

# **CROCODILE SPECIALIST GROUP NEWSLETTER**

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IUCN - Species Survival Commission

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**COVER PHOTOGRAPH:** Philippine crocodiles (*Crocodylus mindorensis*) at Palawan Wildlife Rescue and Conservation Centre (previously Crocodile Farming Institute). Photograph: Charlie Manolis.

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**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.

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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. The Newsletter is distributed to CSG members and to other interested individuals and organizations. All Newsletter recipients are asked to contribute news and other materials.

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- Free electronic, downloadable copy from "<http://www.iucncsg.org/pages/Publications.html>".

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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 2016-2017 (listed below).

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George Saputra, CV Alona Jaya, Jakarta, Indonesia.

Colin Stevenson (UK) and Rene Hedegaard (Denmark)

Toronto Zoo, Ontario, Canada.

Yosapong Temsiripong, Crocodile Cooperative of Thailand,  
Thailand.

Zambia Crocodile Farmers Association, Lusaka, Zambia.

**Contributors (\$250 - \$1000)**

Allan Woodward, Florida, USA.

Croc Encounters of Tampa, Florida, USA.

Crocodile Park, Malaga, Spain.

The Ebey family, New Mexico, USA.

James Hennessey, The National Reptile Zoo, Ireland.

Matthew Shirley, Florida, USA.

## Editorial

I am sorry to report that CSG member, Karen Beverley Seem, from the Sarawak Forestry Department (Sarawak, Malaysia), passed away on 9 April 2017 after a long illness.

The process of updating the CSG Species Action Plans, last published in 2010, is now underway. Various lead authors and contributors have been identified, and contacted by the Executive Officer. It is proposed that updated Plans will be finalised by May 2018. Colin Stevenson and Charlie Manolis will coordinate this task, including review of draft Plans, and editing and compilation of the final documents.

The CSG has established an office for the Central America and Caribbean sub-region in Belize, through Dr. Marisa Tellez (CSG Regional Vice Chair, Latin America and the Caribbean), to further strengthen and co-ordinate membership in this area. Please contact Marisa if you are aware of or are able to identify contact people working with crocodilians in this sub-region.

On 19 June I wrote to all CSG members informing them of the important role played by the international zoo community in the *in-situ* and *ex-situ* care and maintenance of crocodilians.

On 19 May 2017 Sergio Balaguera-Reina (CSG Regional Vice Chair, Latin America and the Caribbean) attended a consultation meeting in Bogota, Colombia, as part of a European Union delegation reviewing trade in *Caiman crocodilus fuscus* and *Crocodylus acutus* products within the framework of CITES.

In June 2017 I wrote to the Japanese CITES Management Authority (Ministry of Economy, Trade and Industry) regarding implementation of CITES Resolution Conf. 11.12 (Rev. CoP15) Universal Tagging System for the Identification

of Crocodile Skins. It was specifically with respect to the use of re-export tags. Resolution Conf. 11.12 (Rev. CoP15) provides for the use of replacement “re-export” tags where the original tag has been lost, damaged or destroyed during the tanning process. It appears that Japan has not implemented the re-export tag component of the resolution, which complicates Japan’s exotic leather industry.

The “2nd Siamese Crocodile Conservation and Husbandry Meeting” and the “Siamese Crocodile Task Force Meeting” were held jointly at Mahidol University, Bangkok, Thailand, on 1-2 June 2017. Of significance, a new project has been funded to reintroduce Siamese crocodiles (*C. siamensis*) into Bueng Boraphet and Pang Sida National Park. A summary of these meetings is available on page 5. The *C. siamensis* reintroduction program at Yod-Dom Wildlife Sanctuary, facilitated through Panyafarm Kampaengsaen Co. Ltd., has been delayed due to recent changes in government policy, but consultation with local communities continues. Crocodiles proposed for release at the Yod-Dom Crocodile Learning Centre contribute to public awareness about crocodiles and the program.

On 17 June 2017 *Crocodylus Porosus* Philippines Incorporated (CPPI) carried out the second release of Philippine crocodiles (*C. mindorensis*) into Paghungawan Marsh, Siargao Island, Philippines. CSG Deputy Chairman Charlie Manolis and CSG Executive Officer Tom Dacey participated in the release (see summary on page 14). Charlie Manolis was also invited to attend the 3rd meeting of the National Committee for Crocodile Conservation (NCCC) in Puerto Princesa City, Palawan, on 19 June 2017.

The website for the 25th CSG Working Meeting, in Santa Fe, Argentina, was launched in May 2017. Registration opened on 7 June 2017 (see <https://www.25wmcsgsantafe.com>). This promises to be a very important and well-attended meeting, in one of the “hotspots” of crocodilian conservation and management, so please try to attend.

Professor Grahame Webb, *CSG Chair*, [gwebb@wmi.com.au](mailto:gwebb@wmi.com.au).

## Species Survival Commission (SSC) Code of Ethics

CSG members, when renewing their membership in February 2017, were requested to agree to be bound by the SSC Code of Conduct (see below). The Code covers the standard broad range of issues, including integrity and professionalism, accountability, mutual respect for colleagues and representation, etc. Following the introduction of the Code, the CSG Chair wrote to all CSG members advising them that the name of the CSG, SSC or IUCN cannot be used by members on their business cards, e-mail signatures, publications or correspondence concerning any issue, without the prior permission of the CSG Chair.

Tom Dacey, *CSG Executive Officer* ([csq@wmi.com.au](mailto:csq@wmi.com.au)).

## Annex 2. SSC Code of Conduct

Every SSC member is expected to contribute to the Vision and Mission of IUCN and the SSC. SSC membership embodies a relationship of mutual trust and respect among all SSC members and also with other parts of IUCN. SSC members are expected to undertake their work and participate in the affairs of the Commission individually and collectively in a responsible, professional and respectful manner, to deal fairly in all transactions and to honour all commitments and promises. As such, each SSC member pledges to achieve the high standards of IUCN Commissions in the following areas:

- Integrity and Professionalism
- Accountability
- Ethical Leadership and Transparency
- Responsiveness and Reliability
- Mutual Respect for Colleagues, Peers, IUCN Secretariat and other Commissions
- Dignity and Cultural Sensitivity
- Paid and Unpaid Work (Including Consultation) for IUCN Secretariat, any Commission or any recognised sub-grouping (SG)
- Representation
- Environmental Responsibility and Safety
- Confidentiality
- Conflicts of Interest
- Response to Violations of this Code

### **Integrity and Professionalism**

- To act honestly, truthfully and with integrity in all dealings, both within IUCN and on its behalf or in its name; to examine the accuracy and source of all relevant information before allowing it to be used in Commission products and advice.
- In all dealings, and especially towards IUCN Commission members, to behave in a professional manner, as part of the collective desire to strengthen the competencies of IUCN and the conservation community.
- To comply with all applicable laws and regulations in all dealings relevant to IUCN and its activities and objectives.

### **Accountability**

- To abide by all relevant governing documents of the relevant SSC.
- To make all reasonable efforts to ensure that SSC's products are delivered in a timely fashion and meet all relevant contractual terms and conditions.
- To treat all who provide funding to, or receive funding from, the IUCN Secretariat, SSC or any SG fairly, openly and honestly throughout the fundraising and fund distribution process, with appropriate acknowledgement of all contributions, and proper accounting therefore.

### **Ethical Leadership and Transparency**

- When fulfilling a leadership role within SSC or any SG:
- to do so ethically, operating transparently and fairly, giving appropriate notice of key leadership decisions to affected members, and avoiding personal or institutional bias or favour.

- to act as a fiduciary with regard to any property or information held on behalf of IUCN, SSC or any SG.
- to make reasonable efforts to listen to stakeholders and understand and respect their needs and concerns.

### **Responsiveness and Reliability**

- To contribute to the work and deliberations within SGs, sharing knowledge, time and expertise; endeavouring to honour all commitments; keeping all partners and stakeholders aware of the status of work under such commitments; and refraining from promising more than the member is capable or authorised to deliver.

### **Mutual Respect for Colleagues, Peers, IUCN and Commissions**

- To recognise all members of the IUCN Commissions as colleagues deserving of respectful treatment both in communications within IUCN and also in communications about them outside of IUCN.
- In cases of disagreement with any position taken by IUCN, SSC and/or any SG, if making any public comment on that position, to express it respectfully.

### **Dignity and Cultural Sensitivity**

- To respect the cultural diversity of our global network and to behave in all communications on behalf of IUCN, SSC and/or any SG and other related interactions with respect for all peoples, cultures and traditions.
- To avoid and refuse to tolerate discriminatory practices that treat groups or individuals less favourably on the basis of culture, national or ethnic origin, gender, marital or other family status, sexual orientation, socio-economic status, age, disability, political alignment or religious belief.

### **Paid and Unpaid Work (Including Consultation) for IUCN or any Commission or SG**

- When engaging in paid or unpaid work with, or in the name of, IUCN, SSC, or any SG, to abide by the contract, as well as the governing documents of IUCN, the Commission and/or the SG.

### **Representation**

- When participating in negotiations and policy discussions as a representative of IUCN, SSC and/or any SG, to endeavour to ensure that all actions taken are informed by the relevant policy positions of IUCN and/or SSC.
- To avoid any communication or use of the name, logo or other formal indications of IUCN, SSC or any SG that has not been authorised by the appropriate person or body or which conveys a misunderstanding about whether that communication is authorised by IUCN, SSC or any SG.
- To avoid any statement or behaviour when undertaking a role in the name of IUCN or SSC that exposes IUCN or SSC to legal liability.

### **Environmental Responsibility and Safety**

- When acting and/or engaging in advocacy affecting conservation or sustainable development, to do so in a manner that reflects IUCN's shared commitment to

sustainability, responsibility and environmental best practice, leading by example and, to the extent possible, working with partners who conform to these standards.

- To avoid, where reasonable and possible, any activity that harms or endangers others, where such danger, harm or injury might be perceived to involve IUCN or SSC and to notify appropriate persons where such activity is unavoidable.

#### **Confidentiality**

- To respect the confidentiality of sensitive information about IUCN, SSC and any SG, including closed discussions involving its members, constituents, donors, board and employees.

#### **Conflicts of Interest**

- To refuse to accept any payment or special consideration from any person or organization whose purpose in providing such a payment is to unduly influence the decisions, policies or actions of the IUCN, SSC or any of its SGs or to interfere in the established decision-making process to accomplish that person/organisation's objectives.
- To refuse to accept tolerate behaviour described in the previous bullet in others, and to disclose to the Commission Chair (or his/her designee), any potential conflict of interest, before engaging in any action or decision-making involving that conflict.
- Where for any reason, any SSC member finds that he/she cannot comply with this Code of Conduct, to notify the SSC Chair (or his/her designee), and from that point onward to refrain from claiming to be an SSC member. (IUCN, SSC and its SGs will not criticise any member who takes this option, as long as that person continues to behave respectfully toward IUCN, SSC and its SGs.

#### **Response to Violations of this Code of Conduct**

- Upon becoming aware of any violation of this Code of Conduct, to request that the person(s) engaging in the violation cease such behaviour.
- To report any continuing violations to the relevant Commission Chair (or his/her designee).
- If serving in a leadership capacity that authorises or mandates such action, to respond to reports of violations of this Code of Conduct promptly and appropriately, ensuring that appropriate notice of such response reaches all interested persons, and using discretion as to whether and how broadly dissemination is to be undertaken.
- SSC shall consider whether to adopt procedures implementing this Code of Conduct.

It is the responsibility of all SSC members to read, understand and abide by the above-described Code of Conduct. Action inconsistent with this Code of Conduct or failure to take action mandated by this Code of Conduct may result in that member's removal from the SSC.

## **CSG Student Research Assistance Scheme**

The Student Research Assistance Scheme (SRAS) provided funding to 5 students in the April-June 2017 quarter, and 3 further applications are currently under review.

1. Brigitte Preciado Salas (Colombia): Perception, use and conservation of the Orinoco crocodile in the Cravo Norte, Ele and Lipa Rivers Complex, Colombia.
2. Jordan Cissell (USA): Mapping changes to *Crocodylus acutus* and *Crocodylus moreletii* habitat in Placencia, Belize, using remote sensing.
3. Sierra McLinn (USA): Investigating the life-cycle of the deadliest crocodilian parasite in North America.
4. Mohamed Ezat (Egypt): Can we use drones to survey crocodile populations?
5. Devon Veldsman (South Africa): Nile crocodile farming: Ideal stocking density.

Tom Dacey, *CSG Executive Officer*, ([csg@wmi.com.au](mailto:csg@wmi.com.au)).

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### **"2nd Siamese Crocodile Meeting on Husbandry and Conservation" and "Siamese Crocodile Task Force Meeting" (1-2 June 2017)**

The "2nd Siamese Crocodile Conservation and Husbandry Meeting", which incorporated a meeting of the "Siamese Crocodile Task Force" (SCTF), was held at Mahidol University, Bangkok, Thailand, on 1-2 June 2017. The Faculty of Veterinary Science at Mahidol University hosted the meetings, with additional financial support from the Crocodile Management Association of Thailand (CMAT) and the Crocodile Cooperatives of Thailand (COCOT; currently representing 80% of *Crocodylus siamensis* production in Thailand).

The meetings were attended by 41 participants, including CSG Executive Officer Tom Dacey, CSG Deputy Chair Charlie Manolis, CSG Regional Vice Chair Adrian Sugiarto, Government personnel from Cambodia (Han Sam), Malaysia (Shaffeque Affendy Bin Zakaria), Indonesia (Agung Nugroho) and Lao PDR (Chantone Photithay), non-government organisations (Jackson Frechette, Fauna and Flora International Cambodia), and Thai researchers (Mahidol and Kasetsart Universities), Government personnel and crocodile farmers.

The meeting was opened by Associate Professor Dr. Parntep Ratanakorn (Mahidol University; Chair of Siamese Crocodile Task Force), and welcome addresses were delivered by Charlie Manolis and Associate Professor Dr. Kangwan Juntarashote (representative of Director General of Department of Fisheries, Ministry of Agriculture and Cooperatives, Thailand). The following presentations were made after the introductory remarks:

1. Conservation of Crocodilians (Charlie Manolis and Tom Dacey, CSG): overview of global conservation efforts with critically endangered crocodilians, with particular emphasis on reintroduction programs (eg *Alligator sinensis*, *Crocodylus intermedius*, *C. rhombifer*, *C. mindorensis*, *C. siamensis*, *Gavialis gangeticus*).
2. Siamese Crocodile Conservation Program in Thailand (Chonlatorn Chamnarnkit, Director of Wildlife Conservation Section, Department of National Parks, Wildlife and Plant Conservation): overview on the current status of wild *C. siamensis* in Thailand.
3. The Cambodian Crocodile Conservation Programme 2016-2017 Update [Jackson Frechette (FFI Cambodia) and Sam Han (Cambodian Forestry Administration)]. The wild *C. siamensis* population in Cambodia is estimated to comprise around 220 adults. Since 2011, 68 *C. siamensis* (including adults) have been released into the wild, with the most recent being the release of 6 ~1.3 m TL juveniles in 2017. Radio-tracking is being carried out on some of these released animals. Crocodile farms have offered to provide 200+ animals per year for release, and some adults have already been provided to Phnom Tamao Wildlife Rescue Centre (Phnom Penh) where FFI carries out captive breeding (3 nests were produced in 2017). The ability to rapidly undertake DNA testing of animals is currently a constraint on the program.
4. Thailand Country Report (Ekkawit Wongsrisung, Thai CITES Management Authority, Department of Fisheries). Regulation of the crocodile industry is through the Wildlife Reservation and Protection Act B.E. 2535 (1992). Responsibility for aquatic animals, including crocodiles, lies with the Department of Fisheries. There were 1,199,478 *C. siamensis* and 156,208 *C. porosus* reported on Thai crocodile farms as of 31 December 2016. In 2016, on the basis of CITES Permit applications, commercial exports of 405 live crocodiles, 29,170 skins and 23,219 products were reported.
5. Crocodile Husbandry in Lao PDR (Chantone Phothitay, Deputy of Wildlife Management Section, Division of Forest Resources Conservation). The crocodile program in Lao PDR has stalled due to lack of funding since 2008. A total of 76 head-started juvenile *C. siamensis* were released into the wild, but surveys need to be carried out to ascertain survivorship of released animals, and current status of the wild population. Lao Zoo is holding some additional juveniles for future release. The program works with communities to ensure the long-term conservation of the species and mutual benefits to local stakeholders.
6. Siamese Crocodile *In Situ* Conservation Project (Parntep Ratanakorn, Mahidol University, Thailand). A 3-year program (2017-2019), funded (\$US300,000) by the Agricultural Research Development Agency (ARDA), is planned for the release and monitoring (including radio-telemetry) of captive-bred *C. siamensis* into Bueng Boraphet Wildlife Non-Hunting Area and Pang Sida National Park. A multi-disciplinary team will survey and select habitats, screen stock to ensure they are pure *C. siamensis*, engage with local communities, and monitor survival of released animals. The expected outcomes are the establishment of crocodile reserves, strengthening of crocodile conservation through community involvement, a platform for a crocodile conservation program in Thailand, and demonstration of crocodile conservation through collaboration of community, Government and industry.
7. Status of Siamese Crocodile Conservation - Country Update of Indonesia (Agung Nugruho, Directorate of Biodiversity Conservation, Indonesia). In September 2016 there was an agreement to list Lake Mesangat and Lake Suwi (Kalimantan) as Ecosystem Essential Areas (EEA). These areas involve four oil palm concessions. EEAs are not as strong a status as other protected areas. The establishment of a Management Forum was the first step, with the Head of the Environment Agency as the Chair. Also involved would be the Minister of Environment and Forestry (MoEF). In November 2016 the forum was updated on the progress of the EEAs. In April 2017 a meeting with East Kutai Environmental Agency (Chair) discussed delineation of the EEA and the results of a field trip. On 31 May 2017 a meeting in MoEF aimed to coordinate further steps, including preparation of a country update for the SCTF meeting in Bangkok.
8. *Crocodylus siamensis* in Mesangat Lake [Hellen Kurniati (LIPI, Indonesian Institute of Sciences); presented by Adrian Sugiarto (Surya Raya Crocodile Farm)]. Some 70% of Lake Mesangat, the last stronghold for *C. siamensis* outside the Southeast Asian mainland, has been converted to oil palm since 2009. Oil palm operators initially diverted water through small dams, but now diversion is at primary rivers that feed the lake, leading to drying of Lake Mesangat. In April 2016 a CSG review team visited Lake Mesangat, and subsequent efforts have been directed at obtaining protective status for the area. An NGO, Yayasan Konservasi Khatulistiwa Indonesia (YASIWA), has been working in the area, but its efforts appear to have been directed at Lake Suwi rather than Lake Mesangat (where *C. siamensis* occurs). Lake Suwi is mainly peat swamp, and record of 3 *C. siamensis* hatchlings has not been able to be verified by Government agencies. Local Government decided to incorporate both Lake Suwi and Lake Mesangat as part of efforts to protect them (see 7. above).
9. Malaysia (Sarawak) Country Report (Shaffeqe Affendy Bin Zakaria, Sarawak Forest Department, Sarawak, Malaysia): overview of the current status of implementation of the Saltwater Crocodile (*Crocodylus porosus*) Management Program in the state of Sarawak. The species was transferred to Appendix II at CoP17 (November 2016).
10. Proper Use of Antibiotics in Crocodile Farming (Wanna Srimanapong, Crocodile Health Research Center, Faculty of Veterinary Science, Mahidol University, Thailand). Antimicrobial Resistance (AMR) is a concern to the industry. Incorrect dosages are often applied, and courses

not completed, resulting in bacterial resistance. Drug-resistant bacteria reach other crocodiles and animals through food, environment (water, soil, air) or by direct contact.

11. Guidelines for Crocodile Farming (Parntep Ratanakorn, Mahidol University, Thailand) have been developed and incorporated into legislation in Thailand. Farms that export skins, meat, etc., which want to get accreditation and certification must follow Good Aquaculture Practices (GAP) [safety for people (eg food), social responsibility, good quality products, animal welfare, environmentally friendly). Requirements for GAP are:

- a. site and registration (eg registration documents, follow sanitary and environmental legislation, located in non-flooding areas, distance from sources of pollution, water quantity and quality, access, infrastructure, quarantine area);
- b. general management (eg technical recommendations, terrestrial and water management, animal ID, training program for staff);
- c. production inputs (eg source of stock, crocodile feed);
- d. crocodile health and welfare management (eg pond design, equipment, substrate quality, follow welfare legislation, proper use of drugs/chemicals);
- e. farm sanitation (eg sanitary system, waste disposal);
- f. harvest and post-harvest handling (eg harvesting plan, legal trade and movement documents, animal welfare, immobilization drugs by veterinarian, safety plan for release);
- g. labour and social welfare (eg legal labour, safety equipment, training)
- h. environment [eg not breed between species (hybrids), no genetic engineering, waste management];
- i. social responsibility (eg prioritise local labour, benefit community, support crocodile conservation in the wild); and,
- j. record-keeping (eg births, deaths, movement, other relevant data).

12. Guidelines for Crocodile Slaughterhouse (Parntep Ratanakorn, Mahidol University, Thailand). Guidelines were developed to cover facilities that produce crocodile meat and other products for export.

13. Other Cases Report (Nlin Arya, Mahidol University, Thailand). Five (5) cases of disease in 2016 (eg *Chlamydia* spp., fungal infection) were presented.

14. Genetics and Genomics Era for the Establishment of a Breeding Program and Reintroduction Plan in Thailand (Kornsorn Srikulnath, Kasetsart University, Thailand). The history of genetics and genomics studies in Thailand were updated and discussed. These researches including chromosome constitution, functional gene analysis, genetic diversity, aberration of gene interaction with environment involving crocodile diseases, and whole genome sequence project will contribute to conservation efforts for Siamese crocodiles, provide an understanding

of the potential climate change, and enhance the high economic value. Methods for species identification were presented and discussed (eg *C. siamensis*, *C. porosus*, and their hybrids and assessment of genetic diversity of crocodile individuals in captivity for reintroduction program using mitochondrial DNA and microsatellite markers). Srikulnath's research group could be the hub service of *C. siamensis* identification. This knowledge gap will effectively support Thailand to maintain a sustainable natural and commercial captive population according to Thai National Policy.

