CROCODILE SPECIALIST GROUP NEWSLETTER

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NEWSLETTER

VOLUME 38 Number 1
JANUARY 2019 - MARCH 2019

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COVER PHOTOGRAPH: Wild Orinoco crocodiles (*Crocodylus intermedius*) at Hato El Cedral, Apure State Venezuela. Photograph: Alvaro Velasco.

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CSG Newsletter

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

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

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Editorial

I am saddened to report that Venezuelan CSG member Ernesto Boede passed away in early March, following a long fight with cancer. See Obituary on page 4.

I attended the "2nd Forum on Crocodiles in the Philippines", with Tom Dacey and Charlie Manolis, on 6-8 March 2019. There were 111 participants, mostly from the Philippines, but including international attendees from 12 countries. It was a great opportunity to meet new people now engaged in a string of research programs, providing updates on the status of research, conservation and management efforts for both *C. porosus* and *C. mindorensis* in the Philippines. Representatives from Indonesia, Malaysia, Thailand and Brunei addressed the growing problem of Human-Crocodile Conflict with *C. porosus*. See summary on pages 13-15.

CSG participation at the 18th Conference of the Parties to CITES (CoP18), Sri Lanka, 23 May-4 June 2019, is now consolidated. Several members of the CSG Future Leaders Program will be attending, as members of the IUCN delegation: others will participate on Party or NGO delegations. We are grateful to several donors for supporting this activity, as CITES is a complex arena in which CSG has long been involved. Mexico has submitted a proposal to transfer its *C. acutus* population from Appendix I to Appendix II, reflecting the significant national recovery of this species.

We were all surprised by fashion company Chanel announcing that it would no longer use exotic skins for leather fashion products, claiming it had become difficult to source such skins "ethically"! Claims by Chanel designer Karl Lagerfeld, that animal rights groups were not involved in this decision, were undermined by these groups claiming victory! Rosie Cooney, Dan Natusch, Tomas Waller and I published an article (https://www.businessoffashion.com/articles/opinion/op-ed-why-chanels-exotic-skins-ban-is-wrong) within days pointing out that actions such as this undermined conservation programs and were hardly consistent with corporate social responsibility! Indeed, they appeared to be knee-jerk reactions, driven by some opportunistic marketing agenda, that seems to assume animal rights activists are important clients of Chanel. Cannot see it myself, but maybe they are. Selfridges, a large retail outlet in London, then adopted a similar position. It is frustrating that these corporations can undermine conservation and livelihoods and claim the high moral ground for doing so (https://www.iucn.org/crossroads-blog/201903/banning-exotic-leather-bad-reptiles).

In January 2019 I attended a meeting of the International Crocodile Farmers Association (ICFA) in Milan, Italy, where three CSG issues were on the agenda. ICFA is developing a set of standards for crocodilian farming, using the latest information on science-based animal welfare, which has been an arduous undertaking. It is important that these standards are extended over time to farms that are not yet ICFA members, and this will be a clear challenge for ICFA. CSG comments on the ICFA standards framework were assembled by Dr. Paolo Martelli, and CSG is yet to see the individual positions on each aspect of farming - these will come later. Perhaps most important, I had the opportunity to address both ICFA and a meeting of "Brands" about the need to ensure "conservation" outcomes were a significant priority when making decisions about crocodilian fashion leather. At the last CSG Working Meeting in Argentina, the negative impact of changes in the market place on conservation was discussed at length.

Another looming battleground for conservation is occurring in State of California, in the USA. California is arguably the 5th largest economy in the world. Around 1970 it banned trade and possession of crocodilian products, through a provision of the penal code, but it was not enforced. Then a series of "sunset" provisions extended the time for which it would not be enforced - the last of these expires in early 2020. If the penal code becomes enforceable, it would seriously impact on Louisiana in particular, which has an extensive and highly successful conservation-management program for *Alligator mississippiensis*, but it would also impact on other countries that export crocodilian products to the USA. I was able to join with Louisiana alligator farmers and wildlife agencies in supporting the concept of conservation through sustainable use. It will take some time before a final decision is made.

The CSG Regional Meeting being organised in Belize by Dr. Marisa Tellez is approaching rapidly (26-29 June 2019), and we hope that it will be well attended (https://www.2019csgregionalmeeting.com). With the theme of "Fostering Regional Conservation through Collaboration", the meeting is intended to extend the network of key stakeholders in Central America and the Caribbean, discuss current conservation and management issues, and further collaborative research within the sub-region.

The 26th CSG Working Meeting will be held at Chetumal, Quintana Roo, Mexico, on 4-7 May 2020, and will be preceded by a veterinary workshop on 2 May, and a CSG Steering Committee meeting on 3 May.

On a more personal note, a recent publication by Dr. Bjarke Jensen entitled "Commemoration of Comparative Cardiac Anatomy of the Reptilia I-IV" [Journal of Morphology

280(4): 623-626] commemorated work that I did on reptile heart anatomy around 50 years ago, as a student. It was a total surprise - but a pleasant and gratifying one. The reptile heart has always been a zoological puzzle, although with today's technology it is being unravelled at a much more rapid pace than ever before.

Professor Grahame Webb, *CSG Chair.*

Obituary

Ernesto Boede (1952-2019)

On 8 March 2019, Ernesto Otto Boede Wantzelius (66) passed away in Valencia, Venezuela, after a long battle with cancer, in the company of Nancy (wife) and his closest friends. Ernesto is survived by sons Oliver and Federico.

Ernesto was born on 30 June 1952, in Caracas. He graduated as a veterinarian from the Central University of Venezuela, and worked as a veterinarian at the National Foundation of Zoos and Aquaria in Venezuela. In 1986, with his wife and business partner Dr. Luis Troya, he created the mixed practice Centro Veterinario Los Colorados Valencia, that continues working to this day and is recognized as the pioneer of wildlife and exotic medicine in Venezuela.

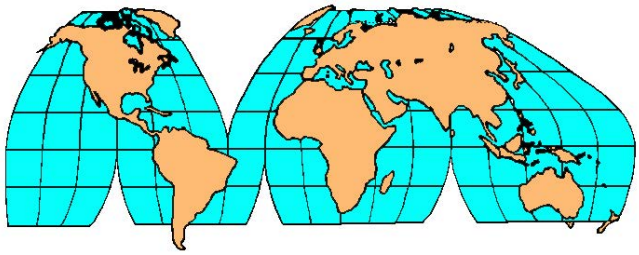
Ernesto began to be involved with Venezuela's wildlife during the 1970s and 1980s, with his principal interest being crocodiles, manatees, jaguars, turtles and Orinoco River dolphins (Toninas). Since the 1990s he was involved with the *Caiman crocodilus* ranching program, and began to advise FUDECI on captive breeding programs with *Crocodylus intermedius* and terrestrial turtles at Puerto Miranda and Masaguaral Ranches.

Ernesto was one of the founders of the Venezuelan Crocodile Specialist Group and was a CSG member. He authored many papers related to wildlife medicine issues such as diseases, sanitary protocols in captivity and wildlife management.

All his friends will remember him by his particular greeting "como esta la vaina".

Alvaro Velasco, *with many thanks to Ernesto's family for information and review of this obituary.*

Regional Reports



Latin America and the Caribbean

Panama

"CROCODYLIA OF MESOAMERICA" SYMPOSIUM. The Symposium "Crocodylia of Mesoamerica: Current Conservation Status and Future Challenges" was held under the auspices of the XXII Congress of the Mesoamerican Society for Biology and Conservation (SMBC) in Panama City, Panama, on 24 November 2018. Miryam Venegas de Anaya, Laura Patricia Porras Murillo, Armando H. Escobedo Galván, and Pablo Siroski as external advisor, coordinated the symposium.

The symposium was logistically and financially supported by Technological University of Panama (TUP) and the Smithsonian Tropical Research Institute (STRI). Additional support was provided by the International Institute in Conservation and Management of Wildlife of the National University of Costa Rica, and Centro Universitario de la Costa of the University of Guadalajara, México.

The idea for the symposium was formed at the CSG working meeting held in South Africa (2016), where Miryam and Laura identified the urgent need for a forum to learn about the status of crocodilians in Mesoamerica. The request for a regional forum originated during the CSG working meeting held in Argentina in 2018. In response, and taking advantage of the fact that the XXII Congress of the Mesoamerican SMBC would be held in Panama on 21-25 November 2018, Miryam, Laura and Armando began to organize the symposium.

The principal objective of the symposium was to know the current status of Mesoamerican crocodilians (*Crocodylus acutus*, *C. moreletii* and *Caiman crocodilus* complex), in order to identify: 1) gaps in knowledge and the conservation challenges of crocodilians in the region; 2) establish future directions in conservation and research in Mesoamerica; and, 3) promote contacts and alliances with administrative and scientific authorities of the countries of the region within CSG activities.

Before the symposium, participants and organizers had breakfast with Dr. Carlos Rovetto, scientific coordinator of TUP, Dr. Luz Graciela Cruz representing the Panamanian National Secretariat of Science and Technology (SENACYT), and Dr. Oris Sanjur representing STRI. The breakfast allowed the establishment of collaboration in crocodilian issues.

Figure 1. Speakers at symposium, from left: John Jairo Gomez (Colombia), Pierre Charruau (Mexico-France), Valerie García (Guatemala) and Miryam Venegas de Anaya (Panama).

Figure 2. Speakers and assistants at Symposium. Standing: Marco López (Mexico), Carolina Sánchez (Mexico), Valerie García (Guatemala), Laura Porras (Costa Rica), Miryam Venegas (Panama), Oris Sanjur (Panama); kneeling: Armando Escobedo (Mexico), Gabriel Barrios (Mexico), John Jairo Gómez (Colombia), Roberto Ibañez (Panama).

Figure 3. Field trip to Barro Colorado Island, the biological station of the Smithsonian Tropical Research Institute.

There were 14 presentations from Mexico, Belize, Guatemala, El Salvador, Honduras (Mario Espinal could not attend the symposium), Costa Rica and Panama. The presentations included topics from national conservation status in Mexico, Belize, Guatemala, Costa Rica and Panama, human-crocodile interactions, the use of new technologies to monitor crocodilians, to specific topics such as blood biometry and trophic ecology of the American crocodile and Spectacled caiman. It was interesting to note that women made most of the presentations.

Following the symposium, an informal working meeting, supported by STRI and SENACYT, was held at Barro Colorado Island (BCI) on 25-26 November. The main goal of this meeting was to analyze the information presented at the symposium and to establish work goals within and between countries with similar conservation problems/challenges. Participants included Marco Antonio López Luna, Gabriel Barrios Quiroz, Pierre Charruau, Armando Escobedo Galván (Mexico), Valerie Corado García (Guatemala), Miryam Venegas Anaya, Stephany del Rosario, Melciellyne Aguilar (Panama) and Laura Porras Murillo (Costa Rica). Pablo Siroski (Argentina/CSG Regional Chair for Latin America and the Caribbean) and Marisa Tellez (Belize/CSG Regional Vice Chair for LAC) were "virtual participants".

In the BCI meeting, the following issues were discussed:

1. Research initiative Mexico-Guatemala for the Usumacinta Basin.
2. Population genetics of *C. acutus* (this topic has been addressed by Miryam for over 10 years), and additional samples to be included from Chinchorro and Cozumel, Mexico (Miryam Venegas de Anaya and Pierre Charruau).
3. Development of a DNA database of samples with minimum sample information (eg date, locality-GPS, type of sample, type of sample conserve, and collector), and keep available for genetic/molecular research with a established protocol for collaboration.
4. Update from Frank Mazzotti or Kent Vliet on the current status of the book-proof on *C. acutus* coordinated by John Thorbjarnarson.
5. Standardization on a permanent marking system, as well as the encounter rate estimates to be able to compare survey data at a regional level.
6. Preparation of a proposal by Guatemala, Costa Rica and Panama to begin regional assessments.

We expect to have some of the meeting's objectives ready for the upcoming CSG regional meeting in Belize in June 2019.

Miryam Venegas de Anaya *(Technological University of Panama and Smithsonian Tropical Research Institute, Panama; dracocodrilo@hotmail.com)*, Laura Patricia Porras Murillo *(International Institute in Conservation and Management of Wildlife, National University, Heredia, Costa Rica; laura.porras.murillo@una.cr)* and Armando H. Escobedo-Galván *(Centro Universitario de Guadalajara, University of Guadalajara; elchorvis@gmail.com)*.

