

CROCODILE SPECIALIST GROUP NEWSLETTER

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COVER PHOTOGRAPH: Local fishing communities taking part in the release of head-started juvenile Gharial (*Gavialis gangeticus*) into the Rapti River, Chitwan National Park, Nepal (see pages 12-13). Photograph: Nurendra Aryal.

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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Editorial

I am saddened to report that CSG member Edmond C. Mouton Jr. (61 y) passed away on 3 March 2018 at his home in Lafayette, Louisiana, with family and friends at his side. He had been diagnosed with leukemia and underwent treatment for several months, before succumbing to the illness (see Obituary on pages 4-5).

Long time CSG member and Madras Crocodile Bank Trust founder, Rom Whitaker, has been awarded the “Padma Shri” for his work in Wildlife Conservation by the Government of India. This is one of India’s highest civilian awards. Instituted in 1954, the Padma awards are awarded to Indian citizens in recognition of their distinguished contribution to various activities, including arts, education, industry, literature, science, sports, medicine, social service and public affairs. All CSG members should join me in congratulating Rom on receiving this deserved award.

In January 2018 “Muggers of Vadodara” by Raju Vyas was formally released at the concluding session of the 5th Charotar Crocodile Count. The book covers the urban Muggers (*Crocodylus palustris*) of Vadodara City, Gujarat State, India, which share their existence with people [see CSG Newsletter 36(4) and www.iucncsg.org homepage].

In February 2018 the Nepalese Department of National Parks and Wildlife Conservation (DNPWC) approached the CSG seeking a review of its “Gharial Conservation Action Plan

for Nepal (2018-2022)”. The document was circulated to a number of CSG members who are familiar with the situation with *Gavialis gangeticus* in Nepal for review and comments. A report summarizing the outcomes of the review was provided to DNPWC in mid-March 2018. The program in Nepal is a pioneering one, and it has contributed seriously to saving the remnant population. It stems from the 1970s, when “conservation ranching” seemed a logical way to go in both Nepal and India. Wild eggs were collected, incubated, reared in captivity, and then released back to the wild. However, the effectiveness of this strategy in both India and Nepal is difficult to measure. The wild population has certainly not rebounded after decades of restocking, and the *ex-situ* program has become institutionalised. While respecting the anthropogenic influences impacting on *in-situ* conservation, the CSG believes the focus should switch back to community engagement in *in-situ* conservation, and this will require an injection of science and wildlife management research in the future.

In February 2018 the CSG carried out a review of a Queensland Government proposal to allow a pilot *Crocodylus porosus* egg harvest at Pormpuraaw, situated on indigenous lands in far North Queensland, Australia. No use of wild crocodiles is currently permitted in Queensland, other than problem animals. The area in which harvesting is proposed is marginal nesting habitat and is prone to flooding during the wet season. The harvest is thus unlikely to be detrimental to the *C. porosus* population at a local, state or national level. The CSG congratulates the Queensland Government, the crocodile industry in North Queensland, and the indigenous community involved as partners in this initiative. Maintaining community support for the conservation of expanding populations of predators such as *C. porosus*, is a growing social and economic challenge, and commercial benefits derived through sustainable use may well be able to add a new suite of values and incentives for landowners to promote stewardship and sustain conservation in local areas.

In late February I wrote to CSG members seeking financial contributions to the “Apaporis Caiman Project Fund”, to help fund a preliminary survey to re-discover and assess the conservation status of *Caiman crocodilus apaporiensis* in Colombia. This is a long-standing CSG priority, which was previously constrained by civil unrest, but now Sergio Balaguera-Reina, in collaboration with the Humboldt Institute (CITES Scientific Authority of Colombia), is taking up the challenge. To date 9 donors have pledged funds to support the project and other fund-raising efforts are underway. Described by Frederico Medem, one of the first CSG members, it will be simply great to discover what has happened to this distinctive caiman and hopefully get samples for genetic analysis.

The Government of East Kutai Regency, East Kalimantan Province, Indonesia, has declared the Siamese crocodile (*Crocodylus siamensis*; known locally as Buaya Badas) as the mascot for the East Kalimantan Provincial Games of 2018! It is hoped that as a mascot for these games it will bring attention to the plight of this critically endangered species. It occurs in Lake Mesangat (East Kutai Regency), and this population

may be the second largest one for this species throughout its range. It is the only population outside mainland Southeast Asia. Drone and spotlight surveys were undertaken recently in Lake Mesangat by WCS-Indonesia (see pages 6-11 for report on surveys), and additional surveys are planned for the area, which is threatened by oil palm development.

Since December 2016 the CSG has collaborated with the IUCN Species Survival Commission to update details of current CSG members in the IUCN-SSC database. The process has not been without its difficulties, and by January 2018 only 342 of 607 CSG members were in the database. However, we have been informed that the technical issues have been resolved, and in March 2018 the CSG Executive Officer submitted the “missing” members for inclusion in the database. The IUCN system relies on members having an e-mail in order to be listed. There are difficulties for both the SSC and the CSG when members change their contact details without advising us. I urge CSG members to notify the CSG Executive Officer if your contact details change.

The latest IACTS (International Alligator and Crocodile Trade Study) report by John Caldwell, published by the UN Environment World Conservation Monitoring Centre (UNEP-WCMC), is now available on the CSG website (www.iucncsg.org). The report shows changing trends in the crocodilian species involved in international trade since 2006, but with special emphasis on the 2013-2015 period, the most recent 3-year period for which there are reasonably complete CITES trade data.

Dates for the 18th Conference of the Parties to CITES (CoP18) have been set, and it will take place in Colombo, Sri Lanka, on 23 May-3 June 2019. Proposals to amend Appendix I or Appendix II pursuant to Resolution Conf. 9.24 (Rev. CoP15) must be communicated to the CITES Secretariat by 24 December 2018. Any amendment proposal submitted pursuant to the ranching resolution [Resolution Conf. 11.16 (Rev. CoP15)] must be submitted by 27 June 2018. A Party intending to submit a proposal to amend the appendices for a species that occurs partly or totally outside of the territory under its jurisdiction and does not intend to consult with Range States before submission, must submit by 27 June 2018.

In May 2017 the process of updating the Species Action Plans (last published in 2010) was initiated, and it was hoped that the new plans would be finalized by the time of CSG working meeting in May 2018. By the end of March 2018, 9 (38%) of the 24 Action Plans were completed. I would like to take this opportunity to thank all of the contributors who have provided their expertise and time to this very important activity.

Many crocodilian populations are now subject to sustainable use programs, and the economic benefits derived have created incentives for Governments and private operators to invest directly and indirectly in their recovery and conservation. But there is currently an oversupply of skins in the international market, and ever-increasing grading standards are creating a strongly bimodal price distribution for Grade 1 versus

Grades 2, 3 and 4 skins. I am concerned that technologically sophisticated production will go beyond the capability of local and indigenous communities directly involved, which could adversely affect programs based on wild skins. This situation risks discouraging the involvement of local people and the benefits they get to support crocodile conservation and biodiversity conservation efforts. Much discussion, innovation and fresh ideas are needed!

The 26th CSG Working Meeting (Santa Fe, Argentina; 7-10 May 2017) is now only about one month away. It promises to be a wonderful meeting and I urge everyone interested in crocodilian conservation, management and research to attend. Please visit the meeting website (<https://www.25wmcsgsantafe.com>) for details on registration, accommodation, etc.

Professor Grahame Webb, *CSG Chair*.

Obituary

Edmond C. Mouton Jr. (1956-2018)



We are saddened to report that CSG member Edmond C. Mouton Jr., aged 61 years, passed away on 3 March 2018 at his residence in Lafayette with family and friends at his side. He had been diagnosed with leukemia and underwent treatment for several months, before succumbing to the illness.

Edmond received his Bachelor of Science degree in Agriculture, and his Master of Science degree in Biology, both from the University of Southwestern Louisiana in Lafayette. He had been an employee of the Louisiana Department of Wildlife and Fisheries since 1994. Starting as a field biologist, he worked his way up through the ranks to become Program Manager of the Fur Division in 2005. This afforded him the opportunity to become familiar with CITES and the international fur trade. He served in that capacity for the remainder of his career, and additionally became the Program Manager of the Alligator Management and Research Section in 2014. That same year he became a CSG member, and attended the 23rd CSG Working Meeting in Lake Charles, Louisiana, that spring, and gave a presentation on Louisiana's alligator program on the opening day of the meeting.

Edmond loved to duck hunt, fish, cook, and above all spend time with his family and friends. He was an avid University of Louisiana baseball fan and member of the Cajun Cooking Club for the UL baseball team. He was a former King of the Krewe of Moss Mardi Gras Krewe in Lafayette. He was a faithful parishioner and longtime usher at St. John's Cathedral. Edmond was a volunteer "trouble shooter" for Festival International and proponent of French and Cajun culture. He was a Boy Scout leader for Troop 405 and an Eagle Scout for Troop 119.

Edmond is survived by his wife, Sandra Houdek Mouton, son, Charles Edmond Mouton, and daughter, Rachel Ann Mouton. Edmond was deeply loved by his family, colleagues, and extended group of friends. He will be missed by all.

Ruth Elsey, *Louisiana Department of Wildlife and Fisheries, and CSG Regional Chair for North America.*

CSG Student Research Assistance Scheme

The Student Research Assistance Scheme (SRAS) provided funding to 13 students in the January-March 2018 quarter, and one further application is currently under review.

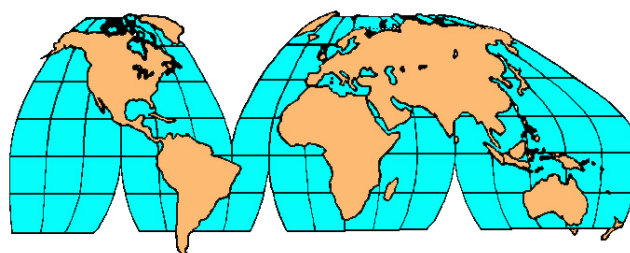
1. Lydia Giddings (UK): Behavioural response to juvenile distress calls as measure of parental care in crocodilians.
2. José António Lemos Barão Nóbrega (Portugal): Population structure and genetics of Morelet's crocodile (*Crocodylus moreletii*) in the Calakmul Eco-region, Campeche, Mexico.
3. Jonathan Rio (UK): Using local ecological knowledge to assess the status and threats of the Critically Endangered Chinese alligator.
4. Diana Maria Diaz Moreno (Colombia): Molecular characterization of *Caiman crocodilus fuscus* in the Magdalena River (Prado and Purificación Municipalities), Colombia.
5. Kathryn Wayne (USA): Establishing crocodilian genital differentiation: New approaches investigating hatchling *Alligator mississippiensis* sexual dimorphisms.
6. Rene Barragan Lara (Mexico): Population status and nest temperatures of the American crocodile (*Crocodylus acutus*) in a central coastal lagoon in Oaxaca, Mexico.
7. Albert Myburgh (South Africa): Stable isotopes of wild Nile crocodiles as a trace for pollution in the upper Olifants River, South Africa.
8. Antoinette Lensink (South Africa): The bacterial and fungal bionomics of the *Crocodylus niloticus* egg in relation to the microstructure of the eggshell.
9. Igor Joventino Roberto (Brazil): Species delimitation of

the *Caiman crocodilus* complex: Towards an integrative taxonomic approach.

10. Evangelina del Valle Viotto (Argentina): Population dynamics of *Caiman latirostris*: Development of a model for its conservation, incorporating possible scenarios of climate change and sustainable use.
11. Veronica Arias Perez (Costa Rica): Analysis of antibiotic sensitivity profiles in *Escherichia coli* isolates obtained from the cloacas of American crocodiles (*Crocodylus acutus*) captured in tilapia ponds in Canas Guanacaste, Costa Rica.
12. Carlos Flores Escalona (Mexico): Population status of Morelet's crocodile (*Crocodylus moreletii*) in the Usumacinta River basin.
13. Sofia Perez Cruz (Mexico): Acoustic characterization of the alarm calls of Morelet's crocodile (*Crocodylus moreletii*) in acoustically contrasting environments.

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

Regional Reports



Latin America and the Caribbean

Venezuela

The Proceedings of the Second Symposium on Ecology and Conservation of Crocodilians of Venezuela [held on 29 November 2017; see CSG Newsletter 36(4): 8] have been published in Volume LXXVII, Nos. 2-3, of the "Boletín de la Academia de Ciencias Físicas Matemáticas y Naturales de Venezuela". Twenty (20) oral presentations (see below) are included in the volume (in Spanish, with Spanish and English abstracts), covering a range of topics. The volume can be downloaded from the CSG website (www.iucncsg.org).

1. Blohm, C.M., Blohm, T. and Boede, E. (2017). Hato Masaguaral, its history. Bol. Acad. C. Fís., Mat. y Nat. Vol. LXXVII Nos. 2-3: 9-15.
2. Boede, E.O. and Hoogesteijn, R. (2017). The commercial hunting of the Orinoco crocodile, *Crocodylus intermedius*, in Venezuela, 1894-1897, 1929-1963, considering methodologies and reports of the era. Bol. Acad. C. Fís., Mat. y Nat. Vol. LXXVII Nos. 2-3: 16-28.

3. Hernández, O., Boede, E.O. and Acosta, J.G. (2017). Evaluation of the reproduction of the Orinoco crocodile (*Crocodylus intermedius*) in the breeding center of the Masaguaral Ranch, 2000-2017. Bol. Acad. C. Fís., Mat. y Nat. Vol. LXXVII Nos. 2-3: 29-38.
 4. Otahola, E.S., Merlo, L. and Aguilera, T. (2017). Conservation program of the Orinoco crocodile (*Crocodylus intermedius*) in the "El Cedral" Ranch, Apure State, Venezuela. Bol. Acad. C. Fís., Mat. y Nat. Vol. LXXVII Nos. 2-3: 39-54.
 5. Velasco, A., Hernandez, O. and Babarro, R. (2017). Nationwide survey of Orinoco crocodile (*Crocodylus intermedius*) in Venezuela. Bol. Acad. C. Fís., Mat. y Nat. Vol. LXXVII Nos. 2-3: 55-62.
 6. Seijas, A.E. (2017). An analysis of research trends on the Crocodilia of Venezuela. Bol. Acad. C. Fís., Mat. y Nat. Vol. LXXVII Nos. 2-3: 63-76.
 7. Babarro G., R. (2017). Priorities and alternatives after three decades of conservation of the Orinoco crocodile (*Crocodylus intermedius*) in Venezuela. Bol. Acad. C. Fís., Mat. y Nat. Vol. LXXVII Nos. 2-3: 77-92.
 8. Nuñez, R. (2017). Evaluative analysis. Courses of ecology and conservation of Crocodylia of Venezuela (2016-2017). Bol. Acad. C. Fís., Mat. y Nat. Vol. LXXVII Nos. 2-3: 93-111.
 9. Nuñez, R. (2017). Impact evaluation on the ecology and conservation of Crocodylia from Venezuela lectures (2005-2015). Bol. Acad. C. Fís., Mat. y Nat. Vol. LXXVII Nos. 2-3: 112-128.
 10. Jiménez-Oraá, M., Heredia-Azuaje, H. and Jiménez-Oraá, M. (2017). School-conservation: Experiences of environmental education for the conservation of the Orinoco crocodile (*Crocodylus intermedius*) and the terecay (*Podocnemis unifilis*), aimed at the child population of the Rabanal Abajo Community, Guarico State, Venezuela. Bol. Acad. C. Fís., Mat. y Nat. Vol. LXXVII Nos. 2-3: 129-134.
 11. Espinosa-Blanco, A., Seijas, A.E., Rodríguez-Clark, K., Señaris, J.C. and González-Oropeza, K.D.V. (2017). Population and reproductive ecology of the Orinoco crocodile (*Crocodylus intermedius*) in the Cojedes River system, Venezuela. Bol. Acad. C. Fís., Mat. y Nat. Vol. LXXVII Nos. 2-3: 135-146.
 12. Pinto, L.F.A. (2017). Population abundance, reproductive aspects and perception of the local inhabitants, of the Orinoco crocodile (*Crocodylus intermedius*, Graves, 1819) in the Lipa, Ele and Cravo Norte Rivers of the Department of Arauca, Colombia. Bol. Acad. C. Fís., Mat. y Nat. Vol. LXXVII Nos. 2-3: 147-158.
 13. Hernández, O., Velasco, A., Castillo, E.L., Amauci, J. and Milano, L. (2017). Evaluation of the reproductive success of the Orinoco crocodile (*Crocodylus intermedius*) during the year 2017 in the Capanaparo River of "Santos Luzardo" National Park, Apure State, Venezuela. Bol. Acad. C. Fís., Mat. y Nat. Vol. LXXVII Nos. 2-3: 159-166.
 14. Moreno, A., Hernández, O., Molina, C. and Amauci, J. (2017). Population decline of the Orinoco crocodile (*Crocodylus intermedius*) in the Santos Luzardo National Park, Apure State, Venezuela, from 2001 to 2011. Bol. Acad. C. Fís., Mat. y Nat. Vol. LXXVII Nos. 2-3: 167-178.
 15. Espinosa-Blanco, A.S., Rosales, Y. and Delfin, Y. (2017). Growth in captivity of Spectacled caiman hatchlings *Caiman crocodilus* with experimental diets in the UNELLEZ Captive Rearing Center, Guanare. Bol. Acad. C. Fís., Mat. y Nat. Vol. LXXVII Nos. 2-3: 179-190.
 16. Hilevski, S., Cordero, T., Rodríguez, R. and Velasco, A. (2017). Habitat characterization of American crocodile (*Crocodylus acutus*, Cuvier 1807) in Turiamo Bay, Aragua State, Venezuela. Bol. Acad. C. Fís., Mat. y Nat. Vol. LXXVII Nos. 2-3: 191-202.
 17. Seijas, A.E., Barreto, R., Seguí, F., Pantoja, D., Pérez, E., Rodríguez, L., Adrianza, J. and Mendoza, J.M. (2017). American crocodile (*Crocodylus acutus*) in the Tucurere-Golfo Triste region, Venezuela. Bol. Acad. C. Fís., Mat. y Nat. Vol. LXXVII Nos. 2-3: 203-214.
 18. Amilibia, J.C., Molina, C. and Pérez-Emán, J. (2017). Population status, habitat use and comparison of the historical record of the Baba (*Caiman crocodilus*) in Masaguaral Ranch, Guarico State, Venezuela. Bol. Acad. C. Fís., Mat. y Nat. Vol. LXXVII Nos. 2-3: 215.
 19. Jaimes, A., Espinosa-Blanco, A.S., Contreras, M. and García-Amado, M.A. (2017). Aerobic bacteria isolation from oral and cloacal swabs of Orinoco crocodile (*Crocodylus intermedius*) from wild populations with high and low human intervention. Bol. Acad. C. Fís., Mat. y Nat. Vol. LXXVII Nos. 2-3: 216.
 20. Rudolf, C., Jaimes, A., Espinosa-Blanco, A.S., Contreras, M. and García-Amado, M.A. (2017). PCR detection of the bacterial genera *Helicobacter*, *Yersinia* and *Vibrio* from wild and captive populations of Orinoco crocodile (*Crocodylus intermedius*) in Venezuela. Bol. Acad. C. Fís., Mat. y Nat. Vol. LXXVII Nos. 2-3: 217.
- Alvaro Velasco, *Fauna Silvestre Productos & Servicios*, Caracas, Venezuela (velascocaiman@gmail.com).

East and Southeast Asia

Indonesia

SECURING THE LAST WILD SIAMESE CROCODILE POPULATION IN INDONESIA: PRELIMINARY RESULTS OF SURVEYS AT LAKE MESANGAT. The Siamese crocodile (*Crocodylus siamensis*) is regarded as one of the most critically endangered crocodilians in the world (Simpson and Bezuijen 2010; IUCN 2012). Over the last 50 years, wild *C. siamensis* populations throughout Southeast Asia have been decimated by illegal hunting for skins and meat, wanton killing, Government-sponsored extermination programs, habitat loss, and over-collecting to stock commercial crocodile farms (Platt and Tri 2000; Platt *et al.* 2004; Simpson *et al.* 2006; Simpson and Bezuijen 2010; Kanwatanakid-Savini *et al.* 2012; Guérin 2013). Fewer than 1000 adult *C. siamensis* are now thought to survive in the wild, and most populations are small, fragmented, and of questionable reproductive viability (Simpson and Bezuijen 2010). Only 11% of the remaining *C. siamensis* habitat is encompassed with the national protected area systems of respective range countries (Ilhow *et al.* 2015).

Lake Mesangat in East Kalimantan Province (Borneo) harbors the only known extant population of *C. siamensis* in Indonesia, and the only population outside of mainland Southeast Asia (Cox *et al.* 1993; Ross *et al.* 1998; Cox 2004; Simpson and Bezuijen 2010; Stuebing *et al.* 2015). Siamese crocodiles in Kalimantan are considered a distinct Evolutionary Significant Unit that differs genetically from mainland conspecifics (Gratten 2003). In addition to *C. siamensis*, Lake Mesangat also hosts a breeding population of *Tomistoma* (*Tomistoma schlegelii*), which is listed as Vulnerable by the IUCN (Stuebing *et al.* 2015). Crocodiles in Lake Mesangat are threatened by egg collection for local sale and domestic consumption, incidental take in fishing nets, illegal electro-fishing, run-off of agrochemicals from nearby oil palm plantations, and most importantly, habitat loss (Kurniati *et al.* 2005; Brien *et al.* 2015; Stuebing *et al.* 2015). Much of Lake Mesangat was logged in the past, about 70% of the wetland has been converted to oil palm production, and water diversion by agricultural interests continues to negatively alter hydrological conditions (Brien *et al.* 2015; Manolis 2017).

