstract: Due to the cultural belief in dragon, indigenous communities living with the last 150 wild Yangtze alligators spontaneously provide alligators with physical and emotional care. Being excluded from their ecological systems by policies launched for the protected zones and nature reserves as well as by outside intruders, indigenous residents always find themselves victims of conservation projects. This article articulates feasibility of community-based conservation of endangered species by describing the efforts both the communities and Government have put in to protect the Yangtze alligators in Anhui Province, China. It attempts to propose re-examination of relevant government policies and sustainable commercial practices.

Sandmaier, S.E.S., Shepard, T., Reeves, A., Bohr, K., Krebs, J. and Herrick, J.R. (2021). Characterisation of sperm production and morphology in the male Philippine crocodile *Crocodylus mindorensis* via voluntary behavioural training. Reproduction, Fertility and Development (doi: 10.1071/RD21016).

Abstract: Philippine crocodiles *Crocodylus mindorensis* are critically endangered due to agricultural and fishing threats that have severely fragmented their habitat and population in the Philippines. Captive management plans are important to safeguard against their extinction, but the current population in US zoos is small, and breeding is hampered by the slow growth of this species and the danger of introducing differently sized animals for breeding. There is little information regarding the sperm characteristics of crocodilians, and none for Philippine crocodiles. In this study, we sought to characterise sperm production in the male Philippine crocodile (n= 1) by performing voluntary (without sedation or restraint) collections (n= 181) over a 3.5-year period. Peak sperm production in this individual occurs from January to July, when the mean (± s.e.m.) total number of spermatozoa recovered was $10.2\times10^6 \pm 3.8\times10^6$ (n= 104), compared with $0.3\times10^6 \pm 0.2\times10^6$ (n= 71) for all other months of the year. Analysis of sperm morphology indicated that 15.9% of spermatozoa exhibited normal morphology. A bent tail was the most common abnormality (48.2%) observed. Understanding the basic reproductive biology of the male Philippine crocodile will facilitate the development of artificial reproductive technologies to improve captive propagation and genetic management of this species.

Challender, D.W.S., Brockington, D., Hinsley, A., Hoffmann, M., Kolby, J.E., Massé, F., Natusch, D.J.D., Oldfield, T.E.E., Outhwaite, W., 't Sas-Rolfes, M. and Milner-Gulland, E.J. (2021). Mischaracterizing wildlife trade and its impacts may mislead policy processes. Conservation Letters (https://doi.org/10.1111/conl.12832).

Abstract: Overexploitation is a key driver of biodiversity loss but the relationship between the use and trade of species and conservation outcomes is not always straightforward. Accurately characterizing wildlife trade and understanding the impact it has on wildlife populations are therefore critical to evaluating the potential threat trade poses to species and informing local to international policy responses. However, a review of recent research that uses wildlife and trade-related databases to investigate these topics highlights three relatively widespread issues: (1) mischaracterization of the threat that trade poses to certain species or groups, (2) misinterpretation of wildlife trade data (and illegal trade data in particular), resulting in the mischaracterization of trade, and (3) misrepresentation of international policy processes and instruments. This is concerning because these studies may unwittingly misinform policymaking to the detriment of conservation, for example by undermining positive outcomes for species and people along wildlife supply chains. Moreover, these issues demonstrate flaws in the peer-review process. As wildlife trade articles published in peer-reviewed journals can be highly influential, we propose ways for authors, journal editors, database managers, and policymakers to identify, understand, and avoid these issues as we all work towards more sustainable futures.

Rio, J. and Mannion, P. (2021). Phylogenetic analysis of a new morphological dataset elucidates the evolutionary history of Crocodylia and resolves the long-standing gharial problem. PeerJ (https://spiral.imperial.ac.uk/handle/10044/1/87574).

Abstract: First appearing in the latest Cretaceous, Crocodylia is a clade of mostly semi-aquatic, predatory reptiles, defined by the last common ancestor of extant alligators, caimans, crocodiles and gharials. Despite large strides in resolving extant and fossil crocodylian interrelationships over the last three decades, several outstanding problems persist in crocodylian systematics. Most notably, there has been persistent discordance between morphological and molecular datasets surrounding the affinities of the extant gharials, *Gavialis gangeticus* and *Tomistoma schlegelii*. Whereas molecular data consistently support asister relationship between the extant gharials, which appear to be more closely related to crocodylids than to alligatorids, morphological data indicate that *Gavialis* is the sister taxon to all other extant crocodylians. Here we present a new morphological dataset for Crocodylia, based on a critical re-appraisal of published crocodylian character data matrices and extensive first-hand observations of a global sample of crocodylians. This comprises the most taxonomically comprehensive crocodylian dataset to date (144 OTUs scored for 330 characters) and includes a new, illustrated character list with modifications to the construction and scoring of characters, and 46 novel characters. Under a maximum parsimony framework, our analyses recover *Gavialis* as more closely related to *Tomistoma* than to other extant crocodylians for the first time based on morphology alone. This result is recovered regardless of the weighting strategy and treatment of quantitative characters. However, analyses using continuous characters and extended implied weighting (with a high k value) produced optimal topologies overall. Resolution of the gharial problem reveals that: (1) several gavialoids lack plesiomorphic features that formerly drew them towards the stem of Crocodylia, and (2) more widespread similarities occur between species traditionally divided into tomistomines and gavialoids, with these interpreted here as homology rather than homoplasy. There remains significant temporal incongruence regarding the divergence timing of the extant gharials, indicating that several putative gavialids ('thoracosaurs') are incorrectly placed and require future re-appraisal. New alligatoroid interrelationships include: (1) support for a North American origin of Caimaninae in the latest Cretaceous; (2) the recovery of the early Paleogene South American taxon *Eocaimanas* a 'basal' alligatoroid; and (3) the paraphyly of

the Cenozoic European taxon *Diplocynodon*. Among crocodyloids, notable results include modifications to the taxonomic content of Mekosuchinae, including biogeographic affinities of this clade with latest Cretaceous-early Paleogene Asian crocodyloids. In light of our new results, we provide a comprehensive review of the evolutionary and biogeographic history of Crocodylia, which included multiple instances of trans-oceanic and continental dispersal.

Dayananda, B., Bezeng Bezeng, S., Karunarathna, S. and Jeffree, R.A. (2021). Climate change impacts on tropical reptiles: Likely effects and future research needs based on Sri Lankan perspectives. Frontiers in Ecology and Evolution 9: 688723.

Abstract: The tropical island nation of Sri Lanka has a rich terrestrial and aquatic reptilian fauna. However, like most other tropical countries, the threat of climate change to its reptile diversity has not been adequately addressed, in order to manage and mitigate the extinction threats that climate change poses. To address this shortfall, a review of the international literature regarding climate change impacts on reptiles was undertaken with specific reference to national requirements, focusing on predicted changes in air temperature, rainfall, water temperature, and sea level. This global information base was then used to specify a national program of research and environmental management for tropical countries, which is urgently needed to address the shortcomings in policyrelevant data, its availability and access so that the risks of extinction to reptiles can be clarified and mitigated. Specifically, after highlighting how climate change affects the various eco-physiological features of reptiles, we propose research gaps and various recommendations to address them. It is envisaged that these assessments will also be relevant to the conservation of reptilian biodiversity in other countries with tropical and subtropical climatic regimes.

Shan, H.Y., Wu, X.C., Sato, T., Cheng, Y.N. and Rufolo, S. (2021). A new alligatoroid (Eusuchia, Crocodylia) from the Eocene of China and its implications for the relationships of Orientalosuchina. Journal of Paleontology (doi: https://doi.org/10.1017/jpa.2021.69).

Abstract: A new crocodylian, *Dongnanosuchus hsui* n. gen. n. sp., is described mainly based on four well-preserved skulls from the Eocene Youganwo Formation of the Maoming Basin, southeastern China. It is an alligatoroid and phylogenetically nested within the Orientalosuchina. *Dongnanosuchus hsui* differs from all other orientalosuchines primarily in certain features of the skull: (1) a preorbital ridge connects posteriorly with the dorsal orbital rim and a ridge around the anteroventral margin of the orbit, (2) the palatine is short and does not reach the posterior border of the suborbital fenestra, (3) the external mandibular fenestra is closed, and (4) the splenial joins the formation of the mandibular symphysis. The discovery of *Dongnanosuchus hsui* confirms the monophyly and North American origin of the Orientalosuchina but suggests that the clade dispersed to Asia via Beringia after diverging from the mainline rather than a sub-lineage of the Alligatoroidea in the Late Cretaceous.

Williams, D.R., Balmford, A. and Wilcove, D.S. (2021). The past and future role of conservation science in saving biodiversity. Conservation Letters (doi: 10.1111/conl.12720).

Abstract: Global biodiversity losses continue despite tremendous growth in the volume of conservation science and many local successes. Research that can achieve conservation science's aims - arresting declines in biodiversity and preventing extinctions - is therefore of ever greater importance. Here, we ask whether conservation science, as currently performed, is progressing in such a way as to maximize its impact. We present a simple framework for how effective conservation research could progress, from identifying problems to diagnosing their proximate and ultimate causes, and from proposing, to designing, implementing, and testing responses. We then demonstrate that for three well-known examples - South Asian vultures, whooping cranes, and bycatch of procellariform seabirds - published studies appear to follow this sequence, with considerable benefits. However, for a representative sample of the wider conservation literature, we find no evidence of such a progression. Instead, the vast majority of papers remain focused on describing the state of nature or on mechanisms directly causing changes, with very little research on designing or implementing conservation responses. This lack of research on the sorts of questions that might most help conservation science deliver its stated mission strongly suggests we will struggle to translate the huge increase in research activity into real-world benefits.

Subramaniam, K., Wong Yi-Li, G., Krishnan, V., Sock Yi, I.C. and bin Mohd Amran, M.A. (2021). Crocodile attack injuries: A failed attempt to conceal homicide. Academic Forensic Pathology (https://doi.org/10.1177/19253621211033472).

Abstract: Crocodile attacks are not uncommon in this region. There have been 92 cases reported since 2015 and 50 cases alone reported in Sarawak. Every year death has been attributed to a crocodile attack. An estimate of 71% of the total cases of crocodile attack ended up dead. However, there are instances where a crocodile attack happened after the death of a person. This is a case of an adult male who was reported missing. His body was found by two local anglers, being mauled by crocodiles. Only partial trunk and lower limbs were found, and the major organs were absent. The postmortem features of the crocodile attacks have been described.

Lien, A.M., Conix, S., Zachos, F.E., Christidis, L., van Dijk, P.P., Bánki, O.S., Barik, S.K., Buckeridge, J.S., Costello, M.J., Hobern, D., Montgomery, N., Nikolaeva, S., Pyle, R.L., Thiele, K., Thomson, S.A., Zhang, Z.Q. and Garnett, S.T. (2021). Towards a global list of accepted species IV: Overcoming fragmentation in the governance of taxonomic lists. Organisms Diversity & Evolution (https://doi.org/10.1007/s13127-021-00499-8).

Abstract: Governance is the act of governing or organizing, that is a system of rules, norms, or shared strategies to guide or regulate the actions of the governed. Since the initial development of Linnaean taxonomy, a diversity of approaches have been adopted for critical taxonomic decisions, introducing pluralism to taxonomic principles and resulting in disagreements about the development of species lists. These disagreements are in part a product of the fragmented governance structure that has developed for the creation of taxonomic lists. To address these challenges and achieve the goal of a single, accepted list of life on Earth, a new governance structure for the development of taxonomic lists is needed. Here, we introduce three high-level categories of governance structure - fragmentation, monocentric governance, and polycentric governance - which differ in the way decision-making power is distributed and coordinated. We then show the problems caused by the fragmented governance structure currently in place for the development of taxonomic lists and consider the potential for a new approach grounded in either monocentric or polycentric governance. Both monocentric and polycentric approaches have the potential to address the problems inherent in the existing fragmented system. Ultimately, the best governance system for taxonomic lists will be the one that the taxonomic community is prepared to accept.

Pascual, U., Adams, W.M., Díaz, S., Lele, S., Mace, G.M. and Turnhout, E. (2021). Biodiversity and the challenge of pluralism. Nature Sustainability (https://doi.org/10.1038/s41893-021-00694-7).

Abstract: The lack of progress in reversing the declining global trend in biodiversity is partly due to a mismatch between how living nature is conceived and valued by the conservation movement on the one hand, and by many different people, including marginalized

communities, on the other. Addressing this problem calls for a pluralistic perspective on biodiversity. This requires consideration of the use of the concept of biodiversity, willingness to expand its ambit, and engagement with the multiple and multi-level drivers of change. We propose ways for conservation science, policy and practice to deliver more effective and socially just conservation outcomes.