Brazil

MULTIPLE USES OF CUVIER'S DWARF CAIMAN, *PALEOSUCHUS PALPEBROSUS*, IN THE SEMI-ARID REGION OF NORTHEASTERN BRAZIL. Crocodilians have been used by humans around the world for a variety of purposes, especially for skins and meat trade (Thorbjarnarson 1999). They are also used in cultural interactions, such as medicinal, ornamental and religious purposes (Pooley *et al*. 2016a,b). Literature about cultural interrelationships

involving crocodilians in Brazil is scarce, except in the north and northeast. The teeth, fat and heads of *Caiman latirostris*, *C. crocodilus* and *Paleosuchus palpebrosus* have reportedly been used to protect against snake bites (Alves *et al*. 2007), and for medicinal, spiritual and religious purposes (Alves *et al*. 2012a,b).

Paleosuchus palpebrosus is widely distributed across different aquatic environments, more frequently near urbanized and populated areas (Campos and Mourão 2006; Campos *et al*. 2015; Muniz *et al*. 2015). Little is known about the environments that this species occupies in the Cerrado/Caatinga ecotone in Brazil, or the threats it faces in this region. Here, we report on the use of *P. palpebrosus* for medicinal and spiritual purpose, and discuss human occupation of the preferential habitat of the species - wet environments of *Mauritia flexuosa* palm groves regionally known as "veredas"or "brejos" - in the states of Maranhão (MA) and Piauí (PI), Brazil. This region is situated in a Cerrado/Caatinga ecotone area in which there is a paucity of aquatic environments due to low annual rainfall (Nimer 1972). In such regions, swamps and lakes represents fragile aquatic environments that are often the result of anthropic processes that have devastated the landscape (Tabarelli and Santos 2004), such as dams, artificial ponds for cattle, irrigation and palm grove exploration.

In May 2017 we visited Baixinha da Santana, a community in the municipality of São Benedito do Rio Preto, MA (3º 19'39.82''S, 43º 31'41.15''W), located near a tropical rainforest stream and its surrounding "brejos". We found *P. palpebrosus* skulls (12.2, 18.5, 16.0, 16.5 and 17.0 cm) hanging on walls facing entrance doors of three houses and a market (Fig. 1A-B), as well as inside a shed (Fig. 1C) on the banks of a stream in the municipality of Barra da Corda, MA (5º 30'19.39''S, 45º 17'43.95''W). Some of the skulls were painted black, and their mouths left open to scare away spirits and protect the homes/market. The residents of the Baixinha community killed the *P. palpebrosus* during the dry season (October 2016) for food, and kept their skins (Fig. 2A) and heads. The feet were fashioned into keychains (Fig 2B), and the scales and bones were used as medicine after being dried and ground and placed in wine. Teeth are strung onto cords to make necklaces to scare away snakes in the municipalities of Carolina (7º 22'31.64"S, 47º 12'24.19"W) and Balsas, MA (7º 33'18.72"S, 46º 20'34.22"W).

Besides the hunting pressure on *P. palpebrosus* in this region, the main habitats of the species are increasingly being threatened by roads (Fig. 3A), urbanization and agricultural and livestock expansion. Corroborating this threat, we found that palm groves in the municipality of Palmeira do Piauí, PI (8º 43'33.64"S, 44º 14'15.49"W) and Brejo do Piauí, PI (8º 18'52.27''S, 42º 52'10''S) had been destroyed by burning and by the installation of irrigation pumps to water a cassava plantation (Fig. 3B-C). Still, we caught 6 *P. palpebrosus* (snout-vent lengths between 17.5 and 62.5 cm) walking in *M. flexuosa* palm grove habitat.

Anthropogenic pressure in this region of Brazil is high,

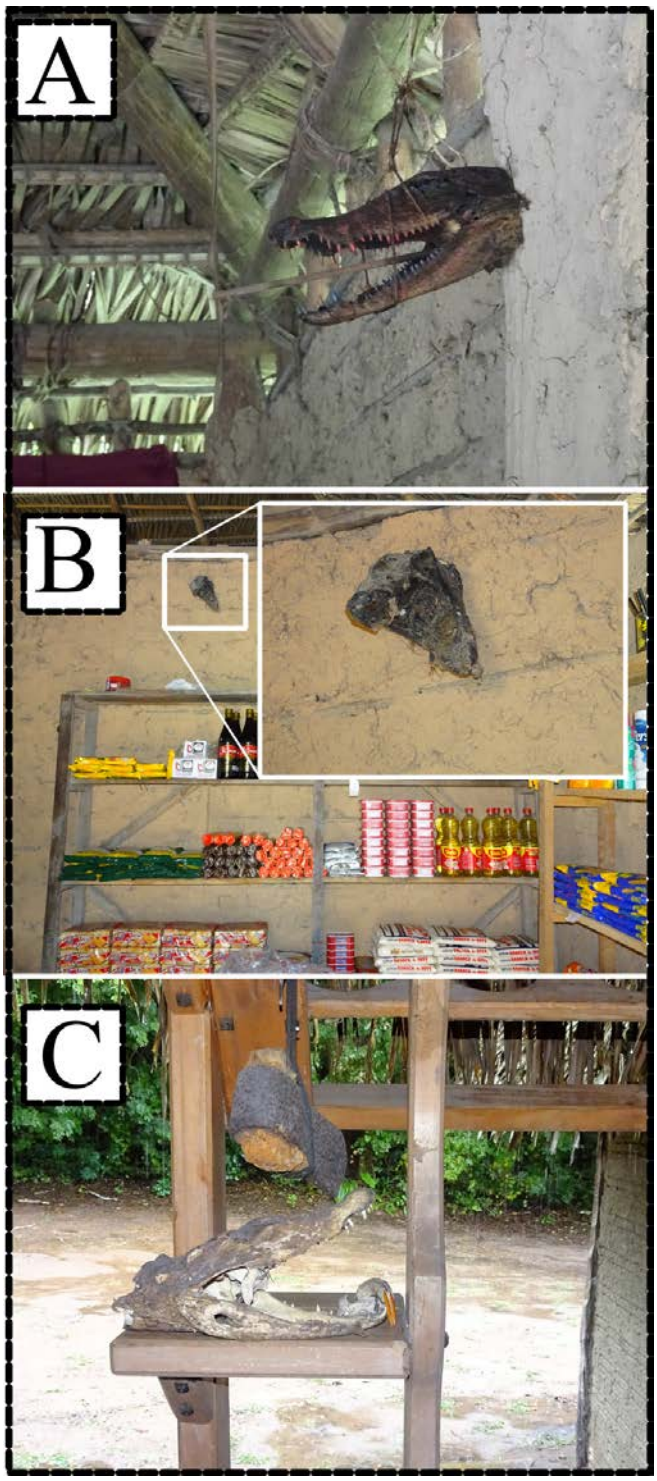


Figure 1. *Paleosuchus palpebrosus* skulls hanging on walls of a house (A) and market (B), and shed (C), in Maranhão State.

not only at the level of individuals but also at the level of destruction of their environments, which are restricted and seasonal due to the scarcity of rainfall. The cities, towns and communities in this region of Brazil are always located in the neighborhood or inside the swampy areas of *M. flexuosa* palm groves. These palm swamp environments require urgent protection to ensure the survival of groups of semi-aquatic and aquatic animals, especially *P. palpebrosus*. The multiple uses to which *P. palpebrosus* is subjected, together with

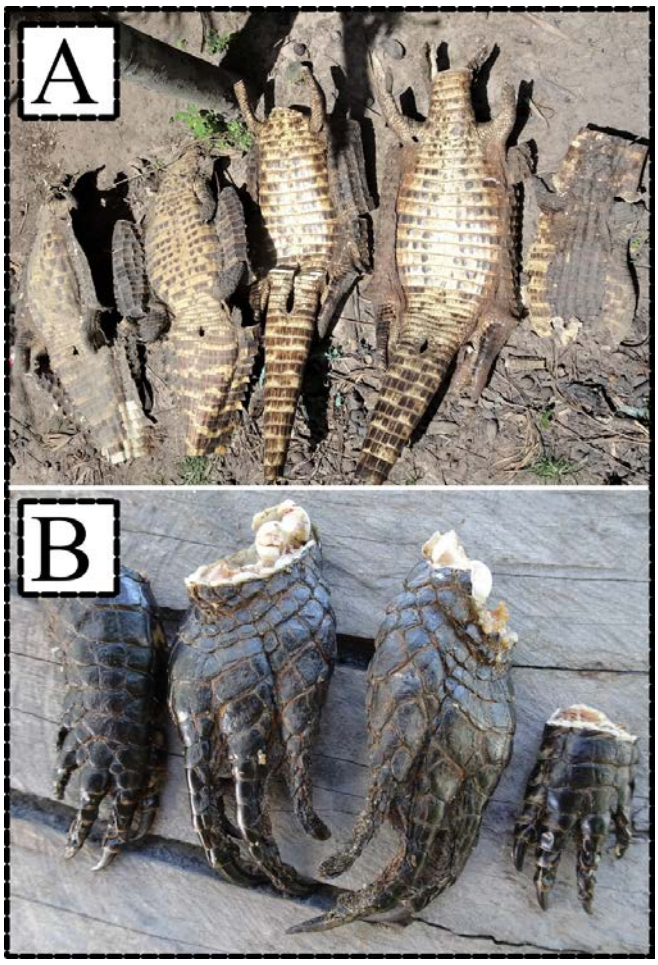


Figure 2. *Paleosuchus palpebrosus* skins (A), and feet (B) used as keychains.

the destruction of its environment, may be leading to low population levels or even local extinction.

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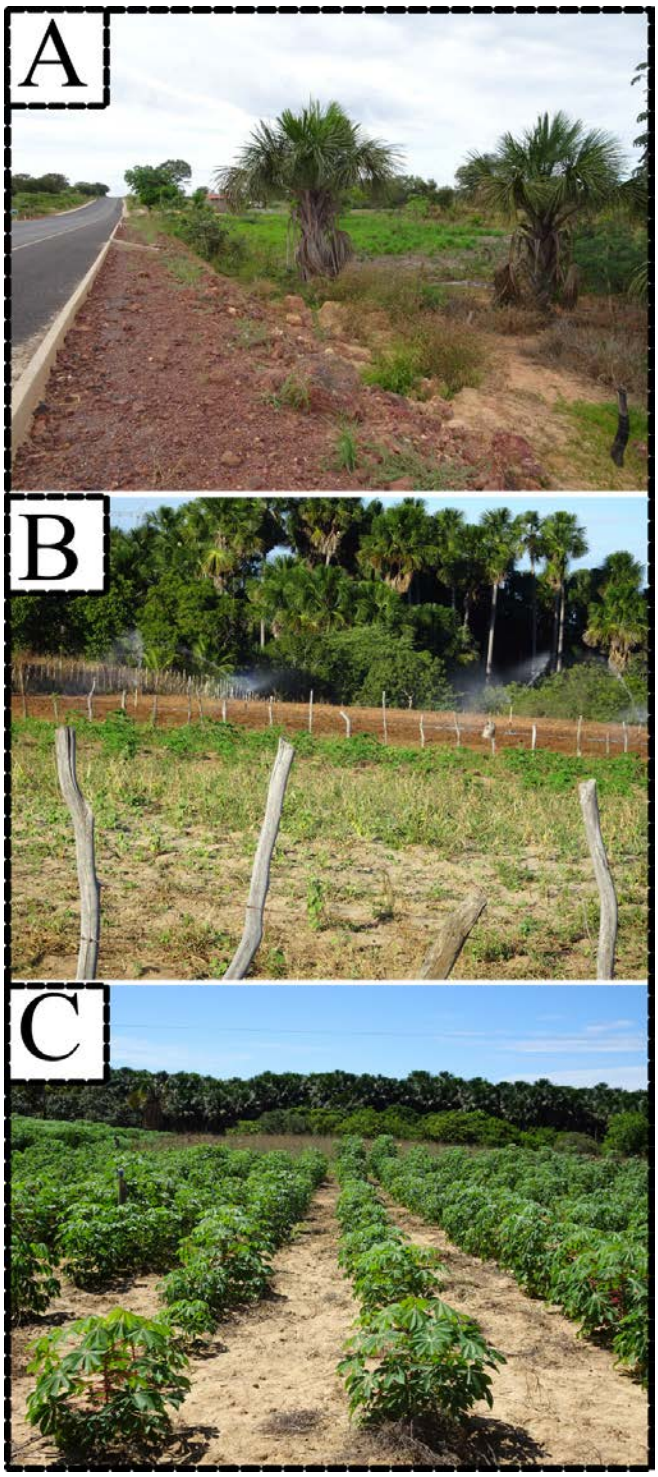

Figure 3. (A) Destruction of *Mauritia flexuosa* palm swamps in Maranhão and Piauí States; (B) use of farm irrigation water pumps in swampy areas, Piauí State; (C) cassava plantation in swampy areas of *M. flexuosa* in Piauí State.