The current population status of *C. siamensis* (and *T. schlegelii*) in Lake Mesangat remains uncertain. Stuebing *et al.* (2015) stated that “reasonable numbers” of *C. siamensis* and *T. schlegelii* are present, but mark-recapture studies (2010-2011) estimated fewer than 30 *C. siamensis* inhabited the lake (N. Behler, unpubl. data). Despite the small number of *C. siamensis* in Lake Mesangat, this population is large relative to wild populations in other range states (reviewed by Simpson and Bezuijen 2010). Indeed, Lake Mesangat likely harbors the single largest population of *C. siamensis* anywhere. Brien *et al.* (2015) consider Lake Mesangat to be a “global stronghold” for the continued survival of *C. siamensis*. Given the urgent need to better understand and protect this population, surveys and other conservation



Figure 1. Crocodile habitat in Lake Mesangat: Top - swamp forest; middle - open marsh; bottom - ecotone between swamp forest and open marsh. The remains of a recent (2017) *C. siamensis* nest mound were found in the ecotone pictured here. Photograph: Steven Platt.

actions at Lake Mesangat were accorded high priority by the Crocodile Specialist Group (Simpson and Bezuijen 2010).

In October 2016 the local Government of East Kutai Timur, with support from the private sector, area communities and NGOs, proposed to the Indonesian Ministry of Environment and Forestry (MoEF) that Lake Mesangat and nearby Kenohan Suwi be designated Essential Ecosystem Areas

(EEA; Kawasan Ekosistem Esensial). The EEA classification is a relatively new legal category intended to confer protection on species of conservation concern occurring outside of the national protected area system. Although the principal focus is on protecting rare species, some level of sustainable resource extraction (eg fishing, collecting non-timber forest resources, etc.) is generally permitted within EEAs. As a first step towards designating Lake Mesangat and Kenohan Suwi as EEAs, a Management Forum was recently established by the district government of East Kutai. The Management Forum consists of various stakeholders who collectively are responsible for developing management plans and monitoring conservation outcomes in the proposed EEAs. The MoFF in turn charged the Wildlife Conservation Society-Indonesia Program with providing demographic and natural history data on crocodiles at Lake Mesangat to the Management Forum; such data are critical for imparting scientific rigor to any future conservation planning. Here, we report the results of preliminary surveys conducted in 2017 to determine the population status of *C. siamensis* in Lake Mesangat. Our initial efforts included drone overflights to identify crocodile nests and nocturnal spotlight counts.

Site Description: Lake Mesangat (7328 ha) and Kenohan Suwi (5478 ha) are part of the extensive Mahakam River system in southeastern Kalimantan. The proposed Lake Mesangat and Kenohan Suwi EEAs are seasonally inundated peat swamps formed within a shallow depression at the confluence of the Secgoi, Mesangat and Kedang Kepala Rivers, and consist of a mosaic of swamp forest and open marsh (Fig. 1; Chokkalingam *et al.* 2005; Stuebing *et al.* 2015).

Swamp forest is dominated by Perpuk (*Lophopetalum javanicum*) and other trees, while open marsh is characterized by various sedges and grasses, *Hanguana malayana*, *Nelumbo* sp. and non-native floating vegetation (*Eichornia crassipes* and *Salvinia molesta*), which often occludes waterways. Water levels fluctuate between 60 and 350 cm depending on season, with minimum levels occurring in June-September.

Lake Mesangat has undergone extensive anthropogenic modification; much of the area was logged in the 1970s and later experienced major human-ignited peat fires during El Niño droughts in 1982-83 and again in 1997-98. In addition to the El Niño conflagrations, villagers frequently burn wetlands during the annual dry season to: 1) clear vegetation from waterways and improve access to the swamp interior; 2) enhance fish populations and habitat; and, 3) facilitate turtle hunting (Chokkalingam *et al.* 2005). Burning at Lake Mesangat has resulted in the conversion of extensive tracts of swamp forest to shrublands and open marsh with charred snags and stumps found throughout (Chokkalingam *et al.* 2005). Fishing and turtle hunting are the principal livelihoods of swamp dwellers and those communities adjacent to Lake Mesangat.

Methods

Drone survey: We used drone overflights to search for *C. siamensis* nests at Lake Mesangat. Female *C. siamensis*

construct nests by scraping vegetation and ground debris into large mounds that we assumed would be readily visible from the air unless obscured by overhead canopy cover (eg Magnusson *et al.* 1978; McNease *et al.* 1994). Although the reproductive phenology of *C. siamensis* in Borneo remains poorly understood, previous work suggested that nest construction is completed by June and July, a period coinciding with the end of annual wet season (Behler 2011). We used a fixed-wing drone equipped with a camera (GOPRO HERO 4 Silver) set to record images at 2-second intervals from an altitude of 80-90 m. The flight path was established using an Auto-Pilot Module APM mission planner. Upon completion of the mission, we retrieved images from the camera and closely examined each to identify potential crocodile nest mounds; these were marked, and their coordinates determined for further mapping using Geosetter version 3.4.16 (© 2011 Friedemann Schmidt). After retrieving all of the images, these were stitched together using Agisoft Photoscan to create a photomosaic. The coordinates of potential nest mounds were then layered onto the stitched images using ArcGIS version 3.10.1 to produce a map of possible nest sites. We used this map to ground-truth these sites and verify the presence of crocodile nests.

Spotlight survey: We conducted spotlight counts to census and determine the size-class distribution of crocodiles at Lake Mesangat. Spotlight counts are a standard census technique used to assess crocodilian populations and other techniques (eg mark-recapture) have confirmed its accuracy (Bayliss 1987; King *et al.* 1990). Our spotlight counts began 15-30 minutes after sundown and continued for several hours, usually terminating between 2300-2400 h. Survey routes tended to follow channels through swamp forest and open marsh; shallow water and dense aquatic vegetation precluded boat access to much of the wetland. We conducted spotlight counts from wooden boats propelled by diesel engines and used Maglite flashlights and 12-volt headlamps to search for the reflective eyeshines of crocodiles. One to three boats containing multiple observers were deployed each night. One person in each boat used a hand-held GPS unit to record the coordinates of the start- and end-points, total distance traversed, and locations of any crocodiles observed during the census. We approached each crocodile as closely as possible to determine species (*C. siamensis* or *T. schlegelii*) and estimate total length (TL). Siamese crocodiles were classified as juveniles (TL<100 cm), sub-adults (TL= 100-150 cm), and adults (TL>150 cm). When species and TL could not be determined, crocodiles were classified as “eyeshine only” (EO). Encounter rates were calculated as the number of crocodiles observed/km of survey route. Encounter rates are powerful indices of relative abundance when survey methods are standardized (Bayliss 1987).

Results

Crocodile nest survey: Nine drone overflights (20-22 July 2017) covered 1789 ha along a 286.6 km flight course, and produced 12,385 individual photographs. Of these, 9042 images were successfully stitched, while 3343 images were discarded owing to poor resolution, often the result

of reflection from the water surface or instability of the aerial platform. The final dataset covered 1549.5 ha with a 10 cm pixel resolution and encompassed about 30% of Lake Mesangat. From individual photographs we identified 35 mounds of vegetation similar in size and appearance to crocodile nests (Fig. 2). These mounds were scattered widely throughout the study area with the majority in open marsh (N= 20) and others beneath a forest canopy (N= 15). Five mounds were in close proximity to locations of Siamese crocodile nests identified during a study in 2010-2011 (A. Staniewicz and N. Behler, unpublished data).



Figure 2. Selection of images taken during drone overflights of Lake Mesangat (July 2017). Each image shows a mound resembling a *C. siamensis* nest (circled). Most mounds could not be reached during subsequent ground-truthing (October 2017) owing to low water levels and dense vegetation.

Ground-truthing to verify crocodile nesting at these sites was carried out from 23-27 October 2017. We were able to successfully locate only five mounds by boat; most proved inaccessible due to dense aquatic vegetation and low water conditions. None of the mounds we examined appeared to be old crocodile nests. However, we accompanied two fishermen to the remains of a Siamese crocodile nest one of them found in either June or July 2017 (memory uncertain). According to the fisherman, the nest contained eggs, but the clutch was subsequently lost when water levels rose dramatically during August 2017. At the time of our visit, the nest consisted of an elevated mound measuring about 10 cm high \times 45 cm wide (fishermen stated the mound was 2-3 times larger in June/July) constructed of vegetation growing at the site (grass, ferns, and *Pandanus* fronds). The nest was located in an ecotone between closed-canopy swamp forest and open marsh (Loa Atoh), and characterized by pools of open water surrounded by widely scattered trees with a thick understory of floating grass and water hyacinth.

Spotlight counts: We observed 17 crocodiles along 89.0 km of survey route (encounter rate= 0.20 crocodiles/km) during spotlight counts conducted in the Abang, Klan Limbot, Loa Balung, and Loa Toh areas of Lake Mesangat from 23-27 October 2017 (Fig. 3). Crocodiles were encountered only in Abang and Loa Toh. Our total included 8 (47.0%) juveniles,

2 (11.7%) sub-adults, and 7 (41.1%) EO. Most of the latter were encountered in open marsh and thus, given the habitat preferences of *C. siamensis* and *T. schlegelii*, are probably attributable to the former; however, one EO in swamp forest was likely *T. schlegelii*. The estimated TL of 5 (62.5%) of the 8 juveniles we recorded was 40-50 cm. An additional crocodile (most likely *C. siamensis*) was observed during a spotlight count along 72.0 km of the Kelinjau River (encounter rate= 0.01 crocodiles/km) on 27 October 2017. Our spotlight counts were conducted during a period of rapidly falling water levels, which limited boat access to many areas and possibly influenced results.



Figure 3. Juvenile *C. siamensis* photographed during spotlight survey in Lake Mesangat (23 October 2017). Photograph: Heryanto Sumanbowo, BKSDA East Kalimantan Province.

Discussion

Our recent surveys confirm the continued occurrence of a low density population of *C. siamensis* within the area encompassed by the proposed Lake Mesangat EEA. Given the tenuous status of other populations in Southeast Asia (Platt *et al.* 2004; Bezuijen *et al.* 2013; Sam *et al.* 2015), Lake Mesangat (and probably Kenohan Suwi) does indeed appear to harbour a globally significant population of Siamese crocodiles (Simpson and Bezuijen 2010; Brien *et al.* 2015; Stuebing *et al.* 2015). Although the total number of Siamese crocodile inhabiting Lake Mesangat remains unknown, the fact that we encountered 17 crocodiles within a relatively small area suggests the previous estimate of 30 individuals is overly conservative.

The encounter rates we recorded during spotlight counts of Lake Mesangat are considered low (Platt and Thorbjarnarson 2000), but might partly be explained by the densely vegetated habitat that restricted surveys to open channels, coupled with low water levels that further curtailed access to many areas of the swamp. During spotlight counts in 2010, Staniewicz and Behler (2010) recorded 155 eyeshines, of which 30 were identified as *C. siamensis*. The following year, Behler (2011) counted 65 eyeshines and identified 33 of these as *C. siamensis*. During both years, the majority of crocodile sightings occurred in Abang and Loa Toh. Encounter rates were not reported for either year. Brien *et al.* (2015) observed

two *C. siamensis* (TL= 30-40 cm) and three eyeshines during a survey of Loa Toh on 30 August 2014, although no encounter rate is given. Encounter rates for spotlight counts of *C. siamensis* from similar habitats in other range countries likewise appear lacking in the literature, making inter-population comparisons of relative abundance problematic.

The size-class distribution of crocodiles observed during our spotlight counts consisted primarily of smaller individuals (juveniles and sub-adults) with adults being conspicuously absent. Previous surveys have likewise reported a preponderance of small crocodiles, with few adults being observed (Staniewicz and Behler 2010; Behler 2011). Again, the prevailing low water conditions may have biased the detectability of different size-classes during our survey. We speculate that falling water levels prompted larger crocodiles to move from shallow habitats and into deeper pools located in inaccessible areas of the swamp or possibly into the Kelinjau River. In contrast, shallow habitats continued to be used by smaller crocodiles, and low water conditions might even have increased the likelihood of detecting them. Regardless, the relatively large number of small crocodiles observed during our survey indicates that adults are successfully reproducing at Lake Mesangat. Based on growth rates reported in captivity (Magill 1982), most of the smaller crocodiles we observed were probably ≤ 2 years old.

Given the constraints imposed by shallow water and densely vegetated habitat, spotlight counts are probably unsuitable for monitoring crocodile populations at Lake Mesangat. Spotlight counts are most effective in open lacustrine and riverine habitats where the likelihood of detecting crocodilians is generally high and ill-suited for use in habitats where detectability is curtailed by aquatic vegetation that obstructs viewing and provides concealment for crocodiles (Webb 2000; Platt *et al.* 2004; Bezuijen *et al.* 2013; Platt *et al.* 2014). Furthermore, because individual sighting probabilities are usually low even where crocodiles are common (Woodward *et al.* 1996), spotlight counts have limited utility for monitoring low density populations. In lieu of spotlight counts, we suggest that future population monitoring is best accomplished by aerial nest surveys using drones.

Drones offer an efficient, cost-effective means to locate crocodile nests, especially in habitats unamenable to foot or boat travel (Koh and Wich 2012; Evans *et al.* 2015; Elsey and Trosclair 2016). That said, we experienced unexpected difficulties when attempting to use drones to locate crocodile nests at Lake Mesangat. First, crocodile nests proved difficult to distinguish from piles of dead vegetation and ground debris at flight altitudes of 80-90 m. This was somewhat surprising as Evans *et al.* (2015) successfully identified Saltwater crocodile (*C. porosus*) nest mounds during drone missions flown at much higher altitudes (300 m). Ground-truthing suspected nest mounds therefore proved necessary, which in turn presented additional challenges because a combination of low water levels and near-impenetrable swamp vegetation precluded access to most sites. We recommend that during future surveys, potential nest mounds first be identified by a drone flying at 80-90 m following the mission criteria

outlined above. Afterwards, promising mounds can be further investigated using a quadcopter drone transported as closely as possible to the target by boat and capable of hovering just above the nest (eg Elsey and Trosclair 2016). Attending female crocodiles, tracks, trails and wallows should be easy to detect at low altitudes.

Finally, our survey highlights the potential value of anthropogenically degraded wetlands such as Lake Mesangat for crocodilian conservation. Indeed, the situation at Lake Mesangat is not without parallel; in southeastern Louisiana, USA, baldcypress (*Taxodium distichum*) swamp forest converted to open marsh by past logging, repeated burning, and increasing water salinity (Platt 1988) now supports high-density American alligator (*Alligator mississippiensis*) populations (Platt *et al.* 1995). As noted by Heinemann *et al.* (2007), anthropogenically disturbed habitats are an underrated component of tropical landscapes that are often tainted with a reputation of being degraded and hence, considered less valuable than undisturbed “pristine” landscapes. However, disturbed habitats are often critical for maintaining high levels of local biodiversity and can play a significant role in delivering ecosystem services and contributing to rural livelihoods (Finegan and Nasi 2004).

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South Asia and Iran

Nepal

119 JUVENILE GHARIALS RELEASED INTO THE RAPTI RIVER, CHITWAN NATIONAL PARK, NEPAL. A total of 119 6-7 year-old Gharials (*Gangeticus gangeticus*), hatched at the Gharial Conservation Breeding Center (GCBC), were released at Kasara, near Chitwan National Park (CNP) headquarters on the Rapti River, between 14 February and 10 March 2018. The Rapti is one of the main rivers that runs through CNP. Most (N= 114; 96%) of the Gharials were females, with mean size of 183.8 cm TL (116-220 cm), 105.3 cm SVL (90-126 cm) and 17.1 kg bodyweight (11-28 kg).

Release procedures have been reported previously (see Khadka 2010, 2012, 2013). In summary, animals were transported by road from the GCBC to the release site in ventilated wooden boxes (26 x 32 x 222 cm). All animal was scute-clipped with a unique identification number for future monitoring. They were released into small temporary enclosures constructed of elephant grass (*Narenga porphyrocoma*) along the river, where water current is low and where fish are available inside the enclosure. Gharials normally remain in the enclosures for 15-20 days before they finally break out and move into the open wild habitats.

Previous releases have involved high-ranking officials, but it was decided this year to involve fishing communities from villages situated along the river in the release ceremony. It is hoped that this will develop greater awareness, ownership and involvement of the communities with the Gharial conservation program. Both fishermen and Gharials rely on the fish resource for food! Participants included the Chairs of the Buffer Zone User Committee of CNP, under which local fishermen operates.

An opening speech by Bed Khadka (the author) informed participants of the value of Gharials and their freshwater habitats, and described how each animal had a unique number through the sequence of scutes cut on the tail (Fig. 1). Each Gharial, and its identification number, was assigned to a local fisherman, who are encouraged to “keep an eye out” for their Gharial as they are carrying their fishing activities. This concept was warmly received by the fishermen, and it aims to create a sense of “ownership” towards the Gharials. Local fishermen have committed to not using gill nets for fishing, as these are potentially harmful to Gharial.

Since 1981, and including this release, 1365 Gharials have

been released into different river systems in Nepal. The GCBC currently has 520 Gharial on hand, ranging in size from hatchlings to adults. Most stock has been produced from a wild egg collection, which has been undertaken since 1978.



Figure 1. The author explaining the Gharial release program to members of local fishing communities. Head-started Gharial were transported to the site in wooden crates. Photograph: Nurendra Aryal.



Figure 2. CNP personnel assist community members to release Gharial into temporary enclosure at release site. Photograph: Nurendra Aryal.

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Submitted Publications

Why Climate Change is Unlikley to Affect Crocodilians

There are frequent claims that organisms (mostly reptiles) that are subject to temperature-dependent sex determination (TDSD) are unusually sensitive to effects of climate change. Specifically that an increase in 'temperature' (ie global mean temperature) of the size anticipated (1-4°C) will push the incubation temperature of nests and eggs outside the current limits and result in either distorted sex ratios or complete failure of hatching.

Climate change is causing a wide variety of profound environmental changes, including increased temperature, wider temperature extremes, changes in precipitation regimes, storm frequency and intensity, arctic and glacial ice melt, rising sea level and increased ocean acidification. All of these may affect crocodilians either directly or mediated through general ecosystem changes in productivity. However, in my view, crocodilians are uniquely well preadapted to survive these changes and specifically the effect on TDSD is an illusion based on misunderstanding.

If TDSD in crocodilians (and sea turtles) were a precise and tightly regulated system to ensure that nests are incubated at or near the pivotal temperature to produce more or less equal numbers of offspring of either gender, then climate change might influence that - but this is not the case. Examination of all of the numerous studies of TDSD in large reptiles indicates that:

- There is a complex spatial matrix of available nest temperatures.
- The response of individual eggs and of clutches to incubation temperature in the critical developmental period is quite variable. The reported pivotal temperatures are invariably statistical medians with quite wide variance.
- The scale of these variations is of the same order - several degrees - as those proposed for climate change. In fact there is a range of temperatures that will produce both male and female offspring.

Temperature dependent sex determination

- Type IA Cool = males - sea turtles
- Type IB Cool = females- tuatara,
- Type II females at extremes, males in the center -turtles, lizards, crocs

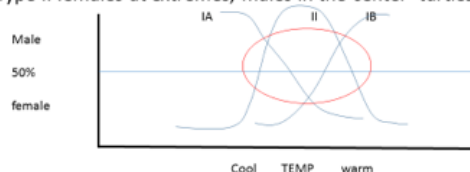


Figure 1. Note the range of temperatures within the ellipse that will produce two genders.

Considering a) spatial variation - temperature in the nesting matrix (ie sand/soil at the actual nesting area) varies in three dimensions of space (of which depth is the most influential), by physical attributes of the area (slope, aspect, shade, etc.), the matrix (soil) composition (material, grain size, porosity, water content) and on a wide range of temporal scales (hour-to-hour, diurnal, seasonal, inter annual and in response to episodic events such as rain, storms, clouds, etc.) and geographically site to site and region to region - at least 17 interacting variable dimensions (there are probably more) giving rather more than 4 billion possible combinations, each of which range across the usual scale of physiologically relevant environmental temperatures - say roughly 20-35°C. Countering this huge range of possible

influences, the dynamics of temperature in soil tends to buffer out such variation and impose significant lag times of between 12 hours and roughly 6 months. Temperature also varies within the volume of egg mass in a nest at a scale similar to the physiologically significant range for TDSD and is additionally influenced (increased) by egg respiration.