15. Instruction for Crocodile Sample Collection (Kornsorn Srikulnath, Kasetsart University, Thailand). Methods of collection, labeling and packaging of blood, tissue and scales were covered.

SCTF members from Cambodia and Vietnam were unable to attend the meeting. Some country reports and updates were provided within the main meeting (see 2-8. above). Although the SCTF was formed in 2012, terms of reference were not developed, and it is sometimes difficult to separate activities undertaken at a country level from the SCTF.

In hindsight, given that the primary goal of the SCTF was to establish a network of members (Government and private) in *C. siamensis* range states (Indonesia, Thailand, Cambodia, Vietnam) for communication and information sharing, a "task force" may not be the most appropriate approach. It was suggested that the SCTF be re-formed as the "Siamese Crocodile Conservation Network", and terms of reference be formulated as soon as possible, to guide members, which can be drawn from within and outside the CSG as considered necessary to achieve its goals.

On the afternoon of 2 June, a workshop on telemetry was convened. The main goal of the workshop was to show participants, including personnel who will be involved in the recently approved reintroduction program in Thailand and SCTF member countries, methods of mounting transmitters on crocodilians (Fig. 1).

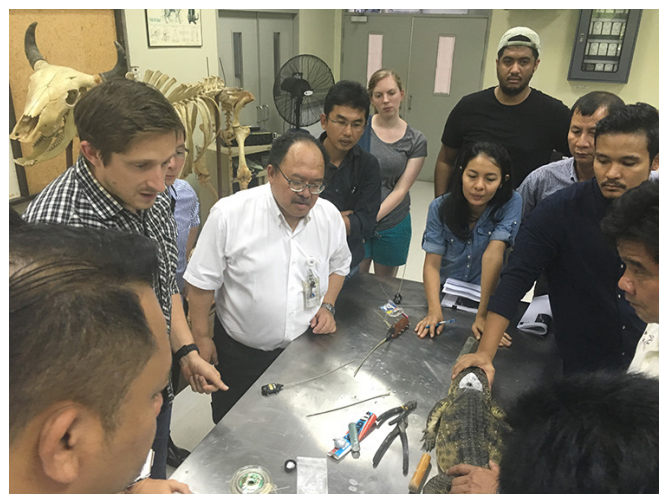


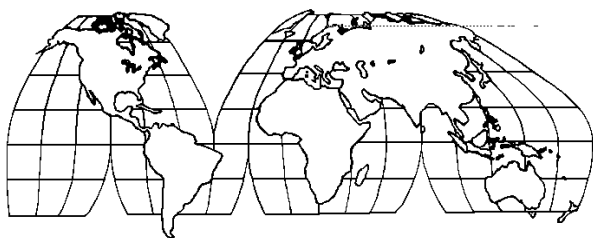
Figure 1. Participants at telemetry workshop.

Charlie Manolis, Han Sam and Jackson Frechette shared their

experiences with participants, and transmitters were attached on the nuchal scales and the tail of a juvenile Siamese crocodile. The pros and cons of each method of attachment were discussed, as were different methods of retrieving data from tagged animals. Thanks to Yosapong Temsiripong who kindly translated (English/Thai) during the meeting and workshop. Thanks also to the Thai organizers, and CMAT, COCOT and ARDA, who sponsored the attendance of participants from Indonesia and Lao PDR.

Charlie Manolis, CSG Deputy Chair, [cmanolis@wmi.com.au](mailto:cmanolis@wmi.com.au).

## Regional Reports



### Australia and Oceania

#### Australia

**CROCODILES AND SAWFISH!** Scientists from Murdoch University (Perth, Western Australia) and indigenous rangers recently examined the scars on freshwater sawfish (*Pristis pristis*) in the Fitzroy River, and found that around 60% of them had bites from crocodiles or bull sharks (Morgan *et al.* 2017). Young sawfish spend around 4-5 years in upstream freshwater areas before migrating from the rivers to the ocean to mature and breed. Freshwater sawfish are listed in the IUCN Red List as Critically Endangered and are the only sawfish from the five sawfish species with a juvenile freshwater phase.



The scars suggest that crocodiles (*Crocodylus johnstoni* and *C. porosus*) attempt to capture sawfish regularly. Although large sawfish may prove too large to be taken by smaller crocodiles, it is likely that large crocodiles may be successful in taking them, especially newborn individuals migrating upstream. Scientists have suggested the removal or alteration

of man-made instream barriers, which attract crocodiles and bull sharks, to allow sawfish to travel safely. Literature Cited

Morgan, D.L., Somaweera, R., Gleiss, A.C., Beatty, S.J. and Whitty, J.M. (2017). An upstream migration fought with danger: freshwater sawfish fending off sharks and crocodiles. *Ecology* 98(5): 1465-1467.

Source: Rebecca Gredley, *Crocodile takes down savage sawfish in Australian waters*, *The Daily Telegraph*, 13 April 2017.

## North America

### USA

**CROCODILIAN BIOLOGISTS AND MANAGERS CONVENE AT THE 2ND PALMETTO ALLIGATOR RESEARCH AND MANAGEMENT SYMPOSIUM.** On 28 April 2017 the second Palmetto Alligator Research and Management Symposium was held at the Clemson University Baruch Institute of Coastal Ecology and Forest Science in Georgetown, South Carolina (the “Palmetto State”). Sixteen speakers from a six states and a diversity of backgrounds gave presentations on crocodilian management and biology, with an emphasis on American alligator populations along the US Atlantic coast (Fig. 1). Over 55 people, representing state and federal agencies, municipalities, private landowners, universities, animal parks, zoos and aquaria, and NGOs attended the symposium. The three “grandfathers” of alligator research and management in South Carolina - Mark Bara, Phil Wilkinson and Tom Murphy - kicked off the meeting with presentations about their work on alligators during the 1960s and 1970s, some of which continues today.



Figure 1. Speakers at the 2nd Palmetto Alligator Research and Management Symposium. Front row (L to R): Thomas Rainwater, Alicia Davis, Allen Boynton, Arnold Brunell. Back row (L to R): Tina Johannsen, Jay Butfiloski, Tom Murphy, Mark Bara, Phil Wilkinson, Jim Jordan, Jon Warner, Chris Murray, Sam Seashole, Stacey Lance, Allan “Woody” Woodward. Photograph: Ben Parrott.

These talks were followed by reports on alligator management and associated issues in North Carolina, South Carolina, Georgia and Florida. Ensuing presentations covered multiple topics including trends and characteristics of alligator bites

on humans in Florida, stress and the crocodilian immune system, alligator population genetics in southwest Georgia, Nile crocodile ecology in St. Lucia, South Africa, and American crocodile ecology, ecotoxicology, and conflict with humans in Costa Rica. The symposium was again followed by a dinner/social where speakers and attendees enjoyed the spring evening weather and a Lowcountry Boil of seasoned potatoes, sausage, corn, and shrimp, and continued conversations about crocodilian research, management, and conservation late into the night.

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## **South Asia and Iran**

### **India**

RESULTS OF ANNUAL CENSUS OF SALTWATER CROCODILES (*CROCODYLUS POROSUS*) IN BHITARKANIKA WILDLIFE SANCTUARY, ODISHA, INDIA. The annual census conducted in the river systems of Bhitarkanika Wildlife Sanctuary/National Park in January 2017 resulted in the sighting of 1682 Saltwater crocodiles (608 hatchlings, 334 yearlings, 266 juveniles, 172 sub-adults, 302 adults). The relative density of crocodiles has increased from 0.87/km in 1976 (61 juveniles, 6 sub-adults, 29 adults) to 13.36/km in 2017 - a 1652% increase in total numbers.

In addition, more than 70 female Saltwater crocodiles (both released and wild) have bred annually, a 1300% increase compared to the mid-1970s with respect to nesting in the wild. With initiation of the Government of India/FAO/UNDP Project "Crocodile Breeding and Management", the Crocodile Conservation and Research Project was launched in different states of India in 1975. The Saltwater Crocodile Conservation and Research Programme, implemented in the State of Odisha, has been a great success. At the national level it is at the top as far as "rear and release" and building up the depleted wild population is concerned. The *C. porosus* population in the Bhitarkanika river systems has gradually been built up over the last 41 years.

The main Bhitarkanika River (from Khola to Pathasala), Thanapati, Mahinsamada, Suhajore and Baunsagada Creeks, and Kalibhanjadia, reported the highest densities of crocodiles, since they satisfy all the basic requirements for survival of the species in this mangrove ecosystem. Bhitarkanika now holds the largest population of wild Saltwater crocodiles in India, which represents about 70% of the total Indian population of the species.

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## **Nepal**

### **DOING THE NEEDFUL IN NEPAL: PRIORITIES FOR GHARIAL CONSERVATION**

#### **Time to Re-Focus**

A recent paper entitled "Conservation and Population Recovery of Gharials in Nepal" (Acharya *et al.* 2017) presents an optimistic overview of conservation efforts in Nepal over the past decade, following the pioneering work of the late T. Maskey (Maskey 2008) and to whom the paper is dedicated. The main message of Acharya *et al.* (2017) is that the decades long *ex-situ* program of egg collection and captive rearing has run its course, and that the Nepal program needs to refocus on the remaining wild populations before it is too late. The authors argue further that: 1) since 2005 wild populations have been gradually "increasing"; 2) there is evidence of "natural recruitment" in the two remaining wild populations at Chitwan National Park (CNP) and Bardia National Park (BNP); and, 3) that these populations are overwhelmingly "female-biased". They conclude by suggesting that future *in-situ* efforts should be channeled toward field assessments, habitat management, and ecological and behavioral research.

Here I comment on this paper, and add my personal assessment of Gharial conservation in Nepal as it now stands and as these efforts are carried forward into the future. My assessment is based on two recent field visits in April and in July 2016, where I stayed at CNP and at BNP and spoke with workers in Government [Department of National Parks and Wildlife Conservation (DNPWC)], the major NGOs [National Trust for Nature Conservation (NTNC), WWF Nepal, Zoological Society of London (ZSL)] as well as independent researchers working with these agencies. I particularly thank all of these people who generously and graciously shared information with me. I emphasize here that my comments are offered to help clarify and refocus current and future conservation efforts in Nepal toward our common goal of Gharial conservation. For the record, I am in full agreement with the main message that the time is right to reframe and refocus Gharial conservation in Nepal, but I also question the assertions that wild population numbers are increasing, and that significant natural recruitment occurs under the current management regime.

#### **Too Many Gharial in Captivity**

First of all, the refocus away from the *ex-situ* approach, and squarely on the status and fate of the two remaining wild populations is long overdue and most welcome. At present, the Gharial Conservation and Breeding Centre (GCBC) at Kasara, within CNP, contains in excess of 600+ Gharial, including several small breeding groups of adults and primarily large juveniles and small sub-adults of unknown sex, most 1.5-2+ m in size and 5-12 years of age. The facility is over-crowded and the feed bill is unmanageable, given the current level of staffing and support. Visitors to CNP have the option to pay a fee and tour the GCBC, but officials

are privately embarrassed by the condition of the facilities, despite the best efforts of the understaffed and underfunded management.

Since 1981, 1156 captive-reared Gharial have been released into five major rivers in lowland Nepal, with 875 released directly into CNP (see Figure 4 in Acharya *et al.* 2017). Although several hundred have been released annually in recent years, these are increasingly older, possibly stunted individuals, with no experience under wild conditions. Many of the recent releases have been done during the winter months, with attendant ceremonies, but little follow-up.

#### Lack of an Effective Release Strategy

This situation, in which captive animals reared primarily from eggs taken from wild nests, and being held until they reach large juvenile or small sub-adult sizes, is increasingly unworkable and more importantly, is of questionable value for the conservation of the two remaining wild populations. The few surveys of released Gharial indicate the loss of 50% within the first year, with only 20% recorded after two years, and an overall survival of ~7% (Ballouard *et al.* 2010; Maskey and Percival 1994). In CNP, if all of the increase in wild numbers surveyed through 2016 were attributable to these released Gharial, the increase would represent only 11% of those released (95/875; Acharya *et al.* 2017). The fate of the other 89% (780/875) is unknown, but anecdotally it is assumed that the survivors ultimately travel down the Narayani and cross into India at the Narayani-Gandak barrage. Nearby, in recent years on the Gandak at the Indo-Nepal border, a small breeding group has been noted with evidence of a small number of successful nests (Choudhury *et al.* 2016).

The larger issue here, and one that is seldom addressed or discussed, is the lack of a comprehensive, coordinated release strategy that targets releases of head-started Gharial 1) in appropriate localities to minimize disturbance and/or predation, and to maximize feeding, basking, etc., 2) at the appropriate age/size to establish residency in the released area, 3) at the appropriate season of the year (ie post-monsoon versus cool winter months, 4) with adequate marking, tracking, and assessment to evaluate the efficacy of the release protocols. All of these elements need to be incorporated into any head-starting and captive-release approach.

Clearly, in the current Nepal situation, the whole *ex-situ* program needs a serious “rethink” and “reboot,” aimed at: 1) drastically reducing captive numbers; 2) targeted release at much younger ages, smaller sizes, of known sexes, etc.; 3) in carefully selected, protected localities; and, 4) in strategic ways (eg right time of year, “soft” releases from *in-situ* enclosures, etc.). As Acharya *et al.* (2017) suggest, most wild nests should be left in place on the nesting banks, with adequate protections and Gharial “guards,” and the *ex-situ* program limited only to rescuing natural nests in jeopardy of flooding or other damage. Resultant hatchlings should be released soon after hatching. They also note that limited continuation of the *ex-situ* program may be an effective hedge

against the vagaries of climate change, with likely changes in river flow and associated habitat changes.

#### Increasing Numbers in the Wild Populations?

Acharya *et al.* (2017) contend that the surveys conducted since 2005 indicate “increasing” population numbers at the two remaining wild localities - CNP and BNP. They state that “the population of Gharials remains low at these locations” (61 in 2004; 156 in 2016), but the numbers of sub-adults have increased. A major factor confounding the survey counts is that fact that hundreds of captive-reared Gharial (1-2+ m TL) have also been released at these locations since 2005 (see Figure 4 in Acharya *et al.* 2017). There is little to no evidence that the presence of sub-adults, or increases in the numbers of sub-adults, indicates successful *in-situ* breeding at either location. In fact, few hatchlings have been recorded at either locality during nationwide surveys conducted in 2008, 2011, 2013 and 2016 (Khadka *et al.* 2008; WWF-Nepal 2011; DNPWC and WWF-Nepal 2013; National Crocodile Survey 2017, draft report cited in Acharya *et al.* 2017).

At this juncture the survey data on adult numbers at these localities are equivocal, in my view. It may be useful to hold judgment on this issue until the 2016 National Crocodile Survey results are detailed in an upcoming report due later in 2017 (Naresh Subedi, NTNC, pers. comm.). However, additional data from the 2013 National Crocodile Survey (comparable in scope and extent of coverage to the 2008, 2011 and 2016 surveys; DNPWC and WWF Nepal 2013) are available, but were not presented or discussed in Acharya *et al.* (2017). Similarly, valuable survey protocol guidelines are outlined in a recent report not referenced (Malla and Thapa 2016).

I have commented on these recent survey data at length in an unpublished critique (downloadable at Academia.edu, Jeffrey Lang). In brief, the 2013 survey shows counts slightly higher than those done previously in 2008 and in 2011, but the 2013 counts are much lower, by 2-3x than the counts reported for the 2016 survey. In my view the 2016 numbers cited in Acharya *et al.* (2017) for CNP and BNP are inexplicably high, and should be viewed with caution pending completion of the Final Report for the National Crocodile Survey in 2016.

#### Natural Recruitment in Wild Populations?

Likewise, the evidence for “natural recruitment” at both remaining wild localities, CNP and BNP, is equivocal. Despite surveys in 2008, 2011, 2013 and 2016, no hatchlings were recorded at the Babai River within BNP and only several were noted in the large Karnali River that borders BNP on the west. The claim of natural recruitment in the Babai in recent years is based on the presence of sub-adults during these surveys (Acharya *et al.* 2017). However, captive-reared stock from the GCBC at Kasara have been released at BNP in recent years, totaling at least 80 animals (10 in 2010, 50 in 2014 and 20 in 2015; unpublished DNPWC report; R.C. Kandel, pers. comm.). In contrast, there is evidence of limited natural recruitment at CNP, in both the Narayani and Rapti Rivers

where hatchlings have been noted in various earlier surveys, but not detected in the 2016 survey (Table 1 in Acharya *et al.* 2017).

A better indicator of natural recruitment is the number of natural nests found in these wild populations. Natural nest numbers are indicative not only of the likelihood of natural recruitment, but also of the number of reproductive females remaining in these populations. To date there is no definitive evidence of natural nesting in BNP in recent years, and no evidence yet of nesting along the Babai River, whose upper course is protected as it runs through the eastern half of BNP. Thus, although BNP is often referred to as the second location of a wild Gharial population in Nepal, evidence that the BNP population is self-sustaining is lacking. Gharial are now extirpated or nearly absent from the large riverine habitats along the Karnali where formerly they were present. In BNP Gharials are confined, with a few possible exceptions, to the smaller Babai River with its source in hills upstream.

In CNP the numbers of natural nests per year on both the Narayani and Rapti Rivers are: 6, 10, 8, 9, 7, 7, 5, 5, 6, 4, 7, 9, 11, 11, 12, 13, 14 and 11, for each year from 2001 through 2017 respectively (Bed Khadka, pers. comm.). During this 18-year period the mean nest number was 8.6, ranging from 5 to 14. This extensive dataset indicates that regular natural nesting occurs in CNP annually at low levels, and also suggests a very moderate increase since 2012, with 10+ nests recorded through 2017. These data, in turn, suggest that despite egg collection for captive rearing from the natural nests at CNP in most years, natural nesting persists in CNP where one or several small breeding wild population reside.

A caution re: inferences about adult female numbers from these nesting numbers - in Nepal, Gharial may not nest annually, but rather every other year, or on a longer cycle (Bed Khadka, pers. comm.). Thus, it is likely that the number of mature reproductive females may be as high as 40, but if only half of these nest each year, then the anticipated nest number would be ~20 nests annually, rather than 40. Studies in captivity of annual breeding should be instructive in this regard, but have not been reported. The actual number of nests, ~10+ annually, recorded at CNP suggests that there are fewer females than the 2016 survey indicates. Acharya *et al.* (2017) report 48 adults in the Narayani, and 20 in the Rapti, for a total of 68 “females” in CNP (2017).

Recent field observations by an independent researcher, Sunil Rajbhandari, in early 2017, recorded two breeding groups in the Narayani adjacent to CNP. He recorded two large ghara males, one within each group and a total of 40 adult females. A total of 89 animals were tallied, including 46 sub-adults and one juvenile in February 2017 at these two sites. Subsequently, 11 nests were located, half at the downstream site, and half upstream near the Rapti confluence (S. Rajbhandari, pers. comm.).

Additionally, Acharya *et al.* (2017) report that available surveys strongly suggest that the remaining adult populations, particularly at CNP, are female-biased, with few mature,

big ghara males recorded. In the 2016 survey at CNP, only one large ghara male was observed. The observations of Rajbhandari and co-workers indicate the presence of at least two large males at CNP, but recently (June 2017), a large male was found dead, entangled in a fishing net on the Narayani near CNP. The loss of a large male at CNP has prompted a discussion of whether additional males should be translocated to CNP, and whether such an action would be an effective solution for the apparent predicament of few mature males in the CNP wild breeding population. This discussion is ongoing, and has garnered considerable media attention, since cross-border solutions could include Indian involvement.

#### A More Realistic in-situ Strategy Directed at Human Threats to Wild Gharial

In concluding their paper, Acharya *et al.* (2017) recommend that the *in-situ* approach be augmented by further studies aimed at management and conservation of the wild populations, at both CNP and BNP. In a field assessment conducted in 2016, more robust suggestions emerged that directly addressed the very real and counterproductive human activities which presently threaten the survival and well being of the remaining wild Gharial, particularly at CNP. These *in-situ* actions include: 1) an allocated budget for *in-situ* conservation; 2) declaration of a no-go restricted zone to exclude fishing, sand and boulder collection, and reduce human disturbances where Gharials reside; 3) restoration of the River Rangers program to patrol and monitor Gharial activities; 4) intensive outreach with local communities using the river, especially those with legal fishing licenses; and, 5) coordination and collaboration with other Gharial conservationists and scientists working worldwide. Additional *in-situ* activities should also include: 6) long-term studies of spatial and nesting ecology; 7) identification of additional release sites; 8) direct protection and monitoring of natural nests; and, 9) penalties for habitat encroachment and destructive fishing practices.

Some of these *in-situ* elements were included in the recent Lacoste-funded program organized by the DNPWC and WWF-Nepal. This program appears to have ended in 2013 when funding ceased. It should be revived and reinvigorated with additional innovative people-directed programs aimed at the local fisher communities bordering the CNP and BNP. Many of these *in-situ* actions were initially successful and are described in Malla *et al.* (2012). In Nepal, conservationists and wildlife scientists have already pioneered many effective ways to conserve large, charismatic megafauna, such as rhinos, elephants, and tigers with buffer zones and community forests managed by local communities. Now is the time to make a major push to engage in similar efforts with local communities which live with their “aquatic tigers,” the Gharial, together with the other river fauna, including the many bird species, otters, river turtles and dolphins along Nepal’s rivers.

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## Latin America and the Caribbean

### **Venezuela**

RANCHING OF ORINOCO CROCODILE FOR CONSERVATION PURPOSES IN VENEZUELA. In May 2017, within the framework of the Orinoco Crocodile Conservation Program in Venezuela, 347 wild *Crocodylus intermedius* hatchlings were collected in the Cojedes and Capanaparo Rivers (the two main populations of the species in the country), and taken to rearing facilities for grow-out and subsequent release back to the wild in 2018.