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South Asia and Iran

India

POPULATION STATUS OF MUGGERS (*CROCODYLUS PALUSTRIS*) IN AND AROUND GIR FOREST, GUJARAT, INDIA. The Gir Wildlife Sanctuary (GWS), Gir National Park (GNP) and Pania Wildlife Sanctuary (PWS) are three protected areas that are collectively known as "Gir Forest", and which are surrounded by numerous seasonal waterbodies, including dams, rivers and streams. There are about a dozen man-made waterbodies of different scales located in and around the Gir Forest region, initially planned and built for agricultural water supply. All of these waterbodies are now habitats for Mugger crocodiles (*Crocodylus palustris*).

A literature search reveals a number of important contributions to the study of Muggers in Gir Forests (Joseph *et al*. 1975; Whitaker and Whitaker 1977; Chellam 1986; Chavan 1989; Vijaykumar 1997; Whitaker 1999, 2002), which indicate the presence of Muggers at Hiran, Singoda, Macchhuandri and Raval Dams. These four major waterbodies, within the protected area (Table 1), are lifelines of the forest, providing agricultural and water needs of the integral areas of Gir Forest. Apart from these, other waterbodies serve minor-medium irrigational purposes.

Muggers are legally protected under the *Indian Wildlife (Protection) Act-1972* as a Schedule-I species, and listed as 'Vulnerable' on the IUCN Red List. Distributed across Iran, Pakistan, India, Bangladesh, Bhutan, Nepal and Sri Lanka (Whitaker and Andrews 2003), during the early 1960s populations were largely depleted across the species' entire range, as a result of various threats, including hunting, habitat destruction, fragmentation and transformation, pollution and increased anthropogenic activities (Da Silva and Lenin 2010). However, Gir Forest has been known to harbour sizeable Mugger populations (Whitaker and Whitaker 1977).

Study Area

Gir Forest is one of the largest, dry deciduous, thorny and savanna habitats in the Saurashtra Peninsula of Gujarat State, western India (Fig. 1). This landscape is the last remaining refuge of the Asiatic Lion (*Panthera leo persica*), and so happens to be the most prestigiously Protected Area within the state, and in the country too.

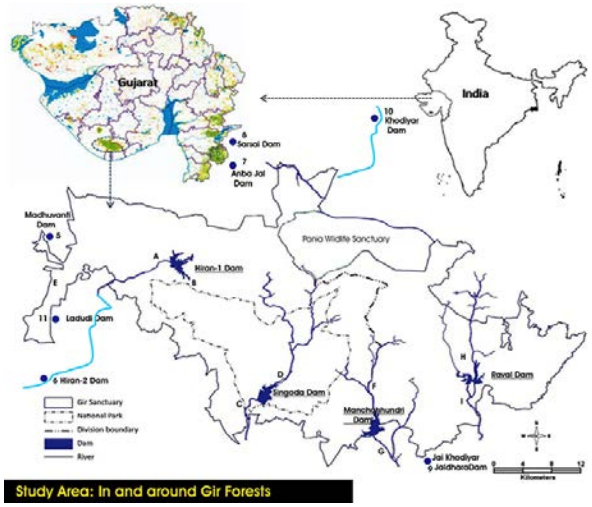

Figure 1. Location of study area within Gujarat State, showing Mugger habitat and waterbodies surveyed: 1-11 = man-made, A-I = rivers, pools and streams; see Table 2.

The study area encompasses an area of about 3200 km^2, including 1451.8 km^2 of Gir Forest (GNP 258.7 km^2, GWS 1153.4 km^2, PWS 39.6 km^2), which is a dry deciduous landscape, falling under the 5A/C1b bio-geographic subtype (Champion and Seth 1968). Further, it can be classified into six broad subtypes (Desai 1972) with dominant and notable tree species of *Tectona grandis* and *Butea monosperma* in combination with *Acacia* sp., *Zizyphus* sp. and *Anogeissus latifolia*.

The whole area topographically slopes downwards towards the southern edge with catchments forming along seven rivers (Bhadar, Ojat, Noli, Hiran, Shentrunji, Sigoda, Macchuandri). However, the area remains drought-prone, while man-made reservoirs built along these rivers suffice as perennial sources

Table 1. Details of man-made waterbodies in the study area, in and around Gir Forest (see Figure 1).

Waterbody	Latitude/Longtitude	Area (km^2)
Protected Areas		
1. Hiran Dam-1 (Kamaleshwar)	21°11' 48.15" N, 70° 39' 57.79" E	3.35
2. Singoda Dam	21° 1' 21.81" N, 70° 46' 50.91" E	5.55
3. Mancchhuandri (on the edge)	20° 59' 8.18" N, 70° 55' 56.24" E	4.47
4. Raval Dam	21° 2' 39.28" N, 71° 3' 44.37" E	2.46
Non Protected Areas		
5. Madhuvanti (nr. Vaniya Vav)	21° 15' 27.69" N, 70° 29' 27.97" E	2.25
6. Hiran Dam- 2 (nr. Talala)	21° 1' 53.29" N, 70° 28' 35.86" E	8.00
7. Amba-jal (nr. Jambudi-Satadhara)	21° 17' 2.05" N, 70° 44' 10.07" E	1.97
8. Sarsai (nr. Visavadar) Dhrafad	21° 20' 44.14" N, 70° 42' 29.27" E	2.93
9. Jai Khodiyar Jaldhara Dam (nr. Jambudi-Khilavad)	20° 57' 29.46" N, 71° 0' 55.43" E	0.50
10. Khodiyar (nr. Dhari)	21° 20' 47.87" N, 71° 2' 24.78" E	6.16
11. Ladudi (nr. Devaliya)	21° 7' 42.68" N, 70° 27' 55.98" E	0.40

of water throughout the year. The entire forest area has a rich biodiversity and supports numerous vertebrate fauna, including amphibians (9 species), reptiles (42 species), birds (310 species) and mammals (38 species) (Bhatt *et al*. 1999; Vyas 2000a,b; Singh and Kamboj 1996; Chavan and Karkaria 2001). Official records indicate over 625 lions and leopards (*P. pardus fusca*) inhabiting Gir Forest - the highest concentration of top carnivores in India (Singh 2017).

Objectives

The Mugger survey is an integral part of the ongoing management program to monitor the species in and around Gir Forest (Nala 2017). The key objectives were to: 1) assess the current status of Muggers within the Protected Areas and surroundings of Gir Forest; and, 2) use citizen science to create awareness about the species amongst the local laymen and forest staff.

Methods

At the time of survey in late May 2017, most wetlands remain as reduced fragmented habitats (Figs. 2-5). The methodology was as suggested by Vasava *et al*. (2015), with slight modification of Vyas (2018). Waterbodies were assigned as one survey unit unless they were more than 2.0 km^2 in area, in which case they were split into two or three survey units (Table 2).

Surveys were carried out with the assistance of State Forest Department staff (Range Forest Officers, foresters, guards and forest trackers) (see Fig. 6), and over 100 volunteers from non-government organizations, and other wildlife enthusiasts. On 24-25 May around 200 participants were provided with training, which included presentations on survey methodology, survey biases and data recording.

Participants were then divided into 36 groups, each with 6-8 members. Each reservoir and river segment was then allotted to one, two or three groups for survey, depending on the size and terrain of the waterbody. Each group member was instructed to walk slowly along the riverbank with binoculars (8 x 40) during the day (for awareness and introduction to Mugger habitat), and with a high beam torch at night for population counts. A standard kit contained equipment such as a digital camera, GPS compass, first-aid kit, snacks, water, etc.

Table 2. Spotlight counts of Muggers in Gir Forest, 29-30 May 2017 (also see Figure 1).

No.	Units	Waterbody	Counts
Protected Areas			
1	3	Hiran Dam-1 (Kamaleshwar)	153
A	1	Downstream to Hiran Dam (5 km)	13
B	1	Upstream of Hiran Dam (5 km)	8
2	3	Singoda Dam	66
C	1	Downstream to Singoda Dam (5 km)	37
D	1	Upstream of Singoda Dam (5 km)	11
3	3	Mancchhuandri (on the edge)	24
F	1	Upstream of Mancchuandri Dam (5 km)	10
G	1	Downstream to Mancchuandri Dam (5 km)	7
4	3	Raval Dam	18
H	1	Downstream to Raval Dam (5 km)	12
I	1	Upstream of Raval Dam (5 km)	5
E	1	Devaliya Safari Park WB	18
	2	Puddles and river pools	60
Sub-total	**23**		**442**
Non-Protected Areas			
5	2	Madhuvanti	56
6	2	Hiran Dam-2	44
7	2	Amba-jal	34
8	2	Sarsai	20
9	2	Jai Khodiyar Jaldhara Dam	14
10	2	Khodiyar	15
11	1	Ladudi	22
Sub-total	**13**		**205**
Total			**647**

Figure 2. Madhuvanti Dam located on the edge of the Gir protected area. Photograph: Devendra Chauhan.

Figure 3. Hiran Dam (also known as Kamleshwar Dam), one of the largest Mugger habitats within the Gir protected area. Photograph: Pranv Vaghasia.

Figure 4. Large Mugger at Sarsai-Dhrafad Dam. Photograph: Raju Vyas.

Figure 5. Large Mugger skull found in dry bed of the Suk-Hiran River. Photograph: Raju Vyas.

Surveys were conducted over two days (29-30 May). On the first day, each group visited its assigned area during daylight hours to familiarize itself with river terrain and the study area generally. A spotlight count survey was carried out on the night of the second day, between 2000 and 2400 h.

Results and Conclusions

A total of 647 Muggers was counted during the spotlight survey, of which 442 (68.3%) were in Protected Areas (GWS, GNP and PWS) and 205 (31.9%) from 7 different water reservoirs situated on the edges or within 10 km of the periphery of the Gir Forest boundary (Table 2). Limited data on sizes of Muggers sighted were recorded [41 juveniles (30.4%), 68 sub-adults (50.4%), 26 adults (19.3%)], and these are considered insufficient to reflect the size structure of the population as a whole.

The count is an underestimate of the actual numbers of Muggers present, although the proportion of the total population that was counted in not known. Spotlight surveys invariably involve a certain proportion of the population not being visible (eg submerged, behind vegetation). The rugged hilly terrain made it difficult to visit and assess all potential Mugger habitats in the study area, and as Muggers use burrows (Fig. 6) as refuges during prolonged periods of hot, dry weather (Whitaker and Whitaker 1984; Ross *et al*. 1989), these individuals could not be counted. The survey represented the first citizen science initiative carried out in Gir Forest, a vast carnivore-dominated area. Thus observer bias may also be a factor to consider in assessing any correction of relative counts to absolute counts. We estimate the Mugger population in the area to be around 800-900 non-hatchlings.

Figure 6. Forest Department staff inspecting a Mugger den at Hiran Dam. Photograph: Raju Vyas.

The highest count (153 individuals) was reported at Hiran Dam 1, and represents the second highest count for this area (Fig. 7). There has been a significant increase in the population at Hiran Dam-1 since 1975. Notable numbers of Muggers were recorded outside Gir Forest, with the highest count being 56 animals at Madhuvanti Dam (Table 2). It is hypothesized that some Muggers move to downstream non-protected areas during monsoons and periods of heavy rainfall.