The outcome in regard to the temperature regime experienced by an egg is that there is a huge range of possibilities within the physiologically relevant and tolerated temperature. That range easily exceeds the proposed 'change' that will occur as the climate continues to change (eg see Grigg and Kirshner 2015, p. 493). In simple terms, eggs already experience a range of temperatures greater than the proposed climate changes.

With regard to b) the response of individual eggs to the actual temperature range they experience - all the experimental studies are plagued by wide variances in response, variously attributed to individual differences, clutch effect and 'random' variation.

Putting this in the context of a female crocodilian or sea turtle laying her nest, she probably attempts to locate a position where incubation conditions will be suitable, but often gets this wrong. The normal high rate of egg and nest failure demonstrates that the available matrix of temperatures and other mortality factors (water level predation, etc.) and its unpredictability into the future (ie incubation period 45-90 days) defeats their best effort to accurately predict nest environment. The evolutionary response is obvious and very effective - lay many nests, do not put all your eggs in one temperature basket, but instead make numerous 'bets' on getting this right. Given that a female only needs to replace herself with an adult female daughter, long-lived multiparous organisms like sea turtles and crocodilians have many bets during their long lives - conservatively in the order of 20-40 for crocodilians and over 100 for sea turtles (average reproductive period x nest frequency).

The failure of a single nest, or even repeated failure at one location or by one maladapted female has no significant consequence given the multiple sites, distant localities (sensu IUCN Red List) and multiparous nature of reproduction. Same for anticipated sex ratio. Distorted sex ratios from a single nest or female or location is buffered by the high variance and multiparity of the population as a whole. To add a little more insurance, these are large mobile organisms that often move their nesting efforts by kilometres or more during their long lives. Notwithstanding reported 'site fixity', both crocodilians and sea turtles demonstrate significant changes in nesting location from year to year.

Crocodilians and sea turtles both survived the Cretaceous extinctions, suggesting a robust life history and ecology that will manage climate change in all its manifestations. The impact on TDSD and resultant sex ratios will be insignificant.

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Lang J.W., Andrews, H.V. and Whitaker, R. (1989). Sex determination and sex ratios in *Crocodylus palustris*. *American Zoologist* 29: 935-952.

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Recent Publications

Pooley, S. (2018). Descent with modification: Critical use of historical evidence for conservation. *Conservation Letters* (DOI: 10.1111/conl.12437).

Abstract: The clear evidence of the accumulating impacts of anthropogenic actions on the Earth system is driving researchers to look to historical data as a resource for understanding the present and predicting the future. In the conservation science literature, using historical sources usually refers to data mining "the past" using the scientific methods of historical ecology. This article considers the often overlooked methodological challenges of sourcing and interpreting historical data. A schema is provided for conservation scientists, summarizing the kinds of questions and metadata required to work rigorously with historical data. This will improve the accuracy of the data we use to construct trends to inform our understanding of the conservation status of particular species and ecosystems. It will also deepen our understanding of the interplays of factors influencing policy and management in particular social-ecological contexts.

Canesini, G., Stoker, C., Galoppo, G.H., Durando, M.L., Tschopp, M.V., Luque, E.H., Muñoz de Toro, M.M. and Ramos, J.G. (2017). Temperature- vs. estrogen-induced sex determination in *Caiman latirostris* embryos: Both females, but with different expression patterns of key molecules involved in ovarian development. *General and Comparative Endocrinology* (<https://doi.org/10.1016/j.ygcen.2017.11.024>).

Abstract: *Caiman latirostris* is a species with temperature dependent sex determination (TSD), which implies that the incubation temperature of the eggs is the main factor that determines the sex during a thermo-sensitive period (TSP). However, estrogens play a critical role in this process. The administration of 17 β -estradiol (E2) previous to TSP overrides the effects of male incubation temperature, producing phenotypic females. This effect has been defined as sex reversal or estrogen-induced sex determination (E2SD). The aim of the present study is to describe similarities and differences in the effects of TSD and E2SD treatment conditions on ovary development. Our results show that the two treatment conditions studied are able to produce different ovaries. Treatment with E2 modified the expression pattern of estrogen receptor alpha and progesterone receptor, and expression of the enzyme aromatase. Moreover, in E2SD females, the proliferation/apoptosis dynamic was also altered and high expression of TAp63 was observed suggesting the presence of greater DNA damage in germ cells. To the best of our knowledge, this is the first report that describes the morphology of the female gonad of *C. latirostris* in three stages of embryonic development and shows the expression of TAp63 during the gonad development of a reptile. It is important to emphasize that the changes demonstrated in E2SD female gonads of embryos show that environmental compounds with proven estrogenic activity alter the follicular dynamics of *C. latirostris* in neonatal as much as in juvenile animals, endangering their reproductive health and possibly bringing consequences to ecology and evolution.

Mikšík, I., Paradis, S., Eckhardt, A. and Sedmera, D. (2017).

Analysis of Siamese crocodile (*Crocodylus siamensis*) eggshell proteome. Protein J. (<https://doi.org/10.1007/s10930-017-9750-x>).

Abstract: The proteins and pigment of the eggshell of the Siamese crocodile (*Crocodylus siamensis*) were analysed. For proteomic analysis, various decalcification methods were used when the two main surface layers were analyzed. These layers are important for antimicrobial defense of egg (particularly the cuticle). We found 58 proteins in both layers, of which 4 were specific for the cuticle and 26 for the palisade (honeycomb) layer. Substantial differences between proteins in the eggshell of crocodile and previously described birds' eggshells exist (both in terms of quality and quantity), however, the entire proteome of crocodilians has not been described yet. The most abundant protein was thyroglobulin. The role of determined proteins in the eggshell of the Siamese crocodile is discussed. For the first time, the presence of porphyrin pigment is reported in a crocodilian eggshell, albeit in a small amount (about 2 to 3 orders of magnitude lower than white avian eggs).

Sasser C.E., Holm G.O., Evers-Hebert E. and Shaffer G.P. (2018). The Nutria in Louisiana: A current and historical perspective. Pp. 39-60 in Mississippi Delta Restoration. Estuaries of the World, ed. by J. Day J. and J. Erdman. Springer: Cham.

Abstract: Nutria is an exotic, aquatic rodent that was introduced to Louisiana wetlands during the early 1930s and can make coastal restoration more challenging. From 1960 to 1990, greater than 36-million nutria were taken when the fur market was lucrative. By 2000, the fur market had collapsed and nutria populations increased. Nutria reach sexual maturity at 4-8 months, may have 2-3 litters per year, and average 13.1 young per female per year. Nutria generally have a small home range in marsh habitats occurring primarily in fresh and intermediate marsh. The organic nature of these soils makes them particularly susceptible to destruction with grazing. Nutria are opportunistic feeders, with a broad diet comprising more than 60 plant species in Louisiana and they are attracted to wetlands that contain a reliable source of nutrient-rich fresh water, such as river diversions and assimilation wetlands. It is imperative that restoration projects that increase input of nutrient-rich fresh water into wetlands have a nutria control program in place. Nutria can consume large amounts of marsh biomass and in certain cases can cause the collapse of marsh locally. Scientific studies investigating effects of nutria on marsh habitats consistently conclude that nutria grazing is damaging to marsh and young forest vegetation. It is generally accepted that nutria damage – in addition to larger scale subsidence, sea level rise, and salinity intrusion – can create an accelerated deterioration of wetlands. Nutria grazing on baldcypress and water tupelo seedlings is extensive and remains a major factor in the inability of baldcypress-water tupelo forests to regenerate. Projects designed to restore coastal swamp forests should include a nutria control component and suitable protection of transplants should be used to minimize mortality from grazing. Eruptions of populations of nutria can cause severe wetland damage and loss. Some areas of the coast have persistent populations creating “Hot Spots” of severe damage, especially in freshwater-intermediate salinity areas of Terrebonne, Barataria, and Breton Sound basins. Nutria densities are relatively low in the Chenier Plain currently compared to historic observations and harvest records. The Coastwide Nutria Control Program (CNCPP) was implemented in 2002-2003 by the LDWF, and since then there has been a reduction in 70,000 acres of marsh damage from 2003 to 2010. Approximately 446,000 nutria were harvested in 2010 in the CNCPP, primarily in the deltaic plain. When considering the costs of creating new wetlands (approximately \$50,000-\$70,000 per acre), the CNCPP is a successful wetland conservation program that has produced measureable reduction in marsh damage. Since 2002-2003, 2,571,480 nutria have been harvested. This program is a success and, from a resource management perspective, should be continued with improvement and expansion if possible. Nutrient enrichment of coastal landscapes may cause nutria population growth and habitat damage. Coastal restoration projects with areas receiving nutrient enrichment should

include nutria control to ensure plant productivity, establishment, and expansion.

Scanes, C.G. (2018). Animal attributes exploited by humans (nonfood uses of animals). Pp. 13-240 in Animals and Human Society, ed. by C.G. Scanes and S.R. Toukhsati. Academic Press: Cambridge.

Abstract: There are many nonfood uses of animals some of which are for leather and furs, go back to almost a million years of human development. This chapter discusses the multiple nonfood uses of vertebrate animals by people. Live animals are the sources of wool; hair; some hormones; antitoxins; animal toxins; muscle power for riding, pulling, and carrying; higher odor senses, such as odor detection in dogs; and innate and learned behaviors, such as those in working dogs together with service and therapy animals. Postslaughter tissues employed by people include the following: hides for leather; pelage for furs; tissues, such as heart valves for transplanting as xenografts; animal macromolecules such as heparin, collagen, and hyaluronic acid for biomedical applications; animal by-products for fertilizers and additions to livestock feeds; and fats from adipose tissue for nonfood uses, such as biodiesel, soaps, lubricants, cosmetics, paints, and explosives.

Phillips, C.J.C. and Kluss, K. (2018). Animal welfare and animal rights. Pp. 483-497 in Animals and Human Society, ed. by C.G. Scanes and S.R. Toukhsati. Academic Press: Cambridge.

Abstract: In this chapter a distinction is made between animal welfare, for which a scientific approach is possible, and animal rights, which requires an ethical consideration. Our relationship with animals has changed most for food-producing animals, having evolved from one of necessity to one of exploitation of many of the managed animals. Farmers face increasing pressure to produce large amounts of animal protein at an affordable price, which has placed some strain on maintaining welfare standards. In response, there has been a tightening of animal welfare legislation in an attempt to curb the worst instances of animal abuse. Although legislative protections are largely directed toward domesticated animals, their welfare standards are often secondary to economic considerations and market demand. The universality of animals' rights is considered and methods of defining and determining animals' welfare and ethics status are described. This includes the advantages and disadvantages of a pluralistic approach. The influences of culture, religion, gender, and other factors driving our attitudes are described. The future of animal welfare and rights is anticipated to be largely negative, being driven by a rapid expansion of intensive animal enterprises worldwide, but particularly in developing countries.

Foth, C., Blanco, M.V.F., Bona, P. and Scheyer, T.M. (2017). Cranial shape variation in jacarean caimanines (Crocodylia, Alligatoroidea) and its implications in the taxonomic status of extinct species: The case of *Melanosuchus fisheri*. Journal of Morphology (doi: 10.1002/jmor.20769).

Abstract: *Melanosuchus niger* (Crocodylia, Alligatoroidea) is one of the six living caimanine species widely distributed throughout the Amazon River basin today. Although there is only one extant species of *Melanosuchus*, fossil material assigned to this genus, represented by *M. fisheri*, has been reported from the late Miocene in South America. However, the validity of this taxon has been questioned and a recent investigation indicates that the referred specimen of *M. fisheri* (MCZ 4336) actually belongs to *Globidentosuchus brachyrostris*, while those diagnostic characters present in the holotype (MCNC 243) fall into the spectrum of intraspecific variation of *M. niger*. Here, we compare the skull shape of the holotype of *M. fisheri* with the ontogenetic series of the four jacarean species (*M. niger*, *Caiman yacare*, *Caiman crocodilus*, and *Caiman latirostris*) using 2D-geometric morphometric analyses in

two different views. The analyses indicate that MCNC 243 falls into the morphospace of *M. niger* and *C. latirostris*. Despite strong shape similarities between juveniles of *C. latirostris* and MCNC 243, further anatomical comparisons reveal notable differences between them. In contrast, no concrete anatomical differences can be found between MCNC 243 and *M. niger*, although shape analyses indicate that MCNC 243 is relatively robust for its size. Thus, this study is able to confirm that the genus *Melanosuchus* was present in the late Miocene, but it still remains unclear if MCNC 243 should be treated as a junior synonym or probably a sister species of *M. niger*. Its Miocene age favors the second option, but as the shape analyses were also not able to extract any diagnostic characters, it should be retained as *Melanosuchus* cf. *niger*.

Campos, Z., Mourão, G. and Magnusson, W.E. (2017). The effect of dam construction on the movement of dwarf caimans, *Paleosuchus trigonatus* and *Paleosuchus palpebrosus*, in Brazilian Amazonia. PLoS ONE 12(11): e0188508.

Abstract: Run-of-the-river hydroelectric dams cause changes in seasonal inundation of the floodplains, and this may cause displacement of semi-aquatic vertebrates present before dam construction. This study evaluated the movement of crocodilians before and after the filling of the Santo Antônio hydroelectric reservoir on the Madeira River in the Brazilian Amazon, which occurred in November 2011. We radio-tracked four adult male *Paleosuchus palpebrosus* and four adult male *Paleosuchus trigonatus* before and after the formation of the reservoir between 2011 and 2013. The home ranges of the *P. palpebrosus* varied from <1 km² to 91 km² and the home ranges of the *P. trigonatus* varied from <1 km² to 5 km². The species responded differently to time since filling and water level in weekly movement and home range. However, overall the dam appears to have had little effect on the use of space by the individuals that were present before dam construction.

Ngwenya, A., Patzke, N., Herculano-Houzel, S. and Manger, P.R. (2017). Potential adult neurogenesis in the telencephalon and cerebellar cortex of the Nile crocodile revealed with doublecortin immunohistochemistry. Anat. Rec. (doi: 10.1002/ar.23738).

Abstract: The brain of the crocodile is known to gain in mass allometrically throughout life, and the addition of neurons (as well as non-neurons) appears to play a significant role in this increasing brain mass. We used immunohistochemistry in the brains of 12 Nile crocodiles ranging between 350 g and 86 kg in body mass and 1.99 g to 7.9 g in brain mass to identify the regions of the brain in which neurons immunopositive for doublecortin (DCX), a marker for potential adult neurogenesis, are found. Similar to other reptiles, potential newly born neurons, those immunopositive for DCX, were found throughout the telencephalon, the main and accessory olfactory bulbs and the olfactory tract, and in the cerebellar cortex; however, no DCX immunopositive neurons were observed in the diencephalon or brainstem. An apparent moderate decrease in the density of DCX labeled neurons in the olfactory bulbs and tract as well as the cerebellar cortex was observed with increasing brain mass, but the observed qualitative density of labeled neurons within the telencephalon was maintained irrespective of brain mass. Three potential neurogenic zones, within the sulci of the lateral ventricle, were identified, and these are similar to those seen in other reptiles. This study indicates that at least part of the gain in brain mass with age in the Nile crocodile may be accounted for by the potential addition and integration of new neurons into the existing circuitry, especially so for the olfactory system, telencephalon and cerebellar cortex.

Marinus du Preez, M., Govender, D., Kylin, H. and Bouwman, H. (2018). Metallic elements in Nile crocodile eggs from the Kruger National Park, South Africa. Ecotoxicology and Environmental

Safety 148: 930-941.

Abstract: The Nile crocodile is the largest predator on the African continent. Recent mass mortalities in the Kruger National Park (KNP) raised concerns about possible influence of pollution. We analysed eggs and their eggshells collected from nests inside the KNP and from a crocodile farm for metallic elements. We found that mercury, selenium, and copper occurred at levels of concern. Eggshells had very high concentrations of iron. Apart from toxicological implications associated with elevated concentrations in eggs, we found iron possibly contributing towards thicker eggshells. Thicker shells may act as a barrier to gas and water exchange, as well as possibly increasing the effort required for the hatchling to emerge from tightly packed shells under sand. Pollutants are transported into the KNP via rivers, and possibly via air. Mercury and copper pollution are waste-, industrial- and mining-related; ecotoxicological concern should therefore be extended to all areas where the four African crocodile species occur. Reptiles are under-represented in ecotoxicological literature in general, and especially from Africa. We know of only one previous report on metals and metalloids in crocodile eggs from Africa (Zimbabwe), published 30 years ago. Reduced fitness, endocrine disruption and effects on behaviour are other possible sub-lethal effects associated with metallic elements that may only become apparent decades later in a long-lived species such as the Nile crocodile. In the face of habitat destruction, pollution, human population increases, and climate change, further research is needed regarding pollutant concentrations and effects in all African reptiles. The rivers that carry water from outside the park sustain its aquatic life, but also transport pollutants into the KNP. Therefore, improved source mitigation remains an important task and responsibility for all involved.

Nisagurwe, B.E. (2017). Economic analysis of Nile crocodile farming in Tanzania: A case study of Kaole crocodile farm, Bagamoyo. MSc thesis, Sokoine University of Agriculture, Morogoro, Tanzania. (<http://www.suair.suanet.ac.tz:8080/xmlui/handle/123456789/2013>).

Abstract: Crocodile products have become popular in the world. In effect, they have attracted the attention of people in many countries including Tanzania. However, the farming practice comprises many activities and time involved before derivation of the commercial products. This study aimed at gaining insight on the economics of Nile crocodile farming in Bagamoyo, Tanzania. The objectives were to determine the reproductive rates of Nile crocodiles, products extracted from the crocodile, costs of inputs, price for various crocodile products, and benefits derived from crocodile farming to the farmer and to the local community. Data were collected using two sampling techniques, purposive sampling in selecting study site and sampling villages while random sampling technique was employed in selecting respondents for determining community benefits. Benefit-Cost Ratio (BCR) was calculated on the crocodile farm after costs and benefits were determined. Crocodile in the farm were 56; males were 35 and females were 21. Only one crocodile laid 35 eggs in the year of study, hatchery rate was 29% and rate of maturation was 40%. Nile crocodile products extracted were live crocodiles and the skins. The cost of a live crocodile was \$US20 from the wild to the farm for purposes of rearing. The skins were exported; Grade 1 sold at \$10/cm², Grade 2 at \$6/cm² and Grade 3 at \$5/cm². The Net Present Value was positive (Tsh8,743,498) whereby BCR was greater than one (1.2) indicating that crocodile farming was profitable to the farmer. Hatchability was low, the reason of which demands investigation. In the study of nearby villages results revealed 27% of the respondent recognizes benefits from crocodile farm while 73% did not recognize. The study recommends that improvement can be achieved by genetic selection of the breeders and eggs should be collected and incubated in a special incubator to enhance hatchability.

Adugna, C., Kiros, S., Dejene, T., Asmelash and Hadgu, K.M.

(2017). Distribution and habitat suitability of Nile crocodile (*Crocodylus niloticus*, L. 1768) in Tekeze River Dam, Tigray, Ethiopia. *International Journal of Biodiversity and Conservation* 9(12): 350-362.

Abstract: Understanding the spatial distribution and habitat utilization by animals play a significant role in wildlife conservation and habitat management for the benefits of both animals and communities living close to protected areas. This study was conducted to identify the distribution and habitat use of *Crocodylus niloticus* in Tekeze River Dam through qualitative and quantitative surveys based on diurnal survey, semi-structured questionnaire and geographic information system (GIS) spatial analysis methods. The Tekeze River Dam representing the study area was divided into seven stratified river stratum. All spatial data were recorded and analyzed using ArcGIS 10 software. The distribution revealed that *C. niloticus* were registered along the main river stretch and its tributaries. Majority of *C. niloticus* prefer river banks, shallow water depth and rocky ground to perform their activity patterns. Along the 71.2 km² of the study area delineated for habitat preferences, 9.78 km² was the highly suitable habitat while 4.63 km² was the least suitable. The influence on communal resources, fishery activities and irrigation practice at small-scale on river banks and increment of water level due to flooding of the Tekeze River Dam were among the primary causes of disturbances induced by human to *C. niloticus* distribution and its habitats. The perception of most respondents to the conservation of this specie was not encouraging although their presence in the river was important in keeping the ecological balance of the ecosystem. It is therefore suggested that the success of conservation programs and habitats management should focus on educating the local community to raise awareness and change their attitudes towards promoting conservation development initiatives of *C. niloticus* in the area.

Lueangsakulthai, J., Phosri, S., Theansungnoen, T., Jangpromma, N., Tamsiripong, T., McKendrick, J.E., Khunkitti, W. and Klaynongsruang, S. (2017). Novel antioxidant and anti-inflammatory peptides from the Siamese crocodile (*Crocodylus siamensis*) hemoglobin hydrolysate. *Biotechnology and Applied Biochemistry* (doi: 10.1002/bab.1628).