Williams, C., Kirby, A., Marghoub, A., Kéver, L., Ostashevskaya-Gohstand, S., Bertazzo, S., Moazen, M., Abzhanov, A., Herrel, A., Evans, S.E. and Vickaryous, M. (2021). A review of the osteoderms of lizards (Reptilia: Squamata). Biological Reviews of the Cambridge Philosophical Society (doi: 10.1111/brv.12788).

Abstract: Osteoderms are mineralised structures consisting mainly of calcium phosphate and collagen. They form directly within the skin, with or without physical contact with the skeleton. Osteoderms, in some form, may be primitive for tetrapods as a whole, and are found in representatives of most major living lineages including turtles, crocodilians, lizards, armadillos, and some frogs, as well as extinct taxa ranging from early tetrapods to dinosaurs. However, their distribution in time and space raises questions about their evolution and homology in individual groups. Among lizards and their relatives, osteoderms may be completely absent; present only on the head or dorsum; or present all over the body in one of several arrangements, including non-overlapping mineralised clusters, a continuous covering of overlapping plates, or as spicular mineralisations that thicken with age. This diversity makes lizards an excellent focal group in which to study osteoderm structure, function, development and evolution. In the past, the focus of researchers was primarily on the histological structure and/or the gross anatomy of individual osteoderms in a limited sample of taxa. Those studies demonstrated that lizard osteoderms are sometimes two-layered structures, with a vitreous, avascular layer just below the epidermis and a deeper internal layer with abundant collagen within the deep dermis. However, there is considerable variation on this model, in terms of the arrangement of collagen fibres, presence of extra tissues, and/or a cancellous bone core bordered by cortices. Moreover, there is a lack of consensus on the contribution, if any, of osteoblasts in osteoderm development, despite research describing patterns of resorption and replacement that would suggest both osteoclast and osteoblast involvement. Key to this is information on development, but our understanding of the genetic and skeletogenic processes involved in osteoderm development and patterning remains minimal. The most common proposition for the presence of osteoderms is that they provide a protective armour. However, the large morphological and distributional diversity in lizard osteoderms raises the possibility that they may have other roles such as biomechanical reinforcement in response to ecological or functional constraints. If lizard osteoderms are primarily for defence, whether against predators or conspecifics, then this 'bony armour' might be predicted to have different structural and/or mechanical properties compared to other hard tissues (generally intended for support and locomotion). The cellular and biomineralisation mechanisms by which osteoderms are formed could also be different from those of other hard tissues, as reflected in their material composition and nanostructure. Material properties, especially the combination of malleability and resistance to impact, are of interest to the biomimetics and bioinspired material communities in the development of protective clothing and body armour. Currently, the literature on osteoderms is patchy and is distributed across a wide range of journals. Herein we present a synthesis of current knowledge on lizard osteoderm evolution and distribution, micro- and macrostructure, development, and function, with a view to stimulating further work.

Campos, Z., Muniz, F., Magnusson, W.E. and Mourão, G. (2021). Effects of the Belo Monte hydro-electric-dam complex on crocodilians in the Xingu River, Brazilian Amazonia. Amphibia-Reptilia (doi: https://doi.org/10.1163/15685381-bja10064).

Abstract: The Belo Monte hydroelectric dam on the Xingu River has the third largest generating capacity of any hydroelectric dam in the world. We conducted surveys of crocodilians (*Caiman crocodilus*, *Paleosuchus trigonatus*) by boat in the Xingu River at the site of the dam prior to (2013-2015), and after filling (2016-2017). While the number of *C. crocodilus* sighted decreased with increasing water level, there was no difference in numbers prior to, and after reservoir filling. The number of *P. trigonatus* was unaffected by both water level prior to and after reservoir filling. Reservoir filling had little effect on the number of crocodilians using the forest around the Xingu River reservoir. Most crocodilians seen in forest surveys were *P. trigonatus*, both before and after reservoir filling, but *C. crocodilus* was recorded occasionally in the forest. It seems that most Amazonian crocodilians are sufficiently generalist to adapt to the new conditions created by the construction of dams, at least in the short-term. However, there may be long-term collateral effects on crocodilian populations from dams, due to as deforestation and improved access for hunters.

Joventino Roberto, I., Fedler, M.T., Hrbek, T., Farias, I.P. and Blackburn, D.C. (2021). The taxonomic status of Florida caiman: A molecular reappraisal. Journal of Herpetology 55(3): 279-284.

Abstract: The state of Florida has the world's highest diversity of established nonnative reptiles, including snakes, lizards, turtles, and crocodilians, most of them introduced from the pet trade. The Spectacled Caiman (*Caiman crocodilus*) is the only nonnative crocodilian established in Florida, with the earliest date of introduction in 1950. Despite its likely origin being Colombia, the taxonomic identity of the subspecies occurring in Florida remains unknown. We report the first study that resolves the taxonomic status of the population of *Ca. crocodilus* in Florida based on molecular analysis of samples collected from the 1970s to 2013. We also investigate the probable origin of this population as well as the specimens of the Dwarf Caimans, *Paleosuchus palpebrosus* and *Paleosuchus trigonatus*, which have been collected in Florida. We identified only one lineage of *Ca. crocodilus* in Florida, corresponding to *Caiman crocodilus fuscus*, and our results indicate the Magdalena River basin in Colombia as the most likely area of origin. We also correct the identification of *Paleosuchus* recorded in Florida and identify the Guiana Shield, and specifically Guyana, as the most likely region from which these specimens were introduced.

Milàn, J., Mateus, O., Mau, M., Rudra, A., Sanei, H. and Clemmensen, L.B. (2021). A possible phytosaurian (Archosauria, Pseudosuchia) coprolite from the Late Triassic Fleming Fjord Group of Jameson Land, central East Greenland. Bulletin of the Geological Society of Denmark 69: 71-80.

Abstract: A large, well-preserved vertebrate coprolite was found in a lacustrine sediment in the Malmros Klint Formation of the Late Triassic Fleming Fjord Group in the Jameson Land Basin, central East Greenland. The size and internal and external morphology of the coprolite is consistent with that of crocodilian coprolites and one end of the coprolite exhibits evidence of post-egestion trampling. As the associated vertebrate fauna of the Fleming Fjord Group contains abundant remains of pseudosuchian phytosaurs, the coprolite is interpreted as being from a large phytosaur.

Rodrigues, G.D., Blodorn, E., Zafalon-Silva, A., Domingues, W., Marques, R., Krolow, T.K., Greif, G., Campos, V.F. and Krüger, R.F. (2021). Molecular detection of *Trypanosoma kaiowa* in *Tabanus triangulum* (Diptera: Tabanidae) from the coastal plain of Rio Grande do Sul, southern Brazil. Acta Parasitologica (https://doi.org/10.1007/s11686-021-00440-1).

Abstract: The species of the genus *Trypanosoma* are carried and transmitted by horseflies parasitizing a high diversity of vertebrates. In the Coastal Plain of Rio Grande do Sul, southern Brazil,

Tabanus triangulum is the most abundant species and, similarly to the other species of horseflies, there is little knowledge about its vector competence. Therefore, this study aimed to screen the field-collected *T. triangulum* for the presence of *Trypanosoma*, to estimate infectivity. Horseflies were sampled by the Malaise trap in the forest fragments at the coastal plain and DNA was extracted from whole body flies. The Polymerase Chain Reaction was performed. Horseflies presented amplification of 18S ribosomal gene-specific of *Trypanosoma* species. DNA sequencing and phylogenetic analysis positioned the strains in the Kaiowa clade with *Trypanosoma kaiowa*, associated with the crocodilian clade of *Trypanosoma*. This study represents the first report of the presence of the *Tr. kaiowa* in *T. triangulum* and the expansion of the parasite's range further south in South America.

Shanker, K. and Oommen, M.A. (2021). The authoritarian biologist reloaded and deep ecology redux: Conservation imperialism and the control of knowledge, money and space. Pp. 37-54 *in* A Functioning Anarchy?: Essays for Ramachandra Guha, ed. by S. Raghavan and N. Sundar. Penguin Random House India Private Limited: India.

Walter, J., Darlim, G., Massonne, T., Aase, A., Frey, E. and Rabi, M. (2021). On the origin of Caimaninae: Insights from new fossils of *Tsoabichi greenriverensis* and a review of the evidence. Historical Biology (https://doi.org/10.1080/08912963.2021.1938563).

Abstract: An incomplete fossil record and unstable phylogenies of extinct taxa hamper reconstructing the early evolution of Caimaninae. We describe previously unpublished articulated fossils of a key species, *Tsoabichi greenriverensis* from the early Eocene Green River Formation of North America, exhibiting further character evidence for the caimanine affinities of this taxon. Parsimony analysis of modified morphological taxon-character datasets coupled with a critical review of character evolution and published phylogenies reveals that fossil evidence for Palaeogene crown group and Late Cretaceous total-group representatives is unreliable due to uncertain character evolution in early Alligatoridae. The earliest unambiguous fossil age for total and crown-group Caimaninae are 63.5 Ma and 18.06 Ma, respectively. These calibration points follow best practices and are vital for better constrained estimates of time calibrated analyses. Phylogeny continues to imply two separate Caimaninae dispersals between North and South America, but instead of a northward back-dispersal, we find two Palaeogene dispersals to South America an equally likely hypothesis. Miocene taxa of Central America previously assigned to the stem lineage ancestral to South American Caimaninae are reinterpreted as part of a Neogene northward expansion of the crown group.

Fungfuang, W., Parunyakul, K., Srisuksai, K., Santativongchai, P., Pongchairerk, U., Ampawong, S. and Tulayakul, P. (2021). The effect of crocodile (*Crocodylus siamensis*) oil on hepatic energy homeostasis mechanism and mitochondrial function in rats. Research Square (doi: https://doi.org/10.21203/rs.3.rs-816046/v1).

Abstract: Fatty acid (FA) consumption can alter hepatic energy metabolism and liver mitochondrial functions. Crocodile oil (CO) is rich in both mono- and polyunsaturated fatty acids that contain natural anti-inflammatory and healing properties. We investigated the effect of CO on energy metabolism and mitochondrial morphology in rat liver. Twenty-one male Sprague-Dawley rats were randomly divided into three groups. Group 1: rats treated with sterile water (RO); group 2: rats treated with CO (3% v/w); and group 3: rats treated with palm oil (PO) (3% v/w). Rats were orally administered sterile water, CO, and PO once daily for 7 weeks. Body weight, food intake, liver weight, energy intake, blood lipid profiles, and liver-targeted metabolites were evaluated. Histopathological study of the liver, mitochondrial architecture of liver cell, and HDHD3 protein expression in liver mitochondria were determined. CO treatment had no effect on body weight, liver weight, liver index, dietary energy intake, and serum lipid profiles. The CO group exhibited significantly lower food intake than the RO group. The CO group also showed significantly higher oxaloacetate and malate levels, which encourage the TCA cycle imbalance, than the PO group. CO treatment significantly ameliorated hepatic steatosis as shown by a greater decrease of total surface area of lipid particles than that seen with PO treatment. CO administration maintained the liver's mitochondrial morphology by upregulating the energetic maintenance protein - HDHD3. Moreover, the chemical-protein interaction also showed that the main fatty acid composition of CO preserved liver metabolism via the AMPK signaling pathway. Crocodile oil could support hepatic function through promoting the TCA cycle, maintaining hepatic mitochondrial architecture, and upregulating HDHD3.

Vovin, A. (2021).Names of large exotic animals and the Urheimat of Japonic. International Journal of Eurasian Linguistics 3(1) (doi: https://doi.org/10.1163/25898833-12340043).

Abstract: This article argues that three words designating large tropical animals not endemic for Japan: kisa 'elephant', tora 'tiger', and wani 'saltwater crocodile' were borrowed into Japonic from Austroasiatic or Kradai languages. If so, this becomes another important piece of evidence for locating the Urheimat of the Japonic Language family in Southern China and/or Northern South-East Asia driving yet another nail into the coffin of the 'Altaic' theory. Since all these words are disyllabic, they also contribute to the reconstruction of the disyllabic words in Austroasiatic and Kradai. This is especially important in the case of Kradai, where in spite of the rather recent fall of the monosyllabic curtain, the idea about the 'primordial' nature of the monosyllabic structure is still enjoying considerable support.

Lara, R.B., Grajales, J.G. and Ramírez, E.M. (2021). Nest temperature assessment in an American crocodile (*Crocodylus acutus*) population on the central coast of Oaxaca, Mexico. Journal of Thermal Biology (doi: 10.1016/j.jtherbio.2021.103012).