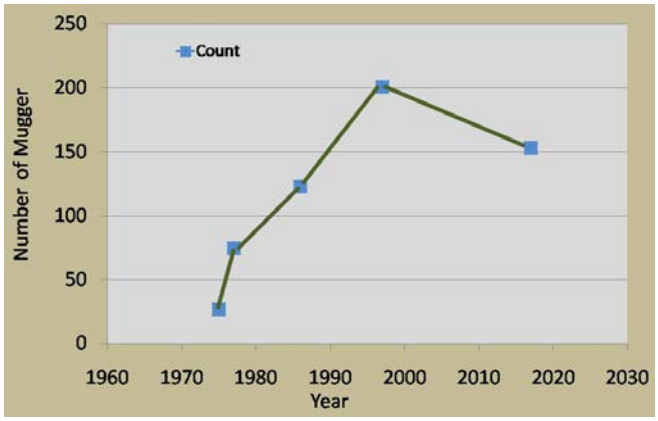

Figure 7. Numbers of Muggers recorded at Hiran Dam, Gir Forest, 1975-1997 (Vijayakumar (1997) and 2017 (this survey).

Gir Forest is a drought prone area, which experiences at least one severe drought (with no rain) every decade, and major waterbodies dry up totally. Such parched conditions force animals to migrate in search of suitable environments. Mugger migration has been recorded from Hiran Dam, when a small population of large Muggers moved downstream of the Hiran River when Hiran Dam almost dried out (Vyas 2001). Similar observations were noted from Barda forest (Whitaker and Whitaker 1984; Vyas 2003).

All rivers that originate from the Gir forests are inhabited by good populations of Muggers. Vyas (2001) stated and pointed out to this concern, "if such environmental condition prevails within the area, then the likelihood of man-mugger conflict is bound to increase, creating a complex and distressful situation for forest authorities too". However, this state of affairs persists not only for Muggers, but also for most other carnivores of Gir Forest. Increasing and most often fatal, this kind of interaction between human beings and wild animals is also an overlooked outcome of breeding success and unmonitored dispersal of wildlife outside of protected areas. Not only impacting the affected flora-fauna, but causing imbalance and threats to the over-all environmental scenario of the entire forest area.

Between 1984 and 1995, 973 Muggers (1.0-1.2 m TL) were released in various waterbodies of Gir Forest (Table 3), as part of a restocking program within the state (Vijaykumar 1997). In addition, Nala (2017) reported that 188 rescued Muggers were released in Hiran Dam over the last 8 years (Fig. 8). The 2017 count (647) is lower than the number of individuals released there. However, without any knowledge of the effects of mortality, immigration, emigration, recruitment, survey biases, etc., on the population, it is unclear whether this difference is of significance. Nonetheless, it is important to monitor the release program and evaluate and reassess the status of released animals.

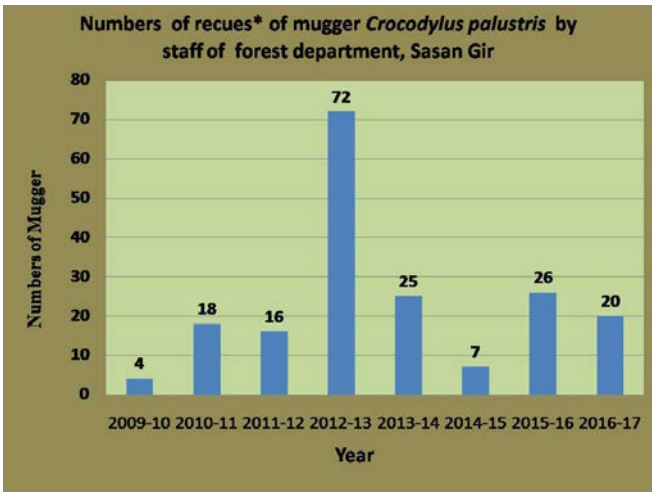

Figure 8. Numbers of Muggers rescued by Forest Department in 2009-2017 and released at Hiran Dam, Gir Forest (Nala 2017).

It is too early to comment on this single initiative of 'citizen science', but with future experiences we hope to confirm the usefulness of such attempts incorporated as long-term practices. Tools like 'citizen science' are absolutely crucial for awareness programs and public sensitization (Vasava 2016).

Table 3. Numbers of Muggers (1.0-1.2 m TL) released from Sasan Crocodile Rearing Center through species restocking program by Forest Department, Gujarat, India (Vijaykumar 1997).

Waterbody	'84	'85	'86	'87	'88	'89	'90	'91	'92	'93	'94	'95	Totals
Hiran Dam-1	53	-	-	-	-	-	-	11	76	2	3	3	148
Raval Dam	-	-	37	63	50	50	-	-	-	-	-	-	200
Singoda Dam	-	-	30	-	61	-	80	5	38	-	-	50	264
Macchhuandri Dam	44	-	-	56	-	100	-	50	44	-	-	-	294
Biliyard-Kankai	-	-	-	-	-	-	-	30	10	-	-	-	40
Jathardi	-	-	-	-	-	-	-	-	-	-	-	-	2
Devalaya	-	-	-	-	-	-	-	5	-	-	-	-	5
Chhodia	-	-	-	-	-	-	-	5	-	-	-	-	5
Mathariyala	-	-	-	-	-	-	-	-	5	-	-	-	5
Bavaria	-	-	-	-	-	-	-	-	5	-	-	-	5
Somasara	-	-	-	-	-	-	-	-	5	-	-	-	5
Totals	**97**	**-**	**67**	**119**	**111**	**150**	**80**	**106**	**183**	**2**	**3**	**53**	**973**

Acknowledgements

Special thanks to Dr. J.A. Khan (Principal Chief Conservator of Forest Wildlife & Chief Wildlife Warden, Gujarat) for allowing us the permission to conduct the study. Also, grateful to Dr. A.P. Singh (Conservator of Forest, Wildlife Circle, Junagadh), Dr. R.R. Nala, Mr. Pradeep Singh (Dy. Conservator of Forest, Sasan Gir), Dr. Sakkira Begum, Mr. N.N. Aparnathi (Asst. Conservator of Forest, Sasan Gir) for supporting the study. Special thanks to Dr. V. Vijaykumar (Director, Gujarat Institute for Desert Ecology, Bhuj-Katch), Rohit Vyas (Member of Wildlife Board, Gujarat), Dr. P. Patankar (Curator, Sayaji Baug Zoo, Vadodara), Kartik Upadhyay, Pranav Vaghasiya, Rakesh Vadhvana, Yogendra Shah, Rahul Solanki, A.S. Pathan, S.S. Sarala, Dhaval Mehta, Anil Gohil, Devendra Chauhan, and many other participants and friends, who duly helped, and some of share photographs and supported this study. Sincere thanks to all the wildlife enthusiasts and staff members of Forest Department who helped with the data collection and valuable participation during the survey. My sincere thanks to Charlie Manolis for his critical review and comments on the draft manuscript.

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East and Southeast Asia

Philippines

2ND FORUM ON CROCODILES IN THE PHILIPPINES. The "2nd Forum on Crocodiles in the Philippines" was held on 6-8 March 2019, at the SEAMEO-Southeast Asian Regional Centre for Graduate Study and Research in Agriculture (SEARCA), University of the Philippines Los Baños (UPLB), Laguna, Philippines. It was hosted by the Department of Environment and Natural Resources (DENR), Department of Agriculture (DA), UPLB-Museum of Natural History (UPLB-MNH), and Crocodylus Porosus Philippines Inc. (CPPI), in collaboration with SEARCA, the ASEAN Centre for Biodiversity (ACB) and the National Museum of the Philippines (NMP).

The theme of the Forum was "Strengthening Partnerships in Conservation Research and Sustainable Management of Crocodiles". It was attended by 111 participants from 13 countries (Australia, Brunei Darussalam, Cambodia, Czech Republic, Germany, Indonesia, Malaysia, Myanmar, Netherlands, Philippines, Singapore, Thailand, USA) with various backgrounds (eg national and international NGOs, industry, researchers, Government agencies, students). Grahame Webb, Charlie Manolis and Tom Dacey from the Crocodile Specialist Group Executive Committee were invited to participate in the forum.

Welcoming addresses were delivered by:

- Dr. Crisanta Marlene P. Rodriguez, Director, Biodiversity Management Bureau, DENR (representing Hon. Roy A. Cimatu, DENR Secretary);
- Dr. Rex B. Demafelis, Vice Chancellor of UPLB (representing Dr. Fernando C. Sanchez Jr., Chancellor, UPLB);
- Dr. Leticia E. Afuang, Associate Professor UPLB (representing Dr. Angel C. Alcala, National Scientist, Chair of Forum Secretariat); and,
- Dr. Arvin C. Diesmos, NMP (representing Dr. Jeremy R. Barns, NMP)

Keynote addresses delivered by Dr. Arvin Diesmos (NMP), Professor Grahame Webb (CSG) and Dr. Theresa Mundita S. Lim (ACB) were followed by a technical session on the status of crocodile research, conservation and management in the Philippines. National Government officers presented the national crocodile management plan, the revised Animal Welfare Act, and governance experience. Presentations on the growth of the crocodile industry and community-based success stories sparked the interest of participants. Oral presentations fell into one of four themes: Natural History and Ecology; Husbandry, Veterinary and Health; Human-Crocodile Coexistence; and, Conservation Research and Management.

It was encouraging to see that additional potential release sites for *Crocodylus mindorensis* have been identified and are now being assessed for their suitability. A tracking study of released *C. mindorensis* on Siargao Island has been initiated, and is already yielding interesting results, including the discovery of individuals using limestone caves in cliffs. HCC in Palawan, where most *C. porosus* occur in the Philippines, is of concern, as are threats such as habitat loss. A nationwide *C. porosus* population estimate is now in the pipeline of field activities. Online (Facebook) trade in reptiles, including crocodilians, for the pet trade, was reported by TRAFFIC.

A side meeting of the National Committee on Crocodile Conservation was convened to discuss 2019 project prioritization across its regional members.

Figure 1. Participants at the "2nd Forum on Crocodiles in the Philippines". Photograph: UPLB-MNH.

A session was devoted to reports from ASEAN Member States [Singapore, Thailand, Sarawak (Malaysia), Brunei Darussalam, Cambodia, West Timor (Indonesia), Cambodia, Myanmar]. The incidence of HCC in West Timor (Indonesia) continues to increase, and authorities are building capacity to deal with problem crocodiles, and develop management strategies to deal with HCC in the long-term. Increased sightings of *C. porosus* in Brunei prompted the establishment of an Action Team in April 2018, comprising members from various agencies (eg wildlife, fire and rescue, police, forestry) - the role of the Action Team is to assess and evaluate, and decide whether to capture crocodiles or install warning signs (part of education and awareness program). Likewise, Singapore is developing its capacity to monitor its *C. porosus* population and develop research programs (eg telemetry). Thailand and Cambodia continue reintroduction efforts with *C. siamensis*.

On the last day of the meeting, participants divided themselves between three workshops, on: Crocodile Breeding and Husbandry Management; Conservation Research and Population Management; and, Managing Human-Crocodile Conflict. The results from each workshop, including 12 Resolutions, were presented at a plenary session. Clarissa Arida, ACB Director, delivered closing remarks on the Forum.

The Proceedings will be published as peer-reviewed research articles in a Special Issue of Museum Publications in the Natural History Journal of the UPLB-MNH, in both electronic and printed formats.

The Forum was sponsored by a number of major and minor sponsors, including CPPI members, Heng Long Leather Co. Pte. Ltd., Crocodile Conservation Institute, Wilcon Depot, and 26 corporate businesses.

Special thanks were extended to the organizing committee - Dr. Arvin Diesmos, Dr. Juan Carlos Gonzalez, Dr. Leticia Afuang, Dr. Ma. Theresa Aquino and Anson Tagtag - together with the technical team, in particular Rainier Manalo, Philip Baltazar, Meljory Corvera, Jake Wilson Binaday, Erickson Tabayag, Leisly Gallegos, Willem van de Ven, Cecile Garcia, Rhia Galsim, Michelle San Pascual, Florante Cruz, Jeremy Naredo and Julius Parcon.