Abstract: Novel antioxidant and anti-inflammatory peptides were isolated from hydrolysates of Siamese crocodile (*Crocodylus siamensis*) hemoglobin. *C. siamensis* hemoglobin hydrolysates (CHHs) were obtained by pepsin digestion at different incubation times (2, 4, 6, and 8 h) at 37°C and subjected to antioxidant and anti-inflammatory activity assessment. CHH obtained by 2-H hydrolysis (2H-CHH) showed the highest anti-inflammatory activity with respect to decreasing nitric oxide (NO) production, whereas the strongest antioxidant activity was found for 6-H hydrolysis (6H-CHH) against nitric oxide radicals. To evaluate the anti-inflammatory and antioxidant activity of individual peptide components, 2H-CHH and 6H-CHH were purified by semipreparative HPLC. Peptide fraction P57 isolated from 6H-CHH was found to exhibit the highest nitric oxide radical inhibition activity (32.0%). Moreover, purification of 2H-CHH yielded peptide fraction P16, which displayed a high efficacy in decreasing NO production of macrophage RAW 264.7 cells (83.2%) and significantly reduced proinflammatory cytokines and inflammatory mediators interleukin-6 (IL-6), interleukin-1 beta (IL-1β), and prostaglandin-E2 (PGE2) production to about 2.0, 0.3, and 1.9 ng/mL, respectively. Using LTQ orbitrap XL mass spectrometry, active peptide sequences were identified as antioxidant KIYFPHF (KF7), anti-inflammatory SAFNPHEKQ (SQ9), and IHNKQVQAHGKKVL (IL15). Additionally, CHHs simulated gastric and intestinal in vitro digestion positively contributed to antioxidant and anti-inflammatory activity. Taken collectively, the results of this work demonstrate that CHHs contain several peptides with anti-inflammatory and antioxidant properties, which may prove valuable as treatment or supplement against diseases associated with inflammation and oxidative stress.

Jansen van Rensburg, L.T. (2017). South African female consumers' luxury value perceptions and needs for traceability information on exotic crocodile leather accessories. MSc thesis, University of Pretoria, South Africa. (<http://hdl.handle.net/2263/63310>).

Abstract: This study explored South African female consumers' value perceptions as well as their needs for traceable information on exotic crocodile leather accessories. The Wiedmann, Hennigs and Siebels' Luxury Value Perception Scale (2007) and the Consumer Decision-making Process (Solomon & Rabolt, 2004:354) served as conceptual framework for the study. A questionnaire was distributed across South Africa and completed by willing participants. All participants were South African citizens, females of varying cultural backgrounds, including: African, Caucasian, Indian, Asian and Coloured individuals. The Consulta Research (Pty) Ltd used their extensive database of female consumers for sampling purposes. They managed to collect 337 completed and usable questionnaires. The Spearman's Correlation Coefficient, descriptive statistics, as well as exploratory factor analysis were used for data analysis. The results indicate that respondents to this questionnaire were not willing to pay market-related prices for exotic crocodile leather accessories. Findings of this study uncovered 5 luxury value perceptions as opposed to the 4 originally recognised by Wiedmann *et al.* (2007), namely Functional, Social, Financial, Individual gifts and Individual pleasure value perceptions. Of these luxury value perceptions, respondents indicated that the functional value perception was the most important to them. Traceable intrinsic and extrinsic-related attributes which can have an impact on decision-making by consumers were also explored. Results indicate that respondents found intrinsic-related attributes moderately important when deciding to purchase an exotic crocodile leather accessory. With regard to extrinsic-related product attributes, results indicate that most respondents found these extrinsic-related attributes moderately important. The notable exception was the position brand-holders held on child labour, which was indicated as important by most respondents. Results further indicated weak-positive, but statistically highly significant relationships between functional value perceptions and the importance of intrinsic-related as well as extrinsic-related information. Weak-positive, but statistically highly significant relationships were also conversely found between financial value perceptions and the importance of intrinsic and extrinsic-related information. There was a weak but statistically highly significant relationship between the individual gift value perception and the importance of extrinsic-related information as well as, conversely, a weak-positive statistically significant relationship between individual gift-value perceptions and the importance of intrinsic-related information. Purchase intent is an important determinant when consumers make decisions. Research results for this study have, however, indicated that respondents had a weak purchase intent for exotic crocodile leather accessories. Most respondents reported that they would never, at any time, buy an exotic crocodile leather accessory. Neither would they at some stage have the intention to buy an exotic crocodile leather accessory, or have a purchase interest for an exotic crocodile leather accessory. Finally, results show that there was a weak-positive, but statistically highly significant relationship between the importance of extrinsic-related product attributes and purchase intent. Results of this study make positive contributions towards the decision-making of various role players within the exotic crocodile leather accessory industry. Role players such as farmers, manufacturers, distributors, retailers and marketers can all benefit from the results. Based on the results of this study, recommendations for industry and future research are made.

Otero, A., Allen, V., Pol, D. and Hutchinson, J.R. (2017). Forelimb muscle and joint actions in Archosauria: insights from *Crocodylus johnstoni* (Pseudosuchia) and *Mussaurus patagonicus* (Sauropodomorpha). *P PeerJ* 5:e3976.

Abstract: Many of the major locomotor transitions during the evolution of Archosauria, the lineage including crocodiles and birds

as well as extinct Dinosauria, were shifts from quadrupedalism to bipedalism (and vice versa). Those occurred within a continuum between more sprawling and erect modes of locomotion and involved drastic changes of limb anatomy and function in several lineages, including sauropodomorph dinosaurs. We present biomechanical computer models of two locomotor extremes within Archosauria in an analysis of joint ranges of motion and the moment arms of the major forelimb muscles in order to quantify biomechanical differences between more sprawling, pseudosuchian (represented the crocodile *Crocodylus johnstoni*) and more erect, dinosaurian (represented by the sauropodomorph *Mussaurus patagonicus*) modes of forelimb function. We compare these two locomotor extremes in terms of the reconstructed musculoskeletal anatomy, ranges of motion of the forelimb joints and the moment arm patterns of muscles across those ranges of joint motion. We reconstructed the three-dimensional paths of 30 muscles acting around the shoulder, elbow and wrist joints. We explicitly evaluate how forelimb joint mobility and muscle actions may have changed with postural and anatomical alterations from basal archosaurs to early sauropodomorphs. We thus evaluate in which ways forelimb posture was correlated with muscle leverage, and how such differences fit into a broader evolutionary context (ie transition from sprawling quadrupedalism to erect bipedalism and then shifting to graviportal quadrupedalism). Our analysis reveals major differences of muscle actions between the more sprawling and erect models at the shoulder joint. These differences are related not only to the articular surfaces but also to the orientation of the scapula, in which extension/flexion movements in *Crocodylus* (eg protraction of the humerus) correspond to elevation/depression in *Mussaurus*. Muscle action is highly influenced by limb posture, more so than morphology. Habitual quadrupedalism in *Mussaurus* is not supported by our analysis of joint range of motion, which indicates that glenohumeral protraction was severely restricted. Additionally, some active pronation of the manus may have been possible in *Mussaurus*, allowing semi-pronation by a rearranging of the whole antebrachium (not the radius against the ulna, as previously thought) via long-axis rotation at the elbow joint. However, the muscles acting around this joint to actively pronate it may have been too weak to drive or maintain such orientations as opposed to a neutral position in between pronation and supination. Regardless, the origin of quadrupedalism in Sauropoda is not only linked to manus pronation but also to multiple shifts of forelimb morphology, allowing greater flexion movements of the glenohumeral joint and a more columnar forelimb posture.

Manosro, J., Chankhampan, C., Manosroi, W. and Manosroi, A. (2017). *In vitro* anti-aging activities of crocodile (*Crocodylus siamensis*) blood extracts. Chiang Mai J. Sci. 44(4): 1334-1346.

Abstract: The objective of this study was to determine anti-aging activities of crocodile (*Crocodylus siamensis*) blood extracts. The extracts were prepared from the whole blood and the precipitated blood (in which the serum was separated). Each was extracted by six different processes including cold water (WC), hot water (WH), cold ethyl acetate (EC), hot ethyl acetate (EH), cold methanol (MC) and hot methanol (MH). The ethyl acetate and methanol extracts were dried by a hot air oven, while the water extracts and the separated serum were by lyophilization. The total of 15 extracts was investigated for *in vitro* anti-aging activities including antioxidant, tyrosinase inhibition and gelatinolytic activity of MMP-2 inhibition on human skin fibroblasts as well as cytotoxicity. The dried blood serum (SR) gave the highest DPPH radical scavenging (SC50 value= 1.83±0.60 mg/ml) and lipid peroxidation inhibition (IPC50 value= 0.91±0.13 mg/ml). The precipitated blood extracted by cold ethyl acetate (POEC) showed the highest metal chelating (MC50= 0.0085±0.007 mg/ml). The tyrosinase inhibition activity of POEC (IC50= 0.016±0.003 mg/ml) was higher than kojic acid of 2.25 times. All extracts gave no cytotoxicity at all concentrations except the blood extracted by cold water (CBWC) at 1 mg/ml. The extract which indicated the highest cell viability at 1 mg/ml was the precipitated blood extracted by hot methanol (POMH). The blood extracted by cold ethyl acetate (CBEC) exhibited the highest

MMP-2 inhibition activity on human skin fibroblasts with the percentages of pro MMP-2 inhibition at 47.30±10.51%, but lower activity than ascorbic acid of 1.93 times. The result from this study has demonstrated the commercial potential of crocodile blood to be developed as raw materials for an anti-aging product.

Sarker, S., Wang, Y., Warren-Smith, B. and Helbig, K.J. (2017). Dynamic changes in host gene expression following *in vitro* viral mimic stimulation in crocodile cells. *Frontiers in Immunology* 8 (doi: 10.3389/fimmu.2017.01634).

Abstract: The initial control of viral infection in a host is dominated by a very well orchestrated early innate immune system; however, very little is known about the ability of a host to control viral infection outside of mammals. The reptiles offer an evolutionary bridge between the fish and mammals, with the crocodile having evolved from the archosauria clade that included the dinosaurs, and being the largest living reptile species. Using an RNA-seq approach, we have defined the dynamic changes of a passaged primary crocodile cell line to stimulation with both RNA and DNA viral mimics. Cells displayed a marked upregulation of many genes known to be involved in the mammalian response to viral infection, including viperin, Mx1, IRF7, IRF1, and RIG-I with approximately 10% of the genes being uncharacterized transcripts. Both pathway and genome analysis suggested that the crocodile may utilize the main known mammalian TLR and cytosolic antiviral RNA signaling pathways, with the pathways being responsible for sensing DNA viruses less clear. Viral mimic stimulation upregulated the type I interferon, IFN-Omega, with many known antiviral interferon-stimulated genes also being upregulated. This work demonstrates for the first time that reptiles show functional regulation of many known and unknown antiviral pathways and effector genes. An enhanced knowledge of these ancient antiviral pathways will not only add to our understanding of the host antiviral innate response in non-mammalian species, but is critical to fully comprehend the complexity of the mammalian innate immune response to viral infection.

Brochu, C.A. (2017). Pliocene crocodiles from Kanapoi, Turkana Basin, Kenya. *Journal of Human Evolution* (<https://doi.org/10.1016/j.jhevol.2017.10.003>).

Abstract: Three crocodylid species are known from the Pliocene Kanapoi locality in the western Turkana Basin. One of these, *Crocodylus thorbjarnarsoni*, includes material previously referred to *Crocodylus niloticus* (the modern Nile crocodile currently living in Lake Turkana) and *Rimasuchus lloydi*. *C. thorbjarnarsoni* was a gigantic horned crocodile similar in overall shape to most other generalized crocodylids, but its closest known relative is another extinct species, *Crocodylus anthropophagus* from the Pleistocene of Olduvai Gorge in Tanzania. It is not closely related to *C. niloticus*. The second is an extinct form of sharp-nosed crocodile (*Mecistops*), a group of slender-snouted crocodylids currently restricted to western and central Africa. The third is *Euthecodon*, a crocodylid with an extremely long, slender, and distinctively notched snout. *Euthecodon* and *C. thorbjarnarsoni* are known from substantial numbers of specimens, but only one *Mecistops* specimen has been identified from the locality. The crocodylian fauna at Kanapoi is taxonomically similar to that of most other Plio-Pleistocene fluviolacustrine deposits in the Turkana Basin. Crocodylian diversity in the Turkana region contracted from a peak of five co-existing species in the late Miocene to one today; this contraction was underway by the early Pliocene, but crocodylian diversity remained stable at three species until well into the Quaternary.

Shaney, K.J., Hamidy, A., Walsh, M., Arida, E., Arimbi, A. and Smith, E.N. (2017). Impacts of anthropogenic pressures on the contemporary biogeography of threatened crocodylians in Indonesia. *Oryx* (<https://doi.org/10.1017/S0030605317000977>).

Abstract: The Greater Sunda region of South-east Asia supports a rich diversity of economically and ecologically important species. However, human pressures are reshaping contemporary biogeography across the region. Megafaunal distributional patterns have been particularly affected because of deforestation, poaching and human–wildlife conflict. Crocodylians are at the centre of these conflicts in Indonesia and yet remain poorly studied across much of the archipelago. We conducted population surveys of salt-water crocodiles *Crocodylus porosus* and false gharials *Tomistoma schlegelii* in Sumatra, and examined whether crocodile abundance and distribution are correlated with variations in human disturbance, fishing pressure, and habitat type. We then used these data to model remaining suitable habitat for *T. schlegelii* across South-east Asia. We found that abundance of *T. schlegelii* and *C. porosus* was correlated with distance from human settlements, and fish-trapping pressure. We recorded the presence of *T. schlegelii* in a river system in which it was previously unknown, thus expanding the known range of the species. We also found that the predicted remaining suitable habitat for *T. schlegelii* in Indonesia is largely limited to areas of low human activity. From these empirical and modelling approaches we propose several key conservation priorities: (1) eliminate the use of fish traps in remaining patches of *T. schlegelii* habitat, (2) prioritize crocodile population surveys in remaining suitable habitat, particularly in remote areas, (3) consider *T. schlegelii* to be potentially Endangered locally in Sumatra, and (4) expand existing reserves around the Lower Kampar River and Berbak National Park/Sembilang National Park areas of Sumatra.

Lemos, A. (2017). Measuring the Economic Value and Social Impact of Crocodile Tourism in Tarcoles, Costa Rica. MSc thesis, Florida International University, Miami, Florida. (<http://digitalcommons.fiu.edu/etd/3329>).

Abstract: This thesis measures the economic value and social impact of tourism associated with crocodiles (*Crocodylus acutus*) in Tárcoles, Costa Rica. Crocodile tourism is unique compared to other tourism operations in Costa Rica because it is managed locally and has grown in an organic matter. Qualitative and quantitative data were collected from tourists and key informants who work, directly or indirectly, in crocodile tourism in the region. The results demonstrated that the economic benefits derived from nature-based tourism is an important strength and incentive for *C. acutus* conservation in Tárcoles. Bringing in an estimated USD 5,292,073.81 per year (estimated for 2014) in indirect sales, tourism is one of the main economic drivers and is central to the economic development of the region. Furthermore, understanding the social impacts of the tourism in Tárcoles is vital for ecosystem management and sustainability of the crocodile tourism industry.

Meador, L. (2018). Who Ate the Subfossil Lemurs? A Taphonomic and Community Study of Raptor, Crocodylian and Carnivoran Predation of the Extinct Quaternary Lemurs of Madagascar. PhD thesis, University of Massachusetts Amherst, USA (https://scholarworks.umass.edu/dissertations_2/1110).

Abstract: Madagascar's Quaternary predator-primate guild included seventeen species of relatively large extinct lemurs. Sharing the landscape with the lemurs, were several relatively large now-extinct predators, including three raptors (two species of *Aquila* and *Stephanoaetus mahery*), a euplerid (*Cryptoprocta spelea*), and a crocodile (*Voay robustus*). This is the first research to systematically study predator-prey relationships among these extinct animals. Here I examine the bones of the extinct lemurs at six subfossil localities (Ampasambazimba, Ankarana, Grotte d'Ankazoabo, Beloha Anavoha, Manombo Toliara, and Tsirave) for evidence of and also collected metric data on these bones. I examined 1141 specimens (crania, mandibles, humeri and femora) representing 14 lemur taxa. These data are interpreted in relation to (1) predator and prey behavior and morphology; (2) taphonomic inferences that can be drawn; (3) variation in predator-prey interactions in different

environments; (4) temporal changes in predator-prey relationships; and (5) direct and indirect consequences of predator-prey interactions. I also provide preliminary comparisons of predator-prey relationships in Madagascar and other primate communities throughout the world. I review previous research on the extinct lemurs and their potential predators examining their morphology, inferred behavior, and geographic and temporal distributions. I summarize taphonomic signatures of each predator type and evaluate the degree of taphonomic interference in the detection of predator modification. *Cryptoprocta spelea* preyed preferentially on *Pachylemur* and *Mesopropithecus*, which were among the smallest of the giant extinct lemurs, although there is evidence that *C. spelea* also preyed on animals as large as *Megaladapis* (up to 85 kg; Jungers *et al.* 2008). I conclude that social hunting likely facilitated the targeting of very large lemurs by mammalian carnivores. Like mammalian carnivores, raptors preferred the smaller extinct lemur genera (*Pachylemur*, *Mesopropithecus* and *Archaeolemur*). Crocodylian predation is the most prevalent of all, and most specimens with crocodile predation were also digested. Crocodiles targeted adult, large-bodied animals, especially *Palaeopropithecus* and *Megaladapis*. Avian, carnivoran, and crocodylian predation is well represented in the subfossil record and taphonomic study of subfossil assemblages contributes significantly to our knowledge of predator-primate dynamics of the Quaternary of Madagascar. Comparison of metric data of lemur prey animals reveals niche partitioning among these predators.

Muhammad Amirul Arib Md Adzhar, M.A.A.M. and Hassan, R. (2017). Relationships among *Tomistoma schlegelii* in Malaysia based on Cyt b-Control Region Gene Analysis. International Journal of Zoology (<https://doi.org/10.1155/2017/5431041>).

Abstract: *Tomistoma schlegelii* is a slender snout crocodile, secretive in nature which is currently under Appendix I of Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES). Limited information is currently available on its wild population, especially in Malaysia. Thus this study aims to describe genetic relationship of *T. schlegelii* populations from Malaysia which was done using partial sequencing of Cytochrome b-control region mtDNA gene. The study reveals that the genetic diversity among *T. schlegelii* is high, ranging from 0.16% to 3.34%, suggesting healthy populations. Analysis showed that there is gene flow among populations (D_{st} = 1.71% to 2.21%) within Western Sarawak, Peninsular Malaysia, and other geographical regions coherent with Sundaland theory, suggesting that there is ancient river system connecting the two regions of Peninsular Malaysia and West Borneo when the Sunda Shelf was exposed. Unique haplotypes had been observed in Northern Sarawak (SAM01 and SAM02) as well as in Sumatra; thus each *T. schlegelii* deserved its own management strategies to ensure the survival of the species.

Van de Ven, W., Telan, S., Jose, E., Lindeyer, F., Tubbs, N., De Jonge, J., Rodriguez, D., Balbas, M., Guerrero, J., Van Weerd, M., Van Der Ploeg, J. and De Iongh, H. (2017). Movements and home ranges of Philippine crocodiles in San Mariano, Isabela. NMP Journal of Natural History 2(1): 38-45.

Abstract: The Philippine crocodile *Crocodylus mindorensis* is a critically endangered endemic freshwater crocodile with an estimated wild population of less than 100 mature individuals. Since its rediscovery in Isabela Province in 1999, a research and conservation program was implemented with the main goal to conserve the Philippine crocodile and its habitat in the wild. Information on crocodile movements and life history is needed as a basis for conservation activities. Five juvenile and seven adult Philippine crocodiles were captured and fitted with VHF radio transmitters. Radio-tagged Philippine crocodiles were intensively monitored for up to 4 months in the years 2005-2009 to determine home ranges and minimum needed sanctuary sizes. Individual crocodile localities were determined, encoded in a database and

mapped. Individual home ranges were calculated using Mid Stream Linear Range. Home ranges of Philippine crocodiles seem to be highly variable. The MSLR of three head started juvenile Philippine crocodiles ranged between 670 and 931 m, while two wild juveniles range between 260 and 3166 m. Adult home ranges vary between 444 and 2886 m in Dinang Creek, and up to 4703 m in Catalangan River. In Disulap River, where adult crocodiles do not make use of any lakes, home ranges of adults are intermediate between 1943 and 4265 m. The head started juveniles in Diwagden make use of a small lake when they are young, but move to a creek and river later in life, which is also the core area of the two adults. In the rainy season they return to the lake when water levels are high. This behaviour was also observed in the wild individuals in Catalangan River and Dunoy Lake. Population densities are higher than expected for adult crocodiles in breeding sites. At least 5 adults were observed in a stretch of 3 km of a small creek. Adult home-ranges of four individuals ranged between 444 and 2886 m, overlapping both in time and space for several individuals. The recorded movements and mapped home ranges will be used to review the existing site-specific crocodile conservation action plans.

J-Q. Lin, Q. Zhou, H-Q. Yang, L-M. Fang, K-Y. Tang, L. Sun, Q-H. Wan, S-G. Fang (2018). Molecular mechanism of temperature-dependent sex determination and differentiation in Chinese alligator revealed by developmental transcriptome profiling. *Science Bulletin* (doi: <https://doi.org/10.1016/j.scib.2018.01.004>).