Abstract: The temperatures at which eggs of crocodilians are incubated plays an important role in embryo survival, rate of embryonic development and sex definition. The aim of this study was to assess the nest temperatures of an American crocodile (*Crocodylus acutus*) population on the central coast of Oaxaca state in Mexico. The fieldwork was carried out from February to June 2018 at Palmasola Lagoon, Oaxaca. Ten natural nests of *C. acutus* were carefully excavated to determine clutch size. When putting the eggs back in the nests, we placed a data logger in the center of the egg mass to determine the temperature parameters in the nest chamber environment, as well as the variation in temperature during the incubation period. All nests were revisited to count the number of hatched eggs (NHE) and to determine the hatching success (HS), along with the duration of the incubation period (IP). Hatching success was 89.04%. The mean clutch size in the American crocodile nests was 30.7 ± 7.83 eggs (ranging from 17 to 46 eggs), and the mean incubation period was 77.6 ± 5.89 days. The mean nest incubation temperature throughout the reproductive season was significantly different among nests. Based on the average temperature during the middle third of the incubation period, the nests should have produced both sexes, but with a higher proportion of males. This study tried to elucidate the impact of nest temperatures during the incubation period on embryo survival, as well as hatchling sex ratio in a local climate on the central coast of Oaxaca.

Achatz, T.J., Brito, E.S., Fecchio, A. and Tkach, V.V. (2021). Description and phylogenetic position of a new species of *Herpetodiplostomum* from *Phrynops geoffroanus* in Brazil and a reevaluation of *Cheloniodiplostomum*. Journal of Parasitology 107(3): 455-462.

Abstract: As presently recognized, *Herpetodiplostomum* is a small genus of proterodiplostomid digeneans parasitic in crocodilians. Most members of *Cheloniodiplostomum*, a genus of proterodiplostomids that parasitize chelonians, were originally placed within *Herpetodiplostomum*. The 2 genera were distinguished based on the presence/absence of papillae on the holdfast organ and anterior extent of vitellarium. Our study of *Herpetodiplostomum* and *Cheloniodiplostomum* revealed a lack of consistent morphological differences between the genera. Therefore, we consider *Cheloniodiplostomum* to be a junior synonym of *Herpetodiplostomum*. Recent molecular phylogenetic studies included a number of proterodiplostomid taxa; however, DNA sequence data are not available for any *Herpetodiplostomum* or *Cheloniodiplostomum* species. Herein, we describe a new *Herpetodiplostomum* species from Geoffroy's side-necked turtle *Phrynops geoffroanus* from Mato Grosso State, Brazil. The new species can be distinguished from other *Herpetodiplostomum* species based on the distribution of vitellarium, level of development of holdfast papillae, and ratio of prosoma:opisthosoma width, among other characters. We provide the first molecular phylogeny of the Proterodiplostomidae that includes a *Herpetodiplostomum* species. The limited geographic distribution of *Herpetodiplostomum* spp. within the geographic ranges of caimans suggests a secondary host switching event from crocodilians to chelonian definitive hosts in the evolution of *Herpetodiplostomum*.

Lawson, L. and Rollinson, N. (2021). A simple model for the evolution of temperature-dependent sex determination explains the temperature sensitivity of embryonic mortality in imperiled reptiles. Conservation Physiology 9(1) (doi: 10.1093/conphys/coab020).

Abstract: A common reptile conservation strategy involves artificial incubation of embryos and release of hatchlings or juveniles into wild populations. Temperature-dependent sex determination (TSD) occurs in most chelonians, permitting conservation managers to bias sex ratios towards females by incubating embryos at high temperatures, ultimately allowing the introduction of more egg-bearing individuals into populations. Here, we revisit classic sex allocation theory and hypothesize that TSD evolved in some reptile groups (specifically, chelonians and crocodilians) because male fitness is more sensitive to condition (general health, vigor) than female fitness. It follows that males benefit more than females from incubation environments that confer high-quality phenotypes, and hence high-condition individuals. We predict that female-producing temperatures, which comprise relatively high incubation temperatures in chelonians and crocodilians, are relatively stressful for embryos and subsequent life stages. We synthesize data from 28 studies to investigate how constant temperature incubation affects embryonic mortality in chelonians with TSD. We find several lines of evidence suggesting that warm, female-producing temperatures are more stressful than cool, male-producing temperatures. Further, we find some evidence that pivotal temperatures (TPiv, the temperature that produces a 1:1 sex ratio) may exhibit a correlated evolution with embryonic thermal tolerance. If patterns of temperature-sensitive embryonic mortality are also indicative of chronic thermal stress that occurs post-hatching, then conservation programs may benefit from incubating eggs close to species-specific TPivs, thus avoiding high-temperature incubation. Indeed, our models predict that, on average, a sex ratio of >75% females can generally be achieved by incubating eggs only 1°C above TPiv. Of equal importance, we provide insight into the enigmatic evolution of TSD in chelonians, by providing support to the hypothesis that TSD evolution is related to the quality of the phenotype conferred by incubation temperature, with males produced in high-quality incubation environments.

Bestwick, J., Unwin, D.M., Henderson, D.M. and Purnell, M.A. (2021). Dental microwear texture analysis along reptile tooth rows: complex variation with non-dietary variables. Royal Society Open Science 8(2): 201754.

Abstract: Dental microwear texture analysis (DMTA) is a powerful technique for reconstructing the diets of extant and extinct taxa. Few studies have investigated intraspecific microwear differences along with tooth rows and the influence of endogenous non-dietary variables on texture characteristics. Sampling teeth that are minimally affected by non-dietary variables is vital for robust dietary reconstructions, especially for taxa with non-occlusal (non-chewing) dentitions as no standardized sampling strategies currently exist. Here, we apply DMTA to 13 species of extant reptile (crocodilians and monitor lizards) to investigate intraspecific microwear differences along with tooth rows and to explore the influence of three non-dietary variables on exhibited differences: (i) tooth position, (ii) mechanical advantage, and (iii) tooth aspect ratio. Five species exhibited intraspecific microwear differences. In several crocodilians, the distally positioned teeth exhibited the 'roughest' textures, and texture characteristics correlated with all non-dietary variables. By contrast, the mesial teeth of the roughneck monitor (*Varanus rudicollis*) exhibited the 'roughest' textures, and texture characteristics did not correlate with aspect ratio. These results are somewhat consistent with how reptiles preferentially use their teeth during feeding. We argue that DMTA has the potential to track mechanical and behavioural differences in tooth use which should be taken into consideration in future dietary reconstructions.

D'Alba, L., Goldenberg, J., Nallapaneni, A., Parkinson, D.Y., Zhu, C., Vanthournout, B. and Shawkey, M.D. (2021). Evolution of eggshell structure in relation to nesting ecology in non-avian reptiles. Journal of Morphology 282(7): 1066-1079.

Abstract: Amniotic eggs are multifunctional structures that enabled early tetrapods to colonize the land millions of years ago, and are now the reproductive mode of over 70% of all terrestrial amniotes. Eggshell morphology is at the core of animal survival, mediating the interactions between embryos and their environment, and has evolved into a massive diversity of forms and functions in modern reptiles. These functions are critical to embryonic survival and may serve as models for new antimicrobial and/or breathable membranes. However, we still lack critical data on the basic structural and functional properties of eggs, particularly of reptiles. Here, we first characterized egg shape, shell thickness, porosity, and mineralization of eggs from 91 reptile species using optical images, scanning electron microscopy, and micro computed tomography, and collected data on nesting ecology from the literature. We then used comparative analyses to test hypotheses on the selective pressures driving their evolution. We hypothesized that eggshell morphology has evolved to protect shells from physical damage and desiccation, and, in support, found a positive relationship between thickness and precipitation, and a negative relationship between porosity and temperature. Although mineralization varied extensively, it was not correlated with nesting ecology variables. Ancestral state reconstructions show thinning and increased porosity over evolutionary time in squamates, but the opposite in turtles and crocodilians. Egg shape, size, porosity and calcification were correlated, suggesting potential structural or developmental tradeoffs. This study provides new data and insights into the morphology and evolution of reptile eggs, and raises numerous questions for additional research.

Achatz, T.J., Bell, J.A., Melo, F.T.V., Fecchio, A. and Tkach, V.V. (2021). Phylogenetic position of *Sphincterodiplostomum* Dubois, 1936 (Digenea: Diplostomoidea) with description of a second species from Pantanal, Brazil. Journal of Helminthology (doi: 10.1017/S0022149X21000018).

Abstract: *Sphincterodiplostomum* is a monotypic genus of diplostomid digeneans that parasitize fish-eating birds in the neotropics. The type species *Sphincterodiplostomum musculosum* has a unique, dorsal, tubular invagination in the opisthosoma with a muscular sphincter. Whereas larvae of *S. musculosum* are relatively commonly reported in Neotropical fish helminth surveys,

adult specimens from birds are rarely collected. Prior to our study, no DNA sequence data for *S. musculosum* were available. Our molecular and morphological study of mature and immature adult *Sphincterodiplostomum* specimens from three species of birds and one species of crocodilian revealed the presence of at least two species of *Sphincterodiplostomum* in the neotropics. We provide the first molecular phylogeny of the Diplostomoidea that includes *Sphincterodiplostomum*. In addition, this is the first record of *S. musculosum* from caimans, along with the first record of fully mature adult *S. musculosum* from green kingfisher *Chloroceryle americana*. The new species of *Sphincterodiplostomum* (*Sphincterodiplostomum joaopinhoi* n. sp.) can be morphologically distinguished from *S. musculosum* based on the anterior extent of vitelline follicles, narrower prosoma, substantially smaller holdfast organ and structure of tegumental spines. Our data revealed 0.7% interspecific divergence in 28S and 10.6-11.7% divergence in cox1 sequences between the two *Sphincterodiplostomum* species.

Al-Quraishy, S., Abdel-Ghaffar, F., Dkhil, M.A. and Abdel-Gaber, R. (2021). Haemogregarines and criteria for identification. Animals (Basel) 11(1):170 (doi: 10.3390/ani11010170).

Abstract: Apicomplexa is a phylum that includes all parasitic protozoa sharing unique ultrastructural features. Haemogregarines are sophisticated apicomplexan blood parasites with an obligatory heteroxenous life cycle and haplohomophasic alternation of generations. Haemogregarines are common blood parasites of fish, amphibians, lizards, snakes, turtles, tortoises, crocodilians, birds, and mammals. Haemogregarine ultrastructure has been so far examined only for stages from the vertebrate host. PCR-based assays and the sequencing of the 18S rRNA gene are helpful methods to further characterize this parasite group. The proper classification for the haemogregarine complex is available with the criteria of generic and unique diagnosis of these parasites.

Greene, S.E., Antell, G.S., Atterby, J., Bhatia, R., Dunne, E.M., Giles, S., Groh, S.S., Hanson, E.M., Hilto, J., Knight, H., Kraftl, P., Morgan, E.1, Rhodes, I., Rockey, F.G.T., Singh, S., Stevenson, C.T., Sun, S., Warren, B.A., Wheeley, J.R. and Yamoah, K.A. (2021). Safety and belonging in the field: A checklist for educators. EarthArXiv (https://doi.org/10.31223/X53P6H).

Abstract: Ensuring taught fieldwork is a positive, generative, collective, and valuable experience for all participants requires considerations beyond course content. To guarantee safety and belonging, participants' identities (backgrounds and protected characteristics) must be considered as a part of fieldwork planning and implementation. Furthermore, getting fieldwork right is an important step in disrupting the ongoing cycle of exclusion of participants from marginalised demographics. This document aims to provide those involved in field teaching in Geography, Earth, and Environmental Sciences (GEES) disciplines with a brief overview about how identity affects experiences of taught fieldwork, as well as some general tips and a practical checklist for creating a safe learning environment for all staff, demonstrators, and students in the field.

Srikulnath, K., Ahmad, S.F., Singchat, W. and Panthum, T. (2021). Why do some vertebrates have microchromosomes? Cells 10: 2182.

Abstract: With more than 70,000 living species, vertebrates have a huge impact on the field of biology and research, including karyotype evolution. One prominent aspect of many vertebrate karyotypes is the enigmatic occurrence of tiny and often cytogenetically indistinguishable microchromosomes, which possess distinctive features compared to macrochromosomes. Why certain vertebrate species carry these microchromosomes in some lineages while others do not, and how they evolve remain open questions. New studies have shown that microchromosomes exhibit certain unique characteristics of genome structure and organization, such as high gene densities, low heterochromatin levels, and high rates of recombination. Our review focuses on recent concepts to expand current knowledge on the dynamic nature of karyotype evolution in vertebrates, raising important questions regarding the evolutionary origins and ramifications of microchromosomes. We introduce the basic karyotypic features to clarify the size, shape, and morphology of macro- and microchromosomes and report their distribution across different lineages. Finally, we characterize the mechanisms of different evolutionary forces underlying the origin and evolution of microchromosomes.

Santos-Barrera , G., García, A., Calzada-Arciniega, R.A., Pérez-Cervantes, N.C. and Pacheco-Rodríguez, J. (2021). Herpetofauna in risk of extinction: Amphibians and reptiles in Mexico, critical areas, and conservation strategies. Imperiled: The Encyclopedia of Conservation (https://doi.org/10.1016/B978-0-12-821139-7.00088-X).