Figure 2. Dr. Arvin C. Diesmos (NMP) delivered a keynote speech on "Revisiting the First Forum on Crocodiles in the Philippines", held in 2007. Photograph: UPLB-MNH.

Figure 3. Each session was followed by a panel discussion, allowing participants to field questions to presenters. Ms. Vannessa E. San Juan (right) acted as moderator for the Forum. Photograph: UPLB-MNH.

Figure 4. From left: Vic Mercado (CPPI), Levita A. Lagrada (Palawan Council for Sustainable Development), Anson Tagtag (Biodiversity Management Bureau, DENR), Dr. Ma. Gracia D. Seynaeve (Bureau of Animal Industry, Department of Agriculture) and Dr. Armie Mariel M. Sebello (National Meat Inspection Service, Department of Agriculture) each receive a Plaque of Recognition for their valued commitment to the conservation and sustainable management of crocodiles in the Philippines. Photograph: UPLB-MNH.

Figure 5. From left: Abegail D. Espianola (Tourism Officer, Municipality of Pilar, Surigao del Norte), Rainier I. Manalo (CPPI) and Dr. Nielson B. Donato (GMA Network Born to be Wild) each receive a Certficate of Appreciation for sharing their community-based experiences with crocodiles from Dr. Juan Carlos T. Gonzalez (at right; UPLB-MNH). Photograph: UPLB-MNH.

Figure 6. CSG Executve Committee members with CPPI's Conservation and Research Team. From left: Jake Binaday, Tom Dacey, Meljory Corvera, Charlie Manolis, Grahame Webb, Philip Baltazar and Rainier Manalo.

Rainer I. Manalo and Vic Mercado, *Crocodylus Porosus Philippines Inc., Philippines (rimanaloecology@gmail.com)*.

Europe

EUROPEAN UNION CONSIDERS LIMIT FOR *SALMONELLA* LEVELS IN REPTILE MEAT. The potential health risk posed by the possible presence of *Salmonella* in reptile (including crocodilians) meat has prompted the European Commission (EC) to propose limits for reptile meat.

Production of reptile meat in the European Union is limited, but an average of 100 tons per annum was imported from 2007 to 2017, primarily to Belgium, France, Germany, Netherlands and the United Kingdom.

The current regulation (EC No 2073/2005), which sets criteria for acceptability of a product on the market, does not cover reptile meat. The new draft regulation states *Salmonella* must not be detected in a 25 g sample, and applies to products placed on the market during shelf-life. Businesses will be obligated to take measures at stages of reptile meat production to reduce the presence of serotypes of *Salmonella* with public health significance.

Source: *Joe Whitworth, Food Safety News, 9 January 2019 (https://www.foodsafetynews.com/2019/01/eu-considers-limit-for-salmonella-levels-in-reptile-meat/)*.

Zoos

WILHELMA ZOO IS NOW HOME TO GERMANY'S LARGEST CROCODILE. "Frederick", a 4.3 m long Saltwater crocodile (*Crocodylus porosus*) arrived in Wilhelma Zoo, Stuttgart, Germany, on 1 March 2019. His journey started at Crocodylus Park, in Darwin, Australia, where he has been a resident since 24 August 1994.

Following around 6 months of planning, Frederick was removed from his enclosure at Crocodylus Park, washed and cleaned, and loaded into a purpose-built wooden crate (Figs. 1-3).

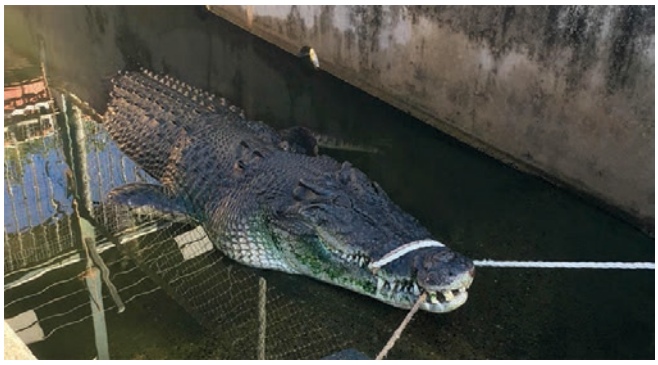

Figure 1. Frederick is caught in his enclosure at Crocodylus Park. Photograph: Grahame Webb.

Figure 2. At Crocodylus Park, Frederick is positioned into his crate, before being secured with wooden partitions and straps, and the lid and ends being put on. Photograph: Grahame Webb.

Figure 3. Charlie Manolis, John Pomeroy and Micky Barratt (Crocodylus Park) provide some "ballast" as the crate (with Frederick), weighing some 900 kg, is prepared for loading into the truck. Photograph: Joan Pomeroy.

The first stage of travel involved a 2-day (3500 km) road trip from Darwin to Brisbane, where he was checked by Crocodylus Park staff prior to being loaded onto an international flight to Frankfurt (24 hours; 16,000 km). In Germany, the final stage of travel involved a 3- hour road trip from Frankfurt to Stuttgart (200 km).

On arrival at Wilhelma Zoo, the crate was carefully manouvered into the exhibit building (Fig. 4). Due to its size and weight, this took around 5 hours and more than 20 personnel. Frederick was finally released from the crate (Figs. 5-7), and has since settled well into his enclosure.

He began feeding within three days (chicken, rats), and shown no ill effects of his trip from Australia. A wire fence currently separates Frederick from the female *C. porosus* with which he shares an enclosure, allowing him to get used to her presence, but prevent any negative social interactions. Eventually the fence will be removed.

As Germany's largest crocodile, Frederick represents a significant addition to Wilhelma Zoo's collection.

Figure 4. Wilhelma team carefully moving crate through the exhibit area. Photograph: Isabel Koch.

Figure 5. Three keepers and zoo Director Dr. Thomas Kölpin freeing Frederick from his crate. Photograph: Isabel Koch.

Figure 6. Frederick slowing leaving his crate, slightly stiff after his long trip. The PVC tube used to keep his mouth open during transport is still visible - it was released within a few hours. Photograph: Isabel Koch.

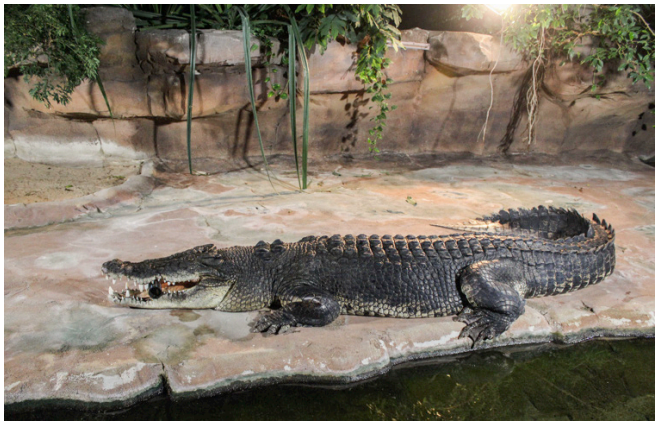

Figure 7. Done! What a beautiful crocodile! Photograph: Isabel Koch.

Isabel Koch *(Curator)* and Kerstin Ludmann *(Registrar/ Animal Transports), Wilhelma Zoo and Botanical Garden, Stuttgart, Germany.*

CSG Student Research Assistance Scheme

The Student Research Assistance Scheme (SRAS) provided funding to 4 students in the January-March 2019 quarter.

1. Bikram Singh (Nepal): Population status, distribution pattern and conservation threats of Gharial (*Gavialis gangeticus*) in the Karnali River, Bardia National Park, Nepal.

2. Orphee Ganaba (Benin): Monitoring of crocodile populations in the Benin W Transboundary Biosphere Reserve (RBTW/B).

3. Kaitlyn Murphy (USA): Xenobiotic Estradiol-17ß and the microbial gut communities of juvenile American alligators (*Alligator mississippiensis*).

4. Ana Romero Calderon (Mexico): Indicators of pohysiological stress in *Crocodylus moreletii* in the Yucatan Peninsula, Mexico.

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

Recent Publications

Chattopadhyay, B., Garg, K.M., Jing, S.Y., Low, G.W., Frechette, J. and Rheindt, F.E. (2019). Conservation genomics in the fight to help the recovery of the critically endangered Siamese crocodile *Crocodylus siamensis*. Molecular Ecology (https://doi.org/10.1111/mec.15023).

Abstract: Endangered species are often characterized by low genetic diversity and it is imperative for conservation efforts to incorporate the knowledge obtained from genetic studies for effective management. However, despite the promise of technological advances in sequencing, application of genome-wide data to endangered populations remains uncommon. In the present study we pursued a holistic conservation-genomic approach to inform a field-based management program of a Critically Endangered species, the Siamese crocodile *Crocodylus siamensis*. Using thousands of single nucleotide polymorphisms from throughout the genome, we revealed signals of introgression from two other crocodile species within our sample of both wild and captive-bred Siamese crocodiles from Cambodia. Our genetic screening of the Siamese crocodiles resulted in the subsequent reintroduction of 12 individuals into the wild as well as the selection of four individuals for captive breeding programs. Comparison of intraspecific genetic diversity revealed an alarmingly low contemporary effective population size in the wild (<50) with evidence of a recent bottleneck around Tonle Sap Lake. We also projected a probable future extinction in the wild (within <5 generations) in this population in the absence of reintroduction efforts. However, an increase in the number of potential breeders through reintroductions, including the one resulting from this project, could counter this trend. Our results have been implemented in ongoing reintroduction and captive breeding programs, with major implications for the conservation management of Siamese crocodiles, and provide a blueprint for the rescue effort of other 'terminally ill' populations of critically endangered species.

Brenot, A., Chuffart, C., Coste-Maniere, I., Deroche, M., Godat, E., Lemoine, L., Ramchandani, M., Sette, E. and Tornaire, C. (2019). Water footprint in fashion and luxury industry. Pp. 95-113 *in* Water in Textiles and Fashion. Consumption, Footprint, and Life Cycle Assessment, ed. by S.S. Muthu. Woodhead Publishing: Cambridge.

Abstract: The increasing consumer awareness of sustainability is leading to some major changes within the strategies of the luxury and fashion brands. With new innovations in the quest for producing sustainable raw materials, the impact this has on water resources remains unquestioned. In the current chapter, we present the steps that the luxury and fashion industry has taken to reduce water use and we present the impact on consumers. Additionally, we show examples of high-water-footprint materials perceived to be environmentally friendly by consumers. We question whether there is a different approach between the fast fashion consumers and the luxury brand consumers and what lies ahead for sustainable water consumption within these sectors.

Iijima, M. and Kobayashi, Y. (2019). Mosaic nature in the skeleton of East Asian crocodylians fills the morphological gap between "Tomistominae" and Gavialinae. Cladistics (https://doi.org/10.1111/cla.12372).

Abstract: Crocodylian systematics has long been confounded by conflicting hypotheses of higher level relationships - although molecular data sets strongly supported the sister-taxon relationship of *Tomistoma* and *Gavialis*, morphological data sets placed *Gavialis* as sister to all other living taxa. One of the perceived difficulties in interpreting morphological character evolution on the molecular tree is the extensive character reversal occurring in Gavialinae, the mechanism of which has yet to be explained. Here, we provide evidence of gavialine-specific atavistic characters from East Asian "tomistomines" *Penghusuchus pani* and *Toyotamaphimeia machikanensis*. These taxa exhibit a mosaic assembly of "tomistomine" and gavialine features, which fill the gap between the two longirostrine groups. Although the parsimony analysis of morphological data (69 taxa, 254 characters) still supports the previous morphological hypothesis, the alternative tree that was forced to fit the molecular hypothesis was insignificantly (5/954 steps; 0.52%) longer than the unconstrained tree, suggesting that morphological evolution can also be interpreted on the molecular tree. Although the problem of stratigraphic gaps remains, future studies may be directed to resolving the interrelationships within Gavialoidea, a large longirostrine group of crocodylians, in the molecular tree context.

Chumsing, W., Boodde, O., Moonjit, P., Lorsunyaluck, B., Sukmak, M., Youngprapakorn, P., Youngprapakorn, K. and Wajjwalku, W. (2018). The modified cultured method for Siamese crocodile (*Crocodylus siamensis*) primary cell culture derived from eyelid and blood vessel. KKU Science Journal 46(4): 689-696.