This activity was coordinated through the Ministry of Environment (MINEA), the Institute of National Parks (INPARQUES), the National Science Academy Foundation (FUDECI), and the Crocodile Specialist Group of Venezuela (GECV), and reflects the strategy of using the reproductive potential of remaining wild populations to support the captive breeding program, boosting the numbers annually reared and increasing chances of survival of wild new-born crocodiles. It also represents a cost-effective way to compensate for the decline in fecundity of older captive adults in the existing breeding facilities, some of which are already reaching the end of their useful lives as breeding stock. It would also help to lessen the possible effect on reduced fitness by the repeated use of captive-reared parents to reinforce wild populations for numerous generations.

The possibility of swapping reared specimens from one locality to the other is also proposed (with strict veterinary screening) in order to increase the genetic variability and reduce inbreeding in both populations, which despite sustained efforts of reinforcement are currently at low levels of abundance and have been geographically isolated for at least half a century.

The importance of this action not only lies in the rearing of crocodiles *per se*, but also during these field activities a detailed census of nests and hatchling pods was performed, which is the best index of the actual population status and reproductive potential of the species in both locations, and complements the data of the national census of the Orinoco crocodile that the GECV is carrying out in 2017 and 2018.

The bad news is that 40% of nests detected in the Capanaparo River were poached by local people. The encouraging news is that in the same river, in the area in which 16 females hatched in the Dallas World Aquarium were released in 2009 (as 2- and 3-years-old), the number of nests has doubled - from 5 to 10.

Perhaps the 27-year population reinforcement program has not yet managed to save *C. intermedius* from the path to extinction path in Venezuela, but it has undoubtedly been a critical factor in reducing the rate of decline. Until the main factors that affect these populations can be reduced to manageable levels, this effort must be maintained at all costs.



Figure 1. Omar Henandez (GECV) collecting newly-hatched Orinoco crocodiles in the Capanaparo River. Photograph: Alvaro Velasco.

Crocodile Specialist Group of Venezuela ([gecvenezuela@gmail.com](mailto:gecvenezuela@gmail.com)).

**8TH AND 9TH COURSES IN ECOLOGY AND CONSERVATION OF THE CROCODYLIA OF VENEZUELA.** The Crocodile Specialist Group of Venezuela (GECV) considers of utmost importance the motivation, education and training of key players in research and conservation of crocodilians in our country. As part of this strategy, the GECV held the 8th and 9th Courses in Ecology and Conservation of the Crocodylia of Venezuela, on 26-31 March and 20-23 June 2017 respectively.

Both courses were organized in Masaguaral Ranch ([www.hatomasaguaral.org](http://www.hatomasaguaral.org)), a wildlife reservoir located in Guárico State, with one of the pioneering Orinoco crocodile breeding facilities in Venezuela, operating since 1984, and a long tradition of support for the conservation and scientific research of Venezuelan wildlife.

The 8th Course was directed at students in biology, veterinary medicine and related fields in the final stage of their studies, who have expressed their interest to develop professional vocation related to crocodilian conservation. The 9th Course was aimed mainly at government park rangers who work in National Parks with the main populations of *Crocodylus intermedius* and *C. acutus*, but also included managers and keepers from zoos and captive-breeding farms who are involved in the *ex-situ* conservation of these species. Both courses were fully subsidized so that the participation was completely free, but subject to a rigorous selection by the GECV.

The issues presented during the courses were an introduction to the order Crocodylia and the current status of conservation in Venezuela, *in-situ* and *ex-situ* conservation programs, survey and population estimation techniques, remote sensors, crocodilians as habitat indicators, sanitary aspects in eggs, hatchlings and adult crocodiles in captivity, crocodile-human conflict, trade, ecotourism potential, environmental education and community participation, among others.

The field practicals included night counts and size class estimation, habitat characterization, capture, body measurement, weighing, sexing and analysis of stomach content of wild *Caiman crocodilus*; collection of eggs and morphometrics of captive *C. intermedius* yearlings at the Masaguaral Ranch breeding facility.



Figure 1. Participants of the 8th Course in Ecology and Conservation of the Crocodylia of Venezuela.



Figure 2. Participants of the 9th Course in Ecology and Conservation of the Crocodylia of Venezuela.



Figure 3. Prof. Andrés Seijas explaining the general characteristics of crocodilians during the night practical.

We hope that this effort will lead to an improvement in the government management and conservation of endangered crocodilians in Venezuelan National Parks and a new generation of researchers interested in this important field of our wildlife conservation.

The GECV thanks: Daryl Richardson (CEO, Dallas World Aquarium) who funded both courses; Luis Sigler for his invaluable support to GECV; and, Gordon Henley (Director, Ellen Trout Zoo) who financed part of the student's course.

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## East and Southeast Asia

### Philippines

**SECOND RELEASE OF PHILIPPINE CROCODILES AT PAGHUNGAWAN MARSH, PILAR, SIARGAO ISLAND.** On 17 June 2017, the second release of Philippine crocodiles (*Crocodylus mindorensis*) by Crocodylus Porosus Philippines Inc. (CPPI) into Panghuwahan Marsh, Siargo Island, took place.

CSG Deputy Chair Charlie Manolis and CSG Executive Officer Tom Dacey were invited to participate in this important event, joining: CPPI board members Vic Mercado, William Bello and Daniel Barlis; the CPPI research team (Edgar Jose, Philip Baltazar, Meljory Corvera) headed by Rainier Manalo; crocodile farm staff (Brian Sibongga, Coral Agri-Venture Farm; Michael Cruz, Pag-asa Farm); Department of Environment and Natural Resources (DENR) staff; and, local Government and community members of the Municipality of Pilar.

The event started in the morning, with official addresses to the community at the municipality offices by Mayor Ma. Liza G. Resurreccion, Pilar Councillor Edito Salvaloa, Vic Mercado (CPPI), Charlie Manolis (CSG) and Celsa Espadero (DENR). In the afternoon, 8 yearling and 21 juvenile *C. mindorensis* (21M, 8F), bred at Pag-asa Farm, and ranging in size from 0.4 to 1.2 m TL, were released into the marsh (Figs. 1 and 2).



Figure 1. Mayor Liza Resurreccion (centre) released the first Philippine crocodile into the marsh. Photograph: Meljory Corvera.



Figure 2. CPPI directors and staff, and CSG representatives, released the final five Philippine crocodiles. From left, with crocodiles: Vic Mercado, William Belo, Rainier Manalo/Brian Sibongga, Charlie Manolis, Daniel Barlis. Photograph: Meljory Corvera.

Members of the Pilar community and other onlookers were given the opportunity to hold some of the crocodiles prior to their release (Fig. 3), which will no doubt stay in people's memories for a long time to come.



Figure 3. Community members and other participants were able to hold crocodiles prior to their release. Photograph: Tom Dacey.

The day before the release, CPPI staff tested a drone over Paghungawan Marsh to assess its effectiveness in surveying open water areas for crocodiles and assessment of habitat. On the day of the release, the drone was used to film the crocodile release and to follow some of the crocodiles as they made their way into the marsh.

The reintroduction program at Paghungawan Marsh has the strong support of the local Pilar community, which has integrated crocodiles into its eco-tourism activities. It has also sparked interest from communities in other parts of Siargao Island, where Saltwater crocodiles (*C. porosus*) occur.

Charlie Manolis, CSG Deputy Chair, [cmanolis@wmi.com.au](mailto:cmanolis@wmi.com.au).

## Science



### Recent Publications

Savage, J. (2017). Crocodilian confusion: The Order-group names Crocodyli, Crocodilia, Crocodylia, and the authorship of the Family-group name Crocodylidae or Crocodylidae. *Herpetological Review* 48(1): 110-114.

Acharya, K.P., Khadka, B.K., Jnawali, S.R., Malla, S., Bhattarai, S., Wikramanayake, E. and Köhl, M. (2017). Conservation and population recovery of Gharials (*Gavialis gangeticus*) in Nepal. *Herpetologica* 73(2).

**Abstract:** The remnant populations of Gharials, *Gavialis gangeticus*, are now confined to the large, deep rivers of northern India and

Nepal. In lowland Nepal, the populations are restricted to a few stretches of the Narayani-Rapti and Karnali-Babai River systems. Periodic censuses of the wild populations have been made over the past 12 years. Here, we present population trends of Gharials in the Narayani, Rapti and Babai Rivers based on these surveys. The results indicate that the combined numbers of adults and sub-adults have been gradually increasing since 2005, but the numbers of adults are low and female biased, with very few males recorded from all study sites. In 1978, Nepal established a captive breeding center in Chitwan National Park, from which captive-bred animals have been periodically released 4-7 years after hatching, at which time the animals are about 1.5 m total length. The detection of hatchlings and sub-adult classes that are smaller than these released animals in the rivers indicates that there is natural recruitment. Therefore, collecting all nests for *ex-situ* breeding might not be the best strategy until more rigorous field assessments are completed to determine the relative contributions of captive-bred versus natural recruitment. We suggest that more effort should be channeled toward field assessments, including mapping and monitoring habitat availability, habitat management to ensure necessary environmental flows to create sand banks and deep pools, and research to better understand the ecology and behavior of Gharials in Nepal's rivers.

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Natusch, D.J.D., Carter, J.F., Aust, P.W., Tri, N.V., Tinggi, U., Mumpuni, Riyanto, A. and Lyons, J.A. (2017). Serpent's source: Determining the source and geographic origin of traded python skins using isotopic and elemental markers. *Biological Conservation* 209: 406-414.

**Abstract:** Commercial production systems for wildlife increasingly involve closed-cycle captive breeding, in which effective regulation requires methods for verifying the provenance of stock. We compared the isotopic and elemental compositions of skin from wild and captive-bred pythons raised under different diet regimes in Indonesia and Viet Nam to examine the efficacy of using these techniques as a means of determining the source and origin of skins entering international trade. We found significant differences in both isotopic and elemental markers between wild and captive-bred snakes, as well as those from different geographic origins. Combinations of both techniques were able to discriminate between diet treatments and geographic origins with up to 100% accuracy. Moreover, our experimental manipulation of python diets confirmed that the application of specific diet regimes (or the addition of known elemental markers) for captive-bred snakes can create signatures specific to those animals, vastly improving the efficacy of these methods. Our study strongly suggests that the analysis of isotope ratios and elemental markers offers a powerful tool for verifying the provenance of reptile skins entering trade - but these methodologies will be most applicable (and cost-effective) for species with small populations of genuine conservation concern, rather than for large volume trade in species for which there is little conservation risk.

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Morgan, G. (2017). Fossil vertebrates from the Cayman Islands. *Flicker* 29: 1-6.

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Singh, H. and Rao, R.J. (2017). Status, threats and conservation challenges to key aquatic fauna (crocodile and dolphin) in National Chambal Sanctuary, India. *Aquatic Ecosystem Health & Management* 7(1-2): 59-70.

**Abstract:** The Chambal River in India supports a rich variety of fauna and flora including the endangered Ganges River Dolphin and Crocodile. Threats to the continued functioning of the Chambal River as a living system have reached a critical level due to the exponential expansion of human populations. Population status of Crocodiles and Dolphins in a 425 km stretch of the Chambal River was determined by surveys conducted every year during 2007 to 2010. The average number of Dolphins recorded during the surveys was  $82.75 \pm 09.1 \text{ yr}^{-1}$  with an encounter rate of  $0.19 \text{ km}^{-1}$  (range

69-91), Gharial  $916.25 \pm 91.6 \text{ yr}^{-1}$  with an encounter rate of  $2.15 \text{ km}^{-1}$  (range 870-996), and Mugger  $235 \pm 27.7 \text{ yr}^{-1}$  with an encounter rate of  $0.56 \text{ km}^{-1}$  (range 194-301). Increasing demands for sand for development activities and water abstraction for irrigation and energy generation, coupled with mortality in fishing nets, are likely to affect these populations. Recommendations for management and research are made to ensure the effective conservation of these species in the Chambal River.

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Cubo, J., Köhler, M. and de Buffrenil, V. (2017). Bone histology of *Iberosuchus macrodon* (Sebecosuchia, Crocodylomorpha). *Lethaia* (doi: 10.1111/let.12203).

**Abstract:** *Iberosuchus macrodon* is a Cenozoic crocodyliform interpreted as a terrestrial, cursorial form. To assess whether this adaptation was accompanied by a high growth rate and an elevated resting metabolic rate (two features commonly attributed to several terrestrial Triassic Crocodylomorpha based on histology), we studied bone histology in the femora of two specimens attributed to *I. macrodon*. Beyond this question is the broader problem of the possible survival to the Cretaceous-Palaeogene extinction event of tachymetabolic sauropsids other than birds. At mid-diaphysis, bone cortices in *Iberosuchus* are made of a parallel-fibred tissue that turns locally to true lamellar bone. Cortical vascularization consists of simple longitudinal canals forming a network of medium density. The spacing pattern of conspicuous lines of arrested growth suggests asymptotic growth for *Iberosuchus*. This general histological structure prevails also in the metaphyseal region of the bones. It is basically similar to that encountered in certain large lizards adapted to active predation, the Varanidae and the Teiidae. In one of the two *Iberosuchus* femora, however, an intracortical meniscus made of a tissue displaying a global radial architecture occurs in the region of the fourth trochanter. Histologically, the latter can be interpreted either as compacted spongiosa or as a fibro-lamellar complex with a gross radial orientation, a tissue corresponding to fast periosteal apposition. These observations suggest that *Iberosuchus* basically had a slow, cyclical growth indicative of an ecto-poikilothermic, lizard-like, resting metabolic rate. However, it might also have retained a limited capacity for fast periosteal accretion in relation to local morphogenetic requirements as, for instance, the development of crests or trochanters.

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Mallon, J.C. (2017). Recognizing sexual dimorphism in the fossil record: lessons from nonavian dinosaurs. *Paleobiology* (doi: 10.1017/pab.2016.51).

**Abstract:** The demonstration of sexual dimorphism in the fossil record can provide vital information about the role that sexual selection has played in the evolution of life. However, statistically robust inferences of sexual dimorphism in fossil organisms are exceedingly difficult to establish, owing to issues of sample size, experimental control, and methodology. This is particularly so in the case of dinosaurs, for which sexual dimorphism has been posited in many species, yet quantifiable data are often lacking. This study presents the first statistical investigation of sexual dimorphism across Dinosauria. It revisits prior analyses that purport to find quantitative evidence for sexual dimorphism in nine dinosaur species. After the available morphological data were subjected to a suite of statistical tests (normality and unimodality tests and mixture modeling), no evidence for sexual dimorphism was found in any of the examined taxa, contrary to conventional wisdom. This is not to say that dinosaurs were not sexually dimorphic (phylogenetic inference suggests they may well have been), only that the available evidence precludes its detection. A priori knowledge of the sexes would greatly facilitate the assessment of sexual dimorphism in the fossil record, and it is suggested that unambiguous indicators of sex (eg presence of eggs, embryos, medullary bone) be used to this end.

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Johnston, S.D., Qualischefski, E., Cooper, J., McLeod, R., Lever,

J., Nixon, B., Anderson, A.L., Hobbs, R., Gosálvez, J., López-Fernández, C. and Keeley, T. (2017). Cryopreservation of saltwater crocodile (*Crocodylus porosus*) spermatozoa. Reproduction, Fertility and Development (<https://doi.org/10.1071/RD16511>).

**Abstract:** The aim of the present study was to develop a protocol for the successful cryopreservation of Saltwater crocodile spermatozoa. Sperm cells were frozen above liquid nitrogen vapour in phosphate-buffered saline (PBS) containing either 0.3M trehalose, 0.3M raffinose or 0.3M sucrose and compared with glycerol (0.3-2.7M). Although the highest levels of mean post-thaw motility were observed following cryopreservation in 0.3M trehalose (7.6%) and 0.3M sucrose (7.3%), plasma membrane integrity (PI) was best following cryopreservation in 2.7M glycerol (52.5%). A pilot study then assessed the cytotoxicity of glycerol and sucrose prior to cryopreservation and revealed no loss of survival when spermatozoa were diluted in 0.68M glycerol or 0.2-0.3M sucrose once cryoprotectants were washed out with PBS or Biggers, Whitten and Whittingham medium containing sperm capacitation agents (BWVAP). A final study refined the combined use of permeating (0.68 or 1.35M glycerol) and non-permeating (0.2 or 0.3M sucrose) cryoprotectants. Spermatozoa were cryopreserved in liquid nitrogen vapour at rates of approximately  $-21^{\circ}\text{C min}^{-1}$  (fast freeze) or  $-6.0^{\circ}\text{C min}^{-1}$  (slow freeze). Post-thaw survival was highest with a combination of 0.2M sucrose and 0.68M glycerol and when these cryoprotectants were washed out with BWVAP, regardless of whether spermatozoa were frozen using a fast (motility  $14.2 \pm 4.7\%$ ; PI  $20.7 \pm 2.0\%$ ) or slow (motility  $12.0 \pm 2.7\%$ ; PI  $22 \pm 4\%$ ) cryopreservation rate.

Mao, X-M., Fu, Q-R., Li, H-L., Zheng, Y-H., Chen, S-M., Hu, X-Y., Chen, Q-X. and Chen, Q.H. (2017). Crocodile choline from *Crocodylus siamensis* induces apoptosis of human gastric cancer. Tumour Biology March 2017: 1-11.

**Abstract:** Crocodile choline, an active compound isolated from *Crocodylus siamensis*, was found to exert potent anti-cancer activities against human gastric cancer cells *in vitro* and *in vivo*. Our study revealed that crocodile choline led to cell cycle arrest at the G2/M phase through attenuating the expressions of cyclins, Cyclin B1, and CDK-1. Furthermore, crocodile choline accelerated apoptosis through the mitochondrial apoptotic pathway with the decrease in mitochondrial membrane potential, the increase in reactive oxygen species production and Bax/Bcl-2 ratio, and the activation of caspase-3 along with the release of cytochrome c. In addition, this study, for the first time, shows that Notch pathway is remarkably deregulated by crocodile choline. The combination of crocodile choline and Notch1 short interfering RNA led to dramatically increased cytotoxicity than observed with either agent alone. Notch1 short interfering RNA sensitized and potentiated the capability of crocodile choline to suppress the cell progression and invasion of gastric cancer. Taken together, these data suggested that crocodile choline was a potent progression inhibitor of gastric cancer cells, which was correlated with mitochondrial apoptotic pathway and Notch pathway. Combining Notch1 inhibitors with crocodile choline might represent a novel approach for gastric cancer.

Matthews, J.C. and Samonds, K.E. (2016). A juvenile subfossil crocodylian from Anjohibe Cave, Northwestern Madagascar. PeerJ 4: e2296.

**Abstract:** Madagascar's subfossil record preserves a diverse community of animals including elephant birds, pygmy hippopotamus, giant lemurs, turtles, crocodiles, bats, rodents, and carnivorans. These fossil accumulations give us a window into the island's past from 80,000 years ago to a mere few hundred years ago, recording the extinction of some groups and the persistence of others. The crocodylian subfossil record is limited to two taxa, *Voay robustus* and *Crocodylus niloticus*, found at sites distributed throughout the island. *V. robustus* is extinct while *C. niloticus* is still

found on the island today, but whether these two species overlapped temporally, or if *Voay* was driven to extinction by competing with *Crocodylus* remains unknown. While their size and presumed behavior was similar to each other, nearly nothing is known about the growth and development of *Voay*, as the overwhelming majority of fossil specimens represent mature adult individuals. Here we describe a nearly complete juvenile crocodylian specimen from Anjohibe Cave, northwestern Madagascar. The specimen is referred to *Crocodylus* based on the presence of caviconchal recesses on the medial wall of the maxillae, and to *C. niloticus* based on the presence of an oval shaped internal choana, lack of rostral ornamentation and a long narrow snout. However, as there are currently no described juvenile specimens of *Voay robustus*, it is important to recognize that some of the defining characteristics of that genus may have changed through ontogeny. Elements include a nearly complete skull and many postcranial elements (cervical, thoracic, sacral, and caudal vertebrae, pectoral elements, pelvic elements, forelimb and hindlimb elements, osteoderms). *Crocodylus niloticus* currently inhabits Madagascar but is locally extinct from this particular region; radiometric dating indicates an age of ~460-310 years before present (BP). This specimen clearly represents a juvenile based on the extremely small size and open sutures/detached neural arches; total body length is estimated to be ~1.1 m (modern adults of this species range from ~4-6 m). This fossil represents the only juvenile subfossil crocodylian specimen reported from Madagascar.

Carr, T.D., Varricchio, D.J., Sedlmayr, J.C., Roberts, E.M. and Moore, J.R. (2017). A new tyrannosaur with evidence for anagenesis and crocodile-like facial sensory system. Scientific Reports 7: 44942 ([doi:10.1038/srep44942](https://doi.org/10.1038/srep44942)).

**Abstract:** A new species of tyrannosaurid from the upper Two Medicine Formation of Montana supports the presence of a Laramidian anagenetic (ancestor-descendant) lineage of Late Cretaceous tyrannosaurids. In concert with other anagenetic lineages of dinosaurs from the same time and place, this suggests that anagenesis could have been a widespread mechanism generating species diversity amongst dinosaurs, and perhaps beyond. We studied the excellent fossil record of the tyrannosaurid to test that hypothesis. Phylogenetic analysis places this new taxon as the sister species to *Daspletosaurus torosus*. However, given their close phylogenetic relationship, geographic proximity, and temporal succession, where *D. torosus* (~76.7-75.2Ma) precedes the younger new species (~75.1-74.4Ma), we argue that the two forms most likely represent a single anagenetic lineage. *Daspletosaurus* was an important apex predator in the late Campanian dinosaur faunas of Laramidia; its absence from later units indicates it was extinct before *Tyrannosaurus rex* dispersed into Laramidia from Asia. In addition to its evolutionary implications, the texture of the facial bones of the new taxon, and other derived tyrannosauroids, indicates a scaly integument with high tactile sensitivity. Most significantly, the lower jaw shows evidence for neurovasculature that is also seen in birds.