Abstract: This article reviews the conservation of threatened herpetofauna of Mexico, (243 amphibian and 101 reptile species) compiled from the IUCN Red List (2020). A geographic analysis was performed to identify areas or centers of species concentration. These are considered top priority areas for Mexican amphibian and reptile conservation. Four areas were recognized for amphibians and two for reptiles (in addition to sea turtle beaches on both Pacific and Atlantic shorelines). Amphibian centers are situated essentially at the Sierra Madre del Sur from Guerrero to Chiapas, and in Veracruz mountains to the east. Reptiles centers coincides with two amphibian ones, at the mountainous regions of Guerrero and Oaxaca. The importance of the presence of Natural Protected Areas (NPAs), as well as non-protected ones for the conservation of Mexican herpetofauna is discussed. It is essential to definitively stop habitat alteration and destruction to ensure the survival of these species in the wild.

Daniel, R.W. (2021). A vestige of the Ptolemaic crocodile cult in a curse from Caesarea Maritima against a pantomime dancer. Religion in the Roman Empire 7(1): 71-77.

Abstract: A curse tablet found during excavations at the Promontory Palace in Caesarea Maritima is directed against a pantomime dancer. Noteworthy among the gods addressed is a group of crocodile gods. Their importance in the curse is underscored by the depiction of a crocodile at the lower right of the text, the only drawing on the tablet. The present article suggests that these crocodile gods are a remnant of the Ptolemaic crocodile cult, which was presumably introduced into the region when it was under Ptolemaic rule in the third century BCE.

Nalenan, J.S., Siki, F., Talan, M.R. and Wabang, R.J. (2021). Cultural ideology in woven fabric motif of Insana communities at the Indonesian-Timor Leste border. The International Journal of Language and Cultural 3(2): 57-63.

Abstract: The Insana woven pattern has a distinctive shape and arrangement. This is considered to be correlated with the socio-cultural life of Insana community. The problem discussed in this study was what cultural ideology that was contained in the Insana woven fabric pattern. This study aimed at describing the cultural ideology in the woven fabric pattern of the Insana community. This study was a qualitative descriptive study. The focus of this study was the Insana woven fabric pattern which led to the cultural ideology it carried. The results reflected that Insana woven fabric consisted of two types, namely sotis and bunak. The basic pattern generally utilized in Insana woven fabric was in the form of a rhombus. In addition to the rhombus, the weavers developed other patterns such as bei' 'crocodile' and leaf shapes. The basic colors of Insana woven fabric were black and white. In addition, other colors such as red,

yellow, and green were also added to enrich the aesthetics value of the woven fabric. The cultural ideologies behind the use of patterns on Insana woven fabrics were (1) the rhombus pattern symbolized the appreciation of the Insana community for the work of the first king, (2) the bei' pattern symbolized the Insana community's appreciation of the crocodile as an effort to commemorate the crocodile's services in the past, (3) the linking relationship between the patterns in the woven fabric symbolized the social strata of the Insana community. In addition, it illustrated that the Insana community could not live individually, but they were social human beings. Another cultural ideology shown in Insana woven fabric pattern was Insana's feudal system of government in the past

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Doss, G.A. and Sladky, K.K. (2021). CPR and euthanasia. Chapter 44. Pp. 738-745 i*n* Exotic Animal Emergency and Critical Care Medicine, ed. by J.E. Graham, G.A. Doss and H. Beaufrère. John Wiley & Sons: New York.

Abstract: Cardiopulmonary-cerebral resuscitation (CPCR) provides a means to reestablish patient spontaneous breathing and circulation. Quick assessment of the critical patient is crucial and the approach to securing an airway and intravascular access can vary depending on the species and size of the animal. Euthanasia is commonly performed in reptiles and amphibians for a variety of medical reasons. However, choosing the proper technique or chemical agents can be confusing due to the unique anatomy and physiology of herptiles. This chapter discusses how to approach CPCR in both reptiles and amphibians with tips for different species and discusses both approved and non-approved methods and agents for euthanasia in these unique pets.

Doss, G.A. and Sladky, K.K. (2021). Restraint and handling. Chapter 40. Pp. 710-715 i*n* Exotic Animal Emergency and Critical Care Medicine, ed. by J.E. Graham, G.A. Doss and H. Beaufrère. John Wiley & Sons: New York.

Abstract: Knowledge of handling and restraint techniques is essential for working with amphibian and reptile patients in order to prevent undue animal stress and, potentially, significant injury to the handler. Restraint is required for obtaining the physical examination, biologic sample collection, and/or diagnostics. This chapter provides guidance on herptile handling and restraint with specific tips for various animal groups, and discusses hospitalization and monitoring suggestions for both amphibian and reptile patients.

Doss, G.A., Mans, C. and Sladky, K.K. (2021). Analgesia, anesthesia, and monitoring. Chapter 45. Pp. 746-757 i*n* Exotic Animal Emergency and Critical Care Medicine, ed. by J.E. Graham, G.A. Doss and H. Beaufrère. John Wiley & Sons: New York.

Abstract: Knowledge of effective and safe sedation, anesthesia, and analgesia protocols is essential in order to provide the appropriate emergency care for reptile and amphibian patients. However, due to the large number of reptile and amphibian species presented to veterinarians, extrapolation is frequently performed, which may not lead to the desired results. Significant differences in anatomy, physiology, and species-specific responses to anesthetic and analgesic drugs should be considered. Therefore, to become an adept clinician, developing an understanding of anesthetic and analgesic efficacy across commonly kept reptile and amphibian species is important.

Khan, N.A., Soopramanien, M., Maciver, S.K., Anuar, T.S., Sagathevan, K. and Siddiqui, R. (2021). *Crocodylus porosus* gut bacteria: A possible source of novel metabolites. Molecules 26(16) (doi: 10.3390/molecules26164999).

Abstract: Crocodiles are remarkable animals that have the ability to endure extremely harsh conditions and can survive up to a 100 years while being exposed to noxious agents that are detrimental to Homo sapiens. Besides their immunity, we postulate that the microbial gut flora of crocodiles may produce substances with protective effects. In this study, we isolated and characterized selected bacteria colonizing the gastrointestinal tract of *Crocodylus porosus* and demonstrated their inhibitory effects against three different cancerous cell lineages. Using liquid chromatography-mass spectrometry, several molecules were identified. For the first time, we report partial analyses of crocodile's gut bacterial molecules.

Lemaire, J., Bustamante, P., Mangione, R., Marquis, O., Churlaud, C., Brault-Favrou, M., Parenteau, C. and Brischoux, F. (2021). Lead, mercury, and selenium alter physiological functions in wild caimans (*Caiman crocodilus*). Environmental Pollution (doi: 10.1016/j.envpol.2021.117549).

Abstract: Environmental contaminants affect ecosystems worldwide and have deleterious effects on biota. Non-essential mercury (Hg) and lead (Pb) concentrations are well documented in some taxa and are described to cause multiple detrimental effects on human and wildlife. Additionally, essential selenium (Se) is known to be toxic at high concentrations but, at lower concentrations, Se can protect organisms against Hg toxicity. Crocodilians are known to bioaccumulate contaminants. However, the effects of these contaminants on physiological processes remain poorly studied. In the present study, we quantified Hg, Pb and Se concentrations in spectacled caimans (*Caiman crocodilus*) and investigated the effects of these contaminants on several physiological processes linked to osmoregulatory, hepatic, endocrine and renal functions measured through blood parameters in 23 individuals. Mercury was related to disruption of osmoregulation (sodium levels), hepatic function (alkaline phosphatase levels) and endocrine processes (corticosterone levels). Lead was related to disruption of hepatic functions (glucose and alanine aminotransferase levels). Selenium was not related to any parameters, but the Se:Hg molar ratio was positively related to the Na+ and corticosterone concentrations, suggesting a potential protective effect against Hg toxicity. Overall, our results suggest that Hg and Pb alter physiological mechanisms in wild caimans and highlight the need to thoroughly investigate the consequences of trace element contamination in crocodilians.

Kouman, C.Y., Ebome, A.E.A., Ahizi, M.N., Ouattara, M., Ouattara, A., Fairet, E. and Shirley, M.H. (2021). Space use and social interactions of Central African slender-snouted crocodiles *Mecistops leptorhynchus* (Bennett, 1835) in Loango National Park, Gabon. Journal of African Ecology (https://doi.org/10.1111/aje.12887).

Abstract: *Mecistops leptorhynchus* (Bennett, 1935) is among the least studied crocodylians worldwide, and little information exists on its movement patterns and habitat use. Using VHF radio tracking, we determined home range, core use areas and spatio-temporal interactions for 30 individual *M. leptorhynchus* (14 females and 16 males), as well as providing a preliminary assessment of their habitat preferences and emergence dynamics in the Echira and Ngové Rivers, Loango National Park (Gabon). During two periods in 2010 (March to June - 106 days, and October to November - 49 days) we recorded 447 relocations of all tagged individuals (mean of 15 relocations/crocodile). Individual home range varied from 3.03 to 164.83 ha (median= 17.91 ha) and core use area from 0.25 to 25.37 ha (median= 1.50 ha). Males exhibited the largest home ranges whereas females recorded the largest core areas. Subadults covered the largest areas at both spatial scale. These difference were not statistically significant. Interestingly, *M. leptorhynchus* showed more space sharing than other crocodylian species, though with significant temporal avoidance - likely an adaptive behaviour used to reduce risks of conflict in high density environments. Our emergence assessment, though potentially confounded by transmitter placement, indicated limited basking behaviour in this species with unknown effect on its detection probability. All individuals,

irrespective of size and sex, principally used main water courses. Ultimately our findings provide the first data on *M. leptorhynchus* home range and social organisation, which may help direct targeted management strategies for this species.

Islam, A., Lijon, M.B., Hasan, M.M., Arif, A.S.M., Siddique, M.P., Hossain, M.T. and Islam, M.A. (2021). Characterization of zoonotic bacteria from captive crocodiles in Bangladesh. International Journal of Biosciences 19(2): 139-152.

Abstract: An attempt was undertaken to characterize the bacterial flora of Saltwater crocodiles (*Crocodylus porosus*) reared on a commercial farm at Valuka, Mymensingh, Bangladesh. Swab samples (n= 60) comprised oral (n= 20), nasal (n= 20) and cloacal (n= 20) swabs, collected from apparently healthy farm-raised crocodiles. Samples were cultured into various selective media to isolate bacteria. Characterization of the isolated bacteria was performed by studying the cultural, staining, biochemical properties followed by polymerase chain reaction. The antimicrobial susceptibility patterns of bacteria were investigated against eight commonly used antibiotics by the disc diffusion method. A total of 135 bacterial isolates belonged to 5 genera such as *Escherichia* (22%), *Salmonella* (22%), *Staphylococcus* (21%), *Bacillus* (16%) and *Vibrio* (19%) were identified. A genus-specific PCR targeting 16s rRNA gene successfully identified *Escherichia coli*, *Salmonella* spp. and *Staphylococcus* spp. In PCR assay, 11 of 30 (36.67%) E. coli isolates were found positive for stx1 and stx2 genes and 4 of 30 (13.33%) isolates were found positive for and hly gene. Five isolates of *Staphylococcus* spp. were found positive with nuc gene, indicating these were pathogenic strains of *Staphylococcus aureus*. Multidrug resistance profile was observed in *E. coli*, *Salmonella* spp. and *Vibrio* spp. The results of this study indicate that captive crocodiles in the farm harbor multidrug-resistant pathogenic bacteria, which may produce infection in crocodiles and might cause health problems if transmitted to a human.

Nhidza, A.Z., Gufe, C., Marumure, J., Makuvara, Z., Chisango, T., Hanyire, G.T., Jongi, G., Makaya, P.V. and Marambe, T.S. (2021). Prevalence and antibiograms of *Salmonella* in commercially produced crocodile meat in Zimbabwe. Tanzania Veterinary Journal 36(1) (doi: 10.4314/tvj.v36i1.1).