Abstract: Siamese crocodile (*Crocodylus siamensis*) is a freshwater crocodile. Its wildly distributed habitat was Southeast Asia. It was commonly found in wild nature of Thailand in the past and presently declared as critically endangered by International Union for Conservation of Nature (IUCN). In Thailand, crocodile farming is allowed in order to conserve pure bred and facilitate rational purpose. However, the purity of Siamese crocodiles' genetic has been decreased due to cross-breeding with saltwater crocodile in many farms. The objectives of this research were to study cell culture method by modifying the cell culturing methods and maintain Siamese crocodile genetic material as primary cell culture for further study on crocodiles' chromosome, host specific disease and providing resource for other diagnosis tools. Eyelid and blood vessel were obtained from the newly dead Siamese crocodile suffering from fighting. The specimens were then excising into small pieces and cultured with two supplement formulas including i) Iscove's Dulbecco's Modified Eagle Medium (IMDM) supplemented with 10% Fetal Bovine Serum (FBS) and ii) IMDM supplemented with 10% crocodile plasma. The antibiotic and antifungal were added in both types of media for preventing contamination. Thereafter the cultured flasks were incubated at 28°C and 37°C with 5% CO_2 supplied. The fibroblast-like cells were observed under the inverted microscope at 2 weeks later. The cells were subcultured until 10 passages and preserved at every single passage under -196°C in liquid nitrogen. The result indicated that both supplement formulas were successfully applied for primary cell culture at the temperature of 28°C and 37°C. The supplementation by FBS is more applicable than crocodile plasma due to commercially available.

Han, Q.H., Sun, R.N., Yang, H.Q., Wang, Z.W., Wan, Q.H. and Fang, S.G. (2019). MHC class I diversity predicts non-random mating in Chinese alligators (*Alligator sinensis*). Heredity (doi: 10.1038/s41437-018-0177-8).

Abstract: The major histocompatibility complex (MHC) has several important roles in kin recognition, pathogen resistance and mate selection. Research in fish, birds and mammals has suggested that individuals optimise MHC diversity, and therefore offspring fitness,

when choosing mates. In reptiles, however, it is unclear whether female mate choice is based on genome-wide genetic characteristics such as microsatellite DNA loci, particular functional-trait loci (e.g., MHC) or both, and MHC's effects on mate choice remain relatively understudied. Herein, we used 13 microsatellite loci and two MHC class I loci to investigate female mate choice of Chinese alligators (*Alligator sinensis*) in the semi-natural condition. We also determined correlations between the MHC genotype of breeding males and male reproductive success. We found that MHC-heterozygous males harbour a greater reproductive success, which probably is the reason that these males are more preferred by the females than MHC-homozygous males. Furthermore, the MHC class I amino-acid distance and functional distance of true mating pairs were higher compared with those of randomly sampled pairs. Analysis of microsatellites revealed that, despite mate choice, females did not completely avoid inbreeding. These findings are the first evidence of MHC-associated mate choice in Chinese alligators, suggesting that females may adopt different mating strategies after assessing the MHC characteristics of potential mates.

Liu, C. (2018). InBranding American alligator leather with a fashion apparel brand: Examining the effects of the ingredient attributes. *In* International Textile and Apparel Association (ITAA) Annual Conference Proceedings (https://lib.dr.iastate.edu/itaa_proceedings/2018/posters/128).

Abstract: Ingredient Branding (InBranding) has been used strategically to make material and component offerings visible to final consumers. Such strategy enables component manufacturers to establish and maintain the competitive advantage while creating commercial success in the consumer market. The American alligator leather is unique and steadily increasing in value. However, the domestic market for alligator leather has been limited to a very narrow range of products mainly targeting male consumers. Furthermore, the inventory of slightly flawed alligator skins has accumulated to a degree that has significantly affected the model of sustainable use of wildlife and the ecologically balanced alligator economy. The purpose of this empirical study is to explore mass market potentials in the fashion apparel category for the slightly flawed American alligator leather through InBranding. A national sample was recruited to empirically test proposed research model. Analysis results supported the majority of research hypotheses. Implications were provided.

Liang, J. (2018). Differentiation of Gonads in Different Stages of Embryonic Development of Chinese Alligator Based on Transcriptomics. MSc thesis, Anhui Normal Unversity, China.

Summary: The sex determination of crocodile is temperature-dependent sex determination (TSD), and the molecular mechanism of sex determination is still unclear. In this paper, *Alligator sinensis* was used as the research object, and the female producing temperature (FPT) and male producing temperature (MPT) of the Chinese alligator were divided into six stages: the gonadal-adrenal-medium complex (gonad), adrenal-mesonephros, GAM) (referred to as gonads in the text) for histochemical analysis and transcriptome sequencing, analysis of its morphological changes and expression profiles, study the molecular mechanism of temperature sex determination, determine the time of sex determination of Chinese alligator, screening and the genes related to sex determination and differentiation of Chinese alligator. The morphological changes of gonads in six developmental stages of FPT and MPT showed that the Chinese alligator mainly produced females at 29°C, and males were mainly produced at 34°C, and the morphological changes of female gonads were most significant between 31 and 41 days. The morphology of male gonads The change is most pronounced between 31 and 36 days. RNA-seq produced 1,150,314,298 clean reads. The differentially expressed genes of gonads during the developmental period of FPT and MPT were 178 and 1268, respectively. The differentially expressed genes of FPT and MPT between the same developmental stage were 1785. Analysis of the expression profiles of the six developmental gonads of FPT and MPT showed that the differences between males and females were greatest at 36 days and 41 days, and genes associated with sex determination and differentiation appeared. By analyzing the morphological changes and expression profiles of the gonads of the developmental stages of FPT and MPT in the Chinese alligator embryos, it is speculated that the sex determination time of female Chinese alligator is between 31 and 41 days, and the sex determination time of male Chinese alligator is between 31 and 36 days. The TSP of the Chinese alligator may be between 31 and 41 days of embryo incubation. In this experiment, genes related to sex determination and differentiation were also screened. In addition to genes such as SOX9, NR5A1 (SF-1) and AMH, which were widely studied in vertebrates, RNF17, FOXI1, JARID2 and KDM6B were also screened. , DDX17, SAFB1 and other genes, as well as a number of enzymes involved in the synthesis of steroid hormones and family members of multiple HSPs. Screen out metabolic pathways related to sex determination and differentiation: Steroid hormone biosynthesis. To provide a basis for the future study of the molecular mechanism of the Chinese alligator TSD.

Wilberg, E.W., Turner, A.H. and Brochu, C.A. (2019). Evolutionary structure and timing of major habitat shifts in Crocodylomorpha. Scientific Reports 9: 514.

Abstract: Extant crocodylomorphs are semiaquatic ambush predators largely restricted to freshwater or estuarine environments, but the group is ancestrally terrestrial and inhabited a variety of ecosystems in the past. Despite its rich ecological history, little effort has focused on elucidating the historical pattern of ecological transitions in the group. Traditional views suggested a single shift from terrestrial to aquatic in the Early Jurassic. However, new fossil discoveries and phylogenetic analyses tend to imply a multiple-shift model. Here we estimate ancestral habitats across a comprehensive phylogeny and show at least three independent shifts from terrestrial to aquatic and numerous other habitat transitions. Neosuchians first invade freshwater habitats in the Jurassic, with up to four subsequent shifts into the marine realm. Thalattosuchians first appear in marine habitats in the Early Jurassic. Freshwater semiaquatic mahajangasuchids are derived from otherwise terrestrial notosuchians. Within nearly all marine groups, some species return to freshwater environments. Only twice have crocodylomorphs reverted from aquatic to terrestrial habitats, both within the crown group. All living non-alligatorid crocodylians have a keratinised tongue with salt-excreting glands, but the lack of osteological correlates for these adaptations complicates pinpointing their evolutionary origin or loss. Based on the pattern of transitions to the marine realm, our analysis suggests at least four independent origins of saltwater tolerance in Crocodylomorpha.

Smith-Paredes, D. and Bhullar, B.A.S. (2019). The skull and head muscles of Archosauria. Pp. 229-251 *in* Heads, Jaws, and Muscles, ed. by J. Ziermann, R. Diaz Jr. and R. Diogo. Fascinating Life Sciences: Springer, Cham.

Abstract: Archosaurs is the clade composed by birds (Aves) and crocodiles, alligators, and the gharial (Crocodylia). This relatedness is not obvious and for a long time was not taken into account, as birds were seen as a group separate even from the rest of reptiles. Both avians and crocodylians are morphologically very distinct and in many aspects different from each other and from the ancestral forms within Archosauria. The skulls of birds are composed of thin and light bones, many fused to each other, and others articulating in mobile joints allowing the beak to move and bend with respect to the rest of the skull. In crocodylians the skulls are massive and heavy, a solid akinetic structure built to crush prey. The accompanying muscle system, attaching onto and responsible for the movement of the head, jaws, eyes, or tongue, is equally distinct. As a result of the striking differences and the relatively recent realization of

crocodylians and avians being closely related, the comparison of their anatomy has never been very straightforward. This chapter's goal is to provide a review of archosaur anatomy and to give at least some sense of the similarities and differences between archosaur musculature.

Coad, L., Fa, J.E., Abernethy, K., van Vliet, N., Santamaria, C., Wilkie, D., El Bizri, H.R., Ingram, D.J., Cawthorn, D.M. and Nasi, R. (2019). Towards a Sustainable, Participatory and Inclusive Wild Meat Sector. CIFOR: Bogor, Indonesia.

Abstract: In this document, we use the term 'wild meat' to refer to terrestrial animal wildlife used for food in all parts of the world. The meat of wild animals has historically been, and still is, an essential source of protein and income for millions of indigenous peoples and local communities in tropical and subtropical regions. Invertebrates, amphibians, reptiles, birds and mammals are eaten across the world; some of them also hold an important place in traditional cultural values and practices. However, unsustainable harvesting rates are causing significant declines in many species, thus threatening the integrity of ecosystems, imperiling the food security of vulnerable households and impacting global biodiversity. As pressure on wild meat resources increases, the question arises of how to ensure sustainable management, in support of both people and wildlife. In response to a call from the Convention on Biological Diversity Secretariat (CBD), this report presents a comprehensive overview of what constitutes the wild meat trade and what drives overexploitation. It also provides guidelines on how to improve wild meat governance and management, to secure wildlife and food security in the long term.

Marrugo-Negrete, J., Durango-Hernández, J., Calao-Ramos, C., Urango-Cárdenas, I. and Díez, S. (2019). Mercury levels and genotoxic effect in caimans from tropical ecosystems impacted by gold mining. Science of the Total Environment (https://doi.org/10.1016/j.scitotenv.2019.01.340).

Abstract: One of the most representative predator species in tropical ecosystems is caiman that can provide relevant information about the impact of mercury (Hg) associated with artisanal and small-scale gold mining. To evaluate the degree to which adverse effects are likely to occur in *Caiman crocodilus*, total Hg (THg) concentrations in different tissues and DNA damage in erythrocytes were determined. Samples of claws, scales, and blood were taken from 65 specimens in sites impacted by upstream gold mining, and in a crocodile breeding center as control site, located in a floodplain in northern Colombia. In all the sites, the highest THg among tissues was in the following order: claws >> scales > blood. High concentrations of THg were found in the different tissues of the specimens captured in areas impacted by mining activities, with mean values in claws (1100 ng/g ww), caudal scutes (490 ng/g ww), and blood (65 ng/g ww), and statistically significant differences compared to those of the control site ($p<0.05$). THg in scutes from impacted sites are 15-fold higher than in control, whereas for claws and blood are 8 times higher, and a high significant correlation with THg was found in all the tissues. The comet assay reveals significant differences in the DNA damage in the exposed reptiles compared to the controls ($p>0.05$), In sum, *C. crocodilus* from La Mojana floodplain presents a high ecological risk given its genotypic susceptibility to Hg levels present in its habitat, which could possibly influence vital functions such as reproduction of the species and the ecological niche that it represents within the ecosystem.

Rodgers, E.M. and Franklin, C.E. (2019). Diving beyond aerobic limits: effect of temperature on anaerobic support of simulated predator-avoidance dives in an air-breathing ectotherm. Physiological and Biochemical Zoology 92(3): 293-302.