Wu, X., Zhang, X., Jin, Z., Song, Y., Luan, F. and Xue, X. (2017). Strontium isotope analysis of Yangtze alligator remains from Late Neolithic North China. *Archaeological and Anthropological Sciences* (<https://doi.org/10.1007/s12520-017-0589-z>).

Abstract: Endangered wild Yangtze alligators (*Alligator sinensis*) inhabit the downstream subtropical lakes and swamps of the Yangtze River at a latitude of approximately 30°N. What remains puzzling is the discovery of the remains of Yangtze alligators at many Middle and Late Neolithic archeological sites in North China, mainly in the form of alligator osteoderms buried in tombs of the elite. To determine whether these Yangtze alligators were indigenous or were part of long-distance trading between the northern and southern parts of China, we conducted a strontium isotope analysis of alligator osteoderms from three archaeological sites dating from the Late Neolithic Age (2500~1900 BC). The results show that these remains are mainly indigenous, which means that the northern boundary of the distribution of Yangtze alligators may even have reached the Yellow River basin 4000 years ago. Based on historical records from the Longshan and Erlitou Periods (2500~1600 BC), which mention some clans specializing in breeding “dragons” during the Yu and Xia Dynasties, combined with the discovery of dragon and alligator images from the Xia and Shang Dynasties, we believe that society at that time viewed Yangtze alligators as the manifestation of “dragons.”

Williams, C.E., McNabb, N.A., Brunell, A., Lowers, R.H., Katsu, Y., Spyropoulos, D.D. and Kohno, S. (2017). Feminizing effects of exposure to Corexit-enhanced water-accommodated fraction of crude oil *in vitro* on sex determination in *Alligator mississippiensis*. *General and Comparative Endocrinology* (<https://doi.org/10.1016/j.ygcen.2017.11.019>).

Abstract: Deepwater Horizon spilled over 200 million gallons of oil into the waters of the Gulf of Mexico in 2010. In an effort to contain the spill, chemical dispersants were applied to minimize the amount of oil reaching coastal shorelines. However, the biological impacts of chemically-dispersed oil are not well characterized, and there is a particular lack of knowledge concerning sublethal long-term effects of exposure. This study examined potential estrogenic effects of CWAFF, Corexit 9500-enhanced water-accommodated fraction of oil, by examining its effect on estrogen receptors and sex determination

in the American alligator, *Alligator mississippiensis*. The alligator exhibits temperature-dependent sex determination which is modulated by estrogen signals, and exposure to 17 β -estradiol (E₂) and estrogenic compounds *in ovo* during the thermosensitive period of embryonic development can induce ovarian development at a male-producing temperature (MPT). CWAFF induced transactivation up to 50% of the maximum induction by E₂ via alligator estrogen receptors *in vitro*. To determine potential endocrine-disrupting effects of exposure directly on the gonad, gonad-adrenal-mesonephric (GAM) organ complexes were isolated from embryos one day prior to the thermosensitive period and exposed to E₂, CWAFF, or medium alone *in vitro* for 8-16 days at MPT. Both CWAFF and E₂ exposure induced a significant increase in female ratios. CWAFF exposure suppressed GAM mRNA abundances of anti-Müllerian hormone (AMH), sex determining region Y-box 9, and aromatase, whereas E₂ exposure suppressed AMH and increased Forkhead box protein L2 mRNA abundances in GAM. These results indicate that the observed endocrine-disrupting effects of CWAFF are not solely estrogenically mediated, and further investigations are required.

Lapbenjakul, S., Thapana, W., Twilprawat, P., Muangmai, N., Kanchanaketu, T., Tamsiripong, Y., Unajak, S., Peyachoknagul, S. and Srikulnath, K. (2017) High genetic diversity and demographic history of captive Siamese and Saltwater crocodiles suggest the first step toward the establishment of a breeding and reintroduction program in Thailand. *PLoS ONE* 12(9): e0184526.

Abstract: The Siamese crocodile (*Crocodylus siamensis*) and Saltwater crocodile (*C. porosus*) are two of the most endangered animals in Thailand. Their numbers have been reduced severely by hunting and habitat fragmentation. A reintroduction plan involving captive-bred populations that are used commercially is important and necessary as a conservation strategy to aid in the recovery of wild populations. Here, the genetic diversity and population structure of 69 individual crocodiles, mostly members of captive populations, were analyzed using both mitochondrial D-loop DNA and microsatellite markers. The overall haplotype diversity was 0.924-0.971 and the mean expected heterozygosity across 22 microsatellite loci was 0.578-0.701 for the two species. This agreed with the star-like shaped topology of the haplotype network, which suggests a high level of genetic diversity. The mean ratio of the number of alleles to the allelic range (M ratio) for the populations of both species was considerably lower than the threshold of 0.68, which was interpreted as indicative of a historical genetic bottleneck. Microsatellite markers provided evidence of introgression for three individual crocodiles, which suggest that hybridization might have occurred between *C. siamensis* and *C. porosus*. D-loop sequence analysis detected bi-directional hybridization between male and female individuals of the parent species. Therefore, identification of genetically non-hybrid and hybrid individuals is important for long-term conservation management. Relatedness values were low within the captive populations, which supported their genetic integrity and the viability of a breeding and reintroduction management plan. This work constitutes the first step in establishing an appropriate source population from a scientifically managed perspective for an *in situ/ex situ* conservation program and reintroduction of crocodile individuals to the wild in Thailand.

Toth, N. (2017). Revised taphonomic perspective on African Pliocene-Pleistocene fauna. *PNAS* 114(50) (doi: 10.1073/pnas.1718815114).

Caspermeyer, J. (2018). Finding their inner bird: Using modern genomics to turn alligator scales into birdlike feathers. *Molecular Biology and Evolution* 35(2): 523-524.

Tipton, J.J., Guillette, L.J. Jr., Lovelace, S., Parrott, B.B., Rainwater, T.R. and Reiner, J.L. (2017). Analysis of PFAs in American alligators Part 2: Potential dietary exposure of South Carolina

hunters from recreationally harvested alligator meat. J. Environ. Sci. (China) 61: 31-38.

Abstract: Exposure to perfluorinated alkyl acids (PFAAs) has been linked to many harmful health effects including reproductive disorders, developmental delays, and altered liver and kidney function. Most human exposure to environmental contaminants, including PFAAs, occurs through consumption of contaminated food or drinking water. This study uses PFAA data from meat samples collected from recreationally harvested American alligators (*Alligator mississippiensis*) in South Carolina to assess potential dietary exposure of hunters and their families to PFAAs. Consumption patterns were investigated using intercept surveys of 23 hunters at a wild game meat processor. An exposure scenario using the average consumption frequency, portion size, and median perfluorooctane sulfonic acid (PFOS) concentration in alligator meat from all hunt units found the daily dietary exposure to be 2.11 ng/kg body weight per day for an adult human. Dietary PFOS exposure scenarios based on location of harvest suggested the highest daily exposure occurs with alligator meat from the Middle Coastal hunt unit in South Carolina. Although no samples were found to exceed the recommended threshold for no consumption of PFOS found in Minnesota state guidelines, exposure to a mixture of PFAAs found in alligator meat and site-specific exposures based on harvest location should be considered in determining an appropriate guideline for vulnerable populations potentially exposed to PFAAs through consumption of wild alligator meat.

Tipton, J.J., Guillette, L.J. Jr., Lovelace, S., Parrott, B.B., Rainwater, T.R. and Reiner, J.L. (2017). Analysis of PFAAs in American alligators Part 1: Concentrations in alligators harvested for consumption during South Carolina public hunts. J. Environ. Sci. (China) 61: 24-30.

Abstract: Environmental contamination resulting from the production or release of harmful chemicals can lead to negative consequences for wildlife and human health. Perfluorinated alkyl acids (PFAAs) were historically produced as protective coatings for many household items and currently persist in the environment, wildlife, and humans. PFAAs have been linked to immune suppression, endocrine disruption, and developmental toxicity in wildlife and laboratory studies. This study examines the American alligator, *Alligator mississippiensis*, as an important indicator of ecosystem contamination and a potential pathway for PFAA exposure in humans. Alligator meat harvested in the 2015 South Carolina (SC) public hunt season and prepared for human consumption was collected and analyzed for PFAAs to determine meat concentrations and relationships with animal body size (total length), sex, and location of harvest. Of the 15 PFAAs analyzed, perfluorooctane sulfonate (PFOS) was found in all alligator meat samples and at the highest concentrations (median 6.73 ng/g). No relationship was found between PFAA concentrations and total length or sex. Concentrations of one or all compounds varied significantly across sampling locations, with alligators harvested in the Middle Coastal hunt unit having the highest PFOS concentrations (median 16.0 ng/g; $p=0.0001$). Alligators harvested specifically from Berkley County, SC (located in the Middle Coastal hunt unit) had the highest PFOS concentrations and the greatest number of PFAAs detected ($p<0.0001$). The site-specific nature of PFAA concentrations in alligator meat observed in this study suggests a source of PFAA contamination in Berkley County, SC.

Wang, H., Yan, P., Zhang, S., Sun, L., Ren, M., Xue, H., Zhang, F., Wu, R. and Wu, X. (2017). Multiple paternity: A compensation mechanism of the Chinese alligator for inbreeding. Anim. Reprod. Sci. 187: 124-132.

Abstract: The Chinese alligator *Alligator sinensis* is a critically endangered species endemic to China. Knowledge about reproductive strategies of a species contributes to their conservation.

Little is, however, known about the reproductive strategies and its impact on the population. In the present study, an easy and non-invasive genetic method was used to improve the understanding of mating system of Chinese alligators and its effect on the population genetic diversity by 9 polymorphic microsatellite loci. There was a high incidence of multiple paternity among 50 clutches, with a total 60% of the clutches having multiple paternity and up to three males contributing to single clutches. In addition, polyandry females choose to mate with males that are more distant in relatedness compared with monogamy females. Multiple paternity can decrease the inbreeding coefficient, while there is no significant difference between single and multiple paternity ($P>0.05$). Furthermore, there was an increased allelic diversity (though not heterozygosity) in multiple paternity sired offspring compared with the single paternity sired offspring in F2 generations ($P<0.05$), as predicted by the genetic diversity hypothesis. Multiple paternity may function as an important inbreeding avoidance compensation mechanism leading to the potential of the species to avoid extinction. These findings will not only enhance the understanding of the mating system and the biological traits of the Chinese alligator, but also improve the captive breeding program management and conservation strategies of the endangered species.

Forrester, J.A., Weiser, T.D. and Forrester, J.D. (2018). An update on fatalities due to venomous and nonvenomous animals in the United States (2008-2015). Wilderness & Environmental Medicine (<https://doi.org/10.1016/j.wem.2017.10.004>).

Abstract: To review recent (2008-2015) United States mortality data from deaths caused by nonvenomous and venomous animals and compare with historical data. The Centers for Disease Control and Prevention Wide-Ranging Online Data for Epidemiologic Research database was queried to return all animal-related fatalities between 2008 and 2015. Mortality frequencies for animal-related fatalities were calculated using the estimated 2011 United States population. Inclusion criteria included all mortalities that were a consequence of bite, contact, attack, or envenomation (International Classification of Diseases 10th revision codes W53-W59 and X20-X29). There were 1610 animal-related fatalities, with the majority from nonvenomous animals (2.8 deaths per 10 million persons). The largest proportion of animal-related fatalities was due to "other mammals," largely composed of horses and cattle. Deaths attributable to Hymenoptera (hornets, wasps, and bees) account for 29.7% of the overall animal-related fatalities and have been steady over the last 20 years. Dog-related fatality frequencies are stable, although the fatality frequency of 4.6 deaths per 10 million persons among children 4 years of age or younger was nearly 4-fold greater than in the other age groups. Appropriate education and prevention measures aimed at decreasing injury from animals should be directed at the high-risk groups of agricultural workers and young children with dogs. Public policy and treatment pricing should align to ensure adequate available medication for those at risk of anaphylaxis from stings from *Hymenoptera*.

Waskow, K., Grzegorzczak, D. and Sander, P.M. (2018). The first record of *Tyrannoneustes* (Thalattosuchia: Metriorhynchidae): a complete skull from the Callovian (late Middle Jurassic) of Germany. PalZ (<https://doi.org/10.1007/s12542-017-0395-z>).

Abstract: Thalattosuchian crocodiles belonging to the taxon Metriorhynchidae are among the first fossil reptiles ever discovered. Taxa belonging to this morphologically distinctive, stratigraphically long-lived, and widely spread group were described long before Richard Owen in 1841 coined the term "dinosaur" (eg *Geosaurus giganteus* described by von Soemmerring in 1814). Here we describe a new find of a *Tyrannoneustes* cf. *lythrodictikos* skull from the Callovian (late Middle Jurassic) of the Weser-Wiehengebirge (North Rhine-Westphalia, Germany). This species represents one of the oldest and most basal macrophagous metriorhynchines known to date. The new find is one of the most complete

Tyrannoneustes skulls with both the cranium and the mandible found in association. It shows most of the autapomorphies typical of *Tyrannoneustes lythrodektikos*, some of which are not as distinctive as in the holotype. Additionally, it shows several characters of “*Metriorhynchus*” *brachyrhynchus*. Unfortunately, the current stage of publication leaves *Metriorhynchus* as a polyphyletic taxon that needs a proper redescription. The new specimen shows characters of both species, with slight variations that are too little to create a new species. Therefore, the specimen found near Münster was assigned to *Tyrannoneustes* cf. *lythrodektikos*. Several characters indicate a subadult ontogenetic stage for the specimen, consistent with its relatively small size compared with other *Tyrannoneustes* individuals.

Charlier, P., Coppens, Y., Augias, A., Deo, S., Froesch, P. and Huynh-Charlier, I. (2018). Mudslide and/or animal attack are more plausible causes and circumstances of death for AL 288 (‘Lucy’): A forensic anthropology analysis. *Medico-Lega Journal* (doi: 10.1177/0025817217749504).

Abstract: Following a global morphological and micro-CT scan examination of the original and cast of the skeleton of *Australopithecus afarensis* AL 288 (‘Lucy’), Kappelman *et al.* have recently proposed a diagnosis of a fall from a significant height (a tree) as a cause of her death. According to topographical data from the discovery site, complete re-examination of a high-quality resin cast of the whole skeleton and forensic experience, we propose that the physical process of a vertical deceleration cannot be the only cause for her observed injuries. Two different factors were involved: rolling and multiple impacts in the context of a mudslide and an animal attack with bite marks, multi-focal fractures and violent movement of the body. It is important to consider a differential diagnosis of the observed fossil lesions because environmental factors should not be excluded in this ancient archaeological context as with any modern forensic anthropological case.

De Oliveira, J.V., Lopes, S.F., Barboza, R.R.D. and Da Nóbrega Alves, R.R. (2018). To preserve, or not to preserve, that is the question: urban and rural student attitudes towards wild vertebrates. *Environment, Development and Sustainability* (<https://doi.org/10.1007/s10668-018-0083-5>).

Abstract: Historically, human interactions with other animals have been marked by an attitudinal affinity-aversion polarization, depending on the animal involved and its local utilitarian value, as well as whether it is related to conflict situations or not. In this sense, the present study aimed to analyse the attitudes (affinity-aversion) of urban and rural students in relation to wild vertebrates and the factors that influence them. Data were obtained from three public schools, one urban and two rural, in the city of Campina Grande, Paraíba, Brazil. Questionnaires were given to 990 students (528 urban and 462 rural), distributed among all levels of basic education (students 6-17 years of age). We used the technique of “content analysis” to categorize the descriptive data and tests of significance and correlation for statistical analyses. No differences were observed in attitudes of affinity (preservation) and/or aversion (elimination) about vertebrates between urban and rural students. However, there was variation in preferences regarding animals as a function of these contexts. There was a common tendency between genders for aversion for snakes, followed by amphibians, mammals, turtles and birds, with slight differences in the specificities of the animals considered. Significant positive correlations ($p < 0.05$) between affinity (preservation) and curricular development, age and family income were observed. Attitudinal antagonism (affinity-aversion), expressed by the variation in preferences for certain animals and repulsion by others, has consequential implications for the conservation of wild fauna, thus demonstrating the relevance of incorporating this reality into the context of educational strategies.

Pakdeesuwana, A., Araki, T., Payoungkiattikun, W., Neubert, L.K., Jangpromma, N. and Klaynongsruang, S. (2018). Development, characterization and determination of biological properties of crocodile hemoglobin (*Crocodylus siamensis*) tablets. *Journal of Food Chemistry* (doi: 10.1111/jfbc.12503).

Abstract: Recently, several biological properties of Siamese crocodile (*Crocodylus siamensis*) hemoglobin (Hb) and its hydrolysate have been discovered. In light of these findings, this study exploring the physical properties and biological activity of *C. siamensis* Hb tablets is disclosed. Notably, all derived tablet formulations of crocodile Hb were proven to possess antibacterial and antioxidant properties. Investigation of long-term stability indicated mild storage temperature of only 4°C is adequate to maintain full biological activity for more than 3 months. Scanning electron microscopy further revealed induction of abnormalities on bacterial cell membranes upon treatment with tableted crocodile Hb. Digestion of crocodile Hb tablets with artificial gastric juice was found non-significant differences on the antibacterial activity between the digested Hb tablets and intact Hb. Using C18 RP-HPLC purification followed by N-terminal sequence analysis, four active peptides originating from the alpha and six from the beta chain of native crocodile Hb were identified. Several studies demonstrated that crocodile hemoglobin (Hb) possesses various biological activities such as antimicrobial, antioxidant, anti-inflammation, and wound healing activity. Hence, this article aims to develop crocodile hemoglobin as food supplementary tablets. Various crocodile Hb tablet formulations have been prepared. After that, the possibility for using tableted crocodile Hb as a food supplement has been investigated in detail. The outcome obtained from this study justified that the development of crocodile Hb tablets provide a protein rich food supplementary product with promising biological activity.

Zhang, S.Z., Meng, T., Zhu, X., Wang, H., Zhou, Y.K. and Wu, X.B. (2017). Molecular characterization and tissue expression profiles of prepro-vasoactive intestinal peptide in the Chinese alligator (*Alligator sinensis*) during the active and hibernating periods. *J. Exp. Zool. A. Ecol. Integr. Physiol.* 327(2-3): 79-88.

Abstract: The Chinese alligator (*Alligator sinensis*), a freshwater crocodilian endemic to China, is one of the most endangered crocodilian species; up to this date, very little is known about the endocrine regulation of its metabolic activities during different physiological states. In this study, we characterized the structure of the prepro-vasoactive intestinal peptide in Chinese alligator (prepro-caVIP) for the first time and examined its expression profiles in various tissues during the active and hibernating periods. The prepro-caVIP cDNA consists of a 221-bp 5'-untranslated region (UTR), a 606-bp complete coding region (CDS), and a 312-bp 3'-UTR, which encodes the 201-amino acid prepro-caVIP containing a 28-amino acid vasoactive intestinal peptide (VIP) and a 27-amino acid PHI (peptide histidine isoleucine). Multiple alignment analysis showed that VIP shares 100% identity with the given birds, reptiles, and African clawed frog, and 89% identity with mammals, 96% with fishes. Real-time quantitative PCR showed that the prepro-caVIP is widely expressed in all the examined tissues, and the expression level is significantly higher in small intestine, stomach, pancreas, lung, and skeletal muscle, whereas lower in heart, liver, spleen, kidney, ovary, and oviduct. During hibernation, the expression level of caVIP was significantly decreased in small intestine ($P < 0.01$), pancreas, and skeletal muscle ($P < 0.05$), whereas significantly increased in liver, spleen, and lung ($P < 0.01$). The wide distribution of caVIP and its differential expression changes in various tissues during hibernation implicated that it might play multiple effects in Chinese alligator and participate in the physiological adaptation of various organs in a paracrine and/or neurocrine manner.

Kohno, S., Katsu, Y., Cipoletti, N., Wang, L.C., Jorgenson, Z.G., Miyagawa, S. and Schoenfeld, H.L. (2017). Divergent responsiveness of two isoforms of the estrogen receptor to mixtures

of contaminants of emerging concern in four vertebrates. J. Appl. Toxicol. (doi: 10.1002/jat.3577).

Abstract: Contaminants of emerging concern (CECs) are ubiquitous in aquatic environments with well-established endocrine-disrupting effects. A data matrix of 559 water samples was queried to identify two commonly occurring CECs mixtures in Great Lakes tributaries. One mixture consisted of eight agricultural CECs (AG), while another contained 11 urban CECs (UB). The known estrogenic compounds bisphenol A, estrone and nonylphenol were present in both mixtures. According to the EPA Tox21 in ToxCast database, AG and UB mixture at an environmentally relevant concentration were estimated to account for 6.5% and 3.4% estrogenicity of the model endocrine disruptor estradiol-17 β , respectively. Two isoforms of the estrogen receptor (Esr1 and -2, former Era and Er β) cloned from fathead minnow, bluegill sunfish, American alligator and human, responded differently to AG and UB mixtures. Human and bluegill Esr1 were the most sensitive to AG and UB mixtures, respectively. Fathead minnow Esr1 and Esr2b were the least sensitive to 10 \times AG and UB in estrogen dose equivalents, respectively. Even at environmentally documented concentrations, UB significantly activated bluegill Esr1. Moreover, 100 \times concentrated UB hyperstimulated fathead minnow Esr1 beyond the maximum induction of estradiol-17 β . These results indicate that efficacious receptors and species differ in their response to CEC mixtures. Furthermore, estrogenicity may be present in some CECs not previously considered estrogenic, or, alternatively, estrogenicity of a mixture may be enhanced through chemical interactions. Our study highlights the need for further studies of CECs utilizing a variety of receptors cloned from diverse species.