DiGeronimo, P.M., Di Girolamo, N., Crossland, N.A., Del Piero, F., Reigh, R.C. and Nevarez, J.G. (2017). Effects of plant protein diets on the health of farmed American alligators (*Alligator mississippiensis*). Journal of Zoo and Wildlife Medicine 48(1): 131-135.

**Abstract:** The objective of this prospective, blinded study was to compare plasma biochemical values and gross and histologic evaluation of kidney and liver from American alligators (*Alligator mississippiensis*) fed extruded diets with protein derived from animal or plant sources. Alligators in two treatment groups were fed an extruded diet with protein derived primarily from plant products for 7 (n = 20) or 10 (n = 20) mo prior to harvest. A control group (n = 20) was fed a commercial diet with protein derived from animal products for the duration of the study. Plasma biochemistry panels were obtained and gross and histologic examination of kidney and

liver tissues was conducted for each animal. No differences were found between alligators fed diets with animal or plant protein in terms of either biochemistry profiles or gross or histologic examination of kidney and liver. Plant-based diets, fed for up to 10 mo, do not appear to have any ill effects on the kidney or liver of American alligators.

Burtner, B.F. and Frederick, P.C. (2017). Attraction of nesting wading birds to alligators (*Alligator mississippiensis*). Testing the 'Nest Protector' Hypothesis. *Wetlands* (doi:10.1007/s13157-017-0900-x).

**Abstract:** Ecological facilitation (mutualism and commensalism) appears to be a strong force shaping biotic communities, and may be more likely in stressful and dynamic environments like wetlands. We examined a specific type of mutualism, 'protective nesting associations,' between herons and egrets (Ardeidae) and American alligators (*Alligator mississippiensis*). We predicted that wading birds would be attracted to sites with alligators. A survey of potential nesting sites in the Everglades showed strong nonrandom association, with wading birds never nesting without alligators. At previously unoccupied nesting colony sites, we experimentally manipulated apparent densities of alligators and birds using alligator and bird decoys. Small day-herons (little blue herons (*Egretta caerulea*), tricolored herons (*E. tricolor*), and snowy egrets (*E. thula*)) were significantly more numerous at sites with both alligator and bird decoys than other treatments. These findings together support the hypothesis that wading birds actively choose predator-protected nesting locations based in part on information from both conspecifics and alligators, and suggest that the mechanism supporting this habitat choice is primarily due to nest protection benefits the alligators inadvertently provide. We propose that this interaction is strong and could be geographically widespread, and suggest that it may be critical to shaping management and conservation of wetland function.

Sellers, K.C., Middleton, K.M., Davis, J.L. and Holliday, C.M. (2017). Ontogeny of bite force in a validated biomechanical model of the American alligator. *Journal of Experimental Biology* (doi: 10.1242/jeb.156281).

**Abstract:** Three-dimensional computational modeling offers tools with which to investigate forces experienced by the skull encountered during feeding and other behaviors. American alligators (*Alligator mississippiensis*) generate some of the highest measured bite forces among extant tetrapods. A concomitant increase in bite force accompanies ontogenetic increases in body mass, which has been linked with dietary changes as animals increase in size. Because the flattened skull of crocodylians has substantial mediolaterally-oriented muscles, they are an excellent model taxon in which to explore the role of mediolateral force components experienced by the feeding apparatus. Many previous modeling studies of archosaur cranial function focused on planar analysis, ignoring the mediolateral aspects of cranial forces. Here we use three-dimensionally accurate anatomical data to resolve 3D muscle forces. Using dissection, imaging, and computational techniques, we developed lever and finite element models of an ontogenetic series of alligators to test the effects of size and shape on cranial loading and compared estimated bite forces to those previously measured *in vivo* in *A. mississippiensis*. We found that modeled forces matched *in vivo* data well for intermediately sized individuals, and somewhat overestimated force in smaller specimens and underestimated force in larger specimens, suggesting that ontogenetically static muscular parameters and bony attachment sites alone cannot account for all the variation in bite force. Adding aponeurotic muscle attachments would likely improve force predictions, but such data are challenging to model and integrate into analyses of extant taxa and are generally unpreserved in fossils. We conclude that anatomically accurate modeling of muscles can be coupled with finite element and lever analyses to produce reliable, reasonably accurate estimate bite

forces and thus both skeletal and joint loading, with known sources of error, which can be applied to extinct taxa.

Wang, H., Zhang, R., Zhang, S., Zhou, Y. and Wu, X. (2017). Immunohistochemical localization of somatostatin in the brain of Chinese alligator *Alligator sinensis*. *Anat. Rec.* 300(3): 507-519.

**Abstract:** In this study, the regional distribution and histological localization of somatostatin (SS) immunoreactive (IR) perikarya and fibers was investigated for the first time in the brain of adult Chinese alligator by immunohistochemical method. The results showed SS-IR perikarya and fibers were widely distributed in various parts of the brain except for olfactory bulbs. In the telencephalon, SS-IR perikarya were predominantly located in the cellular layer and deep plexiform layer of dorsomedial and medial cortex, less in the dorsal and lateral cortex, while SS-IR fibers were found in all layers of the cerebral cortex. SS-IR perikarya and fibers were also detected in the dorsal ventricular ridge, hippocampus cortex, accessory olfactory bulb nucleus, lenticular nucleus, and caudate nucleus. In the diencephalon, SS-IR perikarya and fibers were mainly present in supraoptic nucleus, paraventricular nucleus of hypothalamus, recessus infundibular nucleus, median eminence, the pineal gland and pituitary gland, in which the IR-fibers were abundant, appearing dot-shaped and varicosity-like. In the mesencephalon, they were present in tectum cortex, ependyma of cerebral aqueduct and the periaqueductal grey matter. Additionally, they were also detected in Purkinje's cellular layer of cerebellum, in the reticularis nucleus and raphe nucleus of medulla oblongata. The distribution pattern of SS-IR perikarya and fibers in the brain of Chinese alligator is generally similar to that reported in other reptiles, but also has some specific features. The wide distribution indicated that SS might be a neurotransmitter or neuromodulator which acts on many kinds of target cells with a wide range of physiological functions.

Gatson, B.J., Goe, A., Granone, T.D. and Wellehan, J.F.X. (2017) Intramuscular epinephrine results in reduced anesthetic recovery time in American alligators (*Alligator mississippiensis*) undergoing isoflurane anesthesia. *Journal of Zoo and Wildlife Medicine* 48(1): 55-61.

**Abstract:** Inhalants are commonly used to anesthetize reptiles, but volatile anesthetics have been associated with prolonged recovery times. The objective of this study was to determine the effects of intramuscular (IM) epinephrine on anesthetic recovery times following isoflurane anesthesia in a population of sub-adult American alligators (*Alligator mississippiensis*). In this prospective randomized crossover study, five clinically healthy alligators were anesthetized for 90 min with the use of isoflurane. Alligators were randomly assigned into one of two treatment groups: Group E received IM epinephrine (0.1 mg/kg), and Group S received an equal volume of 0.9% saline administered after isoflurane was discontinued. Time from the end of inhalant administration to return of spontaneous ventilation, return of the palpebral reflex, movement in response to a standardized toe pinch, and spontaneous movement was recorded. The time of extubation was noted and occurred following the return of spontaneous ventilation and movement. Pulse rate, surface body temperature, and airway gases including expiratory and inspiratory isoflurane concentrations and end-tidal carbon dioxide were measured every 5 min throughout the study. The time from the end of anesthesia to extubation was significantly faster in Group E (51.2 ± 16.7 min) compared to Group S (107.4 ± 43.7 min). Pulse rate was significantly higher within the first 15 min following epinephrine injection compared to the saline group at these time points. Therefore, IM epinephrine administered at the end of general anesthesia can significantly hasten anesthetic recovery from isoflurane in alligators.

Prondvai, E., Botfalvai, G., Stein, K., Szentesi, Z. and Ósi, A. (2017). Collection of the thinnest: A unique eggshell assemblage

from the Late Cretaceous vertebrate locality of Iharkút (Hungary). *Central European Geology* 60(1): 73-133.

**Abstract:** As a result of several years of screen-washing activity, a remarkable assemblage of eggshell fragments has been recovered from the Late Cretaceous vertebrate locality of Iharkút, Hungary. Detailed investigation of the assemblage by multiple visualization techniques (scanning electron microscopy, polarizing light microscopy, X-ray micro-computed tomography), quantitative morphometric analyses, and micro X-ray fluorescence spectrometry revealed a diverse composition of five different eggshell morphotypes (MT I-MT V) and three subcategories within the second morphotype (MT II/a, b, c), with MT I being by far the most abundant (83%) in the assemblage. MT I, MT III, and MT V represent theropod dinosaurian eggshells, whereas MT II and MT IV show characteristics of crocodilian and squamate eggshells, respectively. Hence, despite their fragmentary nature, these eggshells represent the first clear evidence that various sauropsid taxa had nesting sites near the ancient fluvial system of Iharkút. Besides the implied taxonomic diversity, two unique features add to the significance of this eggshell assemblage. First, it contains the thinnest rigid crocodilian (MT II/c) and squamate (MT IV) eggshells ever reported. Moreover, one of the identified theropod morphotypes, MT I, is also among the thinnest fossil dinosaurian eggshells, the thinness of which is only rivalled by the eggshells of the smallest Mesozoic avian eggs known to date. Second, the Iharkút eggshell assemblage consists exclusively of thin eggshells ( $\leq 300 \mu\text{m}$ ), a condition unknown from any other fossil eggshell assemblages described to date. Combined with the knowledge acquired from skeletal remains, these peculiarities give additional insights into the paleoecology of the terrestrial sauropsid fauna once inhabiting the ancient island of Iharkút. Finally, the presence of well-preserved eggshells recovered from two different sites representing different depositional environments provides further evidence for previous taphonomic and sedimentological conclusions, and also expands our knowledge of the special conditions that allowed the preservation of these delicate eggshell fragments.

Junker, K., Calitz, F., Govender, D., Krasnov, B.R. and Boomker, J. (2016). Pentastome assemblages of the Nile crocodile, *Crocodylus niloticus* Laurenti (Reptilia: Crocodylidae), in the Kruger National Park, South Africa. *Folia Parasitol (Praha)* (doi: 10.14411/fp.2016.040).

**Abstract:** Thirty-two specimens of the Nile crocodile, *Crocodylus niloticus* Laurenti (Reptilia: Crocodylidae), from the Kruger National Park, South Africa, and its vicinity were examined for pentastomid parasites during 1995 to 1999 and 2010 to 2011. Pentastomid parasites occurred throughout the year and were widespread in the study area with an overall prevalence of 97% and an overall mean abundance of 23.4 (0-81). Pentastome assemblages comprised six species in three sebekid genera: *Alofia nilotici* Riley et Huchzermeyer, 1995, *A. simpsoni* Riley, 1994, *Leiperia cincinnalis* Sambon, 1922, *Sebekia cesarisi* Giglioli in Sambon, 1922, *S. minor* (Wedl, 1861) and *S. okavangoensis* Riley et Huchzermeyer, 1995. The possible influence of host age, gender and geographic location (river system) on pentastome prevalence, abundance and species richness was investigated. Generally, neither host age, gender nor locality did affect infracommunities, likely because all hosts examined were adult or subadult and displayed comparable foraging behaviour, resulting in similar exposure pathways to fish intermediate hosts. Additionally, the longevity of pentastomids would contribute to accumulative infections as hosts mature. Structuring of pentastome assemblages was observed in as far as *S. minor* was the dominant species based on overall prevalence and abundance, followed by the equally common species *S. cesarisi* and *L. cincinnalis*. With an overall prevalence ranging from 34% to 41% and relatively low abundances, *A. nilotici*, *A. simpsoni* and *S. okavangoensis* form the rarer component of pentastome communities.

Pomares, G., Pauchard, N., Dap, F. and Danutel, G. (2016). An articular spacer for metacarpophalangeal fracture: The story of a crocodile bite. *Hand Surg. Rehabil.* 35(5): 371-374.

**Abstract:** Choosing the best option for reconstructing comminuted joint fractures in hand surgery raises technical challenges due to the small size of the anatomical structures and the required early mobilization. Single-stage reconstructions are clearly preferable, but when the infection risk is high, two-stage alternatives are needed. We report a case of fracture of the head of the 2nd metacarpal resulting from a crocodile bite treated by implanting an articular spacer.

Li, J., Guo, L., Li, Y., Lei, Z., Liu, Y., Shi, W., Li, T., Li, W. and Liu, C. (2016). A device mimicking the biomechanical characteristics of crocodile skull for lumbar fracture reduction. *Bioinspir. Biomim.* 11(5): 056004.

**Abstract:** Open surgery is currently the main treatment method for the lumbar burst fracture with neurological deficit but may irreversibly disrupt the lumbar anatomy. The minimally invasive surgery (MIS) techniques have recently gained increasing attention. However, their use is still limited to lumbar burst fractures mainly due to their difficulties in burst fracture reduction and decompression. Here we present a novel bio-inspired MIS device which can be used with an endoscope to reset the bone fragments retropulsed into the spinal canal within the wounded vertebral body. Its head jaw mimics the biomechanical characteristics of a crocodile rostrum to improve the performance in gripping and moving bone pieces in the confined space of a vertebral body. This study may be capable of converting the posterior open surgeries to the MIS procedures, and expands the use of the MIS techniques in the treatment of lumbar burst fractures.

Zhang, J.H., Tang, W., Zhang, Z.X., Luan, B.Y., Yu, S.B. and Sui, H.J. (2016). Connection of the posterior occipital muscle and dura mater of the Siamese crocodile. *Anat. Rec. (Hoboken)* 299(10): 1402-1408.

**Abstract:** The myodural bridge was proposed initially in 1995. The myodural bridge is a connective tissue bridge that connects a pair of deep muscles at the suboccipital region to the dura mater. There have been numerous studies concerning the morphology and function of the myodural bridge. To determine whether a myodural bridge exists in reptiles, six Siamese crocodiles were investigated using gross anatomy dissection and P45 sheet plastination technologies. As a result, we demonstrated that the posterior occipital muscles of the Siamese crocodile are directly or indirectly connected to the proatlas, atlas, and intermembrane between them. Multiple trabeculae existing in the posterior epidural space extended from the ventral surface of the proatlas, atlas, and intermembrane between them to the dorsal surface of the spinal dura mater. This study showed that the posterior occipital muscle in the suboccipital region of the Siamese crocodile is connected to the spinal dura mater through the proatlas, atlas, and the trabeculae. In conclusion, a myodural bridge-like structure exists in reptiles. This connection may act as a pump to provide cerebrospinal fluid (CSF) circulation at the occipitocervical junction. We hypothesize that a physiologic role of the Siamese crocodile's myodural bridge may be analogous to the human myodural bridge.

Murray, C.M., Merchant, M., Easter, M., Padilla, S., Garrigós, D.B., Marin, M.S. and Guyer, C. (2017). Detection of a synthetic sex steroid in the American crocodile (*Crocodylus acutus*): Evidence for a novel environmental androgen. *Chemosphere* 180: 125-129.

**Abstract:** Endocrine-disrupting contaminants (EDC's) are well known to alter sexual differentiation among vertebrates via estrogenic effects during development, particularly in organisms characterized by temperature-dependent sex determination. However, substances producing androgenic effects typically lack potency when tested in

laboratory settings and are virtually unstudied in field settings. Here, we assay levels of a synthetic androgen, 17 $\alpha$ -methyltestosterone (MT), in a heavily male-biased population of American crocodiles in the Tempisque River Basin of Costa Rica based on the recent hypothesis that this chemical is an EDC in developing crocodilian embryos. The presence of MT was documented in all field-collected samples of egg yolk and in plasma of all age classes in among population of crocodiles. Hatchlings exhibited higher plasma MT concentrations ( $102.1 \pm 82.8$  ng/mL) than juveniles ( $33.8 \pm 51.5$ ) and adults ( $25.9 \pm 20.8$  ng/mL). Among populations, crocodiles captured in the Tempisque River ( $62.9 \pm 73.7$  ng/mL) were higher in MT concentration than those from Tarcoles ( $13.3 \pm 11.4$  ng/mL) and negative controls ( $0.001 \pm 0.0002$  ng/mL). A mechanism for the bio-transport of MT and its subsequent effects is proposed.

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Klinkhamer, A.J., Wilhite, D.R., White, M.A. and Wroe, S. (2017). Digital dissection and three-dimensional interactive models of limb musculature in the Australian estuarine crocodile (*Crocodylus porosus*). PLoS ONE 12(4): e0175079.

**Abstract:** Digital dissection is a relatively new technique that has enabled scientists to gain a better understanding of vertebrate anatomy. It can be used to rapidly disseminate detailed, three-dimensional information in an easily accessible manner that reduces the need for destructive, traditional dissections. Here we present the results of a digital dissection on the appendicular musculature of the Australian estuarine crocodile (*Crocodylus porosus*). A better understanding of this until now poorly known system in *C. porosus* is important, not only because it will expand research into crocodilian locomotion, but because of its potential to inform muscle reconstructions in dinosaur taxa. Muscles of the forelimb and hindlimb are described and three-dimensional interactive models are included based on CT and MRI scans as well as fresh-tissue dissections. Differences in the arrangement of musculature between *C. porosus* and other groups within the Crocodylia were found. In the forelimb, differences are restricted to a single tendon of origin for *triceps longus medialis*. For the hindlimb, a reduction in the number of heads of ambiens was noted as well as changes to the location of origin and insertion for *iliofibularis* and *gastrocnemius externus*.

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Pradid, J., Keawwatana, W., Boonyang, U. and Tangbunsuk, S. (2017). Biological properties and enzymatic degradation studies of clindamycin-loaded PLA/HAP microspheres prepared from crocodile bones. Polymer Bulletin (doi:10.1007/s00289-017-2006-2).

**Abstract:** Polylactic acid (PLA)/hydroxyapatite (HAP) biocomposite microspheres with a specific core-shell structure for application as drug carriers were synthesised using an ultrasound field. In addition, the loading efficiency of clindamycin phosphate increased when the HAP content was increased to 30%. The effect of HAP content on enzymatic degradation of PLA/HAP microspheres loaded with clindamycin phosphate was that the degradation rate increased with increasing HAP content. Apatite formed on the surfaces of the PLA and PLA/HAP microsphere loading of clindamycin phosphate showed Ca and P peaks in energy-dispersive X-ray spectroscopy (EDX) data. In addition, the PLA and PLA/HAP microspheres loaded with clindamycin phosphate did not show any cytotoxicity against the human lung fibroblast MRC-5.

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Champion, G. and Downs, C.T. (2017). Status of the Nile crocodile population in Pongolapoort Dam after river impoundment. African Zoology 52(1): 55-63.

**Abstract:** The major Nile crocodile *Crocodylus niloticus* populations in South Africa are threatened by pollution, habitat alteration/destruction, and poaching. This has highlighted the importance of other minor populations. The Phongola River Nile

crocodile population was previously considered as unsubstantial. Consequently, we investigated the Nile crocodile population numbers and status and the effects of the impoundment of the Phongola River on this. In 2009-2010 we determined a minimum population number of 281 Nile crocodiles in Pongolapoort Dam using a combination of survey methods. The population structure was identified as having a minimum of 116 (41.3%) juveniles (<1.2 m total length), 31 (11.0%) subadults (1.2-2.5 m total length) and 134 (47.7%) adults (>2.5 m total length). At the commencement of the breeding season in August, crocodiles congregated at a major basking site where the main tributary entered the dam. Three major nesting areas were identified, two of which were located on the river inlet to the dam. We identified approximately 30 nesting females during the 2009/10 nesting season. Several nests were predated by the Nile monitor *Varanus niloticus*. There was a total recruitment failure of nests along the river inlet to the dam due to a flash flood of the Phongola River in January 2010. This preliminary study suggests that the Pongolapoort Dam Nile crocodile population has a relatively high potential reproductive output, although their annual successes may vary greatly because of loss of nesting sites as a result of water-level fluctuations and predation. It appears that the river impoundment has generally had a positive impact on this Nile crocodile population, although suitable nesting sites may become limited. Continued long-term monitoring of the Nile crocodile population in Pongolapoort Dam is required to determine if the impoundment continues to support a viable population.

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Smith, S., Bagshaw, R.J. and Hanson, J. (2017). The microbiology of crocodile attacks in Far North Queensland: implications for empirical antimicrobial therapy. Med. J. Aust. 206(7): 307-308.

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Field, G.J. and Martill, D.M. (2017). Unusual soft tissue preservation in the Early Cretaceous (Aptian) crocodile cf. *Susisuchus* from the Crato Formation of north east Brazil. Cretaceous Research 75: 179-192.

**Abstract:** A new specimen of the neosuchian crocodylomorph, *Susisuchus* sp. from the Lower Cretaceous (Aptian) Crato Formation of Ceará, North East Brazil is remarkable for extensive preservation of the epidermis and limb musculature. The specimen comprises incomplete post-cranial remains, including an articulated sequence of thirteen thoracic vertebrae, a disarticulated pair of lumbar vertebrae and all four limbs articulated in varying degrees of completeness but divorced from the axial skeleton. Soft tissues are preserved in two distinct modes, in close association with the skeletal remains. An external mould of the dorsolateral scales of the trunk extends over a bedding plane surface while mineralisation of soft tissues preserving the musculature surrounds the left forelimb. Soft tissue preservation is extremely rare in crocodylomorphs and this is only the second report of soft tissue preservation in a crocodilian from the Crato Formation.

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Higbie, C.T., Nevarez, J.G., Roy, A.F. and Del Piero, F. (2017). Presence of West Nile Virus RNA in tissues of American alligators (*Alligator mississippiensis*) vaccinated with a killed West Nile Virus vaccine. Journal of Herpetological Medicine and Surgery (doi: http://dx.doi.org/10.5818/16-12-099.1).