Abstract: Diving optimality models predict air breathers to routinely dive within aerobic limits, but predator avoidance dives may be an exception. Lengthening submergence times during a predation threat may enhance survival probability, and we therefore hypothesized that predator avoidance dives in juvenile estuarine crocodiles (*Crocodylus porosus*) would be partially anaerobically fueled. We also predicted that reliance on anaerobic metabolism would increase at elevated temperatures to offset the faster depletion of body oxygen stores. Crocodiles were maintained at 28° and 34°C for 60 d and subsequently underwent simulated predator avoidance dive trials at two test temperatures (28° and 34°C). Blood was sampled immediately on surfacing to measure plasma lactate concentrations relative to nondiving (control) values. Aerobic dive limits (cADL; min) were also calculated using known body mass and oxygen storage relationships and rates of diving oxygen consumption and compared with observed dive durations. Postdive plasma lactate levels were elevated beyond resting levels at both test temperatures, indicating that aerobic thresholds were surpassed during simulated predator avoidance dives. Similarly, ≥90% of dive durations exceeded cADLs at both test temperatures. Postdive plasma lactate concentrations were independent of water temperature and thermal acclimation treatment. Together, these findings suggest that reliance on anaerobiosis during simulated predator avoidance dives is important regardless of temperature.

Finger, Jr., J.W., Thomson, P.C. and Isberg, S.R. (2019). A pilot study to understand tooth replacement in near-harvest farmed saltwater crocodiles (*Crocodylus porosus*): Implications for blemish induction. Aquaculture 504: 102-106.

Abstract: Saltwater crocodiles (*Crocodylus porosus*) are farmed in Australia primarily for their belly skin. The desirability and ultimately the value of each skin depends on the extent and location of various industry-defined defects. Anecdotal observations suggest that conspecific interactions are the main contributors with the protrusive 4th dentary teeth (ie eye teeth) the most likely cause. It is well known that crocodilians undergo continual tooth replacement, yet no study has investigated tooth replacement rates or tooth growth dynamics in juvenile saltwater crocodiles. In this pilot study, we repeatedly measured eye tooth crown height and observed eye tooth replacement in individually-housed juvenile saltwater crocodiles ($n = 98$) accounting for 290 individual teeth. The majority of teeth were replaced every three to six months ($n= 172$) but nine teeth were not replaced over the 15-month study period. After a tooth was lost, the need to replace it quickly was evidenced by a faster tooth growth rate in the first three months (11.07 ± 0.17 mm) but subsequently slowed to a model-adjusted asymptote of 14.03 ± 0.27 mm ($p<0.001$). Interestingly, teeth on the left side of the mandible were, on average, 0.43 ± 0.16 mm shorter than those on the right ($p<0.001$) and, although just outside 5% significance, were replaced 1.20 times as often. Together this is suggestive that crocodiles may preference food capture with the left-hand side of their mouth but requires more structured behavioural observations to confirm. Unusually, the eye-teeth of eight crocodiles did not protrude, which is a normal characteristic of crocodiles compared to alligators, but instead were observed to be growing into the interior of the mouth. This study begins to provide some context to tooth biology when preemptive solutions to tooth-induced blemishes are being sought.

Domínguez, R., Pateiro, M., Munekata, P.E.S., Gagaoua, M., Barba, F.J. and Lorenzo, J.M. (2019). Exotic meats: An alternative food source. Pp. 385-408 *in* More than Beef, Pork and Chicken - The Production, Processing, and Quality Traits of Other Sources of Meat for Human Diet. Springer: Cham.

Abstract: Exotic meats were a protein source for human diet for many years. However, the massive capture caused the overexploitation and placed many reptiles and amphibious on the verge of extinction. Therefore, the captive rearing, the control during slaughtering and processing has been proposed as an alternative to the capture of wild animals. The present chapter shows the nutritional composition of

this kind of meat, characterized by low levels of fat, high contents of protein, essential amino acids, fatty acids (especially long-chain n-3) and minerals indicating that their consumption may be beneficial for human health. However, very little data is available on the nutritional value of these meats. To concluded, exotic meat is an interesting alternative to be considered as a component of the human diet. In addition, the farming of exotic species could be important in the economy of some regions or countries.

Singh, V.P. (2018). Status and Ecology of Rehabilitated Gharial *Gavialis gangeticus* in Girwa River of Katerniaghat Sanctuary.

Smirnov, A.F. and Trukhina, A.V. (2019). Comparison of Sex Determination in Vertebrates (Nonmammals). IntechOpen

Abstract: The chapter is devoted to the consideration of sex determination in vertebrate groups of nonmammalians: fish, amphibians, reptiles, and birds. Attention is drawn to the fact that all these groups of animals, unlike mammals, are implemented hormonal control options for primary sex determination, and there is a possibility of sex reversion. Determination of gonadal development in vertebrates like testis or ovary was initially controlled mainly by sex hormones (fish and amphibians). Later, various sex determining genes were involved in this process. The system was quite plastic and was able to respond to changes in external conditions (reptiles). The appearance of heteromorphic sex chromosomes (birds) has led to the emergence of some specific W chromosomal signal, which provides estrogen control of the development of a heterogametic sex. In mammals, the control of the primary determination of sex (the appearance of the gonad) becomes purely genetic, and the role of sex hormones is reduced to the differentiation of testis or ovaries.

Traulsen, J. (2018). The desert fathers' beasts: Crocodiles in medieval German monastic literature. Interfaces 5: 78-89.

Abstract: This paper explores the literary representations of one of the most terrifying animals in the medieval imagination, the crocodile, in two monastic texts written in the German vernacular (Väterbuch, Alemannische Vitaspatrum). The literary figure of the crocodile in these religious texts combines ancient knowledge of crocodiles, biblical motifs, allegorical attributions and the lived experience of the Christian hermits, who encountered crocodiles as a part of their environment. Thus, crocodiles appear simultaneously as representations of divine power, as devilish beasts, as challenges to ascetic life in the desert, and as creatures miraculously tamed by the hermits' charisma. The ambiguous status of the desert as a space of temptation and redemption is thus reflected in literary representations of the crocodile, which in turn can be understood as a reflection on monastic life in general, intended for the medieval audience of the texts discussed.

Jensen, B. (2019). Commemoration of Comparative Cardiac Anatomy of the Reptilia I-IV. Journal of Morphology 280(4): 623-626.

Abstract: Our understanding of the anatomy of hearts of ectothermic saurosids, or colloquially "reptiles", was much advanced by the publication of the series of four papers under the heading of Comparative Cardiac Anatomy of the Reptilia in Journal of Morphology between 1971 and 1981. Here, I commemorate the papers, show how they moved our understanding forwards, and briefly describe the state-of-the-art.

Vickaryous, M.K. and Gilbert, E.A.B. (2019). Reptile embryology and regeneration. *In* Vertebrate Embryogenesis. Methods in Molecular Biology, Vol. 1920, ed. by F. Pelegri F. Humana Press: New York.

Abstract: Reptiles (lizards, snakes, turtles, and crocodilians) are becoming increasingly popular as models for developmental investigations. In this review the leopard gecko, Eublepharis macularius, is presented as a reptilian model for embryonic and tissue regeneration studies. We provide details of husbandry and breeding and discuss aspects of embryonic nutrition, egg anatomy, and sex determination. We provide comprehensive protocols for transcardial perfusion, short-term anesthesia using the injectable anesthetic Alfaxan, and full-thickness cutaneous biopsy punches, used in geckos for the study of scar-free wound healing. We also provide modifications to three popular histological techniques (whole-mount histochemistry, immunohistochemistry, and double-label immunofluorescence) and provide details on bromodeoxyuridine (BrdU) labeling and immuno-detection.

Nóbrega Alves, R.R., Carvalho de Araújo, B.M., da Silva Policarpo, I., Mota Pereira, H., Martins Borges, A.K., da Silva Vieira, W.L. and Vasconcellos, A. (2019). Keeping reptiles as pets in Brazil: ethnozoological and conservation aspects. Journal for Nature Conservation (https://doi.org/10.1016/j.jnc.2019.02.002).

Abstract: Regardless of many legal restrictions, the keeping of and trade in reptiles as pets has been increasing in Brazil over the last few years. We present an analysis of the trade and use of reptiles as pets in Brazil and discuss the implications. Data were obtained through semi-structured questionnaires given to 719 owners, who were contacted through reptile-owner groups on the social network Facebook. A total of 69 reptile species were reported as pets in Brazil, of which there were 39 snakes, 17 lizards, 12 chelonians and 1 species of crocodilian. Of the reported species, 46 are native to Brazil and 23 are exotic, including threatened species. Owners were distributed in at least 24 states, with a higher concentration in Southeast Brazil and the Federal District. Owners usually acquire animals through purchase, although prices vary and are high for some species, making reptile ownership more common among high-income individuals. Prices were affected by factors such as beauty, colour pattern, size, sex and even rarity. The keeping of reptiles as pets raises conservation concerns, as the practice directly impacts exploited populations and is a potential introduction pathway for invasive species, including exotic species that have already been recorded in natural habitats in Brazil. A thorough discussion, encompassing various stakeholders - namely, owners, traders and environmental authorities - is much needed, to address management strategies, and propose feasible solutions. Conservation and animal welfare NGOs should also be involved in this process.

Fernández, M.S., Wang, X., Vremir, M., Laurent, C., Naish, D., Kaiser, G. and Dyke, G. (2019). A mixed vertebrate eggshell assemblage from the Transylvanian Late Cretaceous. Scientific Reports 9: 1944.

Abstract: A Late Cretaceous-aged multi-taxon nesting site from Romania preserved in three dimensions reveals the earliest example of nest site sharing yet known from the vertebrate fossil record. Eggshell and osteological evidence combined in this single accumulation demonstrate that at least four vertebrate taxa including enantiornithine birds and another avian of indeterminate affinities as well as crocodylomorphs and gekkotan squamates nested together in the same place. Colonial nesting in enantiornithines was previously described from this site; here, we present the first fossil evidence that other vertebrates also nested in the same place, perhaps exploiting the presence of the large bird colony. We describe four distinct eggshell morphotypes that have been collected from this site and draw palaeoecological inferences based on this unique multi-taxon nesting association.

Merchant, M.E. and Lemieux Jr., F. (2019). Blood product from crocodylian species as a feed supplement for weanling pigs and poultry hatchlings. United States Patent 10195230. http://www.freepatentsonline.com/10195230.html.

Abstract: The present invention is a feed supplement consisting of a blood product from at least one Crocodylian species such as the American alligator (*Alligator mississippiensis*). The blood product is whole blood, hemolyzed blood, serum or plasma. The feed supplement is a liquid or solid. The feed supplement may be combined with a high nutrient feed or starter diet. The feed composition may contain 0.1% or more by weight of the feed supplement. The feed supplement is fed to weanling pigs or poultry hatchlings to increase their weight and feed intake. It is also expected to promote gut health.

Sengupta, D., Chen, S. and Kottapalli, A.G.P. (2019). Nature-Inspired Self-Powered Sensors and Energy Harvesters. Pp. 61-81 *in* Self-Powered and Soft Polymer MEMS/NEMS Devices. SpringerBriefs in Applied Sciences and Technology. Springer: Cham.

Abstract: Chapter 3 presents a comprehensive review of the various biomimetic self-powered and low-powered MEMS pressure and flow sensors that take inspiration from the biological flow sensors found in the marine world. The sensing performance of the biological flow sensors in marine animals has inspired engineers and scientists to develop efficient state-of-the-art sensors for a variety of real-life applications. In an attempt to achieve high-performance artificial flow sensors, researchers have mimicked the morphology, sensing principle, materials, and functionality of the biological sensors. Inspiration was derived from the survival hydrodynamics featured by various marine animals to develop sensors for sensing tasks in underwater vehicles. The mechanoreceptors of crocodiles have inspired the development of slowly and rapidly adapting MEMS sensory domes for passive underwater sensing. Likewise, the lateral line sensing system in fishes which is capable of generating a three-dimensional map of the surroundings was mimicked to achieve artificial hydrodynamic vision on underwater vehicles. Harbor seals are known to achieve high sensitivity in sensing flows within the wake street of a swimming fish due to the undulatory geometry of the whiskers. Whisker inspired structures were embedded into MEMS sensing membranes to understand their vortex shedding behavior. At the outset, this work comprehensively reviews the sensing mechanisms observed in fishes, crocodiles, and harbor seals. In addition, this chapter presents an in-depth commentary on the recent developments in this area where different researchers have taken inspiration from these aforementioned underwater creatures and developed some of the most efficient artificial sensing systems.