Maglen, K. (2018). 'An Alligator Got Betty': Dangerous Animals as Historical Agents. Environment and History Press (doi: <https://doi.org/10.3197/096734018X15137949591945>).

Abstract: In 1932 four year old Betty Doherty was taken from the grasp of her older brother by a fourteen-foot crocodile in Far North Queensland. Through an examination of historical sources as well as the work of psychologists, cognitive scientists and zoologists, this paper explores the role ascribed to the crocodile as well as other 'dangerous' animals that have bitten, stung or consumed settlers across Australia, and asks whether and how they might 'act' or be given voices within our reading and understanding of the past. Animal historians have begun to ask questions about historical agency through analyses of domesticated or working animals, and interactions between people and wild mammals. Insects, fish and reptiles, however, remain anonymous and non-specific, disappearing back beneath the waves or into the dark holes from which they emerged, and yet they were often agents of great change in the human lives they encountered. This paper asks whether historical agency and intent can be found in these less sympathetic and less 'knowable' creatures, and examines how historians might conceive of watery predators or venomous creatures that disappeared from sight or perhaps were never seen at all.

Boucher, M., Tellez, M. and Anderson, J.T. (2018). A tail of two crocs: coding tail-spot patterns for individual identification of American (*Crocodylus acutus*) and Morelet's (*Crocodylus moreletii*) crocodiles. Mesoamerican Herpetology 4(4): 760-762.

Abstract: The marking of wildlife is an effective tool for the conservation and management of many species. A range of marking techniques is used in crocodylian management and conservation, and primarily involves the alteration of caudal scutes and the application of tags. Here we present the methods and application for two natural pattern identification techniques, which are used concurrently with research and monitoring of the American Crocodile (*Crocodylus acutus*) and Morelet's Crocodile (*Crocodylus moreletii*) in Belize. We collected and analyzed 547 photographs of observed and captured crocodiles, and identified individuals by coding the spot

patterns on the lateral portion of the tail. We investigated the efficacy of an established spot pattern coding protocol for crocodylians, and modified the original coding procedure by integrating vertical caudal scutes and irregular scale groups. We generated a total of 191 tail codes for 105 individual crocodiles (*C. moreletii*, n= 27; *C. acutus*, n= 78). The established methodology demonstrated an 84% success rate in differentiating individuals, whereas our new method showed 99% effectiveness in differentiating individuals and species. Using the spot pattern protocols, we identified no individuals with fully repeated codes (both tail sides). This project demonstrates that tail-spot patterns are distinctive, and consequently the coding of spot patterns is an effective way to passively identify individuals across the species. The proposed techniques are a cost-effective and simple tool that can be used by managers and communities to facilitate long-term demographic monitoring, and also can serve to encourage active participation in crocodile conservation via citizen science.

Scheyer, T.M., Delfino, M., Klein, N., Bunbury, N., Fleischer-Dogley, F. and Hansen, D.M. (2018). Trophic interactions between larger crocodylians and giant tortoises on Aldabra Atoll, Western Indian Ocean, during the Late Pleistocene. R. Soc. open sci. 5: 171800.

Abstract: Today, the UNESCO World Heritage Site of Aldabra Atoll is home to about 100000 giant tortoises, *Aldabrachelys gigantea*, whose fossil record goes back to the Late Pleistocene. New Late Pleistocene fossils (age ca. 90-125,000 years) from the atoll revealed some appendicular bones and numerous shell fragments of giant tortoises and cranial and postcranial elements of crocodylians. Several tortoise bones show circular holes, pits and scratch marks that are interpreted as bite marks of crocodylians. The presence of a Late Pleistocene crocodylian species, *Aldabrachampsus dilophus*, has been known for some time, but the recently found crocodylian remains presented herein are distinctly larger than those previously described. This indicates the presence of at least some larger crocodylians, either of the same or of a different species, on the atoll. These larger crocodylians, likely the apex predators in the Aldabra ecosystem at the time, were well capable of inflicting damage on even very large giant tortoises. We thus propose an extinct predator-prey interaction between crocodylians and giant tortoises during the Late Pleistocene, when both groups were living sympatrically on Aldabra, and we discuss scenarios for the crocodylians directly attacking the tortoises or scavenging on recently deceased animals.

Muniz Leão, S., Pianka, E.R. and Pelegrin, N. (2018). Is there evidence for population regulation in amphibians and reptiles? Journal of Herpetology 52(1): 28-33.

Abstract: From the 1950s to the present, many researchers have tested time series data for density dependence. All kinds of organisms have been studied, from microorganisms to insects and vertebrates to plants. A variety of techniques and population growth models were developed, and the conceptual framework to study populations has been improved. We searched for long time series data on amphibians and reptiles in the literature. From 102 population time series, and after filtering the dataset, we tested for density dependence in time series data for 69 populations (52 species) of amphibians (anurans and caudatans), serpents, lacertilians, chelonians, rhynchocephalians, and crocodilians. We used the exponential growth state-space model and the Ornstein-Uhlenbeck state-space model as proxy models for density-independent and density-dependent population growth models, selecting between them with the parametric bootstrap likelihood ratio test. The hypothesis of density independence was rejected for 2 amphibians, 11 serpents, 3 chelonians, 1 rhynchocephalian, and 2 crocodilian populations. Detailed data for serpents and chelonians allowed identification of external factors such as changing food supplies and habitats as drivers of observed changes in population densities. We highlight the need of both long-term and experimental studies on reptile and amphibian populations in semipristine or preserved areas.

Nelson, D., Crossley II, D.A., Elsey, R.M. and Tate, K.B. (2018). Cardiovascular adjustments with egg temperature at 90% incubation in embryonic American alligators, *Alligator mississippiensis*. *Journal of Comparative Physiology B* (<https://doi.org/10.1007/s00360-018-1144-7>).

Abstract: American alligators (*Alligator mississippiensis*) deposit eggs in a mound nest, potentially subjecting embryos to daily variations in temperature. Whilst adult crocodilian cardiovascular responses to changes in temperature have been investigated, similar studies in alligator embryos are limited. We investigated cardiovascular function of embryonic alligators during heating and cooling as well as at different temperatures. We measured arterial blood pressure (Pm) and heart rate (fH) in response to cooling (30–26°C), heating (26–36°C), followed by a reciprocal cooling event (36–26°C) and assessed the cardiac baroreflex at 30 and 36°C. Embryonic fH increased during heating events and decreased during cooling events, while embryos were hypotensive at 26 and 36°C, although Pm did not differ between heating or cooling events. There was a clear temperature-dependent heart rate hysteresis at a given embryo's temperature, depending on whether embryos were cooling or heating. Cardiovascular regulation through the cardiac limb of the baroreflex was not affected by temperature, despite previous studies suggesting that vagal tone is present at both low and high temperatures.

Villamarín, F., Jardine, T.D., Bunn, S.E., Marioni, B. and Magnusson, W.E. (2018). Body size is more important than diet in determining stable-isotope estimates of trophic position in crocodilians. *Scientific Reports* 8: 2020.

Abstract: The trophic position of a top predator, synonymous with food-chain length, is one of the most fundamental attributes of ecosystems. Stable isotope ratios of nitrogen ($\delta^{15}\text{N}$) have been used to estimate trophic position of organisms due to the predictable enrichment of ^{15}N in consumer tissues relative to their diet. Previous studies in crocodilians have found upward ontogenetic shifts in their 'trophic position'. However, such increases are not expected from what is known about crocodilian diets because ontogenetic shifts in diet relate to taxonomic categories of prey rather than shifts to prey from higher trophic levels. When we analysed dietary information from the literature on the four Amazonian crocodilians, ontogenetic shifts in dietary-based trophic position (TP_{diet}) were minimal, and differed from those estimated using $\delta^{15}\text{N}$ data (TP_{SLA}). Thus, ontogenetic shifts in TP_{SLA} may result not only from dietary assimilation but also from trophic discrimination factors (TDF or $\Delta^{15}\text{N}$) associated with body size. Using a unique TDF value to estimate trophic position of crocodilians of all sizes might obscure conclusions about ontogenetic shifts in trophic position. Our findings may change the way that researchers estimate trophic position of organisms that show orders of magnitude differences in size across their life span.

Parrilla-Bel, J. and Canudo, J.I. (2018). New longirostrine crocodylomorph remains from the Blesa Formation (Barremian) in the Iberian Peninsula (Spain). *Journal of Iberian Geology* (<https://doi.org/10.1007/s41513-017-0043-1>).

Abstract: Crocodylomorpha has been a highly morphologically and ecologically diverse clade over time. During the Mesozoic and Cenozoic, several crocodylomorph lineages colonized the marine environment; however, by the late Early Cretaceous the extinction of Thalattosuchia and the origination of new marine forms occur, and the "Middle" Cretaceous is a period of time where marine crocodylomorphs are poorly known. Here we describe two rostrum fragments (MPZ 2016/78 and MPZ 2016/79) collected in the upper part of the Blesa Formation (Barremian, Lower Cretaceous) in Teruel (Spain). The "Upper" Blesa Fm has been interpreted as a coastal–transitional depositional environment. The specimens correspond to long-snouted crocodylomorphs. MPZ 2016/78 is the

left half of a fragmentary rostrum with heterodonty in dentition size, M4? and M5? being the largest alveoli. This suggests that it belongs to a crocodylomorph with a generalist diet. By contrast, MPZ 2016/79 is a fragmentary right half of a more gracile and slender long rostrum. It is homodont in size, with several small teeth, common in animals specialized for ichthyophagy. MPZ 2016/78 and MPZ 2016/79 have been assigned to Crocodylomorpha indet. This new crocodylomorph material, together with the fossil remains of marine vertebrates previously found in the same region (plesiosaurs, chelonians, osteichthyans, chondrichthyans and a new crocodylomorph), suggests that the "Upper" Blesa Formation was a coastal zone with a great wealth of fauna, making it an interesting area for the study of Barremian marine vertebrates.

Gregorovičová, M., Kvasilová, A. and Sedmera, D. (2018). Ossification pattern in forelimbs of the Siamese crocodile (*Crocodylus siamensis*): Similarity in ontogeny of carpus among crocodylian species. *The Anatomical Record* (doi: 10.1002/ar.23792).

Abstract: Crocodylians have highly derived elongated carpus, which is related to their use of forelimbs in many types of gaits as well as in burrowing. The objective of present study was to describe the ossification of the forelimb in five stages of Siamese crocodile (*Crocodylus siamensis*). The ossification begins approximately at stage 20 in arm and forearm bones moving sequentially to the metacarpal elements. The first carpal elements with ossification centers are radiale+intermedium and ulnare (stage 22–23), and their ossification mode is typical of long bones. Between stages 22–24 distal carpals 3, 4, and 5 fuse together to a single formation. In the stage 25, the ossification proceeds to the pisiform, which starts ossifying late during the embryogenesis. The phalangeal formula of the digits is 2,3,4,5,3. Although there are some interspecific differences, it appears that all crocodylians have similarly uniform skeletal pattern, the process of ossification, number of carpal elements and phalangeal formulas probably due to their similar lifestyles.

Behangana, M., Lukwago, W., Dendi, D., Luiselli, L. and Ochanda, D. (2017). Population surveys of Nile crocodiles (*Crocodylus niloticus*) in the Murchison Falls National Park, Victoria Nile, Uganda. *European Journal of Ecology* 3(2): 67–76.

Abstract: A 12-month-long survey (April 2013 to March 2014) for Nile crocodiles (*Crocodylus niloticus*) was conducted along a section of the Victoria Nile/Ramsar site of Murchison Falls National Park, in order to update the historic information on crocodile populations in the area, locating nesting areas, determining seasonality patterns and habitat use, and assess the current abundance and the population size trends since the 1960s. The methods employed included visual encounter surveys, transect counts and opportunistic methods, by using boats. In general, there were diurnal and seasonal fluctuations in the number of crocodile sightings. The crocodile sightings peaked between the months of June and August, with the highest mean number of sightings encountered on any single day being 67 (in July 2013), and the second peak was between January and March with the highest mean of 118 recorded in January 2014. The second peak also coincided with the crocodile breeding season. This clearly shows that the distribution of the sub-population sampled followed a climatic regime. Crocodiles were observed most frequently in water (37%). Grassy banks, islands, river mouths and sandy banks constituted about 47% of the habitats utilised by the crocodile population. Although basking was the most frequent type of activity performed by crocodiles (50%) over the entire survey period, their key activities varied significantly from month to month. Nesting was very visible during the last quarter of the year and the first quarter of the New Year. There was a clear decline of the abundance of crocodiles in this population between 1960s and nowadays. This declining trend was obvious also taking into account the various survey methodologies employed over the decades.

Rodgers, E.M. (2017). Diving in a Warming World. Thermal Constraints on the Diving Capacity of Estuarine Crocodiles (*Crocodylus porosus*). PhD thesis, University of Queensland, Brisbane, Australia.

Abstract: A central challenge in conserving biodiversity is predicting the consequences of anthropogenic climate change on species' distributions and persistence. Forced climate change has severely altered thermal regimes in marine and freshwater habitats. Rapid escalations in environmental temperatures may be particularly threatening to ectothermic species (almost all plants, invertebrates, fish, amphibians and reptiles), where body temperature and concomitant functional performance are strongly tied to the thermal environment. The threat of overheating is salient for air-breathing, ectothermic divers, such as the estuarine crocodile (*Crocodylus porosus*, Schneider, 1801), because submergence times are inversely related to water temperature. It is unknown how *C. porosus* will fare in warming waters but diving oxygen stores are hypothesised to be consumed more rapidly at elevated temperatures leading to a reduction of aerobic dive limits (ie maximum submergence time before lactate is accumulated). Shorter dive durations may force animals to spend more time at the water surface, leaving less time available for obligate underwater activities (eg predator avoidance and hunting for aquatic prey). This thesis assessed the effect of elevated water temperatures (emulating climate change scenarios) on the diving physiology and behaviour of *C. porosus*. The thermal sensitivity of predator avoidance dives (ie minutes submerged) was assessed in juveniles at three water temperatures reflecting climate change scenarios (Chapter 2). Diving performance was thermally sensitive with dive durations halving between the 'no warming' and 'moderate warming' scenarios. Ectotherms are however revered for their thermal acclimation/acclimatisation capacity following long term exposure to novel temperatures; whereby an animal's underlying physiology is responsively altered to maintain or optimise performance. For this reason, the acclimation capacity of *C. porosus* was assessed by exposing crocodiles to thermal acclimation treatments for a minimum of 30 days. Thermal acclimation treatments had no effect on dive durations - a result indicative of absent thermal acclimation capacity at elevated temperatures within 30 days. The physiological mechanisms underlying compromised diving performance at elevated temperatures were subsequently examined (Chapter 3). Reduced diving performance was hypothesised to be linked to increased oxygen demands and a reduced capacity for metabolic depression at elevated temperatures. Diving oxygen uptake, diving heart rate and post-dive plasma-lactate concentrations were assessed at two test temperatures (ie 28C and 34C). Diving metabolic rate increased threefold between 28C and 34C and the capacity to depress metabolic demands (from surface levels) was inhibited by 46%. Post-dive plasma-lactate accumulation was independent of water temperature. Collectively, these results show the aerobic dive limit of *C. porosus* was significantly reduced at elevated temperatures and animals behaviourally terminated dives earlier rather than increasing reliance on anaerobic metabolism. The thermal sensitivity and plasticity of aerobic capacity in juvenile *C. porosus* was examined and compared to diving oxygen uptake rate (VO_{2DIVE}), to assess if diving performance is constrained by aerobic capacity (Chapter 4). Resting ($VO_{2STANDARD}$) and maximum (VO_{2MAX}) rates of oxygen consumption were measured and absolute aerobic scope ($AAS = VO_{2MAX} - VO_{2STANDARD}$) was calculated. Resting rates of oxygen consumption increased markedly between 28-36C and did not differ between thermal acclimation treatments. In contrast, VO_{2MAX} was thermally insensitive but phenotypically plastic; warm-acclimated animals exhibited a twofold increase in VO_{2MAX} compared to animals acclimated to 28C. Absolute aerobic scope maintained a broad plateau of thermal independence between 28-36C and increased in warm-acclimated animals due to elevated VO_{2MAX} . The thermal sensitivity of VO_{2DIVE} ($Q_{10} = 7.4$) was threefold greater than $VO_{2STANDARD}$ ($Q_{10} = 2.28$), and thermal thresholds marking decrements in diving performance did not align with reductions in aerobic capacity. Together, these findings suggest assessing the vulnerability of diving ectotherms based solely on aerobic scope measurements underestimates susceptibility. Lastly, diving

behaviour of adult, free-ranging *C. porosus* inhabiting the Wenlock River in Cape York (Queensland, Australia) was examined to gauge the influence of seasonal thermal fluctuations (Chapter 5). Satellite and acoustic transmitters with wetdry and pressure sensors were attached/surgically implanted in 24 animals, and diving behaviour was logged throughout August-December 2015. Aerobic dive limits were estimated (cADL) for animals in the coldest and warmest month, and compared to observed submergence times. Dive durations were inversely related to water temperature, with mean and maximum dive durations reducing by 40% and 18%, respectively. A greater percentage of maximum dives exceeded cADLs in December (27.4%) compared to August (18.7%). These results suggest the aerobic dive capacity of *C. porosus* is influenced by present-day seasonal thermal increases. This body of work highlights a previously overlooked threat to ectothermic divers - climate change. My findings reveal that thermal acclimation is unlikely to buffer estuarine crocodiles from the negative consequences of elevated temperatures on dive capacity. Reduced dive durations may see time available for underwater activities cut short and forced time at the water surface may increase the conspicuousness of hatchlings and juveniles to predators. If the findings here apply to other air-breathing diving ectotherms, obligate underwater activities of this group will likely experience serious disruption under climate warming.

Arabkhazaeli, F., Rostami, A., Gilvari, A., Nabian, S. and Madani, S.A. (2018). Frequently observed parasites in pet reptiles' feces in Tehran. Iranian Journal of Veterinary Medicine 12(1) (doi: 10.22059/IJVM.2018.233466.1004812).

Abstract: Many wild-caught reptiles harbor some kind of parasites. Captivity with negative effect of poor sanitary and husbandry management may lead to clinical disease. The increasing trend in keeping non-native reptile species in the last decade emerged a need for the specification of reptile parasites and their hosts. The study aims to gain data on intestinal parasites of reptiles kept as pets or in small private collections in close contact with people. A combination of native and iodine stained direct smears along with flotation concentration were used to investigate parasites in pet reptiles' feces. All samples were investigated macroscopically and a smear was prepared and stained by modified Ziehl Neelsen for detection of *Cryptosporidium*. Stool samples from 100 pet or small zoological reptile collections (Lacertilia= 36, Serpentes= 20, Chelonii= 11, Crocodilia= 1) were collected. The total occurrence of parasite was 52%. 64.8% of the examined Lacertilia, 35.3% of Serpentes, 45.5% of Chelonii were infected. *Eimeria*, *Isospora*, *Cryptosporidium*, *Trichomonas*, *Balantidium*, Strongylid and Oxyurid eggs and amoeba were identified. *Cryptosporidium* was detected in Lacertilia, Serpentes and Chelonii. In the only sample from a Nile crocodile no parasites were detected. *Eimeria* was detected in Bearded dragon, Indian python, Albino python and king cobra and *Isospora* was identified in Bearded dragon and the alien Chelonid species Red-eared slider. *Amoeba* was identified in Iguana iguana and Horsfield tortoise. Trichomonads, *Balantidium*, *Cryptosporidium*, *Isospora*, *Eimeria*, amoebae and nematode eggs were identified in the investigated samples. *Cryptosporidium* were detected by specific stains in 14 samples. Sauria was the most infected suborder (64.8%) while 32.4% of snakes and 45.5% of chelonians were infected. Parasites are common in pet reptiles but the parasite species, the degree of infestation and hygienic management will determine the ultimate clinical outcome of the existing parasite infections. Hence examination for endoparasites should be recommended for checking the health status of all captive or newly entering reptiles.

Navara, K.J. (2018). What went wrong at Jurassic Park? Modes of sex determination and adaptive sex allocation in reptiles. Pp. 155-181 in Choosing Sexes. Fascinating Life Sciences, Springer: Cham.

Abstract: While birds and mammals determine sex of offspring via sex chromosomes, reptiles developed a new way to determine

offspring sex - through temperature. We now know that reptiles display a range of sex-determining systems, including systems that show strict genetic sex determination, systems that have genetic sex determination with a temperature override, and finally systems in which temperature determines sex with no apparent genetic underpinning. In this chapter, I will outline the many different modes of sex determination found in reptiles and discuss the evidence for adaptive sex allocation in reptilian systems.