Abstract: The presence of *Salmonella* in food products and emergence of antibiotic resistance are the major challenges facing public health policies. A total of 2749 crocodile meat samples obtained from the Central Veterinary Laboratories in Zimbabwe were screened for *Salmonella* species were collected from three Zimbabwean commercial farms between the year 2012 and 2019 for a retrospective observational study to determine the prevalence and magnitude of antibiotics resistant *Salmonella* species in crocodile meat. The isolation of *Salmonella* was in accordance with the ISO 6579:2002 and the antibiotic susceptibility testing was carried out based on Clinical and Laboratory Standard Institute's recommendations by means of the Kirby-Bauer disk diffusion method. SILAB Database was used to determine the prevalence of *Salmonella* species. Prevalence was stratified by year and farms. Twenty *Salmonella* isolates were identified using biochemical tests, and 15 were confirmed by polymerase chain reaction (PCR). Antimicrobial susceptibility profiles of the confirmed *Salmonella* isolates were examined using 14 antibiotics. The overall prevalence of *Salmonella* species in crocodile meat samples was 0.5%. The prevalence of *Salmonella* species ranged from 0.04% to 0.44% in the crocodile meat samples and annual prevalence ranged from 0.01% to 1%. The highest prevalence of *Salmonella* (4.4%) was recorded in the year 2012. *Salmonella* isolates from one of the three tested farms were resistant to Erythromycin (73.33%), Ampicillin (80%), and Penicillin G (100%). Generally, *Salmonella* isolates displayed lower resistance to Cefepime, Ceftriaxone, Amikacin, Tetracycline, Ertapenem, Florfenicol, and Erythromycin (0-53.33%) whereas all *Salmonella* isolates showed susceptibility to Cefepime, Ceftriaxone, Ertapenem, and Florfenicol. Although the study indicates low prevalence of *Salmonella* species in crocodile meat, there is a need for strict implementation of Hazard Analysis Critical Control Point (HACCP) to reduce contamination rates in meat and its products.

López González, E.C., Odetti, L.M., Poletta, G.L., Denslow, N., Kroll, K.J., Siroski, P.A. and Parachú Marcó, M.V. (2021). Optimizing protocols for high-quality RNA extraction from blood and liver tissues of the Broad-snouted caiman. Russian Journal of Herpetology 28(4) (doi: https://doi.org/10.30906/1026-2296-2021-28-4-197-204).

Abstract: Transcriptomic information provides fundamental insights into biological processes and can be used to determine gene expression in cell, tissue, or organism under specific physiological conditions, or in response to any environmental perturbation. Extraction of high quality RNA is a challenging step mainly in non-traditional organisms, and protocols for preservation and isolation need to be adjusted in many cases. In the present work, we aimed to develop a protocol for preservation and isolation of high-quality and quantity of RNA from blood and liver tissues of *Caiman latirostris*. Three preservation methods were tested: 1) flash freezing (LN2) and storage at -80°C; 2) RNAlater® conservation with progressive cooling up to -80°C); 3) preservation in TRIzol® reagent, flash freezing in LN2 and storage at -80°C. Methods 1 and 2 were tested for liver, while 2 and 3 for blood. Our results showed that both preservation methods resulted in excellent outcomes for liver samples. For blood samples however, TRIzol® preservation was an efficient procedure for adequate RNA quality, quantity, and integrity, while conservation in RNAlater® solution was inadequate in both quality and quantity for an optimal RNA extraction. Appropriate protocols were established for each tissue and are being used now for transcriptomic studies in this sentinel organism.

Rummy, P., Wu, X.C., Clark, J.M., Zhao, Q., Jin, C.Z., Shibata, M., Jin, F. and Xu, X. (2021). A new paralligatorid (Crocodyliformes, Neosuchia) from the middle Cretaceous of Jilin Province, northeastern China. Cretaceous Research (https://doi.org/10.1016/j.cretres.2021.105018).

Abstract: Numerous dinosaurian, crocodyliform, and testudine fossils have been recently recovered from the middle Cretaceous of the Yanji Basin, Jilin Province, China. Among the crocodyliform remains, the specimen (YJDM 00009) described here represents a new genus and new species, *Yanjisuchus longshanensis* gen. et sp. nov. It is the third Cretaceous crocodyliform found in Jilin Province after *Paralligator sungaricus* and *Rugosuchus nonganensis*. *Y. longshanensis* is a medium-to-large neosuchian characterized mainly by the frontal with a wedge-shaped elevation anteriorly, a transversely oriented, grooved preorbital ridge, the fused dentaries, and the dentary dentition with a diastema. *Y. longshanensis* was a neosuchian and situated phylogenetically within the Paralligatoridae, with *Rugosuchus nonganensis* and many other species of *Paralligator* from Central Asia. The discovery of *Y. longshanensis* not only adds a new group to the local reptilian fauna but also is important to our understanding of the biogeography and diversity of Paralligatoridae in Asia.

Barajas-Valero, S., Rodríguez-Almonacid, C., Rojas-Sereno, Z., Moreno-Torres, C. and Matta, N.E. (2021). Hematology, biochemistry reference intervals, and morphological description of peripheral blood cells for a captive population of *Crocodylus intermedius* in Colombia. Frontiers in Veterinary Science 8: 694354 (doi: 10.3389/fvets.2021.694354).

Abstract: The Orinoco crocodile (*Crocodylus intermedius*, Graves, 1918) is the most threatened crocodilian of South America. There is only scarce information available about the physiology of this neotropical crocodile. This study aimed to propose baseline

hematological and biochemistry reference data and intervals and a morphological description of the peripheral blood cells of captive *C. intermedius*. Blood was collected from 318 clinically healthy individuals maintained in captivity at Villavicencio, Colombia. Eight of these individuals were sampled and resampled, and these data were compared. Reference intervals were proposed for hematological values [packed cell volume (PCV), red blood cell count, white blood cell count, mean corpuscular volume, mean corpuscular hemoglobin, mean corpuscular hemoglobin concentration, hemoglobin, and white blood cell count differential counts] and biochemistries [total solids, alanine aminotransferase (ALT), aspartate aminotransferase, alkaline phosphatase, lactate dehydrogenase, creatine kinase, glucose, albumin, cholesterol, uric acid, creatinine, and lactate] including adults and juveniles, males and females' crocodiles. Blood cell morphology for the species is described. Significant differences between sex and age were observed. The intraindividual analysis concluded differences for total solids ($P \leq 0.01$) and red blood cell counts ($P \leq 0.01$). Some biochemical analytes showed a moderate correlation between them, such as ALT-alkaline phosphatase and ALT-uric acid. We present here novel and baseline data with special importance for the clinical diagnosis, improving the national reintroduction programs from either *in situ* and *ex situ* populations.

Staniewicz, A., Foggett, S., McCabe, G. and Holderied, M. (2021). Courtship and underwater communication in the Sunda gharial (*Tomistoma schlegelii*). Bioacoustics (https://doi.org/10.1080/09524622.2021.1967782).

Abstract: Many threatened crocodilians are shy and difficult to observe in the wild, limiting the current knowledge of their behaviour and ecology. Although acoustic communication is commonly used by adults during courtship and territory defence, the signals produced vary between taxa. Here we provide the first classification of adult vocalisations in *Tomistoma schlegelii* - a rare gavialid inhabiting swamp forests in Southeast Asia - and describe the behaviour produced during courtship. Using video and passive underwater acoustic monitoring we recorded a breeding captive pair of *T. schlegelii* housed indoors, as well as monitored 12 captive adults kept in a semi-natural outdoor enclosure over a period of two months. Courtship behaviour during 18 recorded mating events followed that observed in other crocodilians, but acoustic signals were restricted to mating activity and were only recorded in the two animals housed indoors. We identified 7 signal types produced by *T. schlegelii*, which differed in duration, dominant frequency, and the presence of harmonic structure. These results suggest the species uses short-range, underwater acoustic signals during courtship and mating, with little vocal activity outside of those events, and provide foundation for future studies of this rare crocodilian.

Brown, C.M., Currie, P.J. and Therrien, F. (2021). Intraspecific facial bite marks in tyrannosaurids provide insight into sexual maturity and evolution of bird-like intersexual display. Paleobiology (doi: https://doi.org/10.1017/pab.2021.29).

Abstract: Intraspecific aggression, or agonism, is a widespread intrasexual selective behavior important to understanding animal behavioral ecology and reproductive systems. Such behavior can be studied either by direct observation or inferred from wound/scar frequency in extant species but is difficult to document in extinct taxa, limiting understanding of its evolution. Among extant archosaurs, crocodylians display extensive intrasexual aggression, whereas birds show extreme visual/vocal intersexual display. The evolutionary origin of this behavioral divergence, and pattern in non-avian dinosaurs, is unknown. Here we document the morphology, frequency, and ontogeny of intraspecific facial bite lesions (324 lesions) in a large sample of tyrannosaurids (202 specimens, 528 elements) to infer patterns of intraspecific aggression in non-avian theropods. Facial scars are consistent in position and orientation across tyrannosaurid species, suggesting bites were inflicted due to repeated/postured behavior. Facial scars are absent in young tyrannosaurids, first appear in immature animals (~50% adult skull length), are present in ~60% of the adult-sized specimens, and show aggressor:victim size isometry. The ontogenetic distribution of bite scars suggests agonistic behavior is associated with the onset of sexual maturity, and scar presence in approximately half the specimens may relate to a sexual pattern. Considered in a phylogenetic context, intraspecific bite marks are consistent and widely distributed in fossil and extant crocodyliforms and non-maniraptoriform theropods, suggesting a potential plesiomorphic behavior in archosaurs. Their absence in maniraptoriform theropods, including birds, may reflect a transition from boney cranial ornamentation and crocodylian-like intrasexual aggression to avian-like intersexual display with the evolution of pennaceous feathers.

Daly, R., Le Noury, P., Hempson, T.N., Ziembicki, M., Olbers, J.M., Brokensha, G.M. and Mann, B.Q. (2021). Bull shark *Carcharhinus leucas* recruitment into the St Lucia Estuary, South Africa, after prolonged mouth closure, and the first observation of a neonate bull shark preyed on by a Nile crocodile *Crocodylus niloticus*. African Journal of Marine Science (https://doi.org/10.2989/1814232X.2021.1964599).

Abstract: Estuaries provide critical nursery habitat for juvenile bull sharks *Carcharhinus leucas*, as they have the ability to withstand a wide range of salinities. St Lucia is the largest estuarine lake in Africa and was once a key nursery for bull sharks until a prolonged and near-continuous period of mouth closure and drought between 2002 and 2021. The estuary mouth was opened for the first time in 13 years on 6 January 2021, and, within 10 days, bull shark pups recruited into the estuary. On 16 January, an adult Nile crocodile *Crocodylus niloticus* was observed preying on a live neonate bull shark which it swallowed whole. This observation provided the first photographic evidence in Africa and highlighted a unique interaction between these species, which are top predators in the freshwater and coastal environments, respectively. Estuaries remain important nursery habitats for bull sharks in the region and we assembled the known records of bull shark occurrence in all South African estuaries. In summary, the rapid recruitment of bull shark pups into St Lucia Estuary is notable for the management and conservation implications for this important estuarine system, as well as for regional bull shark populations.

Díaz-Moreno, D.M., Hernández-Gonzalez, F., Moncada-Jimenez, J.F., Mora, C., Prada, C., Jiménez-Alonso, G. and Balaguera-Reina, S.A. (2021). Molecular characterization of the spectacled caiman (*Caiman crocodilus*) in the upper Magdalena River basin, Colombia: Demographic and phylogeographic insights. Systematics and Biodiversity (https://doi.org/10.1080/14772000.2021.1968975)

Abstract: Maintenance of high levels of genetic diversity is crucial for the recovery of overexploited species and gaining knowledge of genetic diversity of natural populations is crucial to define effective conservation strategies. Spectacled caimans (*Caiman crocodilus*) were unsustainably exploited for decades in Colombia causing drastic population reductions with unknown effects on genetic structure. We molecularly characterized three spectacled caiman populations from the upper Magdalena River basin (UMRB), analyzing them within the context of the trans-Andean *C. c. fuscus sensu stricto* lineage, assessing nucleotide and genetic diversity, demographic history, and phylogeography at different scales. Seventeen of the 23 mitochondrial haplotypes currently described for Colombia are present in the UMRB, showing high levels of genetic diversity even when compared with the trans-Andean region (uncorrected genetic distances 0.00-0.87%). Mutational steps between closest haplotypes ranged from one to four while the most differentiated haplotypes were separated by 19 mutational steps across the whole trans-Andean region. Distribution of pairwise nucleotide differences and raggedness tests showed unimodal patterns of mismatch distribution curves fitting the sudden expansion model. Average time since

demographic expansion for UMRB, Colombia, and trans-Andean region were inferred as 10,540, 7591 and 7071 years before present, respectively, placing the latest expansion close to the Pleistocene-Holocene boundary. Intriguingly, samples from Tolima were overall more related to those collected from Panama and Costa Rica (0.34±0.15%) than the ones collected across Choco (0.45±0.15%), Cauca (0.70±0.09%) and Nariño (0.60±0.14%) Departments. We discuss our genetic findings in the context of the management policies carried out in the country during the last decades (unsustainable and sustainable use, and population restocking), evaluating the implications of these events for the genetic integrity and conservation of the species.

Paulina-Carabajal, A., Barrios, F.T., Méndez, A.H., Cerda, I.A. and Lee, Y-N. (2021) A Late Cretaceous dinosaur and crocodyliform faunal association - based on isolate teeth and osteoderms - at Cerro Fortaleza Formation (Campanian-Maastrichtian) type locality, Santa Cruz, Argentina. PLoS ONE 16(9): e0256233.