**Abstract:** West Nile virus (WNV) causes significant mortalities in captive reared American alligators (*Alligator mississippiensis*). Alligators can amplify the virus, serve as a reservoir host, and represent a source of infection for humans. A killed WNV vaccine is commercially available for use in alligators. In 2014, a case of suspected WNV infection from an alligator farm in Louisiana revealed that tissues of previously vaccinated animals were positive for WNV by reverse transcriptase polymerase chain reaction (RT-PCR), while non-vaccinated animals were negative. Further testing demonstrated that the RT-PCR could detect viral RNA in the vaccine product itself. Virus isolation was negative in the tissues and the

vaccine. These findings suggest that the RT-PCR detects the viral RNA from the killed vaccine in the tissues.

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Richardson, D.J., Moser, W.E., Hammond, C.I., Lazo-Wasem, E.A., McAllister, C.T. and Pulis, E.E. (2017). A new species of leech of the genus *Placobdella* (Hirudinida, Glossiphoniidae) from the American alligator (*Alligator mississippiensis*) in Mississippi, USA. *ZooKeys* 667: 39-49.

**Abstract:** To date, the only species of leech reported from the American alligator, *Alligator mississippiensis* is *Placobdella multilineata*. Seven specimens of a previously undescribed species of *Placobdella* were collected from the feet and lower jaw of a single female alligator from the Pascagoula River Wildlife Management Area, George County, Mississippi. The new species was named *Placobdella siddalli* Richardson & Moser, sp. n., in honor of the contributions of Dr. Mark Siddall to our understanding of the biology of leeches. *Placobdella siddalli* Richardson & Moser is similar to other papillated members of the genus *Placobdella*, but differs from *Placobdella ali* Hughes & Siddall, 2007, *Placobdella rugosa* (Verrill, 1874), *Placobdella multilineata* Moore, 1953, and *Placobdella papillifera* (Verrill, 1872) in coloration, papillation, ventral striping, and in the possession of a relatively large caudal sucker. In addition, molecular comparison of 626 nucleotides of CO-I between the new species and other papillated leeches (*P. ali*, *P. multilineata*, *P. ornata*, *P. papillifera*, *P. rugosa*) revealed interspecific differences of 14.0-18.0% (88-113 nucleotides).

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Tellez, M., Arevalo, B., Paquet-Durand, I. and Heflick, S. (2017). Population status of Morelet's crocodile (*Crocodylus moreletii*) in Chiquibul Forest, Belize. *Mesoamerican Herpetology* 4(1): 8-21.

**Abstract:** We conducted a population survey of *Crocodylus moreletii* in Chiquibul Forest, Cayo District, Belize, in April, June, and July of 2016. Of the 162 individuals observed (encounter rate= 3.6 crocodiles/km), we classified 22 as yearlings (13%), 45 as juveniles (28%), 19 as sub-adults (12%), 27 as adults (17%), and 49 as eyeshine only (30%). The sex ratio of *C. moreletii* in Chiquibul Forest illustrates a strong female bias (0.29:1). The distribution of subadults and adults did not differ significantly among the rivers surveyed, although we found a higher abundance of yearlings and juveniles along the Macal River. The prevalence of the cutaneous parasite *Paratrichosoma* sp. was high (79%), and the overall calculations of body index (K) suggest a healthy population of *C. moreletii* in Chiquibul Forest. Given the data collected in this study, in conjunction with past research of *C. moreletii* in Belize, we suggest that the population in Chiquibul Forest is unique given its isolation, and that appropriate conservation management plans are warranted to protect this population's genetic and ecological integrity.

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Waskow, K. and Mateus, O. (2017). Dorsal rib histology of dinosaurs and a crocodile from western Portugal: Skeletochronological implications on age determination and life history traits. *Comptes Rendus Palevol*. (<http://doi.org/10.1016/j.crpv.2017.01.003>).

**Abstract:** Bone histology is an important tool for uncovering life history traits of extinct animals, particularly those that lack modern analogs, such as the non-avian dinosaurs. In most studies, histological analyses preferentially focus on long bones for understanding growth rates and determining age. Here we show, by analyzing ornithischians (a stegosaur and an ornithomimid), saurischians (a sauropod and a theropod), and a crocodile, rib histology is a suitable alternative. The estimated age for all sampled taxa ranges between 14 to 17 years for *Lourinhanosaurus antunesi* and 27 to 31 years estimated for *Draconyx loureiroi*. The theropod *Baryonyx* was skeletally mature around 23-25 years of age but showed unfused neurocentral sutures, a pedomorphic feature possibly related to aquatic locomotion. Our results show that ribs can contain a nearly

complete growth record, and reveal important information about individual age, point of sexual maturity, and, in some cases, sex. Because ribs are more available than long bones, this method opens new possibilities for studying rare and incomplete fossils, including holotypes.

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Nojima, K. and Itoigawa, J. (2017). Tomistominae gen. et sp. indet. (Crocodylia: Crocodylidae) from the Lower Yage Formation (Middle Pleistocene) in Hamamatsu City, Shizuoka Prefecture, Japan. *Bulletin of the Mizunami Fossil Museum* 43: 35-46.

**Abstract:** A total of approximately 1200 well-preserved fossil crocodylian bones was recovered from the freshwater fish-bone bed of the Lower Yage Formation (Middle Pleistocene, MIS 9, 367-347 ka) in Yage, Inasa-cho, Hamamatsu City, Shizuoka Prefecture, Japan. These specimens are identical with Tomistominae gen. et sp. indet. Skulls, mandibles, ribs, vertebrae, humeri, femora, and osteoderms are described.

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Tsai, S., Abdelhamid, A., Khan, M.K., Elkarargy, A., Widelitz, R.B., Chuong, C.M. and Wu, P. (2016). The molecular circuit regulating tooth development in crocodylians. *J. Dent. Res.* 95(13): 1501-1510.

**Abstract:** Alligators have robust regenerative potential for tooth renewal. In contrast, extant mammals can either renew their teeth once (diphyodont dentition, as found in humans) or not at all (monophyodont dentition, present in mice). Previously, the authors used multiple mitotic labeling to map putative stem cells in alligator dental laminae, which contain quiescent odontogenic progenitors. The authors demonstrated that alligator tooth cycle initiation is related to  $\beta$ -catenin/Wnt pathway activity in the dental lamina bulge. However, the molecular circuitry underlying the developmental progression of polyphyodont teeth remains elusive. Here, the authors used transcriptomic analyses to examine the additional molecular pathways related to the process of alligator tooth development. The authors collected juvenile alligator dental laminae at different developmental stages and performed RNA-seq. This data shows that Wnt, bone morphogenetic protein (BMP), and fibroblast growth factor (FGF) pathways are activated at the transition from pre-initiation stage (bud) to initiation stage (cap). Intriguingly, the activation of Wnt ligands, receptors and co-activators accompanies the inactivation of Wnt antagonists. In addition, the authors identified the molecular circuitry at different stages of tooth development. The authors conclude that multiple pathways are associated with specific stages of tooth development in the alligator. This data shows that Wnt pathway activation may play the most important role in the initiation of tooth development. This result may offer insight into ways to modulate the genetic controls involved in mammalian tooth renewal.

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Zhang, R., Yin, Y., Sun, L., Yan, P., Zhou, Y., Wu, R. and Wu, X. (2017). Molecular cloning of ESR2 and gene expression analysis of ESR1 and ESR2 in the pituitary gland of the Chinese alligator (*Alligator sinensis*) during female reproductive cycle. *Gene* (doi: 10.1016/j.gene.2017.04.028).

**Abstract:** Estrogens play critical roles in reproductive physiology via estrogen receptors (ESRs) in vertebrates, including reptiles. Chinese alligator (*Alligator sinensis*) is an endemic and endangered reptile species in China. In the present study, we cloned ESR2 gene from the ovary using rapid amplification of cDNA ends (RACE), investigated the spatial expression of ESRs in various tissues and temporal expression of ESRs in the pituitary glands during the reproductive cycle in Chinese alligators by quantitative real-time PCR (qPCR). Bioinformatics and phylogenetic analysis of deduced ESR2 protein were also performed. The full-length cDNA of the ESR2 is 1647bp in length, with an open-reading frame encoding 548 amino acids. The bioinformatics analysis indicated that the deduced amino acid sequence of alligator ESR2 was highly conserved with

that of other vertebrate species. In addition, compared to human ESR2, the 14 amino acids in the alligator ESR2 that are essential for specific recognition of estradiol are entirely conserved. The phylogenetic analysis showed that alligators were more closely related to birds than to other reptiles. The results of qPCR showed that the tissue distribution patterns of both ESR subtype mRNAs appeared to be different. In male tissues, the highest mRNA level of both ESRs is in the liver. While in female tissues, ESR1 and ESR2 showed the highest mRNA level in the hypothalamus and pituitary gland, respectively. During the female reproductive cycle, the expression level of ESR1 mRNA increased from the initial post-hibernation period to the reproductive period, reached its peak in the reproductive period, and then decreased in the autumn active period and hibernation period. Conversely, the highest transcription level of ESR2 was observed in the hibernation period.

Nilsen, F.M., Kassim, B.L., Delaney, J.P., Lange, T.R., Brunell, A.M., Guillette Jr., L.J., Long, S.E. and Schock, T.B. (2017). Trace element biodistribution in the American alligator (*Alligator mississippiensis*). *Chemosphere* 181: 343-351.

**Abstract:** Routine monitoring of contaminant levels in wildlife is important for understanding chemical exposure and ultimately the link to ecosystem and human health. This is particularly important when the monitored species is recreationally hunted for human consumption. In the southeastern United States, recreational alligator harvesting takes place annually and in locations that are known to be contaminated with environmental pollutants. In this study, we investigated the biodistribution of trace elements in the American alligator (*Alligator mississippiensis*) from five sites in Florida, USA. These sites are locations where annual recreational alligator harvesting is permitted and two of the sites are identified as having high mercury contamination with human consumption advisories in effect. We utilized routinely collected monitoring samples (blood and scute), a commonly consumed tissue (muscle), and a classically analyzed tissue for environmental contaminants (liver) to demonstrate how the trace elements were distributed within the American alligator. We describe elemental tissue compartmentalization in an apex predator and investigate if noninvasive samples (blood and scute) can be used to estimate muscle tissue concentrations for a subset of elements measured. We found significant correlations for Hg, Rb, Se, Zn and Pb between noninvasive samples and consumed tissue and also found that Hg was the only trace metal of concern for this population of alligators. This study fills a gap in trace elemental analysis for reptilian apex predators in contaminated environments. Additionally, comprehensive elemental analysis of routinely collected samples can inform biomonitoring efforts and consumption advisories.

Frederickson, J.A., Cohen, J.E., Hunt, T.C. and Cifelli, R.L. (2017). A new occurrence of *Dakotasuchus kingi* from the Late Cretaceous of Utah, USA, and the diagnostic utility of postcranial characters in Crocodyliformes. *Acta Palaeontologica Polonica* 62 (doi:https://doi.org/10.4202/app.00338.2016).

**Abstract:** Cenomanian mesoeucrocodylians from North America are known primarily from isolated teeth and scutes; any associated remains of this age are noteworthy and represent welcome additions to knowledge. Herein, we describe postcranial elements belonging to a single individual goniopholidid from the Mussentuchit Member of the Cedar Mountain Formation. We argue that this individual represents only the second fossil referable to *Dakotasuchus kingi*, based on overlapping elements, such as the coracoid, dorsal vertebrae, and scutes, which are strikingly similar to their counterparts in the holotype. The coracoid, in particular, is readily distinguished from those belonging to other closely-related crocodylian taxa; enough so to warrant detailed comparisons in the absence of diagnostic cranial material. The new *D. kingi* specimen is nearly 20% larger than the holotype, with body length and mass estimates comparable to modern American alligators (*Alligator mississippiensis*), making it

one of the largest aquatic predators in the Mussentuchit ecosystem.

Pierce, S.E., Williams, M. and Benson, R.B.J. (2017). Virtual reconstruction of the endocranial anatomy of the early Jurassic marine crocodylomorph *Pelagosaurus typus* (Thalattosuchia). *PeerJ* 5:e3225.

**Abstract:** Thalattosuchians were highly specialised aquatic archosaurs of the Jurassic and Early Cretaceous, and represent a peak of aquatic adaptation among crocodylomorphs. Relatively little is known of their endocranial anatomy or its relevance for the evolution of sensory systems, physiology, and other aspects of biology. Nevertheless, such data have significance for two reasons: (1) thalattosuchians represent an important data point regarding adaptation to marine life in tetrapods; and (2) as early-diverging members of the crocodylian stem-lineage, thalattosuchians provide information on the evolutionary assembly of the brain and other endocranial structures in crocodylomorphs. Here we use  $\mu$ CT data to virtually reconstruct the endocranial anatomy of *Pelagosaurus typus*, an early thalattosuchian with plesiomorphic traits of relevance to the split between the two major subgroups: Teleosauroida and Metriorhynchoidea. Interpretation of these data in a broad comparative context indicate that several key endocranial features may be unique to thalattosuchians, including: a pyramidal morphology of the semicircular canals, the presence of an elongate endosseous cochlear duct that may indicate enhanced hearing ability, the presence of large, paired canals extending anteriorly from an enlarged pituitary fossa, a relatively straight brain (possibly due to the presence of large, laterally placed orbits), and an enlarged venous sinus projecting dorsally from the endocranium that is confluent with the paratympanic sinus system. Notably, we document a large expansion of the nasal cavity anterior to the orbits in *Pelagosaurus* as an osteological correlate of an enlarged salt gland previously only documented in Late Jurassic metriorhynchoids. This is the first anatomical evidence of this structure in early thalattosuchians. *Pelagosaurus* also shares the presence of paired olfactory bulbs with metriorhynchoids, and shows an enlarged cerebrum, which may also be present in teleosauroids. Taken together, our findings indicate that physiological and sensory adaptations to marine life occurred early in thalattosuchian evolution, predating the origins of flippers, tail flukes, and hydrodynamic body forms seen later in metriorhynchoids.

France, D.L. (2017). Comparative Bone Identification. Human Subadult to Nonhuman. CRC Press: Boca Raton, USA.

**Preface:** This book is the third volume in the Human and Nonhuman Bone Identification books. The first volume, Human and Nonhuman Bone Identification: A Color Atlas, primarily compared adult human to nonhuman mammal species. The second book, Human and Nonhuman Bone Identification: A Concise Field Guide, was a shorter version of the first volume, but also included a short section on bird skeletons. This book will show some human subadult skeletons as well as a more in-depth section on birds plus sections on four reptiles (alligator, crocodile lizard [or crocodile monitor lizard], iguana and snapping turtle), three marine mammals (sea otter, sea lion, and harbour porpoise), three fish (white sturgeon, pacific cod, and three individuals of a rock fish species), and a small bit of information about a frog. This book, like the original books, is intended to give law enforcement, medicolegal death investigators, forensic anthropologists, and even the general public examples of each of the taxonomic classes listed above. Very little of the introductory information about human and nonhuman mammal skeletons will be repeated in this volume. This is not an exhaustive guide to human or nonhuman bones. Any of these species could be presented in a book by itself, and should not be considered a complete representation of their class of animals. There is great variation among mammals, birds, reptiles, and fish, and to talk about a bird skeleton should not imply that we know everything about all bird skeletons. The penguin, for example, is not an accurate representation of all of the

bones of the raptors, nor is the iguana an accurate representation of all of the bones of a tortoise (or even of all iguana species). Snakes are not included in this book, as they are primarily a head with a long string of vertebrae and ribs, none of which is likely to be mistaken for a human.

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Steadman, D.W., Singleton, H.M., Delancy, K.M., Albury, N.A., Soto-Centeno, J.A., Gough, H., Duncan, N., Franklin, J. and Keegan, W.F. (2017). Late Holocene historical ecology: The timing of vertebrate extirpation on Crooked Island, Commonwealth of The Bahamas. *The Journal of Island and Coastal Archaeology* (<http://dx.doi.org/10.1080/15564894.2017.1305469>).

**Abstract:** We report 8 new accelerator-mass spectrometer (AMS) radiocarbon ( $^{14}\text{C}$ ) dates performed directly on individual bones of extirpated species from Crooked Island, The Bahamas. Three dates from the hutia (*Geocapromys ingrahami*), recovered from a culturally derived bone assemblage in McKay's Bluff Cave (site CR-5), all broadly overlap from AD 1450 to 1620, which encompasses the time of first European contact with the Lucayan on Crooked Island (AD 1492). Marine fish and hutia dominate the bone assemblage at McKay's Bluff Cave, shedding light on vertebrate consumption by the Lucayans just before their demise. A fourth AMS  $^{14}\text{C}$  date on a hutia bone, from a non-cultural surface context in Crossed Cave (site CR-25), is similar (AD 1465 to 1645) to those from McKay's Bluff Cave. From Pittstown Landing (site CR-14), an open coastal archaeological site, a femur of the Cuban crocodile (*Crocodylus rhombifer*) yielded an AMS  $^{14}\text{C}$  date of AD ~1050-1250, which is early in the Lucayan cultural sequence. From a humerus in a non-cultural surface context in 1702 Cave (site CR-26), we document survival of the Cuban crocodile on Crooked Island until AD ~1300-1400, which is several hundred years later than the well-documented extinction of Cuban crocodiles on Abaco in the northern Bahamas. We lack a clear explanation of why Cuban crocodiles likely survived longer on Crooked Island than on a larger Bahamian island such as Abaco. One AMS  $^{14}\text{C}$  date on Crooked Island's extinct, undescribed species of tortoise (*Chelonoidis* sp.) from 1702 Cave is BC 790 to 540 (2740 to 2490 cal BP), which is ~1500-1700 years prior to human arrival. A second AMS  $^{14}\text{C}$  date, on a fibula of this tortoise from McKay's Bluff Cave, is AD 1025 to 1165, thereby demonstrating survival of this extinct species into the period of human occupation.

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Bangma, J.T., Bowden, J.A., Brunell, A.M., Christie, I., Finnell, B., Guillelte, M.P., Jones, M., Lowers, R.H., Rainwater, T.R., Reiner, J.L., Wilkinson, P.M. and Guillelte, Jr., L.J. (2017). Perfluorinated Alkyl Acids in plasma of American alligators (*Alligator mississippiensis*) from Florida and South Carolina. *Environmental Toxicology and Chemistry* 36: 917-925.

**Abstract:** The present study aimed to quantitate 15 perfluoroalkyl acids (PFAAs) in 125 adult American alligators at 12 sites across the southeastern United States. Of those 15 PFAAs, 9 were detected in 65% to 100% of samples: perfluorooctanoic acid, perfluorononanoic acid, perfluorodecanoic acid (PFDA), perfluoroundecanoic acid (PFUnA), perfluorododecanoic acid, perfluorotridecanoic acid (PFTriA), perfluorotetradecanoic acid, perfluorohexanesulfonic acid (PFHxS), and perfluorooctane sulfonate (PFOS). Males (across all sites) showed significantly higher concentrations of 4 PFAAs: PFOS ( $p=0.01$ ), PFDA ( $p=0.0003$ ), PFUnA ( $p=0.021$ ), and PFTriA ( $p=0.021$ ). Concentrations of PFOS, PFHxS, and PFDA in plasma were significantly different among the sites in each sex. Alligators at both Merritt Island National Wildlife Refuge (FL, USA) and Kiawah Nature Conservancy (SC, USA) exhibited some of the highest PFOS concentrations (medians of 99.5 ng/g and 55.8 ng/g, respectively) in plasma measured to date in a crocodilian species. A number of positive correlations between PFAAs and snout-vent length were observed in both sexes, suggesting that PFAA body burdens increase with increasing size. In addition, several significant correlations among PFAAs in alligator plasma may suggest conserved sources

of PFAAs at each site throughout the greater study area. The present study is the first to report PFAAs in American alligators, to reveal potential PFAA hot spots in Florida and South Carolina, and to provide a contaminant of concern when assessing anthropogenic impacts on ecosystem health.

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Zoboli, D. and Pillola, G.L. (2017). Early Miocene insular vertebrates from Laerru (Sardinia, Italy): Preliminary note. *Rivista Italiana di Paleontologia e Stratigrafia* (Research in Paleontology and Stratigraphy) 123(1): 149-158.

**Abstract:** A new vertebrate assemblage was discovered in an Early Miocene lacustrine deposit near the village of Laerru (northern Sardinia, Italy). The assemblage is composed by mammals, reptiles and a bird. The mammals are represented by three ruminants (cf. *Sardomeryx oschiriensis*, Pecora indet. small size and Pecora indet. very small size) and one dormouse (*Peridyromys* aff. *murinus*) while reptiles are represented by turtles (Trionychidae?) and crocodiles (cf. *Diplocynodon* sp.). A bird bone fragment is also reported and referred to *Palaeortyx* cf. *brevipes* (Galliformes). The assemblage can be related to the "Oschiri fauna", one of the oldest endemic insular fauna known in the Mediterranean. The age of the Laerru vertebrates is early-middle Burdigalian, between 18.8 and 18.3 Ma, corresponding to the mammal unit of the main land MN3. The predominance of ruminants confirms the good capacity of these mammals to colonize insular environments.

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Viloria-Lagares, T.A., Moreno-Arias, R.A. and Bloor, P. (2017). Assessment of American crocodile, *Crocodylus acutus* (Crocodylidae), and Brown caiman, *Caiman crocodilus fuscus* (Alligatoridae), populations in the Paramillo National Natural Park, Colombia. *Herpetological Conservation and Biology* 12: 24-32.

**Abstract:** We assessed abundance and population structure of the American crocodile (*Crocodylus acutus*) and Brown caiman (*Caiman crocodilus fuscus*) from the Manso and Tigre Rivers in Paramillo National Natural Park (NNP), Department of Córdoba, Colombia. This is a protected area in the remote northwest of the country, and is a potentially important area for the conservation of crocodilians. We surveyed 27.9 km of the Manso and Tigre Rivers during February 2015. We observed 64 crocodilians, of which we reliably identified 49 (77%) individuals to species, with 37 identified as *C. acutus* and 12 identified as *C. c. fuscus*. Average encounter rate was 5.7 individuals/km for *C. acutus* and 2.8 individuals/km for *C. c. fuscus*. The total estimated population for the entire area surveyed of the Manso and Tigre Rivers was 87 *C. acutus* and 35 *C. c. fuscus*. We found no significant difference in population structure (adults versus juveniles) between the species. We did find a significant difference in abundance and habitat preference between the two species, with *C. acutus* associated with flooded forest and *C. c. fuscus* associated with riverside forest. Our study highlights the importance of the Paramillo NNP for both national and regional crocodilian conservation planning.