Shartau, R.B., Crossley II, D.A., Kohl, Z.F., Elsey, R. and Brauner, C. (2018). American alligator (*Alligator mississippiensis*) embryos tightly regulate intracellular pH during a severe acidosis. Canadian Journal of Zoology (https://doi.org/10.1139/cjz-2017-0249).

Abstract: Crocodilian nests naturally experience high CO₂ (hypercarbia), which leads to increased blood PCO₂ and reduced blood pH (pH_e) in embryos; their response to acid-base challenges is not known. During acute hypercarbia, snapping turtle embryos preferentially regulate tissue pH (pH_i) against pH_e reductions. This is proposed to be associated with CO₂ tolerance in reptilian embryos and is not found in adults. In the present study, we investigated pH regulation in American alligator *Alligator mississippiensis* (Daudin, 1802) embryos exposed to 1 h hypercarbia hypoxia (13 kPa PCO₂, 9 kPa PO₂). Hypercarbia hypoxia reduced pH_e by 0.42 pH units while heart and brain pH_i increased, with no change in pH_i of other tissues. The results indicate American alligator embryos preferentially regulate pH_i, similar to snapping turtle embryos, which represents a markedly different strategy of acid-base regulation than what is observed in adult reptiles. These findings suggest that preferential pH_i regulation may be a strategy of acid-base regulation used by embryonic reptiles.

Nickum, M.J., Masser, M., Reigh, R. and Nickum, J.G. (2018). Alligator (*Alligator mississippiensis*) aquaculture in the United States. Reviews in Fisheries Science & Aquaculture 26(1). (https://doi.org/10.1080/23308249.2017.1355350).

Abstract: Commercial production of American alligator (*Alligator mississippiensis*) under intensive aquaculture conditions began in the 1980s. During the last 30 years, alligator farming has become an aquacultural industry worth millions of dollars in the southern United States. In 2014, farmers in Louisiana, the nation's largest producer of captive-reared alligators, sold more than 383,000 skins valued at more than \$77 million. Most alligator farming operations utilize wild-sourced eggs, which are collected from wetland habitats under the authority of permits issued by State agencies. Typically, these permits include a requirement to return a portion of farm-reared animals to the same area where eggs were collected to maintain wild populations. Intensive rearing of alligators requires an abundance of warm water and good quality food. Extruded feeds formulated specifically for alligator are the industry standard in modern production systems. Disease can be an occasional problem in alligator production operations but risks can be minimized with provision of clean water, high-quality feed, and good hygienic conditions in grow-out facilities. Belly skins are the primary product of alligator aquaculture, but alligator meat is also sold in niche markets. Although products made from alligator skins have strong consumer appeal, the relatively high cost of products made with alligator leather limits sales to more affluent consumers. Growth of alligator farming, using current production methods, will be limited by the natural productivity of the wild resource upon which the industry depends and demand for products utilizing alligator leather. From 2004 to 2013, global demand for skins of all species of crocodilians averaged 1.4 million skins annually, of which 24.3% were American alligator.

Iijima, M., Momohara, A., Kobayashi, Y., Hayashi, S., Ikeda, T., Taruno, H., Watanabe, K., Tanimoto, M. and Furui, S. (2018). *Toyotamaphimeia* cf. *machikanensis* (Crocodylia, Tomistominae)

from the middle Pleistocene of Osaka, Japan, and crocodylian survivorship through the Pliocene-Pleistocene climatic oscillations. Palaeogeography, Palaeoclimatology, Palaeoecology.

Abstract: Crocodylians are ectothermic animals, and their past distribution has been greatly influenced by changing climate since their Cretaceous origin. The Pliocene-Pleistocene witnessed a contraction of the crocodylian latitudinal ranges due to rapid cooling with superimposed pronounced orbital-scale climate oscillations. However, a chronologically-continuous record of the geographically marginal populations of crocodylians is yet to be provided for this time interval, and crocodylian response to such climatic changes is poorly known. This study describes a partial crocodylian skeleton from the Middle Pleistocene of Osaka, Japan, diagnosed as *Toyotamaphimeia* cf. *machikanensis*, on the basis of character comparisons, including ontogenetic skull shape change, and consideration of the reconstruction error in the holotype of *T. machikanensis*. Pliocene-Pleistocene record of fossil crocodylians in the Kinki, Tokai, and Kanto districts of Japan extends from ~3.5 Ma to ~0.3 Ma. The paleotemperature estimates for the crocodylian-bearing horizons indicate that late Early-Middle Pleistocene crocodylians in the Kinki district of Japan were living near their lower thermal limit. During the glacial periods, they might have moved to the southern extremity of Japan or locally became extinct from Japan, while re-expanding their range after the end of glacial periods.

Bravo, A.M., Sevilla, P. and Barroso-Barcenilla, F. (2018). Avian and crocodilian eggshells from the upper Barremian site of Vadillos-1 (Lower Cretaceous, Cuenca province, Spain). Cretaceous Research 85: 28-41.

Abstract: The new upper Barremian microfossil site of Vadillos-1 (Lower Cretaceous, Beteta Gorges, Cuenca province, Spain) has yielded a rich fossil assemblage consisting of numerous eggshell fragments along with diverse skeletal remains of fishes, amphibians, turtles, crocodyliforms and dinosaurs. Crocodilian eggshells constitute the main fraction of the eggshell assemblage which includes abundant material belonging to the oofamily Krokolithidae, as well as a new type of crocodilian eggshells (*Neokrokolithes trigonalis* oogen. et oosp. nov.) characterised by a type of ornamentation and microstructure of the basal knobs not described before. Few fragments of the oospecies cf. *Mycormorphoolithus kohringi*, attributed to non-eusuchian crocodylomorphs, have been also found in this site thus expanding the record of this oospecies to the upper Barremian. The eggshell assemblage has also yielded the first record of avian eggshells (*Tristatioolithus minuta* oogen. et oosp. nov.) from the Lower Cretaceous of Europe. Comparisons with Lower Cretaceous avian eggshells suggest its possible attribution to *Enantiornithes*. The tiny eggshell fragments assemblage found at Vadillos-1 site is representative of a small sized fauna. Besides, the diversity appears strongly biased with >90% of the eggshells belonging to crocodilians and approximately 9% to Aves. As established for similar outcrops, this bias may reflect differences in preservation of eggshell types or represent, at least in part, a wetland ground nesting site.

Holthaus, K.B., Strasser, B., Lachner, J., Sukserree, S., Sipos, W., Weissenbacher, A., Tschachler, E., Alibardi, L. and Eckhart, L. (2018). Comparative analysis of epidermal differentiation genes of crocodilians suggests new models for the evolutionary origin of avian feather proteins. Society for Molecular Biology and Evolution (https://academic.oup.com/gbe/advance-article-abstract/doi/10.1093/gbe/evy035/4852790).

Abstract: The epidermis of amniotes forms a protective barrier against the environment and the differentiation program of keratinocytes, the main cell type in the epidermis, has undergone specific alterations in the course of adaptation of amniotes to a broad variety of environments and lifestyles. The epidermal differentiation

complex (EDC) is a cluster of genes expressed at late stages of keratinocyte differentiation in both sauropsids and mammals. In the present study we identified and analyzed the crocodilian equivalent of the EDC. The gene complement of the EDC of both the American alligator and the saltwater crocodile were determined by comparative genomics, *de novo* gene prediction and identification of EDC transcripts in published transcriptome data. We found that crocodilians have an organization of the EDC similar to that of their closest living relatives, the birds, with which they form the clade Archosauria. Notable differences include the specific expansion of a subfamily of EDC genes in crocodilians and the loss of distinct ancestral EDC genes in birds. Identification and comparative analysis of crocodilian orthologs of avian feather proteins suggest that the latter evolved by cooption and sequence modification of ancestral EDC genes, and that the amplification of an internal highly cysteine-enriched amino acid sequence motif gave rise to the feather component Epidermal Differentiation Cysteine Rich Protein (EDCRP) in the avian lineage. Thus, sequence diversification of EDC genes contributed to the evolutionary divergence of the crocodilian and avian integuments.

Werner, J., Sfakianakis, N., Rendall, A.D. and Griebeler, E.M. (2018). Energy intake functions and energy budgets of ectotherms and endotherms derived from their ontogenetic growth in body mass and timing of sexual maturation. *Journal of Theoretical Biology* (<https://doi.org/10.1016/j.jtbi.2018.02.007>).

Abstract: Ectothermic and endothermic vertebrates differ not only in their source of body temperature (environment vs. metabolism), but also in growth patterns, in timing of sexual maturation within life, and energy intake functions. Here, we present a mathematical model applicable to ectothermic and endothermic vertebrates. It is designed to test whether differences in the timing of sexual maturation within an animal's life (age at which sexual maturity is reached vs. longevity) together with its ontogenetic gain in body mass (growth curve) can predict the energy intake throughout the animal's life (food intake curve) and can explain differences in energy partitioning (between growth, reproduction, heat production and maintenance, with the latter subsuming any other additional task requiring energy) between ectothermic and endothermic vertebrates. With our model we calculated from the growth curves and ages at which species reached sexual maturity energy intake functions and energy partitioning for five ectothermic and seven endothermic vertebrate species. We show that our model produces energy intake patterns and distributions as observed in ectothermic and endothermic species. Our results comply consistently with some empirical studies that in endothermic species, like birds and mammals, energy is used for heat production instead of growth, and with a hypothesis on the evolution of endothermy in amniotes published by us before. Our model offers an explanation on known differences in absolute energy intake between ectothermic fish and reptiles and endothermic birds and mammals. From a mathematical perspective, the model comes in two equivalent formulations, a differential and an integral one. It is derived from a discrete level approach, and it is shown to be well-posed and to attain a unique solution for (almost) every parameter set. Numerically, the integral formulation of the model is considered as an inverse problem with unknown parameters that are estimated using a series of empirical data.

Buenfil-Rojas, A.M., Alvarez-Legorreta, T. and Cedeño-Vázquez, J.R. (2018). Mercury and metallothioneins in blood fractions and tissues of captive Morelet's crocodiles in Quintana Roo, Mexico. *Chemosphere* 199: 630-636.

Abstract: Even though studies of heavy metals and their relation with metallothioneins (MTs) in reptile tissues have been conducted, research on heavy metals and MTs in organs and blood fractions of crocodylians is limited. To date there are no studies on the distribution of MTs in organs and their relation with mercury

(Hg), or the concentration of MTs in plasma and erythrocytes of crocodylians. In order to understand the role of MTs in crocodylians, our aim was to assess the detoxification mechanisms for exposure to metals in Morelet's crocodile (*Crocodylus moreletii*) by using two biomarkers (Hg and MTs) in blood fractions and tissues, and comparing them with concentrations between two populations of crocodiles, one previously wild and currently captive (Theme Park) and another raised in a Wildlife Management Unit (WMU). The caudal scutes from the Theme Park showed higher concentrations of Hg than those from the skin in the WMU samples, and significant negative relationships were observed between the total length (TL) and Hg in the scutes. The significant negative relationship between Hg and hemoglobin (Hb) may be due to disorders in the oxidation process and even denature of this protein, while the positive trend observed between MTs and Hb is consistent with the detoxifying functions and the protection against oxidative damage. This study is the first to report Hg in the erythrocytes of crocodylians and the use of MTs for testing the potential of these biomarkers as a tool to assess Hg exposure in crocodile's habitats.

Naquiah, N., Ali, M.E., Hossain, M.A.M., Sultana, S. and Ahamad, M.N.U. (2018). Double gene targeting PCR assay for the detection of *Crocodylus porosus* in commercial products. *Food Additives and Contaminants Part A*. (<https://doi.org/10.1080/19440049.2018.1440644>).

Abstract: The demand for crocodile meat is quickly growing because of its exotic and organoleptic appeal and also low content of cholesterol and lipids. Moreover, crocodile oil and blood have been used in alternative medicines for treating asthma and several other ailments since ancient times. Furthermore, crocodile hides have great demand in leather industries. All of these have collectively contributed to the extensive hunting, illegal trading and consequent decline of crocodiles in most parts of the world. To keep pace with the growing demands, some crocodile species such as *Crocodylus porosus* have been raised in farms and its commercial trades have been legalized. However, demand for wild crocodiles in foods and medicines has continued in high gear. Recently, several DNA based methods have been proposed for crocodile detection but those assays are based on single gene and longer-sized amplicon target that breaks down during extensive processing. To address the gap, here we developed and validated a highly stable double gene targeted multiplex polymerase chain reaction assay for the identification of *C. porosus* materials in commercial products. The assay involved two short-sites from *C. porosus* atp6 (77 bp) and cytb (127 bp) genes and a universal internal control (99 bp) for eukaryotes. The PCR primers were cross-tested against 18 species, validated under pure and mixed matrices under extensive boiling, autoclaving and microwave cooking conditions. Finally, it was used to identify five crocodile-based commercial products. The lower limits of detection for atp6 and cytb genes were 0.001 ng and 0.01 ng DNA, respectively, in pure meat and 1% under mixed matrices. Some inherent features such as 77-127 bp amplicon sizes, exceptional stability and superior sensitivity suggested the assay could be used for the identification *C. porosus* in any forensic specimens.

Erkol, Z. and Hösükler, E. (2018). Postmortem animal attacks on human corpses. Chapter 4. Pp. 35-56 in *Post Mortem Examination and Autopsy - Current Issues From Death to Laboratory Analysis*, ed. by K.H. Dogan. InTechOpen.

Abstract: Postmortem animal activity is an important step in incorporating protein, fat, and carbohydrates in corpses to the food chain. Many animal species are members of this food chain. Outdoor corpses may be attacked by many predacious and scavenger animals and exposed to complete destruction, and bones and belongings of the dead person may be scattered all over a large area due to postmortem animal activity. Indoor corpses may be attacked by pets, domestic dogs, cats, ants, and rodents during postmortem period. Besides, if the corpse is in shallow water, other terrestrial predators

may harm the corpse. The most important issue in the presence of lesions on the corpse caused by animals is to accurately discriminate between antemortem and postmortem wounds. The extent of the lesions caused by the animals varies according to the sizes of their dentition and jaws, but they share some common characteristics. Lack of bleeding from bitten tissue excepting small amount of extravasated blood, absence of active bleeding, edema, and erythema on the edges of the wound are among these shared characteristics. In this chapter, the subject of postmortem animal attacks on human corpses will be evaluated by revising the recent references.

Yi, H., Tennant, J.P., Young, M.T., Challands, T.J., Foffa, D., Hudson, J.D., Ross, D.A. and Brusatte, S.L. (2017). An unusual small-bodied crocodyliform from the Middle Jurassic of Scotland, UK, and potential evidence for an early diversification of advanced neosuchians. *Earth and Environmental Science Transactions of the Royal Society of Edinburgh* (<https://doi.org/10.1017/S1755691017000032>).

Abstract: The Middle Jurassic is a poorly sampled time interval for non-pelagic neosuchian crocodyliforms, which obscures our understanding of the origin and early evolution of major clades. Here we report a lower jaw from the Middle Jurassic (Bathonian) Duntulm Formation of the Isle of Skye, Scotland, UK, which consists of an isolated and incomplete left dentary and part of the splenial. Morphologically, the Skye specimen closely resembles the Cretaceous neosuchians *Pachycheilosuchus* and *Pietraroiasuchus*, in having a proportionally short mandibular symphysis, shallow dentary alveoli and inferred weakly heterodont dentition. It differs from other crocodyliforms in that the Meckelian canal is dorsoventrally expanded posterior to the mandibular symphysis and drastically constricted at the 7th alveolus. The new specimen, together with the presence of *Theriosuchus* sp. from the Valtos Formation and indeterminate neosuchians from the Kilmaluag Formation, indicates the presence of a previously unrecognised, diverse crocodyliform fauna in the Middle Jurassic of Skye, and Europe more generally. Small-bodied neosuchians were present, and ecologically and taxonomically diverse, in nearshore environments in the Middle Jurassic of the UK.

Uluwaduge, P., Edirisooriy Menike, K.V.D., Senevirathna, E.M.T.K. and Pathirana, G.C.L. (2018). Mitigating the human-crocodile conflict in Sri Lanka: A study based on the Nilwala River area in Matara District. *Procedia Engineering* 212: 994-1001.

Abstract: Human and crocodile have been coexisting for many years in Sri Lanka, particularly close to the Nilwala River area in Matara District, but fatalities were rarely reported. However, during the last decade the threats from crocodiles to humans have enhanced in the Nilwala River area, mainly during the years of 2005, 2008, 2009, 2012, 2013, 2014 and 2015. Some 26 attacks, killing 18 humans by saltwater crocodiles were recorded since 2000 in this area. In retaliation to these attacks, people in this area killed several crocodiles, and recorded the saltwater crocodile under the threatened category in Sri Lanka. Therefore, it is a worth to form a dialogue to mitigate human-crocodile conflict in the Nilwala River area in Sri Lanka. The Study was mainly based on primary and secondary data. Primary data was collected from semi-structured interviews. Sample size was consisted of 45 respondents. Secondary data was collected through published books, research reports, symposia proceedings, journal articles and websites, etc. Collected data from different sources, as mentioned above was analyzed using qualitative and quantitative methods, and it was presented using maps, texts, tables and figures. The study found that sand mining, population rise, using the river for daily needs such as drinking, bathing, washing clothes and fishing, unauthorized buildings in the river bank, scrub jungles, slow flowing of river are the major causes of the human-crocodile conflict in Nilwala River area. The study further found that Piladuwa, Fort and Thihagoda are the most vulnerable areas for human-crocodile conflict. "Kimbulkotuwa" or Crocodile Excluding

Enclosure (CEEs) is a main method used to mitigate the human-crocodile conflict in this area.

Campos, J.C., Mobaraki, A., Abtin, E., Godinho, R. and Brito, J.C. (2018). Preliminary assessment of genetic diversity and population connectivity of the Mugger Crocodile in Iran. *Amphibia-Reptilia* (10.1163/15685381-16000173).

Abstract: The Mugger Crocodile (*Crocodylus palustris*) is a threatened reptile inhabiting the Indian Sub-continent and Western Asia. Despite its "Vulnerable" conservation status, data about population genetic structure and connectivity are unavailable. This study makes a preliminary assessment of the genetic diversity, population structure and habitat connectivity of *C. palustris* in Iran. Ten tissue samples collected along the Sarbaz-Bahukalat basins were analysed and a set of 12 microsatellites was genotyped. Genetic diversity indices were estimated and population substructuring was assessed through Bayesian clustering analysis. Potential connectivity was verified through Remote Sensing water indexes, further implemented in a circuit analysis. Low genetic diversity was observed (mean observed heterozygosity= 0.35; mean expected heterozygosity = 0.43) and no population structure was found ($K=1$). Water index and circuit analysis suggested possible connection among sites. This study highlights the potential vulnerability of crocodile populations and the importance of habitat connectivity for their persistence in the arid regions of Iran.

Peng, F., Chen, X., Meng, T., Li, E., Zhou, Y. and Zang, S. (2018). Hematology and serum biochemistry parameters of captive Chinese alligators (*Alligator sinensis*) during the active and hibernating periods. *Tissue and Cell* 51: 8-13.

Abstract: The Chinese alligator *Alligator sinensis* is an endangered freshwater crocodilian species endemic to China. Hematology and serum biochemistry reference range are useful in the assessment and management of animal health condition. In this study, a total of 74 Chinese Alligators (30 males and 44 females) were examined to establish reference range values of hematology and serum biochemistry parameters during the active and hibernating periods. We measured and analyzed 9 hematology and 21 serum biochemistry parameters including 4 serum electrolyte parameters, and described the morphology of different types of blood cells. No statistical differences between the sexes were found for hematology parameter, while significant differences were noted for some serum biochemistry parameters, with males having greater alkaline phosphatase activity level and lower globulin concentration value than females. There were some significant differences between the two different periods with alligators during the active period possessing lower values for mean corpuscular volume, mean corpuscular hemoglobin, total bilirubin and creatine kinase, but higher values for red blood cell and white blood cell counts, monocyte percentage, aspartate aminotransferase, a-amylase, blood urea nitrogen, creatinine, triglycerides, and cholesterol. These baseline data were essential for health condition evaluation and disease diagnosis of this endangered species.

Winiarti, S., Prahara, A., Murinto and Ismi, D.P. (2018). Pre-trained convolutional neural network for classification of tanning leather image. *International Journal of Advanced Computer Science and Applications* 9(1): 212-218.

Abstract: Leather craft products, such as belt, gloves, shoes, bag, and wallet are mainly originated from cow, crocodile, lizard, goat, sheep, buffalo, and stingray skin. Before the skins are used as leather craft materials, they go through a tanning process. With the rapid development of leather craft industry, an automation system for leather tanning factories is important to achieve large scale production in order to meet the demand of leather craft materials. The challenges in automatic leather grading system based on type

and quality of leather are the skin color and texture after tanning process will have a large variety within the same skin category and have high similarity with the other skin categories. Furthermore, skin from different part of animal body may have different color and texture. Therefore, a leather classification method on tanning leather image is proposed. The method uses pre-trained deep convolution neural network (CNN) to extract rich features from tanning leather image and Support Vector Machine (SVM) to classify the features into several types of leather. Performance evaluation shows that the proposed method can classify various types of leather with good accuracy and superior to other state-of-the-art leather classification method in terms of accuracy and computational time.