Abstract: The Late Cretaceous dinosaur record in southern South America has been improved recently; particularly with findings from Chorrillo and Cerro Fortaleza formations, both bearing ankylosaur remains, a clade that was not previously recorded in the Austral Basin. The dinosaur fauna of the type locality of Cerro Fortaleza Formation is known from - and biased to - large-sized sauropod remains and a single described taxon, the titanosaur *Dreadnoughtus schrani*. Here, we report the taxonomic composition of a site preserving 13 isolated teeth and several osteoderms belonging to three dinosaur clades (Abelisauridae, Titanosauria, and Nodosauridae), and at least one clade of notosuchian crocodyliforms (Peirosauridae). They come from sediments positioned at the mid-section of the Cerro Fortaleza Formation, which is Campanian-Maastrichtian in age, adding valuable information to the abundance and biodiversity of this Cretaceous ecosystem. Since non-titanosaur dinosaur bones are almost absent in the locality, the teeth presented here provide a window onto the archosaur biodiversity of the Late Cretaceous in southern Patagonia. The nodosaurid tooth and small armor ossicles represent the first record of ankylosaurs for this stratigraphic unit. The peirosaurid material also represents the most austral record of the clade in South America.

Dollman, K.N., Clark, J.M., Viglietti, P.A., Browning, C. and Choiniere, J.N. (2021). Revised anatomy, taxonomy and biostratigraphy of *Notochampsa istedana* Broom, 1904, a Lower Jurassic crocodyliform from the Clarens Formation (Stormberg Group), and its implications for early crocodyliform phylogeny. Journal of Systematic Palaeontology (https://doi.org/10.1080/14772019.2021.1948926).

Abstract: The early-branching crocodylomorph species Notochampsa istedana is known from a single South African specimen collected more than 100 years ago. This species is potentially important for understanding early crocodylomorph evolution, but it is of uncertain taxonomic status and its stratigraphic position is poorly constrained. Here we reinvestigate the anatomy, taxonomy, systematics and biostratigraphy of the holotype specimen, SAM-PK-4013. SAM-PK-4013 has a unique suite of features that distinguish it from the closely related taxa *Orthosuchus* and *Protosuchus*. These features include the length and shape of the dentary symphysis, the number and shape of dentary teeth, and the number of dorsal ribs with expanded intercostal ridges. *Notochampsa* is therefore a valid taxon, and our phylogenetic analysis recovers it as sister to *Orthosuchus*, in a monophyletic Notochampsidae. *Notochampsa* and *Orthosuchus* share a ventrally expanded squamosal flange and expanded intercostal ridges on the dorsal ribs. Notochampsidae is in turn sister to Protosuchidae, forming the monophyletic group Notochampsoidea. Fieldwork and stratigraphic revisions show definitively that SAM-PK-4013 is from the Clarens Formation, approximately ~65 m above the Elliot contact, ageing *Notochampsa* to the Pliensbachian stage, a period of vertebrate body fossil scarcity. Thus, *Notochampsa istedana* is the youngest known occurrence of a crocodylomorph (and vertebrate body fossil) from the Karoo Basin of South Africa.

Rampersadh, C.V., Welgemoed, L-A. and Cloete, T.J. (2021). A multispecies investigation of the strain rate sensitivity of the modulus of cortical bone. EPJ Web of Conferences 250: 06003 (https://doi.org/10.1051/epjconf/202125006003).

Abstract: The stiffness of cortical bone shows both inter- and intra-species variation. Currently, it is unclear whether this variation is due to differing testing protocols or an inherent feature of the material. Additionally, there is a lack of literature dealing with species other than human and bovine, particularly in the intermediate strain rate regime. In this study, cortical bone specimens were machined from the femurs of four species: baboon, crocodile, sheep and ostrich. Specimens were tested in the quasi-static and intermediate strain rate regimes using consistent testing protocols implemented by a single researcher. The results show a similar strain rate dependence for all species, i.e. the modulus shows negligible rate effects in the quasi-static regime, but a significant increase when moving to intermediate strain rates. This suggests that while the stiffness of the bone is species dependent, the effect of strain rate may be species independent. The observed intra- and inter-species variation is less than that reported in literature, highlighting the importance of a consistent testing protocol in multi-species studies.

Haroun-Díaz, E., Blanca-López, N., Martín-Pedraza, L., Ruano, F.J., Somoza, M.L., Vázquez de la Torre, M., Pérez-Alzate, D., López-González, P., Prieto-Moreno, A., Bartolomé, B., Blanca, M. and Canto, G. (2021). Sensitization profile to related animal proteins (crocodile, frog, and chicken) among fish-allergic patients. Journal of Investigational Allergology and Clinical Immunology (doi: 10.18176/jiaci.0705).

Greenberg, D.A., Pyron, R.A., Johnson, L.G.W., Upham, N.S., Jetz, W. and Mooers, A. Ø. (2021). Evolutionary legacies in contemporary tetrapod imperilment. Ecological Letters (doi: 10.1111/ele.13868).

Abstract: The Tree of Life will be irrevocably reshaped as anthropogenic extinctions continue to unfold. Theory suggests that lineage evolutionary dynamics, such as age since origination, historical extinction filters and speciation rates, have influenced ancient extinction patterns - but whether these factors also contribute to modern extinction risk is largely unknown. We examine evolutionary legacies in contemporary extinction risk for over 4000 genera, representing ~30,000 species, from the major tetrapod groups: amphibians, birds, turtles and crocodiles, squamate reptiles and mammals. We find consistent support for the hypothesis that extinction risk is elevated in lineages with higher recent speciation rates. We subsequently test, and find modest support for, a primary mechanism driving this pattern: that rapidly diversifying clades predominantly comprise range-restricted, and extinction-prone, species. These evolutionary patterns in current imperilment may have important consequences for how we manage the erosion of biological diversity across the Tree of Life.

Brown, J.C., Shirley, M.H., Yog-yog, A., van Weerd, M., Balbas, M.G., Tarun, B.A. and Siler, C.D. (2021). Use of diet and body condition assessments as intermediate indicators of translocation success in the Critically Endangered Philippine crocodile (*Crocodylus mindorensis*). Aquatic Conservation: Marine and Freshwater Ecosystems (doi: 10.1002/aqc.3700).

Abstract: Intermediate metrics of translocation success are useful for long-lived, slow to mature species where survival and reproduction happen over decades. With fewer than 150 individuals in the wild, the Critically Endangered Philippine crocodile (*Crocodylus*

mindorensis) is one of the most threatened species on Earth. This study presents the first analysis of diet and body condition of wild Philippine crocodiles and headstarted (ie captive-reared) individuals released into the wild over the last decade, and uses these results to show how diet and body condition can be pertinent intermediate metrics of translocation success. Analyses of stomach contents revealed 17 different aquatic and terrestrial invertebrate and vertebrate prey species. Interestingly, 70% of Philippine crocodiles showed snails to be the predominent prey type, followed by fish (36.7%), birds (33.3%) and reptiles (33.3%). More than 50% of crocodiles consumed the invasive golden apple snail, a leading agricultural pest. Regardless of crocodile history (wild vs. headstarted) or size class (juvenile vs. adult), no evidence was found for dietary differences in percentage occurrence, percentage composition or prey diversity. Body condition was significantly higher in wild compared with headstarted individuals when analysed together in a pooled group, although neither group differed significantly from the standardized expectation, and headstarted individuals were not significantly different when body condition was derived independently for the two groups. This study provides a working example of how assessing the convergence of diet and body condition between translocated and wild individuals can provide complementary monitoring parameters to demonstrate post-release establishment of translocated crocodylians. The congruent dietary composition and comparable body condition observed in this study suggest that headstarted crocodiles adapt well following release.

Knoll, F., Lautenschlager, S., Kawabe, S., Martínez, G., Espílez, E., Mampel, L. and Alcalá, L. (2021). Palaeoneurology of the early cretaceous iguanodont *Proa valdearinnoensis* and its bearing on the parallel developments of cognitive abilities in theropod and ornithopod dinosaurs. Journal of Comparative Neurology (https://doi.org/10.1002/cne.25224).

Abstract: *Proa valdearinnoensis* is a relatively large-headed and stocky iguanodontian dinosaur from the latest Early Cretaceous of Spain. Its braincase is known from three specimens. Similar to that of other dinosaurs, it shows a mosaic ossification pattern in which most of the bones seem to have fused together indistinguishably while a few (frontoparietal, basioccipital) might have remained loosely attached. The endocasts of the three specimens are described based on CT data and digital reconstructions. They show unmistakable morphological similarities with the endocast of closely related taxa, such as *Sirindhorna khoratensis* (which is close in age but from Thailand). This supports a high conservatism of the endocranial cavity. The issue of volumetric correspondence between endocranial cavity and brain in dinosaurs is analyzed. Although a brain-to-endocranial cavity (BEC) index of 0.50 has been traditionally used, we employ instead 0.73. This is indeed the mid-value between the situation in adults of *Alligator mississippiensis* and *Gallus gallus*, which are members of the extant bracketing taxa of dinosaurs (Crocodilia and Aves). We thence gauge the level of encephalization of *P. valdearinnoensis* through the calculation of the encephalization quotient (EQ), which remains valuable as a metric for assessing the degree of cognitive function in extinct taxa, especially those with fully ossified braincases like dinosaurs and other archosaurs. The EQ obtained for *P. valdearinnoensis* (3.611) suggests that this species was significantly more encephalized than most if not all extant nonavian, nonmammalian amniotes. Our work adds to the growing body of data concerning theoretical cognitive capabilities in dinosaurs and supports the idea that an increasing encephalization was fostered not only in theropods but also in parallel in the shorter-lived lineage of ornithopods. *P. valdearinnoensis* was ill-equipped to respond to theropod dinosaurs and possibly lived in groups as a strategy to mitigate the risk of being predated upon. We hypothesize that group-living and protracted caring of juveniles in this and possibly many other iguanodontian ornithopods favored a degree of encephalization that was outstanding by reptile standards.

Savu, A.N., Schoenbrunner, A.R., Politi, R. and Janis, J.E. (2021). Practical review of the management of animal bites. Plastic and Reconstructive Surgery - Global Open 9: e3778.

Abstract: Animal bites are common worldwide. Due to the plethora of animals, here are diverse pathogens with specific associated risks and treatment algorithms. It is crucial to understand these to develop and execute appropriate management plans. This practical review was designed to amalgamate the most common bites worldwide and synthesize data to help guide treatment plans. A PubMed literature search was performed focusing on the major animal bites. High-level studies were preferred and analyzed but lower-level studies were also used if high-level studies did not exist. The tables presented in this article cover the pertinent information regarding the incidence, common presentation, initial treatment, and potential complications associated with bites from dogs, cats, horses, rodents, snakes, marine life, and spiders. Many of the pathogens associated with the bites are treatable with various and somewhat common antimicrobials, though some are less easy to access. Basic irrigation, debridement, and wound culture are common to almost every animal and should be the first step in treatment. Based on the current studies, the most important factor in treating animal bites is timely presentation to a medical facility and/or physician. It is critical that the offending animal be accurately identified to help guide medical and surgical algorithms, including specific antimicrobial treatment guided by the most commonly presenting pathogens specific to certain animals.

Melstrom, K.M., Angielczyk, K.D., Ritterbush, K.A. and Irmis, R.B. (2021). The limits of convergence: the roles of phylogeny and dietary ecology in shaping non-avian amniote crania. Royal Society Open Science 8: 202145.

Abstract: Cranial morphology is remarkably varied in living amniotes and the diversity of shapes is thought to correspond with feeding ecology, a relationship repeatedly demonstrated at smaller phylogenetic scales, but one that remains untested across amniote phylogeny. Using a combination of morphometric methods, we investigate the links between phylogenetic relationships, diet and skull shape in an expansive dataset of extant toothed amniotes: mammals, lepidosaurs and crocodylians. We find that both phylogeny and dietary ecology have statistically significant effects on cranial shape. The three major clades largely partition morphospace with limited overlap. Dietary generalists often occupy clade-specific central regions of morphospace. Some parallel changes in cranial shape occur in clades with distinct evolutionary histories but similar diets. However, members of a given clade often present distinct cranial shape solutions for a given diet, and the vast majority of species retain the unique aspects of their ancestral skull plan, underscoring the limits of morphological convergence due to ecology in amniotes. These data demonstrate that certain cranial shapes may provide functional advantages suited to particular dietary ecologies, but accounting for both phylogenetic history and ecology can provide a more nuanced approach to inferring the ecology and functional morphology of cryptic or extinct amniotes.