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Parachú Marcó, M.V., Leiva, P., Iungman, J.L., Simoncini, M.S. and Piña, C.I. (2017). New evidence characterizing Temperature-dependent Sex Determination in Broad-snouted caiman, *Caiman latirostris*. *Herpetological Conservation and Biology* 12: 78-84

**Abstract:** Temperature-dependent sex determination (TSD) occurs in all three families of the Crocodylia. This study explored the sex ratio of hatchlings under incubation temperatures not previously tested in *Caiman latirostris* to delineate the transitional range of temperature (TRT) between male- and female-producing temperatures. We also estimated the pivotal temperature (Tpiv) of *C. latirostris* from our study site. We incubated eggs at various temperatures (31°, 32°, 33°, and 34°C). Incubation temperature had a significant effect on sex determination, but had no effect on hatching success. Eggs incubated at 31°C produced 100% females, 32°C produced approximately 70%

females, and incubation at 33°C and 34°C produced only males. The TRT was >31° to <33°C for female to male transitions, and >34°C and a temperature >34.5°C male to female. Results indicate that the limits of T<sub>piv</sub> should be between 32-33°C (lower T<sub>piv</sub>), and between 34-34.5°C (upper T<sub>piv</sub>) for the population of *C. latirostris* in Santa Fe, Argentina. Our analysis support the female-male-female (FMF) pattern, but higher temperature females may be rarely seen in wild because survival of females incubated at such high temperatures is very low.

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Villegas, A., Mendoza, G.D., Arcos-García, J.L. and Reynoso, V.H. (2017). Nesting of Morelet's crocodile, *Crocodylus moreletii* (Dumeril and Bibron), in Los Tuxtlas, Mexico. *Braz. J. Biol.* (<http://dx.doi.org/10.1590/1519-6984.19015>).

**Abstract:** We evaluated the nesting by *Crocodylus moreletii* in Lago de Catemaco, Veracruz, southeastern, Mexico. During the nesting and hatching seasons, we searched for nests along the northern margins of the lake and small associated streams. We investigated egg mortality by weekly monitoring each of the nests found, recording sign of predation (tracks and holes dug into the nest) and the effect of water level fluctuations. We not found differences to nest between inland or flooded zones. However, we found that egg size varied among nests. In nests built inland, predation was the major cause of egg mortality whereas flooding resulted in more deaths of eggs in the flooding zone. Flooding killed 25% of eggs monitored in this study. We suggest that to increase nest success in the Morelet's crocodile it is necessary to promote conservation of nesting areas around the lake, recently occupied by urban or tourist developments.

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Pagoda, L.R. (2017). Crocodile human encounter patterns in Sri Lanka. *Prehosp. Disaster Med.* 32 (Suppl. 1): s117 (doi:10.1017/S1049023X17003338).

**Abstract:** Aim of this study is to identify what species of crocodile's attacks humans, their pattern when they attacked, where they attacked, what parts of the human body they prefer to grab most, why do they attack humans, and how crocodile human encounters are minimized so both species can live peacefully. Crocodilians represent one of the oldest constant animal lineages on the planet, in no small part due to their formidable array of predatory adaptations. As both human and crocodilian populations expand, they increasingly encroach on each other's territories, bringing morbidity and mortality to both populations. Sri Lanka has two species of crocodiles - the Mugger (*Crocodylus palustris* or "crocodile of the marsh") mainly found in freshwater tanks, and the Saltwater crocodile (*C. porosus* or estuarine crocodile) which prefers estuaries and lagoon habitats. Research found both were responsible for attacking humans. The reported cases of crocodile attacks from 2010 to 2015 were reviewed. During the 5-year period 150 attacks were reported and 51 were fatal. The aim was to identify the attacks by two different species of crocodiles that live in Sri Lanka. We studied timeframe, location, causes, and how they attacked humans. The popular belief is only Saltwater crocodiles are man-eaters, and Muggers are less aggressive. But our research shows that fatal attacks are done by both groups. The Saltwater crocodile attacked and killed 27 people, and Muggers killed 49 humans, not much difference. The usual attack sites for both groups are either in shallow water or close proximity to croc-infested water. This amounts to nearly 60% of attacks (90 incidents), of which 116 (77%) victims were males. They were attacked during bathing, washing clothes, swimming, collecting grass in marshy lands and playing in the water. Females were attacked while bathing, washing clothes and utensils. There were three rare cases where people were ambushed by Saltwater crocodiles in a marshy area when they regularly collect firewood. Ninety-five percent of the victims were dragged to the water by both groups of crocodiles. Most of the incidents limbs were attacked; there were reports of attacking to the head and torso by both groups of crocodiles. Most of the victims (>92%) were aware that the water

sources are infested with crocodiles, but did not care enough to think of the impending danger. We found that some people were attacked non-fatal, by Saltwater crocodiles when they approached a crocodile nest, the attacks launched to defend the nest. An interesting observation that emerged from the accounts on crocodile attack victims and witnesses, was that it appeared that the animals had observed people engaged in water-based activity, like bathing and washing clothes, over a period of time before the attack. This would imply that at least some attacks, were not the result of a casual encounter with potential prey, but the culmination of a hunt at a spot where prey was known to gather. Hunting the reptile for meat or for skin made them endangered species. It has been observed that reptiles were poisoned after attacking humans, in some parts of the island. The climatic change is also an important factor as temperature decides the gender of the siblings. Reducing the crocodile land due to encroachment by humans, sand mining and destruction of mangroves, made reptiles attack humans as well as loitering in the land areas searching for food. In this review, we examined the features of crocodilians that contribute to explaining their evolutionary success, as well as the potential hazard they pose to humans. Only by understanding reptiles' capabilities and respecting its right to live, it is possible to mitigate the potential threat to life and limb of humans.

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Ferguson, A.L., Varricchio, D.J., Pina, C.I. and Jackson, F.D. (2017). From eggs to hatchlings: Nest site taphonomy of American crocodile (*Crocodylus acutus*) and Broad-snouted caiman (*Caiman latirostris*). *PALAIOS* 32(5): 337-348.

**Abstract:** Nesting behaviors of extant vertebrates can serve as taphonomic models for interpreting extinct archosaurian reproduction. Past studies have examined birds with open nests and nest-bound young and tortoises with buried nests and precocial young. Here we taphonomically describe nesting sites of two crocodylians, American crocodile (*Crocodylus acutus*) at Turkey Point, Florida and broad-snouted caiman (*Caiman latirostris*) from Santa Fe and Chaco Provinces, Argentina. Surveys focused on eggshell abundance, orientation, and distribution and nest modification of successfully hatched nests. American crocodiles excavate triangular or semi-circular depressions into their nest during hatching. Maximum depths of these parent-assisted hatching traces ranged from 20-45 cm, with a breadth of 50-80 cm. Eggshell orientations outside these excavated pits favored concave down (53.1-80.0%). Broad-snouted caiman constructed mound nests of predominantly plant debris in forested areas with organic rich soil or on vegetation islands. Nests ranged in diameter from 1.2-1.6 m with a height of 0.3-0.6 m. Eggshell orientations within opened egg chambers favored concave up (61.8%), whereas fragments outside the chamber were nearly evenly distributed (51.8% concave-up). Eggshell distribution and orientation at these nesting sites result from adult females assisting and transporting eggs and young during hatching. Observed eggshell orientations in and around the egg chamber in caiman nests are similar to the 60:40 up:down hatching ratio reported in both bird and tortoise nests, whereas crocodile nests are more similar to a 40:60 ratio of trampled shell. Documentation of these nest characteristics and eggshell orientations may facilitate interpretations of parental assistance in the fossil record.

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Manfredi, K. and Georgi, J. (2017). Ontogenetic changes in the terrestrial locomotion of the American alligator (*Alligator mississippiensis*). *The FASEB Journal* 31(1), Supplement 577.19.

**Abstract:** Ontogenetic changes in the musculoskeletal system, ecological niche, and feeding habits of the American alligator (*Alligator mississippiensis*) have all been hypothesized to relate to similar ontogenetic shifts in locomotion. Anecdotal evidence of the loss of galloping in some crocodilian taxa lends some support to this hypothesis. This study represents the first systematic evaluation of terrestrial locomotor mechanics across an ontogenetic series of crocodilian in order to evaluate if there is an identifiable change.

American alligators representing 23 different sizes (ranging in length from 0.63 to 1.64 m in total length) were tracked with a VICON motion tracking system as they moved across a packed dirt floor. For all walking strides that included less than 20° of direction change, stride length, stride duration and duty factor were calculated from the 3D data. These stride parameters were compared to a geometric mean of skull measurements to calculate scaling factors. In addition to overall scaling patterns, the data were sorted into two large (n= 11) and small (n= 12) groups, correlating to the difference between juveniles and adults (less than or greater than approximately 1 m in length). Scaling patterns between these groups were then compared. Across all specimens, length and duration showed significant positive correlation with size ( $p < 0.001$  and  $p = 0.016$  respectively), but duty factor did not ( $p = 0.079$ ). In only smaller alligators, length exhibited a positive correlation with size ( $p < 0.001$ ), duty factor a strong negative correlation ( $p = 0.002$ ) and duration no correlation ( $p = 0.288$ ). In contrast, larger alligators demonstrated a different pattern with length and duty factor both showing positive correlations with size ( $p = 0.002$  and  $p = 0.001$  respectively) and no correlation between duration and size ( $p = 0.204$ ). Comparisons between the large and small groups found significantly different scaling factors for both length ( $p = 0.008$ ) and duty factor ( $p = 0.007$ ). Thus, we have shown that there is a major shift in the scaling of the fundamental parameters of alligator locomotion at approximately the sub-adult stage. This transition decreases the scaling factor of stride length from positive allometry (slope= 1.64) to negative (slope= 0.54) and completely reverses the scaling trend of duty factor from decreasing duty factor (slope= -0.18) to increasing duty factor (slope= 0.40).

Cedillo-Leal, C., Simoncini, M.S., Leiva, P.M.L., Larriera, A., Lang, J.W. and Piña, C.I. (2017). Eggshell structure in *Caiman latirostris* eggs improves embryo survival during nest inundation. *Proceedings of the Royal Society B* (doi: 10.1098/rspb.2016.2675).

**Abstract:** Egg inundation often results in poor hatching success in crocodylians. However, how tolerant eggs are to submergence, and/or how eggshell ultrastructure may affect embryo survival when inundated, are not well understood. In this study, our objective was to determine if embryo survival in *Caiman latirostris* is affected by eggshell surface roughness, when eggs are submerged under water. Tolerance to inundation was tested early (day 30) versus late (day 60) in development, using 8 clutches (four per time treatments), subdivided into four groups: (N= 9 per clutch per treatment;  $9 \times 4 = 36$  eggs per group). 'Rough' eggshell represented the natural, unmodified eggshell surface structure. 'Smooth' eggshell surface structure was created by mechanically sanding the natural rough surface to remove surface columnar elements and secondary layer features, eg irregularities that result in 'roughness'. When inundated by submerging eggs under water for 10 h at day 30, 'smooth' eggshell structure resulted in more than twice as many dead embryos (16 versus 6, smooth versus rough; N= 36), and fewer than half as many healthy embryos (6 versus 13, smooth versus rough, respectively; N= 36). By contrast, at day 60, inundation resulted in very low hatching success, regardless of eggshell surface structure. Only two hatchlings survived the inundation, notably in the untreated group with intact, rough eggshells. Inundation produced a high rate of malformations (58% at day 30), but did not affect hatchling size. Our results indicate that eggshell roughness enhances embryo survival when eggs are inundated early in development, but not late in development. Apparently, the natural surface 'roughness' entraps air bubbles at the eggshell surface during inundation, thereby facilitating gas exchange through the eggshell even when the egg is submerged under water.

Eckles, J.K., Mazzotti, F., Giardina, D., Hazelton, D. and Rodgers, H.L. (2016). First evidence for reproduction of Nile Monitors (*Varanus niloticus*) in Palm Beach County. *Southeastern Naturalist* 15(sp8): 114-119.

**Abstract:** *Varanus niloticus* (Nile Monitor) is a large, carnivorous

lizard native to sub-Saharan Africa. A breeding population of Nile Monitors was documented in southwestern Florida (Lee County) in 2004. In 2011, the Florida Fish and Wildlife Conservation Commission began surveying the C-51 canal on the southeastern Florida coast in Palm Beach County in response to multiple reports of monitor lizards. These surveys resulted in observations of 9 Nile Monitors, including a hatchling and copulating pair. Three additional hatchlings were later reported by private citizens. These observations provide evidence of a breeding population of these non-native lizards in southeastern Florida.

Noble, D.W.A., Stenhouse, V. and Schwanz, L.E. (2017). Developmental temperatures and phenotypic plasticity in reptiles: a systematic review and meta-analysis. *Biological Reviews* (doi: 10.1111/brv.12333).

**Abstract:** Early environments can profoundly influence an organism in ways that persist over its life. In reptiles, early thermal environments (nest temperatures) can impact offspring phenotype and survival in important ways, yet we still lack an understanding of whether general trends exist and the magnitude of impact. Understanding these patterns is important in predicting how climate change will affect reptile populations and the role of phenotypic plasticity in buffering populations. We compiled data from 175 reptile studies to examine, and quantify, the effect of incubation temperature on phenotype and survival. Using meta-analytic approaches (standardized mean difference between incubation treatments, Hedges'  $g$ ), we show that across all trait types examined there is, on average, a moderate to large magnitude of effect of incubation temperatures (absolute effect:  $|g| = 0.75$ ). Unsurprisingly, this influence was extremely large for incubation duration, as predicted, with warmer temperatures decreasing incubation time overall ( $g = -8.42$ ). Other trait types, including behaviour, physiology, morphology, performance, and survival experienced reduced, but still mostly moderate to large effects, with particularly strong effects on survival. Moreover, the impact of incubation temperature persisted at least one-year post-hatching, suggesting that these effects have the potential to impact fitness in the long-term. The magnitude of effect increased as the change in temperature increased (eg 6°C versus 2°C) in almost all cases, and tended to decrease when temperatures of the treatments fluctuated around a mean temperature compared to when they were constant. The effect also depended on the mid-temperature of the comparison, but not in consistent ways, with some traits experiencing the greatest effects at extreme temperatures, while others did not. The highly heterogeneous nature of the effects we observe, along with a large amount of unexplained variability, indicates that the shape of reaction norms between phenotype and temperature, along with ecological and/or experimental factors, are important when considering general patterns. Our analyses provide new insights into the effects of incubation environments on reptile phenotype and survival and allow general, albeit coarse, predictions for taxa experiencing warming nest temperatures under climatic change.

Griffin, R. and Mei, A. (2017). Investigation of the populations of Morelet's crocodile (*Crocodylus moreletii*) and tortuga blanca (*Dermatemys mawii*) in the Rios San Pedro y Sacluc 2016. Indigo Expeditions.

Goldsmith, E.B. (2017). Manufacturer responsibilities. Pp. 515-526 in *Consumer Perception of Product Risks and Benefits*, ed. by G. Emilien, R. Weitkunat and F. Lüdicke. Springer International Publishing.

**Abstract:** This chapter describes how manufacturers make products from raw materials by the use of manual labor or machines. The ultimate end user is the consumer. Things often go wrong in the manufacturing process. Most recently, car recalls and contaminated food have been in the news. The manufacturing process can take place anywhere from small villages to multi-national factories.

China, Europe, the United States, and Japan lead the world in manufacturing output. Governments regulate the process, and internally, industries self-regulate through quality control. There is an academic theory and managerial practice called Corporate Social Responsibility (CSR) which seeks to benefit consumer welfare and increase quality of life. It is up to manufacturers to make consistent, technologically advanced, high quality products useful to society while upholding ethics and industry standards and taking care to protect consumers and the environment.

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Poelmann, R.E., Gittenberger-de Groot, A.C., Biermans, M.W.M., Dolfin, A.I., Jagessar, A., van Hattum, S., Hoogenboom, A., Wisse, L.J., Vicente-Steijn, R., de Bakker, M.A.G., Vonk, F.J., Hirasawa, T., Kuratani, S. and Richardson, M.K. (2017). Outflow tract septation and the aortic arch system in reptiles: lessons for understanding the mammalian heart. *EvoDevo* 2017 8:9 (doi: 10.1186/s13227-017-0072-z).

**Abstract:** Cardiac outflow tract patterning and cell contribution are studied using an evo-devo approach to reveal insight into the development of aorto-pulmonary septation. We studied embryonic stages of reptile hearts (lizard, turtle and crocodile) and compared these to avian and mammalian development. Immunohistochemistry allowed us to indicate where the essential cell components in the outflow tract and aortic sac were deployed, more specifically endocardial, neural crest and second heart field cells. The neural crest-derived aorto-pulmonary septum separates the pulmonary trunk from both aortae in reptiles, presenting with a left visceral and a right systemic aorta arising from the unseptated ventricle. Second heart field-derived cells function as flow dividers between both aortae and between the two pulmonary arteries. In birds, the left visceral aorta disappears early in development, while the right systemic aorta persists. This leads to a fusion of the aorto-pulmonary septum and the aortic flow divider (second heart field population) forming an avian aorto-pulmonary septal complex. In mammals, there is also a second heart field-derived aortic flow divider, albeit at a more distal site, while the aorto-pulmonary septum separates the aortic trunk from the pulmonary trunk. As in birds there is fusion with second heart field-derived cells albeit from the pulmonary flow divider as the right 6th pharyngeal arch artery disappears, resulting in a mammalian aorto-pulmonary septal complex. In crocodiles, birds and mammals, the main septal and parietal endocardial cushions receive neural crest cells that are functional in fusion and myocardialization of the outflow tract septum. Longer-lasting septation in crocodiles demonstrates a heterochrony in development. In other reptiles with no indication of incursion of neural crest cells, there is either no myocardialized outflow tract septum (lizard) or it is vestigial (turtle). Crocodiles are unique in bearing a central shunt, the foramen of Panizza, between the roots of both aortae. Finally, the soft-shell turtle investigated here exhibits a spongy histology of the developing carotid arteries supposedly related to regulation of blood flow during pharyngeal excretion in this species. This is the first time that is shown that an interplay of second heart field-derived flow dividers with a neural crest-derived cell population is a variable but common, denominator across all species studied for vascular patterning and outflow tract septation. The observed differences in normal development of reptiles may have impact on the understanding of development of human congenital outflow tract malformations.

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Augustine, L., Pryes, K. and Evans, M. (2017). Social behavior in captive Cuban crocodiles (*Crocodylus rhombifer*) at the Smithsonian's National Zoological Park. *Herpetological Review* 48(1): 75-82.

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Augustine, L. (2017). Crocodilian perivitelline membrane-bound sperm detection. *Zoo Biol.* (doi: 10.1002/zoo.21367).

**Abstract:** Advanced reproductive technologies (ART's) are often

employed with various taxa to enhance captive breeding programs and maintain genetic diversity. Perivitelline membrane-bound (PVM-bound) sperm detection has previously been demonstrated in avian and chelonian species as a useful technique for breeding management. In the absence of embryonic development within an egg, this technique can detect the presence of sperm trapped on the oocyte membrane confirming breeding, male reproductive status, and pair compatibility. PVM-bound sperm were successfully detected in three clutches of Cuban crocodile (*Crocodylus rhombifer*) eggs at the Smithsonian's National Zoological Park (NZP) for the first time in any crocodilian species. PVM-bound sperm were detected in fresh and incubated *C. rhombifer* eggs, as well as eggs that were developing (banded) and those that were not (not banded). The results of this study showed significant differences in average sperm densities per egg between clutches ( $p=0.001$ ). Additionally, there was not a significant difference within clutches between eggs that banded and those that did not band (Clutch A,  $p=0.505$ ; Clutch B,  $p=0.665$ ; Clutch C,  $p=0.266$ ). The results of this study demonstrate the necessity to microscopically examine eggs that do not develop (do not band), to determine if sperm is present, which can help animal managers problem solve reproductive shortcomings. PVM-bound sperm detection could be a useful technique in assessing crocodilian breeding programs, as well as have potential uses in studies assessing sperm storage, artificial insemination, and artificial incubation.

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Reber, S.A., Janisch, J., Torregrosa, K., Darlington, J., Vliet, K.A. and Fitch, W.T. (2017). Formants provide honest acoustic cues to body size in American alligators. *Sci. Rep.* 7(1): 1816. (doi: 10.1038/s41598-017-01948-1).

**Abstract:** In many vertebrates, acoustic cues to body size are encoded in resonance frequencies of the vocal tract ("formants"), rather than in the rate of tissue vibration in the sound source ("pitch"). Anatomical constraints on the vocal tract's size render formants honest cues to size in many bird and mammal species, but it is not clear whether this correlation evolved convergently in these two clades, or whether it is widespread among amniotes (mammals, birds, and non-avian reptiles). We investigated the potential for honest acoustic cues in the bellows of adult American alligators and found that formant spacing provided highly reliable cues to body size, while presumed correlates of the source signal did not. These findings held true for both sexes and for all bellows whether produced in or out of water. Because birds and crocodilians are the last extant Archosaurs and share common ancestry with all extinct dinosaurs, our findings support the hypothesis that dinosaurs used formants as cues to body size. The description of formants as honest signals in a non-avian reptile combined with previous evidence from birds and mammals strongly suggests that the principle of honest signalling via vocal tract resonances may be a broadly shared trait among amniotes.

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Coblentz, K.E., Rosenblatt, A.E. and Novak, M. (2017). The application of Bayesian hierarchical models to quantify individual diet specialization. *Ecology* (doi: 10.1002/ecy.1802).