Gross, B.A. (2017). Evaluating the Effects of Three Preservation Methods on DNA Quality and Morphology of Museum Specimens of the American Alligator (*Alligator mississippiensis*). MSc thesis, Texas Tech University, Lubbock, Texas, USA.

Abstract: Museums specimens are preserved in a way that provides a unique perspective of gathering information that can date from the present to millions of years ago. This information allows scientists to have access to an exceptional resource of species that would otherwise prove difficult to obtain. The purpose of this study is to examine two size groups (juveniles and adults, $n=9$ per age group) of the American alligator (*Alligator mississippiensis*) to: (1) compare the efficacy of three methods (dermestid beetles, burial, cold water maceration) of cleaning and preserving full body skeletons and give a taphonomic ranking system to the skeletons; (2) evaluate which method yields the highest quantity of DNA by comparing DNA concentrations between three types of bones (articular, tooth cavity, and femur) while also examining two different processes (completely destructive vs. minimally destructive). With the extraction method of choice (Rohland and Hofreiter 2007) and from a simple two-sample t-test, there was no significant difference between the “minimally destructive” and the “completely destructive” process of the bones from all preservation methods. However, for the dermestid beetle colony analysis, there was a significant difference for the femur between juveniles and adults (p -value = 0.02984); and between femur and articular regardless of size groups ($p=0.0005971$). These results allow for recommendations to museum curators, scientific researchers, who may be interested in working with/studying crocodylian museum specimens.

Rojtinnakorn, N., Tamsiripong, Y., Pimchan, T. and Eumkeb, G. (2018). Siamese crocodile plasma synergizes with ceftazidime against ceftazidime-resistant *Enterobacter cloacae*. Tropical Journal of Pharmaceutical Research 17(2): 307-317.

Abstract: Purpose: To evaluate whether Siamese crocodile plasma exhibits antibacterial properties and if it synergizes with ceftazidime against ceftazidime-resistant *Enterobacter cloacae* (CREnC). Methods: Protein fractions were from crocodile plasma and tested on CREnC strains. Multiplex polymerase chain reaction (PCR) screening test was performed for extended-spectrum β -lactamase (ESBL) phenotype and AmpC gene. The effects of the antibacterial agents were analyzed using a bacterial suspension standard curve, minimum inhibitory concentration (MIC), Checkerboard assays, viability curves, membrane permeability assays, enzyme assays, and transmission electron microscopy. Results: CREnC strains expressed ESBL-AmpC gene combinations. The MICs of resuspended protein 1 (P1), protein 5 (P5), ceftazidime, cefotaxime, and benzylpenicillin against all tested CREnC and *E. coli* strains were in the range of $>1024 \mu\text{g/mL}$, indicating resistance. However, P1 and P5 exhibited a synergistic effect against test CREnC and *E. coli* strains when used in combination with ceftazidime and cefotaxime, with fraction inhibitory concentration indices of <0.062 and 0.28 , respectively. A kill curve demonstrated that the combination treatments had synergistic activity and inhibited β -lactamase. Conclusion: The synergistic activity of P1 and P5 in combination with ceftazidime is achieved in multiple ways, including increased cytoplasmic and outer

membrane permeability, β -lactamase inhibition, and peptidoglycan damage. Therefore, the combination therapy of Siamese crocodile plasma and ceftazidime may be a novel therapeutic approach for treating recalcitrant *E. cloacae* infection.

Yang, H., Zhao, L., Han, Q. and Fang, S. (2017). Nest site preference and fidelity of Chinese alligator (*Alligator sinensis*). Asian Herpetological Research 8(4): 244-252.

Abstract: Oviparous female reptiles select nesting sites with optimal ecological factors that contribute to egg development. Chinese alligator (*Alligator sinensis*), an oviparous reptile, is a critically endangered crocodilian with temperature-dependent sex determination. Research on its nesting behavior may facilitate the protection of this species. In this study, we monitored nesting behavior over 8 years. We compared selected frequency of nest sites, distance from nest site to water, height from nest site top to the water surface, distance from nest site to human activity region, and canopy density between nest sites on the island and bank. The results showed that 45 nest sites were used by female alligators over 8 years and each site was selected from one to 10 times. The selected frequency of nest site occurrence on the island was higher than that on the bank ($P<0.001$). We observed that 88% of the individual alligators (15/17) showed different degrees of nest site fidelity. However, Chinese alligators might not always be loyal to only one nest site because of environmental changes or interspecific competition at nest sites. Our findings suggest that female alligators prefer to nest at island, which might be because of the nests on the island had a higher canopy density ($P=0.010$) and were further from the human activity region ($P<0.001$) than those on the bank did. It would be beneficial to reduce human activities during the breeding season and protect the vegetation of Chinese alligator habitats in the future.

Gorcak, R., Chaves, R.O., Teixeira, M.L., De Freitas, Í.B., Martins, R.C., Valandro, M.A., Copat, B. and Soares, A.V. (2018). Anesthesia in American alligator (*Alligator mississippiensis*) for a limb amputation. Acta Scientiae Veterinariae 45 (http://www.ufrgs.br/.../CR_195.pdf).

Abstract: An 8-year-old female American alligator, 2 m long and 268 964 pounds, with fight history with another animal six months ago and resulted to a wound in the right thoracic limb is reported. It was during the breeding season when the lesion so treatment was not opted during the time. An X-ray of the member was performed which showed among other changes, osteomyelitis and septic arthritis, and limb amputation was indicated. Ketamine (10 mg/kg) and medetomidine (0.1 mg/kg) were used as anaesthetic premedication, both administered intramuscularly. Propofol (4 mg/kg) was then administered intravenously. The animal was intubated using an endotracheal tube number 11 without inflating the cuffing, and for the maintenance it was employed isoflurane. The heart rate was measured using Doppler and the respiratory rate by visual and balloon observation in the oxygen circular system. The other parameters were measured using a multiparameter monitor sensor connected to the tongue. The local anaesthetic block was made close to the incision line, the medium third humerus with 2 mg/kg of 2% lidocaine without vasoconstrictor, diluted in 0.9% NaCl until the volume of 10 mL is completed to assist in analgesia. The parameters recorded during the procedure, which lasted 80 min, remained within the normal pattern of species (three breaths per minute, 30 heart beats per min and 80.6°F temperature). Meloxicam (0.2 mg/kg) and atipamezole reverser (0.5 mg/kg) were administered intramuscularly after surgery. The animal took ~ 7 h to fully recover from anaesthesia. It is concluded that the anaesthetic protocol based on premedication with ketamine and medetomidin, and propofol induction and maintenance with isoflurane, besides local anaesthesia with lidocaine is effective and safe for thoracic limb amputation surgery in an American alligator.

Ariel, E., Elliott, E., Meddings, J.I., Miller, J., Santos, M.B. and Owens, L. (2018). Serological survey of Australian native reptiles for exposure to ranavirus. *Dis. Aquat. Organ.* 126(3): 173-183.

Abstract: Ranaviruses have been isolated from many ectothermic vertebrates, and serological surveys of both amphibians and reptiles have shown the presence of ranaviral antibodies in a proportion of these populations. An enzyme-linked immunosorbent assay (ELISA) was developed to measure serum antibodies against ranavirus in Australian reptiles. The ELISA was validated with serum from challenge trials with Bohle iridovirus (BIV) in 6 reptilian species. A preliminary sero-survey of northern Queensland riparian reptile fauna (saw-shelled turtles *Myuchelys latisternum*, Krefft's river turtles *Emydura macquarii krefftii*, freshwater crocodiles *Crocodylus johnstoni*, as well as the snakes *Boiga irregularis*, *Dendrelaphis punctulatus*, *Tropidonophis mairii*, *Morelia spilota*, *Liasis childreni* and *L. fuscus*) revealed evidence of past exposure to Bohle iridoviral antigens in part of the population at several locations sampled. Furthermore, in Krefft's river turtles and freshwater crocodiles, a statistically significant trend was apparent for larger reptiles to be more likely to have BIV-reactive sera than smaller individuals. The use of adult tortoise populations as sentinels can assist in monitoring the presence of BIV in northern Australian freshwater streams, and thereby the potential dangers to native fauna from this agent.

Graefe M. (2018). BERLIN: The Zoological Collection of the Stadtmuseum Berlin. Pp. 135-139 in *Zoological Collections of Germany. Natural History Collections*, ed. by L. Beck. Springer: Cham.

Abstract: The zoological collection of the Stadtmuseum Berlin was founded in 1978 as part of the Naturwissenschaftliche Sammlung Berlin by a sponsorship association, the "Fördererkreis der naturwissenschaftlichen Museen Berlins e.V.". In 1995 the collection was integrated into the newly founded Stadtmuseum Berlin, Landesmuseum für Kultur und Geschichte Berlins. The small collection mainly contains lifelike mounted specimens of birds and mammals as well as casts of fishes, reptiles and amphibians created for exhibition purposes. There are only few scientific collections, especially of insects. According to the focus of the Stadtmuseum, the collection is concentrated on the regional reference. Besides specimens living in Berlin in our days, there are also some examples of formerly native species of the region, like the wolf and the brown bear. Some formerly prominent inhabitants of the Zoological Garden Berlin also belong to the collection, for example, the giant panda Tien Tien, the male hippopotamus Knautschke and the American alligator Swampy.

Gallagher, A.J., Papastamatiou, Y.P. and Barnett, A. (2018). Apex predatory sharks and crocodiles simultaneously scavenge a whale carcass. *Journal of Ethology* (<https://doi.org/10.1007/s10164-018-0543-2>).

Abstract: Scavenging is an important component to the overall ecology of consumers in virtually all ecosystems on Earth. Given the energetic benefits of foraging on these resource subsidies, opportunistic predators will adjust their behaviors accordingly to maximize access. One of the many consequences of large-scale scavenging opportunities is species interactions that are rarely observed in nature. Here we describe the first published record of predatory sharks (tiger sharks, *Galeocerdo cuvier*) and saltwater crocodiles (*Crocodylus porosus*) foraging together in space and time, as documented on a large whale carcass off Western Australia. We report on and discuss the behaviors of the sharks and crocodiles in the hope of shedding new light on the interactions between apex predators that are rarely seen together, but may overlap under specific contexts.

Iijima, M., Kubo, T. and Kobayashi, Y. (2018). Comparative limb proportions reveal differential locomotor morphofunctions of

alligatoroids and crocodyloids. *R. Soc. open sci.* 5: 171774.

Abstract: Although two major clades of crocodylians (Alligatoroidea and Crocodyloidea) were split during the Cretaceous period, relatively few morphological and functional differences between them have been known. In addition, interaction of multiple morphofunctional systems that differentiated their ecology has barely been assessed. In this study, we examined the limb proportions of crocodylians to infer the differences of locomotor functions between alligatoroids and crocodyloids, and tested the correlation of locomotor and feeding morphofunctions. Our analyses revealed crocodyloids including *Gavialis* have longer stylopodia (humerus and femur) than alligatoroids, indicating that two groups may differ in locomotor functions. Fossil evidence suggested that alligatoroids have retained short stylopodia since the early stage of their evolution. Furthermore, rostral shape, an indicator of trophic function, is correlated with limb proportions, where slender-snouted piscivorous taxa have relatively long stylopodia and short overall limbs. In combination, trophic and locomotor functions might differently delimit the ecological opportunity of alligatoroids and crocodyloids in the evolution of crocodylians.

Leiva, P.M.L., Simoncini, M.S., Portelinha, T.C.G., Larriera, A. and Piña, C.I. (2018). Size of nesting female Broad-snouted Caimans (*Caiman latirostris* Daudin 1802). *Brazilian Journal of Biology* (<http://dx.doi.org/10.1590/1519-6984.180892>).

Abstract: The southern distribution of the Broad-snouted Caiman (*Caiman latirostris* Daudin 1802) in Argentina occurs in Santa Fe Province, where its population has been under management by "Proyecto Yacaré" since 1990. From 1997 to 2016, we captured 77 nesting female Broad-snouted Caimans in Santa Fe Province. Our results suggest that previously defined size classes for Broad-snouted Caiman do not adequately describe the reproductively mature female segment of the population. Here we propose to change size ranges for general size classes for Broad-snouted Caiman. In addition, we have observed that reintroduced reproductive females by Proyecto Yacaré represent about 32% of captured females. These results indicate that reintroduced females by the management program are surviving and reproducing in the wild at least up to 20 years.

Chanhiran, P. (2008). The role of Crocodiles in Thai Tales. MA thesis, Chulalongkorn University, Bangkok, Thailand (<https://cuir.car.chula.ac.th/handle/123456789/57225>).

Abstract: This thesis aims to study the characteristic and the role of crocodile in Thai tales. The researcher collected 107 stories from oral and literary versions, which are 152 crocodiles. It is found that the crocodile characters appear in 9 forms of Thai tales which are myth, religious tale, fable, fairy tale, novella, legend, explanatory tale, animal tale, and Jest. The crocodile characters are either natural crocodiles or supernatural ones. The natural crocodiles have all external appearances like the ordinary ones and are always bad characters. On the other hand, the supernatural crocodiles have external appearances, births and magic powers that are different from those of the ordinary crocodiles. The supernatural crocodiles in Thai tales are always good characters. The crocodile character in Thai tales must be categorized in one of the four groups which are a protagonist, an antagonist, a helper, and a supporting character. Crocodile characters have 6 roles that are a destroyer, a protector, a protagonist helper, a carrier, a traditional bearer, and an instructor. It is found that the crocodile characters always be a destroyer and a protector, that are opposite roles but cause from a crocodile's fear too. Thai tales make at least 2 symbols of crocodile that are a symbol of the sacred animal and a symbol of the stingy person who never give charity.

Kohei Tanaka, K., Zelenitsky, D.K., Therrien, F. and Kobayashi, Y. (2018). Nest substrate reflects incubation style in extant archosaurs with implications for dinosaur nesting habits. *Scientific Reports* 8:

Abstract: Dinosaurs thrived and reproduced in various regions worldwide, including the Arctic. In order to understand their nesting in diverse or extreme environments, the relationships between nests, nesting environments, and incubation methods in extant archosaurs were investigated. Statistical analyses reveal that species of extant covered nesters (i.e., crocodylians and megapodes) preferentially select specific sediments/substrates as a function of their nesting style and incubation heat sources. Relationships between dinosaur eggs and the sediments in which they occur reveal that hadrosaurs and some sauropods (i.e., megaloolithid eggs) built organic-rich mound nests that relied on microbial decay for incubation, whereas other sauropods (i.e., faveoololithid eggs) built sandy in-filled hole nests that relied on solar or potentially geothermal heat for incubation. Paleogeographic distribution of mound nests and sandy in-filled hole nests in dinosaurs reveals these nest types produced sufficient incubation heat to be successful up to mid latitudes ($\leq 47^\circ$), 10° higher than covered nesters today. However, only mound nesting and likely brooding could have produced sufficient incubation heat for nesting above the polar circle ($>66^\circ$). As a result, differences in nesting styles may have placed restrictions on the reproduction of dinosaurs and their dispersal at high latitudes.

Nayak, L., Sharma, S.D. and Pati, M.P. (2018). Conservation and management of Saltwater crocodile (*Crocodylus porosus*) in Bhitarkanika Wildlife Sanctuary, Odisha, India. Pp. 307-321 in Management of Marine Ecosystems, ed. by M.N. Islam and S.E. Jorgensen. CRC Press: Boca Raton.

Fernandez Blanco, M.V. (2018). Análisis morfológico del esqueleto de las especies argentinas del género *Caiman* (Alligatoridae: Caimaninae). PhD thesis, National University of La Plata, Buenos Aires.

Briscoe, S.D. and Ragsdale, C.W. (2018). Molecular anatomy of the alligator dorsal telencephalon. Journal of Comparative Neurology (https://doi.org/10.1002/cne.24427).

Abstract: The evolutionary relationships of the mammalian neocortex and avian dorsal telencephalon (DT) nuclei have been debated for more than a century. Despite their central importance to this debate, non-avian reptiles remain underexplored with modern molecular techniques. Reptile studies harbor great potential for understanding the changes in DT organization that occurred in the early evolution of amniotes. They may also help clarify the specializations in the avian DT, which comprises a massive, cell-dense dorsal ventricular ridge (DVR) and a nuclear dorsal-most structure, the Wulst. Crocodylians are phylogenetically and anatomically attractive for DT comparative studies: they are the closest living relatives of birds and have a strikingly bird-like DVR, but they also possess a highly differentiated reptile cerebral cortex. We studied the DT of the American alligator, *Alligator mississippiensis*, at late embryonic stages with a panel of molecular marker genes. Gene expression and cytoarchitectonic analyses identified clear homologs of all major avian DVR subdivisions including a mesopallium, an extensive nidopallium with primary sensory input territories, and an arcopallium. The alligator medial cortex is divided into three components that resemble the mammalian dentate gyrus, CA fields, and subiculum in gene expression and topography. The alligator dorsal cortex contains putative homologs of neocortical input, output, and intratelencephalic projection neurons and, most notably, these are organized into sublayers similar to mammalian neocortical layers. Our findings on the molecular anatomy of the crocodylian DT are summarized in an atlas of the alligator telencephalon.

Pablo S. Hernández-Hurtado, P.S., Nolasco-Soria, H., Carrillo-Farnés, O., Hernández-Hurtado, H., García de Quevedo-Machain,

R., Casas-Andreu, G., Montoya-Martínez, C. and Vega-Villasante, F. (2018). Contributions to the nutrition of the American crocodile *Crocodylus acutus* (Cuvier, 1807). Latin American Journal of Aquatic Research 46(1): 15-19.

Abstract: In this work evaluated basics aspects of *Crocodylus acutus* nutrition, through the knowledge of the essential amino acid (aa) profile of its muscle and calculating their chemical score of main proteins used in their diet in captivity. The separation and identification of aa is carried out by high performance liquid chromatography (HPLC) with fluorescence detection. The calculation of chemical score (CS) was obtained by dividing the value of essential aa between aa of the reference protein. The amino acids present in greater quantities in the tail muscle are glutamic acid, lysine and leucine (16.96, 9.84 and 8.87 g aa / 100 g protein, respectively), whereas histidine, methionine and tryptophan (2.99, 2.93 and 0.59 g aa/100 g of protein) were the lowest. The results obtained with the CS show that the proteins of animal origin, preferably marine fish and supplemented with terrestrial animals ingredients, beef liver among these appear to be the most effective. The incorporation of plant proteins in diets for *C. acutus* does not appear as a viable alternative due to deficiencies in several of the essential amino acids such as methionine, lysine and threonine. Therefore, the essential amino acid profile of *C. acutus* muscle and the CS of protein sources may suggest a optimal diet, preferably supplemented with marine fish and terrestrial animal ingredients, such as beef liver. Our results suggest that both protein sources provide essential amino acids similar to the amino acid profile of *C. acutus* muscle.

Malte, C.L., , Bundgaard, J., Jensen, M.S., Mads Frost Bertelsen, M.F. and Wang, T. (2018). The effects of morphine on gas exchange, ventilation pattern and ventilatory responses to hypercapnia and hypoxia in dwarf caiman (*Paleosuchus palpebrosus*). Comparative Biochemistry and Physiology Part A: Molecular & Integrative Physiology (https://doi.org/10.1016/j.cbpa.2018.03.008).

Abstract: Morphine and other opioids cause respiratory depression in high doses and lower the ventilatory responses to hypoxia and hypercapnia in mammals. Recent studies indicate that turtles respond similarly, but although they are used routinely for post-surgical analgesia, little is known about the physiological effects of opioids in reptiles. We therefore investigated the effects of morphine (10 and 20 mg kg⁻¹) on gas exchange and ventilation in six dwarf caiman (*Paleosuchus palpebrosus*) using pneumotachography in a crossover design. Intraperitoneal injections of morphine changed the ventilation pattern from a typical intermittent/periodic pattern with a few or several breaths in ventilatory bouts to single breaths and prolonged the apnoea, such that respiratory frequency was depressed, whilst tidal volume was elevated. Furthermore, the duration of inspiration and especially expiration was prolonged. The resulting decrease in minute ventilation was attended by a lowering of the respiratory exchange ratio (RER) (especially for 20 mg kg⁻¹ dose) indicating CO₂ retention with a long time constant for approaching the new steady state. The changes in ventilation pattern and gas exchange reached a new stable level approximately 3 h after the morphine injection and did not significantly affect steady state O₂ uptake, ie O₂ consumption. As expected, the ventilatory response to 5% O₂ was lower in morphine-treated caimans, but minute ventilation upon exposure to 2% CO₂ did not differ significantly different from control animals.

Shapiro, R. and Calander, V. (2018). Social impact of hair loss. Chapter 13: 176-19 in Hair and Scalp Diseases, ed. by M. Hodinskiy (http://www.worldfueinstitute.com/article/13/).

Excerpt: ... One of the oldest known medical texts is an ancient Egyptian papyrus scroll. Among its remedies is an ointment for restoring hair loss consisting of equal parts crocodile and hippopotamus fat.....

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