Gholamhosseini, A., Banaee, M., Soltanian, S. and Sakhaie, F. (2021). Heavy metals in the blood serum and feces of Mugger crocodile (*Crocodylus palustris*) in Sistan and Baluchistan Province, Iran. Biological Trace Element Research (https://doi.org/10.1007/s12011-021-02916-7).

Abstract: This study was conducted to measure concentrations of cadmium (Cd), lead (Pb), arsenic (As), mercury (Hg), copper (Cu), chromium (Cr), and iron (Fe) in blood serum and feces of mugger crocodile (*Crocodylus palustris*) and in water and sediment of their habitat (Negour site, Chabahar County in Sistan and Baluchistan Province, Iran). Heavy metal contents in crocodile serum and feces, water, and sediments were analyzed by inductively coupled plasma optical emission spectrometry (ICP-OES spectrometer - Spectro Genesis). The highest levels of heavy metals in the mugger crocodile's serum were Fe > Hg > Pb > Cr > Cu > Cd > As, respectively. The total

metal concentrations in the feces exhibited the following decreasing order from Fe>As>Pb=Cr>Hg>Cd>Cu. The highest average levels of heavy metals in water were Hg>Fe>As>Pb>Cu>Cr>Cd respectively and As>Fe>Pb>Cu>Hg>Cd>Cr in the sediment of lagoons. A significant difference was observed in the concentration of Fe and Pb between male and female crocodiles. Moreover, correlation analysis indicated significant negative correlations between sex and bioconcentrations of Cd, Fe, Pb, As, and Hg in the serum. In conclusion, this study showed that the environmental conditions of Negour lagoons are not suitable for crocodiles regarding habitat health and water quality. Furthermore, since these lagoons and fish are the most important sources of drinking water and seafood for the residents of the area, contamination of these pools with heavy metals can also threaten people's health.

De Meester, G. and Baeckens, S. (2021). Reinstating reptiles: From clueless creatures to esteemed models of cognitive biology. Behaviour (doi:10.1163/1568539X-00003718).

Abstract: Non-avian reptiles have long been neglect in cognitive science due to their reputation as slow and inflexible learners, but fortunately, this archaic view on reptile cognition is changing rapidly. The last two decades have witnessed a renewed interest in the cognitive capacities of reptiles, and more ecologically relevant protocols have been designed to measure such abilities. Now, we appreciate that reptiles possess an impressive set of cognitive skills, including problem-solving abilities, fast and flexible learning, quantity discrimination, and even social learning. This special issue highlights current research on reptiles in cognitive biology and showcases the diversity of research questions that can be answered by using reptiles as study model. Here, we briefly address (the key results of) the contributing articles and their role in the endeavour for total inclusion of reptiles in cognitive biological research, which is instrumental for our understanding of the evolution of animal cognition. We also discuss and illustrate the promising potential of reptiles as model organisms in various areas of cognitive research.

Alesi, D. (2021). Consuming Empire: Eating Animals in the Early Modern Atlantic World, 1492-1630. PhD thesis, University of Nebraska, Lincoln, Nebraska, USA.

Abstract: This dissertation demonstrates how the concept of edibility as it pertained to animals was both culturally constructed and changed over time as settler colonialism took root in the early modern Atlantic World. In the first phases of Atlantic World colonization, Europeans traveled throughout the Americas and ate a wide variety of unfamiliar indigenous animals. Indigenous species, like iguanas, armadillos, crocodiles, and manatees appear throughout early colonization narratives as food that the Europeans ate, and largely enjoyed, usually at the behest of their Indigenous hosts. However, as Europeans created more permanent settlements, increased the importation and production of European livestock, and developed their colonial systems, most of these animals, disappeared from the colonial diet. Instead, European settlers placed increasing importance on eating European food, especially animals and animal products, to preserve their identities and distinguish themselves from Indigenous populations. Thus, certain animals became less "edible" in the eyes of European settlers for purely cultural reasons.

Barragán-Lara, R., García-Grajales, J. and Martínez-Ramírez, E. (2021). Nest temperature assessment in an American crocodile (*Crocodylus acutus*) population on the central coast of Oaxaca, Mexico. Journal of Thermal Biology 99 (https://doi.org/10.1016/j.jtherbio.2021.103012).

Abstract: The temperatures at which eggs of crocodilians are incubated plays an important role in embryo survival, rate of embryonic development and sex definition. The aim of this study was to assess the nest temperatures of an American crocodile (*Crocodylus acutus*) population on the central coast of Oaxaca state in Mexico. The fieldwork was carried out from February to June 2018 at Palmasola Lagoon, Oaxaca. Ten natural nests of *C. acutus* were carefully excavated to determine clutch size. When putting the eggs back in the nests, we placed a data logger in the center of the egg mass to determine the temperature parameters in the nest chamber environment, as well as the variation in temperature during the incubation period. All nests were revisited to count the number of hatched eggs (NHE) and to determine the hatching success (HS), along with the duration of the incubation period (IP). Hatching success was 89.04%. The mean clutch size in the American crocodile nests was 30.7 ± 7.83 eggs (ranging from 17 to 46 eggs), and the mean incubation period was 77.6 ± 5.89 days. The mean nest incubation temperature throughout the reproductive season was significantly different among nests. Based on the average temperature during the middle third of the incubation period, the nests should have produced both sexes, but with a higher proportion of males. This study tried to elucidate the impact of nest temperatures during the incubation period on embryo survival, as well as hatchling sex ratio in a local climate on the central coast of Oaxaca.

Gutiérrez-Cervantes, A., Ahuja-Aguirre, C., López-deBuen, L. and ViverosPeredo, S. (2022). Blood cell morphology and leukocyte differential of Morelet's crocodile (*Crocodylus moreletii*) (Crocodylidae). Acta Biológica Colombiana 27(1) (https://doi.org/10.15446/abc.v27n1.85418).

Abstract: The objective of the study was to determine the morphological characteristics of peripheral blood cells (erythrocytes, leukocytes, thrombocytes) and the leukocyte differential count (heterophils, eosinophils, basophils, lymphocytes, monocytes, azurophils) of captive Morelet's crocodiles (*Crocodylus moreletii*) from Veracruz, Mexico. Peripheral blood from 80 apparently healthy farmed crocodiles (39 subadults [19 females, 20 males] and 41 adults [18 females, 23 males]) was examined for morphology through stained blood smears and manual count was used for the leukocyte differential. Blood was collected during the non-breeding (n= 42) and breeding (n= 38) seasons. Blood examination indicated similar morphological characteristics of blood cells in subadult and adult individuals and in females and males in both seasons. Erythrocytes were the largest blood cells and lymphocytes the smallest. The leukocyte differential count showed that lymphocytes were the most abundant leukocytes and basophils the least numerous. The percentages of some leukocytes showed difference by season (non-breeding and breeding) in subadult and adult males ($p<0.05$) and by size (subadults and adults) in males and females but only in the non-breeding season ($p<0.05$). The leukocytes that showed the greatest variation were lymphocytes, heterophils and eosinophils. The knowledge of blood cell morphology and the leukocyte differential count in healthy farmed Morelet's crocodiles will allow the accurate diagnosis of some diseases of captive and wild individuals.

Mans, D.R.A., Djotaroeno, M., Pawirodihardjo, J. and Friperson, P. (2021). Exploring the global animal biodiversity in the search for new drugs - Reptiles. Journal of Translational Science (doi:10.15761/JTS.1000457).

Abstract: New drug discovery and development efforts have traditionally relied on ethnopharmacological information and have focused on plants with medicinal properties. In the search for structurally novel and mechanistically unique lead compounds, these programs are increasingly turning to the bioactive molecules provided by the animal biodiversity. This not only involves bioactive constituents from marine and terrestrial invertebrates such as insects and arthropods, but also those from amphibians and other 'higher' vertebrates such as reptiles. The venoms of lizards and snakes are complex mixtures of dozens of pharmacologically active compounds. So far, these substances have brought us important drugs such as the angiotensin-converting enzyme inhibitors captopril and its derivates for treating hypertension and some types of congestive

heart failure, and the glucagon-like peptide-1 receptor agonist exenatide for treating type 2 diabetes mellitus. These drugs have been developed from the venom of the Brazilian pit viper *Bothrops jararaca* (Viperidae) and that of the Gila monster *Heloderma suspectum* (Helodermatidae), respectively. Subsequently, dozens of potentially therapeutically applicable compounds from lizards' and snakes' venom have been identified, several of which are now under clinical evaluation. Additionally, components of the immune system from these animals, along with those from turtles and crocodilians, have been found to elicit encouraging activity against various diseases. Like the venoms of lizards and snakes, the immune system of the animals has been refined during millions of years of evolution in order to increase their evolutionary success. This paper addresses some of the bioactive compounds from reptiles, and elaborates on the therapeutic potential of some of them as anticoagulants and antiplatelet drugs, as well as wound healing-promoting, antileishmanial, antiviral, immunomodulating, antimicrobial, and anticancer compounds.

Zungum, I.U. and Imam, T.S. (2021). Ecotoxicity and associated threat of polycyclic aromatic hydrocarbons (PAHs) to biodiversity: A review. Preprints (doi:10.20944/preprints202109.0377.v1).

Abstract: There is a sustained rise in incidence of cancer and toxicity related to chemicals exerting enormous burden to public health and biodiversity. Polycyclic Aromatic Hydrocarbons (PAHs) are mong such contaminants, precisely the sixteen-priority characterized by United States Environmental Protection Agency (USEPA). Therefore, this review is aimed at further elaboration about the 16 USEPA characterized PAHs and threat portend to public health and biodiversity. PAHs are a class of very stable organic pollutants produced most commonly, by incomplete combustion of fossil fuel and are formed when complex organic substances are exposed to heat. PAHs in great amount due to build up over time by bioaccumulation can be perilous: to human beings of all age and levels, aquatic organisms, amphibians and reptiles. The soil like the aquatic environment contains substantial quantity of PAHs since, atmospheric PAHs sediments on the soil due to dry and wet deposition, terrestrial organism are impacted if the soil is saturated with PAHs. Therefore, PAHs are a great source of trepidation for food safety, public health and biodiversity sustenance. Hence, tackling the spade of the menacing ubiquity of PAHs becomes necessary from its sources by encouragement of alternatives to petroleum fuels for machines and vehicles.

Vashistha, G., Deepika, S., Khudsar, F.A., Dhakate, P.M. and Kothamasi, D. (2021). Anthropogenic restocking of gharial individuals prevents genetic isolation of gharial population in Girwa River, India by geographic barriers imposed by a barrage. Research Square (doi: https://doi.org/10.21203/rs.3.rs-900712/v1).

Abstract: Gharial (*Gavialis gangeticus*) is a critically endangered fresh water crocodile endemic to the Indian subcontinent. The species has suffered >95% decline in population and habitat size. A small population of Gharials comprising of 50 breeding adults is resident in a 20-km stretch of the River Girwa in Katerniaghat wildlife sanctuary, India. Gharials in this 20-km stretch have been genetically isolated since 1976 by a barrage that functions as a barrier to gene flow. A captive rear and release program has been initiated since 1979 under Project Crocodile for restocking declining wild Gharial populations. Thousands of Gharial eggs were collected from Gharial populations at Girwa and Chambal Rivers. Hatchlings from the collected eggs were captive-reared at a common location in Kukrail Gharial Centre, India and released back to multiple Gharial populations including the isolated population at Girwa. This restocking program was not preceded by a genetic screening of captive animals or wild populations to identify genetic diversity and genetic structure of both captive and wild animals. In this study we investigate whether release of captive-reared Gharials into the resident population at Girwa River has prevented genetic isolation caused due to barriers imposed by the barrage. Using a combination of empirical analysis using microsatellite markers and a systematic review of data from previous workers on molecular characterization of gharial populations, we analysed genetic differentiation in Gharial populations at Girwa and Chambal. We found similar genetic variability in Gharial populations of Girwa and Chambal. There was low inter-population genetic differentiation and evidence of genetic migration between the two populations. Our findings indicate that anthropogenic intervention via release of captive animals has compensated for the genetic isolation in Girwa population caused by the barrage.

Bianchi, C., Adami, C., Dirrig, H., Cuff, A., d'Ovidio, D and Monticelli, P. (2020). Mandibular nerve block in juvenile Nile crocodile: A cadaveric study. Veterinary Anaesthesia and Analgesia (https://doi.org/10.1016/j.vaa.2020.04.016).

Alibardi, L. and Meyer-Rochow, V.B. (2021). Regeneration in reptiles generally and the New Zealand Tuatara in particular as a model to analyse organ regrowth in amniotes: A review. Journal of Developmental Biology 9(3) (doi: 10.3390/jdb9030036).