**Abstract:** Intraspecific variation in ecologically relevant traits is widespread. In generalist predators in particular, individual diet specialization is likely to have important consequences for food webs. Understanding individual diet specialization empirically requires the ability to quantify individual diet preferences accurately. Here we compare the currently used frequentist maximum likelihood approach which infers individual preferences using the observed prey proportions to Bayesian hierarchical models that instead estimate these proportions. Using simulated and empirical data, we find that the approach of using observed prey proportions consistently overestimates diet specialization relative to the Bayesian hierarchical approach when the number of prey observations per individual is low or the number of prey observations vary among individuals, two common features of empirical data. Furthermore, the Bayesian hierarchical approach permits the estimation of point

estimates for both prey proportions and their variability within and among levels of organization (ie individuals, experimental treatments, populations), while also characterizing the uncertainty of these estimates in ways inaccessible to frequentist methods. The Bayesian hierarchical approach provides a useful framework for improving the quantification and understanding of intraspecific variation in diet specialization studies.

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Labarre, D., Charreau, P., Platt, S.G., Rainwater, T.R., Cedeño-Vázquez, J.R. and González-Cortés, H. (2017). Morphological diversity of the American crocodile (*Crocodylus acutus*) in the Yucatán Peninsula. *Zoomorphology* (doi:10.1007/s00435-017-0356-9).

**Abstract:** Recent evidence suggests that morphological divergence of the American crocodile (*Crocodylus acutus*) occurred in Greater Antilles under conditions of prolonged isolation and hybridization with the Cuban crocodile (*C. rhombifer*). We investigated morphological diversity in *C. acutus* in the coastal zone of the Yucatán Peninsula, where isolation and hybridization have also been reported. We compared the relationships among various morphological traits between insular and coastal populations. Our results suggest morphological diversity in the region, which is possibly related to population isolation and mechanical constraints imposed by differences in diet. A broad-snouted morphotype appears typical of island populations. Hybridization could also cause morphological variation, but its importance in this case remains to be confirmed. Sexual dimorphism of the American crocodile in the region appears to be less pronounced than for other crocodilians. We also provide population-specific size estimation models for two populations (Banco Chinchorro and Cozumel) to improve future monitoring.

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Morgan, D.L., Somaweera, R., Gleiss, A.C., Beatty, S.J. and Whitty, J.M. (2017). An upstream migration fought with danger: freshwater sawfish fending off sharks and crocodiles. *Ecology* 98(5): 1465-1467.

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Swan, N., Barlow, J. and Parry, L. (2017). Expert elicitation as a method for exploring illegal harvest and trade of wild meat over large spatial scales. *Oryx* 51(2): 298-304.

**Abstract:** New evidence of commercialization and consumption of wild meat in Amazonian cities has exposed an alarming yet poorly understood threat to Neotropical biodiversity. In response to the limitations of field sampling for large-scale surveys, we sought to develop a method of rapidly assessing wildlife harvest and trade in multiple areas using expert knowledge. Using caiman as a model taxon, we surveyed experts across the Brazilian Amazon. Expert responses to a Likert-style questionnaire suggest that caiman hunting, generally considered a localized rural activity, is in fact common and geographically widespread. Contrary to previous assumptions we found evidence that urban demand is partly driving the harvest, including via interstate trafficking. We highlight the need for further field validation of wild-meat trade and urban consumption patterns in Amazonia. We conclude that expert elicitation is a simple, cost-effective technique that can be a valuable precursor to inform and direct applied conservation research, especially where there are significant knowledge gaps and at large spatial scales.

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Wahyudi, D., Kusneti, M. and Suimah (2017). Biodiversity inventory and conservation opportunity of Suwi wetlands, Muara Ancalong, East Kalimantan, Indonesia. *AIP Conference Proceedings* 1813(1): 020013. (<http://dx.doi.org/10.1063/1.4975951>).

**Abstract:** Suwi wetlands lays in location permit of palm oil plantation, which has been cleared partially, but then abandoned because is not suitable for palm oil. Considering the biological richness and the usage, the wetlands is important to be conserved,

the most possible is managed as an Essential Ecosystem. The main objective of this study was to conduct an inventory of species diversity of Suwi wetlands. Habitat condition and utilization was recorded as important supporting information. The fieldworks have been done from 2013 to 2016. Camera traps and mistnetts were used and randomly done several times in a place where animal were suspected presence. Direct observations were done in the morning and afternoon especially for bird and mammal inventory while dark night observations were done for the presence of crocodile. The result of fieldworks found 12 species of mammals, 63 species of birds, 9 species of reptiles and 38 species of fish, which 30 of the total 122 species are protected, based on Indonesian law as well as international rule. Proboscis monkey (*Nasalis larvatus*) is an endemic and one of conservation priority species of Indonesia. Meanwhile, Siamese crocodile (*Crocodylus siamensis*) is one of the most world's endangered crocodilians.

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Ziegler, T., Rauhaus, A. and Schmidt, F. (2017). Review of crocodiles in zoological gardens with a focus on Europe. *Der Zoologische Garten* (<https://doi.org/10.1016/j.zoolgart.2017.04.004>).

**Abstract:** To gain an overview of crocodile species held in zoos, the number of individuals kept, and the number of keeping institutions, we analyzed collection information from the Zoological Information Management System (ZIMS) database. Our analysis performed from June to July 2016 revealed that there were 24 species of crocodiles kept globally in 451 zoos, with 22 species kept in 185 European zoos. Two globally-kept species were lacking in European zoo holdings according to ZIMS. Of the 27 currently recognized species of crocodiles, one (*Mecistops* sp.) is not held in zoos at present. In addition we have opposed ZIMS data with information available from European studbooks and, based on literature evaluation, analyzed the development of crocodile collections in Europe during the last 40 years. Although ZIMS data is not complete, there is a trend discernible that only a few species are widely kept by the zoo community, whereas most species are represented in smaller numbers. We further discuss the importance of "Regional Collection Plans", viz. long-term crocodile collection planning, and provide recommendations for population management such as considering a shift from very commonly kept species towards species that are in greater need of conservation support through zoo husbandry efforts.

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Aramendia, J., Maté-González, M.A., Yravedra, J., Cruz Ortega, M., Arriaza, M.C., González-Aguilera, D., Baquedano, E. and Domínguez-Rodrigo, M. (2017). Discerning carnivore agency through the three-dimensional study of tooth pits: Revisiting crocodile feeding behaviour at FLK Zinj and FLK NN3 (Olduvai Gorge, Tanzania). *Palaeogeography, Palaeoclimatology, Palaeoecology* (<https://doi.org/10.1016/j.palaeo.2017.05.021>).

**Abstract:** Hominins and carnivores have shared similar habitats in Africa, evolving as direct competitors for the same prey and spaces. The overlap of their ecological niches has raised an important debate on the role that carnivores played in archaeological site formation. Different analytical techniques differentiate the action of carnivores and humans and identify the type of carnivore involved of which tooth mark analyses are prominent. However, available taphonomic studies present some limitations given the great overlap among tooth mark sizes from different carnivores, enabling only the distinction of size groups, not specific carnivores. In this work, we use a new technique combining three-dimensional (3D) reconstruction and geometric morphometrics (GMM) of tooth pits on equid and bovid bone created by different carnivores (including crocodiles, hyenas, jaguars, lions and wolves) in controlled settings. The 3D methodology we present isolates and differentiates tooth marks generated by different carnivores. We also test the applicability of the technique to ascribe tooth pits recorded on some hominin specimens from FLK Zinj and FLK NN 3 (Bed I, Olduvai Gorge). The tooth marks on the Olduvai OH8 and OH35 hominin fossils, previously assigned to crocodiles show that while OH8 tooth pit morphology falls in the range created by crocodiles, the pits on OH35 can not be

interpreted as crocodile-inflicted marks.

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Aktekin, U., Alkan, G.D. and Kayalica, D. (2017). Turkish Court of Cassation refuses to extend scope of protection of Lacoste's well-known trade marks. *Journal of Intellectual Property Law & Practice* 12(4): 271-272.

**Abstract:** The Turkish Court of Cassation, reversing its previous decisions on the matter, has rejected the action brought by Lacoste against registration of a 'Crocodile' trade mark for goods in classes 11, 20 and 21 of the Nice Agreement. The court has provided detailed criteria to assess the scope of protection of a well-known trade mark in relation to goods and services different from those for which the trade mark is registered.

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Soares, P., Borghesan, T.C., Tavares, L.E.R., Ferreira, V.L., Gerales Teixeira, M.M. and Paiva, F. (2017). *Hepatozoon caimani* Carini, 1909 (Adeleina: Hepatozoidae) in wild population of *Caiman yacare* Daudin, 1801 (Crocodylia: Alligatoridae), Pantanal, Brazil *Parasitol. Res.* (doi:10.1007/s00436-017-5467-1).

**Abstract:** Previous studies showed infections of *Hepatozoon caimani* in wild populations of caimans in wide regions from Brazil; some of those demonstrated that trophic chain are linked to natural infections through paratenic hosts or by the direct ingestion of vectors. These studies life cycle of *H. caimani* contributed inestimably to the knowledge of transmission routes, yet but lack enhancement tools for better detail of parasite. This study reports the forms in the blood and tissues, and also partial molecular characterization of the *H. caimani* following part of the 18S rRNA region. In the southern Pantanal, there were sampling 39 adult caimans (*Caiman yacare*), where 31 (79.5%) were parasitized by *H. caimani*. Free gametocytes had an average intensity of 19.6% and intraerythrocytic forms 7.42%, in the blood smears. In stained smears of the liver and lungs of naturally infected caimans which were examined, monozyotic and dizoic cysts were found in these tissues, generally next to the vessels. In the histopathology, meronts were observed in the wall of vessels from liver and kidney ducts. Blood samples were forwarded to PCR process and produced amplicons with about 600 and 900 bp, respectively, for the primers HEPF300/HEP900 and HEMO1/HEMO2. This was the first report of molecular confirmation of *Hepatozoon* in populations of naturally infected caimans of morphological detail of the gametocytes in scanning electron microscopy and histology of merogony in livers and kidneys of *C. yacare*.

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McCurry, M.R., Evans, A.R., Fitzgerald, E.M.G., Adams, J.W., Clausen, P.D. and McHenry, C.R. (2017). The remarkable convergence of skull shape in crocodilians and toothed whales. *Proceedings of the Royal Society B* (doi: 10.1098/rspb.2016.2348).

**Abstract:** The striking resemblance of long-snouted aquatic mammals and reptiles has long been considered an example of morphological convergence, yet the true cause of this similarity remains untested. We addressed this deficit through three-dimensional morphometric analysis of the full diversity of crocodilian and toothed whale (Odontoceti) skull shapes. Our focus on biomechanically important aspects of shape allowed us to overcome difficulties involved in comparing mammals and reptiles, which have fundamental differences in the number and position of skull bones. We examined whether diet, habitat and prey size correlated with skull shape using phylogenetically informed statistical procedures. Crocodilians and toothed whales have a similar range of skull shapes, varying from extremely short and broad to extremely elongate. This spectrum of shapes represented more of the total variation in our dataset than between phylogenetic groups. The most elongate species (river dolphins and gharials) are extremely convergent in skull shape, clustering outside of the range of the other taxa. Our results suggest the remarkable convergence between long-snouted river dolphins and gharials is driven by diet rather than physical factors intrinsic to

riverine environments. Despite diverging approximately 288 million years ago, crocodilians and odontocetes have evolved a remarkably similar morphological solution to feeding on similar prey.

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Lee, S.A. (2016). Incubation times of dinosaur eggs via embryonic metabolism. *Phys. Rev. E* 94(2-1): 022402.

**Abstract:** The incubation times for the eggs of 21 dinosaurs are determined from an estimate of their embryonic metabolic rate and the mass of the hatchlings via a mass growth model based on conservation of energy. Embryos in extant birds and crocodiles are studied in order to determine the best model for embryonic metabolism and growth. These results are used to develop a theoretical model that predicts the incubation times of an egg. This model is applied to dinosaur eggs and provides a unique window into dinosaur reproduction. The dinosaurs studied come from both Saurischia and Ornithischia. The incubation times vary from about 28 days for *Archaeopteryx lithographica* to about 76 days for *Alamosaurus sanjuanensis*.

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Iijima, M. (2017). Assessment of trophic ecomorphology in non-alligatoroid crocodylians and its adaptive and taxonomic implications. *Journal of Anatomy* (doi: 10.1111/joa.12626).

**Abstract:** Although the establishment of trophic ecomorphology in living crocodylians can contribute to estimating feeding habits of extinct large aquatic reptiles, assessment of ecomorphological traits other than the snout shape has scarcely been conducted in crocodylians. Here, I tested the validity of the proposed trophic ecomorphological traits in crocodylians by examining the correlation between those traits and the snout shape (an established trophic ecomorphology), using 10 non-alligatoroid crocodylian species with a wide range of snout shape. I then compared the ontogenetic scaling of trophic ecomorphology to discuss its adaptive and taxonomic significance. The results demonstrated that degree of heterodonty, tooth spacing, size of supratemporal fenestra (STF), ventral extension of pterygoid flange and length of lower jaw symphysis are significantly correlated with snout shape by both non-phylogenetic and phylogenetic regression analyses. *Gavialis gangeticus* falls outside of 95% prediction intervals for the relationships of some traits and the snout shape, suggesting that piscivorous specialization involves the deviation from the typical transformation axis of skull characters. The comparative snout shape ontogeny revealed a universal trend of snout widening through growth in the sampled crocodylians, implying the existence of a shared size-dependent biomechanical constraint in non-alligatoroid crocodylians. Growth patterns of other traits indicated that *G. gangeticus* shows atypical trends for degree of heterodonty, size of STF, and symphysis length, whereas the same trends are shared for tooth spacing and ventral extension of pterygoid flange among non-alligatoroid crocodylians. These suggest that some characters are ontogenetically labile in response to prey preference shifts through growth, but other characters are in keeping with the conserved biomechanics among non-alligatoroid crocodylians. Some important taxonomic characters such as the occlusal pattern are likely correlated with ontogeny and trophic ecomorphology rather than are constrained by phylogenetic relationships, and careful reassessment of such characters might be necessary for better reconstructing the morphological phylogeny of crocodylians.

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Hone, D.W.E. and Mallon, J.C. (2017). Protracted growth impedes the detection of sexual dimorphism in non-avian dinosaurs. *Palaeontology* (doi: 10.1111/pala.12298).

**Abstract:** Evidence for sexual dimorphism is extremely limited in the non-avian dinosaurs despite their high diversity and disparity, and despite the fact that dimorphism is very common in vertebrate lineages of all kinds. Using body-size data from both *Alligator mississippiensis* and *Rhea americana*, which phylogenetically bracket the dinosaurs, we demonstrate that even when there is

strong dimorphism in a species, random sampling of populations of individuals characterized by sustained periods of growth (as in the alligator and most dinosaurs) can result in the loss of this signal. Dimorphism may be common in fossil taxa but very hard to detect without ontogenetic age control and large sample sizes, both of which are hampered by the limitations of the fossil record. Signal detection may be further hindered by Type III survivorship, whereby increased mortality among the young favours the likelihood that they will be sampled (unless predation or taphonomic bias against small size acts against this). These, and other considerations relating to behaviour and ecology, provide powerful reasons to suggest that sexual dimorphism in dinosaurs may be very difficult to detect in almost all currently available samples. Similar issues are likely also to be applicable to many fossil reptiles, or animals more generally.

Singo, A. (2017). Microcystin Concentrations in a Nile Crocodile (*Crocodylus niloticus*) Breeding Dam and Vertical Transmission to Eggs. MSc Thesis, University of Pretoria, South Africa.

**Abstract:** Cyanobacteria or blue green algae are known for their extensive and highly visible blooms in rivers or dams. One of the most important cyanobacteria is *Microcystis aeruginosa* which can synthesize various microcystins that can affect the health of terrestrial and aquatic animals. Commercial Nile crocodile (*Crocodylus niloticus*) farming in South Africa is based on keeping breeders (adult males and females) in big dams on farms (captive-bred approach). Unfortunately, cyanobacterial blooms in the breeder dams are a concern to farm owners, managers and veterinarians. This research project focussed on the monitoring of microcystins in the Hartbeespoort Dam and a crocodile breeding dam over a period of nine months. A commercial, but expensive, Abraxis ELISA kit was compared to a much cheaper and robust Norwegian-developed ELISA to detect microcystins in fresh water. Another objective was to determine if microcystins were present in the contents of crocodile eggs and dead hatchlings. Water samples were collected monthly from August 2014 to April 2015 at two sites, the Hartbeespoort Dam (control site) and the breeding dam of a commercial Nile crocodile farm. In addition, various water quality parameters including nitrate, phosphorous, chlorophyll a, oxygen saturation, pH and total dissolved solids (TDS) were determined to assess eutrophication. During the crocodile hatching season microcystin concentrations in unfertilized eggs, egg-shell membranes and in the yolk and liver of dead hatchlings were determined using liquid chromatography-mass spectrometry (LC-MS). Water quality parameters showed that there was no significant difference between the two dams' (the Hartbeespoort and the breeding dam) eutrophic state i.e. phosphates, TKN and nitrates; they both seemed to be becoming more eutrophic as the nutrient supply to the dam was increasing. Furthermore, microcystin concentrations during peak summer months were generally higher at the Hartbeespoort Dam compared to the crocodile breeding dam. The two ELISAs as performed on water samples "as is" and following an adsorbent disk/methanol extraction method were positively correlated; however, the correlation between the two assays was much stronger when using the adsorbent disk/methanol extraction as compared to using water "as is". Besides dissolved oxygen all the other water quality parameters were not significantly different ( $p > 0.05$ ) between the two sites. Microcystin concentrations (MC-LR, MC-RR, MC-YR) in the crocodile egg and hatchling samples collected from batches with a good hatching rate ( $\geq 90\%$ ) ranged between 0-1.76 ng/g, with the highest concentration in the eggshell membranes. Microcystin concentrations in samples collected from batches with a bad hatching rate ( $\leq 10\%$ ) ranged from 0-1.63 ng/g with the highest concentration detected in the hatchling yolk. Although the "tissue" concentration levels were probably underestimated with the extraction method employed for LC-MS as the percentage recovery from spiked samples were very low. Bayesian analysis suggests that the liver, yolk and unfertilized egg all have similar microcystin concentrations, while the membranes have (with moderate to high certainty) higher microcystin concentrations. In conclusion, when using the Norwegian ELISA it seems as though the use of a resin-containing adsorbent disk followed by methanol extraction is more reliable than analysing water "as is".

Following methanol extraction the results of the two ELISAs were strongly correlated, which suggests that the two ELISAs provide comparable results. There appears to be no difference in microcystin concentrations among good and bad clutches across all tissue types or within a specific tissue type. Vertical transmission of microcystins to the Nile crocodile egg does occur, but due to the small sample size, final conclusion cannot be made if microcystin affects Nile crocodile hatchling mortality and/or hatching of eggs. Future studies will include a longitudinal study to be done since a single season of breeding is insufficient to conclude that microcystins do not contribute to the low hatching rate in Nile crocodiles.

Singo, A., Myburgh, J.G., Laver, P.N., Venter, E.A., Ferreira, G.C.H., Rösemann, G.M. and Botha, C.J. (2017). Vertical transmission of microcystins to Nile crocodile (*Crocodylus niloticus*) eggs. *Toxicon*. (doi: 10.1016/j.toxicon.2017.05.017).

**Abstract:** Cyanobacteria or blue green algae are known for their extensive and highly visible blooms in eutrophic, stagnant freshwater bodies. Climate change and global warming have also contributed to a rise in toxic cyanobacterial blooms. One of the most important cyanobacteria is *Microcystis aeruginosa*, which can synthesize various microcystins that can affect the health of terrestrial and aquatic animals. Commercial Nile crocodile (*Crocodylus niloticus*) farming in South Africa is based on keeping breeders (adult males and females) in big dams on farms (captive-bred approach). Unfortunately, cyanobacterial blooms in the breeder dams are a concern to farm owners, managers and veterinarians. The main objectives of this research project were to determine if microcystins were present in the contents of crocodile eggs and the liver and yolk of dead hatchlings, and to determine if the reduced hatchability on commercial farms might be caused by these toxins. Furthermore, the concentration of microcystins in the breeder dam was monitored on a monthly basis spanning the ovulation and egg laying period. During the hatching season microcystin concentrations in unfertilized eggs, egg shell membranes and in the yolk and liver of dead hatchlings were determined using liquid chromatography-high resolution mass spectrometry (LC-HRMS). Microcystins were detected in Nile crocodile egg and hatchling samples. Microcystin (MC-LR, MC-RR, MC-YR) concentrations in the crocodile egg and hatchling samples collected from clutches with a good hatching rate ( $\geq 90\%$ ) ranged between 0 and 1.76 ng g<sup>-1</sup>, with the highest concentration in the eggshell membranes. Microcystin concentrations in samples collected from clutches with a bad hatching rate ( $\leq 10\%$ ) ranged from 0-1.63 ng g<sup>-1</sup> with the highest concentration detected in the hatchling yolk. However, the concentrations were probably underestimated as the percentage recovery from spiked samples was very low with the extraction method employed. Bayesian analysis suggests that the liver, yolk and unfertilized egg all have similar microcystin concentrations, while the membranes have (with moderate to high certainty) higher microcystin concentrations. There appears to be no difference in microcystin concentrations among good and bad clutches across all tissue types or within a specific tissue type, but due to the small sample size, it was not possible to determine whether microcystin affected the hatchability of Nile crocodile eggs. However, vertical transmission of microcystin variants to the Nile crocodile egg does occur and the possible implications for the survival of wild Nile crocodile populations should be ascertained.

Kubo, T., Shibata, M., Naksri, W., Jintasakul, P. and Azuma, Y. (2017). The earliest record of Asian Eusuchia from the Lower Cretaceous Khok Kruat Formation of northeastern Thailand. *Cretaceous Research* (<https://doi.org/10.1016/j.cretres.2017.05.021>).