Abstract: The ability to repair injuries among reptiles, i.e., ectothermic amniotes, is similar to that of mammals with some noteworthy exceptions. While large wounds in turtles and crocodilians are repaired through scarring, the reparative capacity involving the tail derives from a combined process of wound healing and somatic growth, the latter being continuous in reptiles. When the tail is injured in juvenile crocodilians, turtles and tortoises as well as the tuatara (Rhynchocephalia: *Sphenodon punctatus*, Gray 1842), the wound is repaired in these reptiles and some muscle and connective tissue and large amounts of cartilage are regenerated during normal growth. This process, here indicated as "regengrow", can take years to produce tails with similar lengths of the originals and results in only apparently regenerated replacements. These new tails contain a cartilaginous axis and very small (turtle and crocodilians) to substantial (eg in tuatara) muscle mass, while most of the tail is formed by an irregular dense connective tissue containing numerous fat cells and sparse nerves. Tail regengrow in the tuatara is a long process that initially resembles that of lizards (the latter being part of the sister group Squamata within the Lepidosauria) with the formation of an axial ependymal tube isolated within a cartilaginous cylinder and surrounded by an irregular fat-rich connective tissue, some muscle bundles, and neogenic scales. Cell proliferation is active in the apical regenerative blastema, but much reduced cell proliferation continues in older regenerated tails, where it occurs mostly in the axial cartilage and scale epidermis of the new tail, but less commonly in the regenerated spinal cord, muscles, and connective tissues. The higher tissue regeneration of *Sphenodon* and other lepidosaurians provides useful information for attempts to improve organ regeneration in endothermic amniotes.

Harvey, R.G., Dalaba, J.R., Ketterlin, J., Roybal, A., Quinn, D. and Mazzotti, F.J. (2021). Growth and spread of the Argentine Black and White Tegu population in Florida. IFAS Extension WEC437 (doi.org/10.32473/edis-UW482-2021).

Rio, J.P. and Mannion, P.D. (2021). Phylogenetic analysis of a new morphological dataset elucidates the evolutionary history of Crocodylia and resolves the long-standing gharial problem. PeerJ 9: e12094.

Abstract: First appearing in the latest Cretaceous, Crocodylia is a clade of semi-aquatic, predatory reptiles, defined by the last common ancestor of extant alligators, caimans, crocodiles, and gharials. Despite large strides in resolving crocodylian interrelationships over the last three decades, several outstanding problems persist in crocodylian systematics. Most notably, there

has been persistent discordance between morphological and molecular datasets surrounding the affinities of the extant gharials, *Gavialis gangeticus* and *Tomistoma schlegelii*. Whereas molecular data consistently support a sister taxon relationship, in which they are more closely related to crocodylids than to alligatorids, morphological data indicate that *Gavialis* is the sister taxon to all other extant crocodylians. Here we present a new morphological dataset for Crocodylia based on a critical reappraisal of published crocodylian character data matrices and extensive firsthand observations of a global sample of crocodylians. This comprises the most taxonomically comprehensive crocodylian dataset to date (144 OTUs scored for 330 characters) and includes a new, illustrated character list with modifications to the construction and scoring of characters, and 46 novel characters. Under a maximum parsimony framework, our analyses robustly recover *Gavialis* as more closely related to *Tomistoma* than to other extant crocodylians for the first time based on morphology alone. This result is recovered regardless of the weighting strategy and treatment of quantitative characters. However, analyses using continuous characters and extended implied weighting (with high k-values) produced the most resolved, well-supported, and stratigraphically congruent topologies overall. Resolution of the gharial problem reveals that: (1) several gavialoids lack plesiomorphic features that formerly drew them towards the stem of Crocodylia; and (2) more widespread similarities occur between species traditionally divided into tomistomines and gavialoids, with these interpreted here as homology rather than homoplasy. There remains significant temporal incongruence regarding the inferred divergence timing of the extant gharials, indicating that several putative gavialids ('thoracosaurs') are incorrectly placed and require future re-appraisal. New alligatoroid interrelationships include: (1) support for a North American origin of Caimaninae in the latest Cretaceous; (2) the recovery of the early Paleogene South American taxon Eocaiman as a 'basal' alligatoroid; and (3) the paraphyly of the Cenozoic European taxon *Diplocynodon*. Among crocodyloids, notable results include modifications to the taxonomic content of Mekosuchinae, including biogeographic affinities of this clade with latest Cretaceous-early Paleogene Asian crocodyloids. In light of our new results, we provide a comprehensive review of the evolutionary and biogeographic history of Crocodylia, which included multiple instances of transoceanic and continental dispersal.

González Solórzano, M., Gómez Torres, M.A., López Luna, M.A. and Escobedo Galván, A.H. (2021). Saurocoría en cocodrilos no favorece la dispersión y viabilidad de semillas. Acta Biológica Colombiana 27(1) (https://doi.org/10.15446/abc.v27n1.88615).

Abstract: Seed dispersal by reptiles (saurochory) has recently received attention, and the consumption of fruits and seeds has been reported in crocodilians despite being mainly carnivores, acting as potential seed dispersers. We evaluate whether saurochory by *Crocodylus acutus* and *C. moreletii* affect the seed viability of three species of plants (*Delonix regia*, *Inga* sp., and *Citrullus lanatus*). We performed feeding trials, using three juvenile individuals of each species of crocodile, and fed them 22 seeds per plant species for a total of 66 seeds per enclosure (132 for both species). Seeds were combined with the usual diet each week. The unconsumed and excreted seeds were collected and planted in soil treated with compost to evaluate the relative germination rate. A total of 99 seeds were consumed, of which only 14 seeds of *C. lanatus* were recovered from the faeces, and only one of those germinated (7.14%) with respect to 50% in the control group. The results indicate that saurochory by *C. acutus* and *C. moreletii* has a negative effect on seed viability and germination of the plant species studied, as found in other studies using different species.

Phonarknguen, R., Assawasuparerk, K. and Rawangchue, T. (2021). Comparison of efficacy of crocodile blood extract against inhibition of cell viability in hepatocellular carcinoma and human cholangiocarcinoma cell lines. Bulletin of the Department of Medical Sciences 63(3): 618-627.

Abstract: Crocodile (*Crocodylus siamensis*) blood extracts (CE) consisting of natural active peptides, which are used in cancer therapy. This study investigated the activity of CE and their effects on cell viability of hepatocellular carcinoma (HepG2) and human cholangiocarcinoma (HuCCA) cell lines by MTT assay. A range from 100 to 1600 µg/mL of CE decreased the viability of HepG2 and HuCCA cells as compared with control group, while CE statistically reduced cell viability of HepG2 more than HuCCA cells ($p<0.001$). The 50% inhibitory concentration (IC_{50}) of CE on HepG2 and HuCCA cells dose suggested to approximately 120.36 µg/mL and 846.28 µg/mL, respectively. The treatment of CE could induce nuclear morphological changes apoptotic cells, nuclear chromatin condensation and fragmentation by Hoechst 33342 staining. In conclusion, CE could inhibit cell viability and induce apoptosis in HepG2 and HuCCA cells and it could reduce cell viability of HepG2 cells more than HuCCA cells. This study indicated that CE had more promising treatment of hepatocellular carcinoma than cholangiocarcinoma *in vitro* study.

Ahmad, Y. and Suratman, M.N. (2021). The roles of mangroves in sustainable tourism development. Pp. 401-417 *in* Mangroves: Ecology, Biodiversity and Management, ed. by R.P. Rastogi, M. Phulwaria and D.K. Gupta. Springer: Singapore.

Abstract: Mangrove and its ecosystem have contributed significantly to the environment, community, and economy. Mangrove forests became a tourism attraction for decades, and the demand for nature-based tourism of mangrove forests is increasing throughout the world. Unsustainable mangrove tourism efforts may lead to many drawbacks, which include forest loss, depletion of natural resources, and also increase of pollution in mangrove forests and their surroundings. While aiming to maximise the economic earnings from mangrove tourism, it should be balanced with mangrove ecosystem conservation's efforts to ensure sustainable tourism development. This situation can be realised through implementing effective strategies, including continuous conservation and restoration efforts of mangroves; enhancing the policies and legislation on the use and management of mangroves; enhancing infrastructure and facilities, and efficient use of resources through sound technologies; and encouraging community participation and engagement. Balancing the economic activity of mangrove tourism while maintaining mangrove forests through preservation, conservation, and restoration are the key success to achieve sustainable tourism development.

Burbrink, F.T. and Ruane, S. (2021). Contemporary philosophy and methods for studying speciation and delimiting species. Ichthyology & Herpetology 109(3): 874-894.

Species delimitation is a first step for realizing the extent of biodiversity and is relevant for all downstream applications in biology. The production of large genome-scale datasets for non-model organisms combined with the development of methodological tools have allowed researchers to examine fine-scale processes of speciation such as timing of origin, degree of migration, population-size changes, selection, drift, and recombination. Studies using reptiles and amphibians have, in part, paved the way for the development and use of such methods for exploring speciation and delimitation. While these methodologies have improved our understanding of processes of diversification, researchers are far from agreeing upon a set of criteria to delimit species. In cases where genetic lineages are discovered that are unique to geographic areas, researchers usually agree that two entities exist. Disagreement about taxonomic status often centers on the degree of reproductive isolation between taxa and probability of remaining distinct. However, reproductive isolation is frequently inferred without examining gene flow, understanding the nature of hybrid zones, or determining the amount and type of introgression. Here, we review some of the vexing problems for delimiting reptiles and amphibians, which include isolation by distance, gene flow and differential allelic introgression, hybrid zone dynamics, and the nature of genomic

islands of divergence. We also respond to recent literature criticizing modelbased species delimitation in North American snakes in the context of these methodological advancements and address how scientists can move forward with studies on speciation.

Taborda, J.R.A., Desojo, J.B. and Dvorkin, E.N. (2021). Biomechanical skull analysis of an aetosaur *Neoaetosauroides engaeus* using finite element analysis. Ameghiniana 58(5) (doi: https://doi.org/10.5710/AMGH.23.07.2021.3412).

Abstract: Aetosaurs are an archosaur group with a worldwide distribution during the Late Triassic. They were quadrupedal amniotes, had small heads relative to their body size, and had a long tail. Characterized by a dorsal and ventral carapace formed by ornamented and articulated osteoderms, aetosaur feeding ecology is poorly understood. Although aetosaurs are historically considered as the only herbivore among early pseudosuchian archosaurs, some authors have proposed omnivorous and/or scavengers habits for this group. *Neoaetosauroides engaeus* Bonaparte, 1969, an aetosaur from Late Triassic known from three relatively well preserved skulls (from the Los Colorados Formation, La Rioja, Argentina), is an excellent taxon to make biomechanics models of feeding to decipher the feeding ecology of this clade. We applied the Finite Element Method (FEM) for estimating the bite force and evaluated the structural response of the skull at different positions during the food processing. Our results show that the skull of *N. engaeus* generated a bite force of 3.6 kN (magnitude comparable with the measurement made in *Alligator mississippiensis*) and could resist lateral and longitudinal forces during feeding. This indicates that these animals were capable of hunting of small living prey with their jaws (eg cynodonts), and/or drag carcasses of larger sizes (eg dicynodont). These results support possible zoophagy or omnivory for *N. engaeus*, and thus expanding the potential ecological roles of aetosaurs.

Figueiredo, A., Alves-Martins, N. and Nogueira-Costa, P. (2021). Predation attempt by the Spectacled caiman, *Caiman crocodilus* (Linnaeus, 1758), on the microhylid *Elachistocleis carvalhoi* Caramaschi, 2010 in the southeastern Amazon of Brazil. Herpetology Notes 14: 1227-1229.

Russell, A.P. and Bauer, A.M. (2021). Vocalization by extant nonavian reptiles: A synthetic overview of phonation and the vocal apparatus. Anatomical Record 304: 1478-1528.

Abstract: Among amniote vertebrates, nonavian reptiles (chelonians, crocodilians, and lepidosaurs) are regarded as using vocal signals rarely (compared to birds and mammals). In all three reptilian clades, however, certain taxa emit distress calls and advertisement calls using modifications of regions of the upper respiratory tract. There is no central tendency in either acoustic mechanisms or the structure of the vocal apparatus, and many taxa that vocalize emit only relatively simple sounds. Available evidence indicates multiple origins of true vocal abilities within these lineages. Reptiles thus provide opportunities for studying the early evolutionary stages of vocalization. The early literature on the diversity of form of the laryngotracheal apparatus of reptiles boded well for the study of form-function relationships, but this potential was not extensively explored. Emphasis shifted away from anatomy, however, and centered instead on acoustic analysis of the sounds that are produced. New investigative techniques have provided novel ways of studying the form-function aspects of the structures involved in phonation and have brought anatomical investigation to the forefront again. In this review we summarize what is known about hearing in reptiles in order to contextualize the vocal signals they generate and the sound-producing mechanisms responsible for them. The diversity of form of the sound producing apparatus and the increasing evidence that reptiles are more dependent upon vocalization as a communication medium than previously thought indicates that they have a significant role to play in the understanding of the evolution of vocalization in amniotes.

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