**Abstract:** We describe remains of a new crocodyliform found from the Lower Cretaceous (Aptian) Khok Kruat Formation, northeastern Thailand. Remains consist of two caudal ends of mandibles, two rostral symphyseal parts of right rami of mandibles, a dorsal part of postorbital, a cranial end of squamosal and one osteoderm. Phylogenetic analyses supported inclusion of this crocodyliform into the Eusuchia as it shares several morphological characters with

other eusuchians, such as a dorsocaudally oriented retroarticular process, smooth lateral surface of the caudoventral region of mandible, and a craniocaudally oriented ridge on the dorsal surface of retroarticular process. The shape of symphyseal region showed this crocodyliform had a longirostrine snout shape, which is uncommon in early eusuchians. Finding of this crocodyliform draws back the oldest record of Asian eusuchians, which was *Tadzhikosuchus*, approximately 30 million years and it is the only Mesozoic eusuchian found in East and Southeast Asia.

Diogo Dutra Araújo (2017). *Paleosuchus palpebrosus* (Cuvier's Dwarf caiman) - diet. Herpetology Notes 10: 169-170.

**Abstract:** Here, we described a diet record for Dwarf caiman, *Paleosuchus palpebrosus*, which is one of the smallest and most secretive species of crocodilians in the world. Information its their natural history and ecology is still scarce (Magnusson and Campos, 2010). Throughout its geographic range, *P. palpebrosus* occupies a wide variety of habitats, such as flooded forests, canals, rivers, lakes and even roadside borrow pits. Because different habitats have different prey availability, the diet of the species is expected to vary regionally (Magnusson 1985; Campos *et al.* 2010; Magnusson and Campos 2010 op.cit.). Based on the known diet for other Amazonian caiman species (Da Silveira and Magnusson 1999; Magnusson *et al.* 1987) we could expect *P. palpebrosus* to have an opportunistic-generalist diet, though, the variety of prey consumed and the feeding behavior is poorly known (Botero-Arias 2007; Campos *et al.* 1995). We captured a Cuvier's Dwarf caiman preying on a Neckband Ground-Snake, *Atractus torquatus* (Dipsadidae), in lower Purus River, central Amazonia, Brazil. The caiman (male, 50 cm SVL, 95 cm TL, 2.8 kg) was captured on 25 March 2013 in a seasonally flooded forest located on the southern bank of the Purus River (4°16'3" S; 61°43'52" W, WGS84, ELE. = 60 m). The caiman had a snake (male, 48 cm TL) in its mouth, which was almost intact and was preserved in 10% formalin and deposited in the herpetological section of the Zoological Collection of the Instituto Nacional de Pesquisas da Amazônia, Manaus, Brazil (INPA-H 33818). During night surveys in the same region in August 2014, we observed two additional *P. palpebrosus* holding snakes in their mouths, suggesting that this food type may consumed frequently.

Kvasilova, A., Gregorovicova, M. and Sedmera, D. (2017). Development of the cardiac conduction system in the selected groups of reptiles as determined by HNK-1 expression. The FASEB Journal.

**Abstract:** Reptilian hearts show different stages of ventricular septation from its complete absence in the basal squamates to a fully septated heart in crocodiles. We have tested the hypothesis that evolution of the specialized ventricular conduction system is linked to ventricular septation, rather than homeothermy, as originally postulated. We studied hearts of selected reptilian species (*Pogona vitticeps* – no ventricular septum, *Varanus indicus* – partial septum, *Crocodylus siamensis* – complete septum) at various stages of development to uncover any morphological evidence for specialized conduction pathways. Immunohistochemistry using smooth muscle or sarcomeric actin as myocardial markers and HNK-1 as a marker of cardiac conduction system showed HNK-1 expression in the myocardium of the sinus venosus, where the main cardiac pacemaker is located. There was also staining of various intensity in the extracellular matrix of cardiac cushions in all the species examined. There was an HNK-1 positive ring-like structure of the developing ventricular septum in the *Crocodylus*, and increased positivity in the *Varanus*, while there was no myocardial staining in the ventricle of the *Pogona*. In all species there was a strong staining in the cardiac nervous fibers and ganglia, and in the epicardium of the *Varanus*. We conclude that a primordial conduction system is present in reptilian hearts. The embryonic crocodilian hearts possess a morphological preferential conduction pathway similar to one present in the hearts of birds and mammals. Its emergence correlates with completion of ventricular septation.

Cubo, J., Köhler, M. and de Buffrenil, V. (2017). Bone histology of *Iberosuchus macrodon* (Sebecosuchia, Crocodylomorpha). Lethaia (doi: 10.1111/let.12203).

**Abstract:** *Iberosuchus macrodon* is a Cenozoic crocodyliform interpreted as a terrestrial, cursorial form. To assess whether this adaptation was accompanied by a high growth rate and an elevated resting metabolic rate (two features commonly attributed to several terrestrial Triassic Crocodylomorpha based on histology), we studied bone histology in the femora of two specimens attributed to *I. macrodon*. Beyond this question is the broader problem of the possible survival to the Cretaceous-Palaeogene extinction event of tachymetabolic sauropsids other than birds. At mid-diaphysis, bone cortices in *Iberosuchus* are made of a parallel-fibred tissue that turns locally to true lamellar bone. Cortical vascularization consists of simple longitudinal canals forming a network of medium density. The spacing pattern of conspicuous lines of arrested growth suggests asymptotic growth for *Iberosuchus*. This general histological structure prevails also in the metaphyseal region of the bones. It is basically similar to that encountered in certain large lizards adapted to active predation, the Varanidae and the Teiidae. In one of the two *Iberosuchus* femora, however, an intracortical meniscus made of a tissue displaying a global radial architecture occurs in the region of the fourth trochanter. Histologically, the latter can be interpreted either as compacted spongiosa or as a fibro-lamellar complex with a gross radial orientation, a tissue corresponding to fast periosteal apposition. These observations suggest that *Iberosuchus* basically had a slow, cyclical growth indicative of an ecto-poikilothermic, lizard-like, resting metabolic rate. However, it might also have retained a limited capacity for fast periosteal accretion in relation to local morphogenetic requirements as, for instance, the development of crests or trochanters.

Cespedes, H.A., Zavala, K. and Opazo, J. (2017). Evolution of the  $\alpha 2$ -adrenoreceptors in vertebrates: ADRA2D is absent in mammals and crocodiles. bioRxiv (doi: <https://doi.org/10.1101/106526>).

**Abstract:** Evolutionary studies of genes that have been functionally characterized and whose variation has been associated with pathological conditions represent an opportunity to understand the genetic basis of pathologies.  $\alpha 2$ -adrenoreceptors (ADRA2) are a class of G protein-coupled receptors that regulate several physiological processes including blood pressure, platelet aggregation, insulin secretion, lipolysis, and neurotransmitter release. This gene family has been extensively studied from a molecular/physiological perspective, yet much less is known about its evolutionary history. Accordingly, the goal of this study was to investigate the evolutionary history of  $\alpha 2$ -adrenoreceptors (ADRA2) in vertebrates. Our results show that in addition to the three well-recognized  $\alpha 2$ -adrenoreceptor genes (ADRA2A, ADRA2B and ADRA2C), we recovered a clade that corresponds to the fourth member of the  $\alpha 2$ -adrenoreceptor gene family (ADRA2D). We also recovered a clade that possesses two ADRA2 sequences found in two lamprey species. Furthermore, our results show that mammals and crocodiles are characterized by possessing three  $\alpha 2$ -adrenoreceptor genes, whereas all other vertebrate groups possess the full repertoire of  $\alpha 2$ -adrenoreceptor genes. Among vertebrates ADRA2D seems to be a dispensable gene, as it was lost two independent times during the evolutionary history of the group. Additionally, we found that most examined species possess the most common alleles described for humans; however, there are cases in which non-human mammals possess the alternative variant.

Taylor-Brown, A. and Polkinghorne, A. (2017). New and emerging chlamydial infections of creatures great and small. New Microbe and New Infect. 18: 28-33.

**Abstract:** Until recently, our knowledge of the host range and diversity of members of the Chlamydiaceae, obligate intracellular bacterial pathogens of humans and animals, was thought to be nearly complete. Aided by advances in molecular diagnostics, a

new picture is emerging, however, that the host barriers may be looser than previously thought for many chlamydial species. While cross-host transmission of chlamydial species is a concern for animal health, new reports highlight an emerging zoonotic risk for several species associated with intensification of farming and the widespread popularity of companion animals. The description of an expanded cohort of new species within this family from avian and reptilian hosts has also highlighted how much we still have to learn about the biology and pathogenicity of the Chlamydiaceae as a whole. Reports emerging about these relatives of the traditional chlamydial pathogens are matched by the continued identification of novel Chlamydia-related bacteria in the phylum Chlamydiae, providing evidence that many may be pathogenic to humans or animals and pose a zoonotic or vector-borne risk. The review examines the new hosts described for well-characterized chlamydial veterinary pathogens, emerging novel chlamydial species and the potential for these to cause disease in their respective hosts.

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Oliveira, A.T., Santos, M.Q.C., Pantoja-Lima, J., Machado, M.R.F., Lemos, J.R.G., Tavares-Dias, M. and Aride, P.H.R. (2017). First record of microfilaria in the blood of black caiman *Melanosuchus niger* (Crocodylia: Alligatoridae) specimens from the Amazon River basin. Brazilian Journal of Biology (<http://dx.doi.org/10.1590/1519-6984.04716>).

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Meador, L.R., Godfrey, L.R., Rakotondramavo, J.C., Ranivoharimanana, L., Zamora, A., Sutherland, M.R. and Irwin, M.T. (2017). *Cryptoprocta spelea* (Carnivora: Eupleridae): What did it eat and how do we know? Journal of Mammal Evolution (doi:10.1007/s10914-017-9391-z).

**Abstract:** The extent to which Madagascar's Holocene extinct lemurs fell victim to nonhuman predators is poorly understood. Madagascar's Holocene predator guild included several now-extinct species, ie, crocodiles, carnivorans, and raptors. Here we focus on mammalian carnivory, specifically the roles of *Cryptoprocta spelea* and its still-extant but smaller-bodied sister taxon, *C. ferox*, the fosa. *Cryptoprocta spelea* was the largest carnivoran on Madagascar during the Quaternary. We ask whether some extinct lemurs exceeded the upper prey-size limits of *C. spelea*. We use univariate and multivariate phylogenetic generalized least squares regression models to re-evaluate the likely body mass of *C. spelea*. Next, we compare characteristics of the forelimb bones of *C. ferox* and *C. spelea* to those of other stealth predators specializing on small, mixed, and large-bodied prey. Finally, we examine humeri, femora, crania, and mandibles of extinct lemurs from six sites in four ecoregions of Madagascar to identify damage likely made by predators. We test the relative prevalence of carnivory by mammals, raptors, and crocodiles at different sites and ecoregions. Our data reveal that crocodiles, raptors, and the largest of Madagascar's mammalian predators, *C. spelea*, all preyed on large lemurs. *Cryptoprocta* opportunistically consumed lemurs weighing up to ~85 kg. Its forelimb anatomy would have facilitated predation on large-bodied prey. Social hunting may have also enhanced the ability of *C. spelea* to capture large, arboreal primates. *Cryptoprocta* carnivory is well represented at cave and riverine sites and less prevalent at lake and marsh sites, where crocodylian predation dominates.

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Nifong, J.C. and Silliman, B. (2017). Abiotic factors influence the dynamics of marine habitat use by a highly mobile “freshwater” top predator. Hydrobiologia (doi: 10.1007/s10750-017-3255-7).

**Abstract:** Cross-ecosystem movements of mobile consumers are a primary mechanism by which energy and nutrients are exchanged between disparate ecosystems. While factors influencing variation in bottom-up subsidies between ecosystems have been well studied, much less is known regarding how biotic and abiotic factors influence the dynamics of mobile consumer-driven connectivity. In

a literature survey, we found only 14% of studies examined factors contributing to variation in cross-ecosystem marine foraging by freshwater-adapted consumers. Here, we examine the relationships between abiotic factors and cross-ecosystem movements of a highly mobile freshwater-adapted top predator, *Alligator mississippiensis* (American alligator). As alligators lack physiological adaptations to survive in marine environments, we predict this linkage would be affected by factors that modify the ability to cope with high salinities. Our results reveal that multiple abiotic factors (eg relative humidity, temperature, total precipitation) are key explanatory variables of the duration of cross-ecosystem foraging trips by alligators, and that the absence of salt glands does not preclude them from performing long forays into marine environments. More broadly, our results expand our understanding of mobile consumer-driven ecosystem connectivity at the land-sea interface by demonstrating connectivity is highest when physical stressors are relaxed, and access to and availability of resources are maximized.

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Emerling, C.A. (2017). Archelosaurian color vision, parietal eye loss, and the crocodylian nocturnal bottleneck. Mol. Biol. Evol. 34(3): 666-676.

**Abstract:** Vertebrate color vision has evolved partly through the modification of five ancestral visual opsin proteins via gene duplication, loss, and shifts in spectral sensitivity. While many vertebrates, particularly mammals, birds, and fishes, have had their visual opsin repertoires studied in great detail, testudines (turtles) and crocodylians have largely been neglected. Here I examine the genomic basis for color vision in four species of turtles and four species of crocodylians, and demonstrate that while turtles appear to vary in their number of visual opsins, crocodylians experienced a reduction in their color discrimination capacity after their divergence from Aves. Based on the opsin sequences present in their genomes and previous measurements of crocodylian cones, I provide evidence that crocodylians have co-opted the rod opsin (RH1) for cone function. This suggests that some crocodylians might have reinvented trichromatic color vision in a novel way, analogous to several primate lineages. The loss of visual opsins in crocodylians paralleled the loss of various anatomical features associated with photoreception, attributed to a “nocturnal bottleneck” similar to that hypothesized for Mesozoic mammals. I further queried crocodylian genomes for nonvisual opsins and genes associated with protection from ultraviolet light, and found evidence for gene inactivation or loss for several of these genes. Two genes, encoding parietopsin and parapinopsin, were additionally inactivated in birds and turtles, likely co-occurring with the loss of the parietal eye in these lineages.

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Company, J. and Pereda-Suberbiola, X. (2016). Long bone histology of a eusuchian crocodyliform from the Upper Cretaceous of Spain: Implications for growth strategy in extinct crocodiles. Cretaceous Research 72: 1-7.

**Abstract:** The long bone histology of a Late Cretaceous eusuchian crocodyliform from the Iberian Peninsula reveals clear variations in the cortical structure which reflects changes in the speed of bone deposition (ie skeletal growth) related to ontogeny. The presence of secondary woven-fibred bone tissue in the perimedullar region of the cortex, and the existence of an external fundamental system in the most external periosteal cortex, which is a proxy for somatic maturity and effective cessation of growth, challenges the former idea that the growth strategy of extinct crocodylians fit in the typical ectotherm condition, according to which these animals grew slowly during life under an indeterminate growth strategy. The analysed specimen lived for a minimum of 16 years and the highest preserved apposition rates took place in an advanced ontogenetic stage. The study suggests that the general aspects of the modern crocodylian growth strategy were already in place in some lineages by the Cretaceous.

Gabrey, S.W. and Elsey, R.M. (2017). Birds in the diet of American alligators. *Journal of Louisiana Ornithology* 10: 1-10.

**Abstract:** American alligators (*Alligator mississippiensis*) are opportunistic predators that prey upon or scavenge a wide variety of vertebrates and invertebrates. Fish and crustaceans are typically the most frequently encountered items in most diet analyses whereas birds are relatively uncommon in comparison. However, most alligator food habits analyses rely on stomachs collected from alligators legally harvested during short (one month in the fall) hunting seasons. Thus, these analyses may underrepresent the importance of birds because they provide data from a short period during which birds may not be readily available. In this paper we report on the frequency of birds found in a sample of over 500 stomachs collected by Louisiana alligator hunters and review published and unpublished accounts of alligator consumption of birds. In most cases, we could not tell whether the bird was caught and consumed alive or scavenged; however, several reports of direct observation of alligator depredation illustrate that alligators will prey on live birds when available. Considering all sources, we found evidence of alligators consuming at least 40 bird species, including two waterfowl species (Black-bellied Whistling Duck *Dendrocygna autumnalis* and Blue-winged Teal *Anas discors*) not previously reported as alligator food. Among the most frequently recorded species were waterfowl and wading birds, two groups of birds that may be particularly susceptible to alligator depredation as flightless or naïve juveniles or as flightless adults during summer molt. Because alligator food habit studies typically do not occur during the summer when these groups of birds are breeding and population densities relatively high, their importance in alligator diets may be underestimated.

Jirak, D. and Janacek, J. (2017). Volume of the crocodilian brain and endocast during ontogeny. *PLoS ONE* 12(6): e0178491.

**Abstract:** Understanding complex situations and planning difficult actions require a brain of appropriate size. Animal encephalisation provides an indirect information about these abilities. The brain is entirely composed of soft tissue and, as such, rarely fossilises. As a consequence, the brain proportions and morphology of some extinct vertebrates are usually only inferred from their neurocranial endocasts. However, because the morphological configuration of the brain is not fully reflected in the endocast, knowledge of the brain/endocast relationship is essential (especially the ratio of brain volume to endocast volume or the equivalent proportion of interstitial tissue) for studying the endocasts of extinct animals. Here we assess the encephalic volume and structure of modern crocodilians. The results we obtained using *ex vivo* magnetic resonance imaging reveal how the endoneurocranial cavity and brain compartments of crocodilians change configuration during ontogeny. We conclude that the endocasts of adult crocodilians are elongated and expanded while their brains are more linearly organised. The highest proportion of brain tissue to endocast volume is in the prosencephalon at over 50% in all but the largest animals, whereas the proportion in other brain segments is under 50% in all but the smallest animals and embryos. Our results may enrich the field of palaeontological study by offering more precise phylogenetic interpretations of the neuroanatomic characteristics of extinct vertebrates at various ontogenetic stages.

Corey, B., Webb, G.J.W., Manolis, S.C., Fordham, A., Austin, B.J., Fukuda, Y., Nicholls, D. and Saalfeld, K. (2017). Commercial harvests of saltwater crocodile *Crocodylus porosus* eggs by Indigenous people in northern Australia: lessons for long-term viability and management. *Oryx* (<https://doi.org/10.1017/S0030605317000217>).

**Abstract:** Sustainable commercial use of native wildlife is an alternative economic means of land use by Indigenous people in remote rural areas. This situation applies within large tracts of land owned by Indigenous people across northern Australia. The commercial use of saltwater crocodiles *Crocodylus porosus* is

a growing industry in Australia's Northern Territory. Although Indigenous people sell crocodile eggs and hatchlings, the majority of harvesting and incubation is done by non-indigenous people from less remote areas. One Indigenous community has been heavily involved in this industry and now manages its own harvest and incubation program. We present a case study of this program, which has transitioned from outside agencies managing the harvest, to complete local ownership and management. Egg harvests and incubation success rates declined by 40% following the switch to local management. Income increased, as did production costs; in particular, royalty payments made to Indigenous landowners. The declines reflect the community's motives for engaging in the industry, which have been socially rather than commercially driven, and damage to nesting habitat by feral animals. The increase in royalties reflects the need to compete with non-indigenous harvesters from outside the township, who are strictly commercially driven. Harvesting, incubation and trade in crocodile eggs and hatchlings can form a viable and sustainable enterprise for remote Indigenous communities. However, efficiency needs to be improved to fulfil the need for a reliable and dependable supply chain, and regulatory institutions should give Indigenous harvesters sufficient freedom to pursue innovative and viable livelihood options.

Villamarín, F., Jardine, T.D., Bunn, S.E., Marioni, B. and Magnusson, W.E. (2017). Opportunistic top predators partition food resources in a tropical freshwater ecosystem. *Freshwater Biology* (doi: 10.1111/fwb.12952).

**Abstract:** The structure of food webs may be strongly influenced by the distribution of top predators in space and time. The Amazon biome is the only region in the world where four alligatorid species are known to occur in sympatry, and they attain high densities in some regions. As top predators with a diverse range of prey species occupying different trophic levels, their impact upon food webs should be substantial, but the degree to which crocodilians differ in their food sources, and potentially avoid competitive exclusion where they occur syntopically is not well understood. Although most crocodilians are considered generalist opportunistic predators that feed on any source of protein available in the environment, Amazonian crocodilians show broad differences in the proportions of prey items they consume. It is believed that these differences may in part reflect habitat use, but it is unknown to what extent they represent interspecific differences in prey preferences or are a direct function of habitat selection. Stable carbon isotope data ( $\delta^{13}\text{C}$ ) of crocodilians and their potential prey were used to assess differences in reliance on terrestrial versus aquatic resources. These data were then placed in a spatial context using classified maps that reflect habitat types (headwater streams, mid-order flooded-forest streams and varzea floodplains) to elucidate whether dietary differences are explained by habitat selection or are more likely a reflection of prey preferences. We found evidence for differences in types of basal resources supporting these crocodilians. Mean  $\delta^{13}\text{C}$  values were highest in *Paleosuchus trigonatus* (Schneider's Dwarf caiman,  $-25.7 \pm 1.2\text{‰}$ ), intermediate in *Caiman crocodilus* (Spectacled caiman,  $-27.4 \pm 1.2\text{‰}$ ) and *Paleosuchus palpebrosus* (Cuvier's Dwarf caiman,  $-27.7 \pm 1.1\text{‰}$ ) and lowest in *Melanosuchus niger* (Black caiman,  $-29.9 \pm 1.3\text{‰}$ ). A progressive decrease in  $\delta^{13}\text{C}$  values of crocodilian tissues occurred from headwaters to floodplains, which most likely reflects a progressive increase in autochthonous over allochthonous inputs in lower reaches of streams. The shift from terrestrial to aquatic resources sustaining these sympatric predators mirrors their spatial distribution along this ecotone. However, after taking into account the habitat in which pairs of syntopic individuals of distinct species occurred, significant differences in  $\delta^{13}\text{C}$  values suggest that *P. trigonatus* and *P. palpebrosus* have different prey bases. Thus, despite being opportunistic predators, our results show that differences in crocodilian diets likely result from prey preferences and not only from habitat selection. These findings suggest that some species of crocodilians may be less generalist than traditionally thought and their influence on terrestrial or aquatic food webs might be species specific.

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