Clarac, F., Goussard, F., de Buffrénil, V. and Sansalone, V. (2019). The function(s) of bone ornamentation in the crocodylomorph osteoderms: a biomechanical model based on a finite element analysis. Paleobiology 45(1): 182-200.

Abstract: This paper aims at assessing the influence of the bone ornamentation and, specifically, the associated loss of bone mass on the mechanical response of the crocodylomorph osteoderms. To this end, we have performed three-dimensional (3D) modeling and a finite element analysis on a sample that includes both extant dry bones and well-preserved fossils tracing back to the Late Triassic. We simulated an external attack under various angles on the apical surface of each osteoderm and further repeated the simulation on an equivalent set of smoothed 3D-modeled osteoderms. The comparative results indicated that the presence of an apical sculpture has no significant influence on the von Mises stress distribution in the osteoderm volume, although it produces a slight increase in its numerical score. Moreover, performing parametric analyses, we showed that the Young's modulus of the osteoderm, which may vary depending on the bone porosity, the collagen fiber orientation, or the calcification density, has no impact on the von Mises stress distribution inside the osteoderm volume. As the crocodylomorph bone ornamentation is continuously remodeled by pit resorption and secondary bone deposition, we assume that the apical sculpture may be the outcome of a trade-off between the bone mechanical resistance and the involvement in physiological functions. These physiological functions are indeed based on the setup of a bone superficial vessel network and/or the recurrent release of mineral elements into the plasma: heat transfers during basking and respiratory acidosis buffering during prolonged apnea in neosuchians and teleosaurids; compensatory homeostasis in response to general calcium deficiencies. On a general morphological basis, the osteoderm geometric variability within our sample leads us to assess that the global osteoderm geometry (whether square or rectangular) does not influence the von Mises stress, whereas the presence of a dorsal keel would somewhat reduce the stress along the vertical axis.

Tarailo, D.A. (2018). Diversity and Dispersal Trends Following the Latest-Permian Mass Extinction. PhD thesis, University of Iowa, USA.

Abstract: The latest-Permian mass extinction was the greatest biotic crisis of the Phanerozoic. The extinction decimated both marine and terrestrial communities, and changed the evolutionary trajectory of multicellular life on the planet. The unique nature of the extinction's aftermath has prompted attention from paleontologists seeking to understand the timing and pattern of the Triassic recovery. With this dissertation I have sought to shed additional light on the terrestrial side of the extinction by examining different patterns by which its survivors responded to the extinction. Temnospondyl amphibians were one of the few tetrapod clades that were able to take advantage of the extinction to expand their diversity. In Chapter 1 I examine the relationship between taxonomic and ecological diversity of temnospondyls across the Permian-Triassic (P-Tr) boundary in the Karoo Basin of South Africa. Ecomorphological diversity, as implied by differences in cranial shape, was incorporated into the study by the use of a landmark-based geometric morphometric analysis. Both taxonomic diversity and cranial disparity were low during the Permian and increased across the Permian-Triassic boundary. Taxonomic diversity was stable through the Triassic, but disparity showed subsequent increases during the Olenekian and Anisian. Temnospondyls were restricted in size immediately following the extinction, but size range fully rebounded by the Olenekian. Tests of phylogenetic signal demonstrate that cranial shape was heavily influenced by phylogenetic relatedness, and the observed increases in disparity may be partly the result of decreases in the net relatedness of coeval Karoo stereospondylomorph temnospondyls in younger faunas. The increase in community-level taxonomic diversity for temnospondyls in the Karoo following the latest-Permian mass extinction was likely facilitated by an influx of distantly related and ecologically distinct species from other parts of Pangea. In Chapter 2, I discuss the merits of different potential methods for quantifying rates of dispersal within clades. I then apply some of these methods to two very different scenarios, first the dispersal of crocodylians across oceanic barriers during the Late Cretaceous and Cenozoic, and second the dispersal of different groups of tetrapods across Pangea during the Permo-Triassic interval. For crocodylians, because they were dispersing across substantial geographic obstacles, I opted for a direct measurement approach utilizing the optimization of discrete dispersals onto phylogenies. I examined the history of crocodylian biogeography using both parsimony and maximum likelihood on three distinct topologies with several different methods for estimating branch lengths. Across all analyses, members of the clade Alligatoroidea consistently dispersed across oceanic barriers less frequently than did non-alligatoroids. This is consistent with the hypothesis that the greater degree of salt tolerance observed in extant crocodyloids and gavialoids played a role in shaping crocodylian biogeography. The phylogenetic and temporal distribution of high dispersal rates points to an acquisition of greater salt tolerance early in the history of Crocodyloidea and Gavialoidea, potentially near the base of Longirostres if the combined evidence topology is correct. Patterns observed for changes in dispersal rate within individual clades can be largely attributed to changes in global climate and continental configuration over their history. The greater geographic ambiguity represented by the Permo-Triassic continental configuration makes a direct measurement approach inappropriate. For this study I instead

opted for a proxy measurement approach, using the phylogenetic clustering of taxa within a community, measured using the Net Relatedness Index. I examined temporal changes in the phylogenetic clustering of five major tetrapod clades that span the Permian-Triassic boundary (Stereospondylomorpha, Parareptilia, Neodiapsida, Anomodontia, and Eutheriodontia) in order to examine patterns of extinction and origination through time, as well as rates of geographic dispersal. Some clades (Stereospondylomorpha, Parareptilia, and Neodiapsida) show evidence of phylogenetically selective extinction across the boundary, but this is not a universal pattern. Only one clade, Stereospondylomorpha, shows an unambiguous increase in dispersal rate following the mass extinction event. Other clades either show no change in dispersal rate, or have results that are mixed, depending on the parameters used in the analysis. These results show that stereospondylomorph temnospondyls were dispersing between geographical regions at increased rates during the Early Triassic, and this may explain much of their apparent increase in diversity following the latestPermian mass extinction. In Chapter 3, I perform a comparison between the timing of the Triassic recovery with that following the Cretaceous-Paleogene (K-Pg) mass extinction. Three terrestrial fossil-bearing successions were examined, the Lower Triassic Beaufort Group in South Africa and Cis-Ural succession in Russia, and the Paleocene faunas of the American northern Great Plains. A comparison of generic diversity of tetrapods through time for the post-extinction intervals reveals a temporal disparity between the length of terrestrial recovery after the latest-Permian and K-Pg extinctions. Both Permo-Triassic successions show a period of low taxonomic richness (4-5Myr) after the extinction event, followed by an eventual rise in richness. The North American K-Pg succession shows a different pattern, with an immediate rise in richness culminating in a plateau shortly after the extinction (1-3 Myr). This disparity in recovery times may result from prolonged deleterious environmental conditions following the P-Tr events, although several important differences exist between these sequential fossil assemblages that may be affecting the apparent speed of recovery.

Brown, G.J., Forbes, P.B.C., Myburgh, J.G. and Nöthling, J.O. (2019). Nile crocodile (*Crocodylus niloticus*): Egg mass relative to egg component mass in unbanded and fertile eggs. Aquaculture (https://doi.org/10.1016/j.aquaculture.2019.03.006).

Abstract: *Crocodylus niloticus* eggs are a useful starting point to study reproduction in this species. Using samples collected from a single farm during a single breeding season, the present research aimed to describe and compare the masses of unbanded and fertile eggs and their components. The clustering effect of clutch on egg and egg component mass was investigated, and the relationship between the mass of unbanded eggs and their components, together with the effect of possible confounding variables was explored. Estimated egg volume (ellipsoid volume) was strongly positively correlated with egg mass. A strong positive linear relationship existed between egg mass and the combined mass of the foetus and intra-abdominal yolk, as well as between egg mass and the isolated yolk-free foetal mass. If egg mass and incubation period were kept constant, foetal mass increased by 1.1 g for each gram that yolk decreased. The wet yolk and dried shell masses of fertile eggs were significantly lower than those of size-matched unbanded eggs. Clutch had a strong clustering effect on all component masses, particularly total egg mass and hatchling mass. Unbanded egg mass and its individual component masses tended to be similar within a clutch, however some variability existed which should not be discounted. The mass of an egg was strongly positively linearly correlated with the mass of each of its components. The period within the laying season an egg was laid had no effect on its mass nor the mass of any of its components, whereas the breeding pond in which the female resided did affect these measurements. The strong clustering effect of clutch on total egg mass and the masses of all egg components must be accounted for when selecting samples for future studies. The potential confounding effect of breeding pond of origin (which related to female size in the current study) should be considered, particularly where the age or size of females differ among ponds.

Iijima, M. and Kubo, T. (2019). Comparative morphology of presacral vertebrae in extant crocodylians: taxonomic, functional and ecological implications. Zoological Journal of the Linnean Society (https://doi.org/10.1093/zoolinnean/zly096).

Abstract: Despite its systematic and functional relevance, the axial skeleton of crocodylians has received considerably less attention than the cranial and appendicular skeleton due to the assumed evolutionary conservativeness. The current study provides comprehensive comparisons of presacral vertebrae in extant crocodylians to demonstrate: (1) taxonomic variation, (2) size-dependent shape changes and (3) potential integration between vertebrae and skull functional modules. Our comparisons highlighted the uniqueness of the Indian gharial, *Gavialis gangeticus*, among extant crocodylians. The presacral vertebrae of *G. gangeticus* are characterized by reduced level of regionalization and increased intervertebral mobility in the neck (more narrowly placed zygapophyses and short vertebral processes), which would help lateral head sweeping under water for foraging. The scaling relationships of vertebral dimensions against the body size proxy indicate that dorsal vertebrae become stiffer with increasing body size: positive allometries were observed in areas and heights of inter-central joints, and lengths of vertebral processes (neural spines and transverse processes). These structural changes presumably serve to resist increasing compression loads and dorsiflexion bending moment on dorsal vertebrae of larger individuals during terrestrial locomotion. The analyses of correlation between vertebral dimensions and snout shape revealed that slender-snouted species tend to have more laterally mobile necks (specifically narrow zygapophyses), implying the potential integration of cranial and neck modules to optimize the foraging strategy.

Muniz, F.L., Ximenes, A.M., Bittencourt, P.S., Hernández-Rangel, S.M., Campos, Z., Hrbek, T. and Farais, I.P. (2019). Detecting population structure of *Paleosuchus trigonatus* (Alligatoridae: Caimaninae) through microsatellites markers developed by next generation sequencing. Molecular Biology Reports (https://doi.org/10.1007/s11033-019-04709-7).

Abstract: We isolated and characterized 10 new microsatellites loci for *Paleosuchus trigonatus* using ION TORRENT Sequencing Technology. We tested the transferability of these loci to three related species of the subfamily Caimaninae, and used these bi-parental markers to test population structure and genetic diversity of two populations of *P. trigonatus* impacted by hydroelectric dam construction on the Madeira (N = 16) and Xingu (N = 16) Rivers. We also investigated the transferability of these markers to three related species: *Paleosuchus palpebrosus* (N = 5), *Caiman crocodilus* (N = 6) and *Melanosuchus niger* (N = 6). The genetic diversity of P. trigonatus was low in both the Madeira (He: 0.535 ± 0.148) and Xingu (He: 0.381 ± 0.222) populations, but the loci were sufficiently polymorphic to be used in system of mating and kinship studies in P. trigonatus. DAPC analysis with our set of microsatellites loci was able to separate the four species of Caimaninae studied and to detect a shallow genetic structure between Madeira and Xingu populations of *P. trigonatus*. AMOVA and STRUCTURE analyses using locprior model corroborate this shallow genetic structure. These novel molecular markers will be also useful in conservation genetics and phylogeographic studies of *P. trigonatus*, since they improve our ability to monitor the putative effects of dams on the loss of genetic diversity and allow us to investigate population dynamics and microevolutionary processes that occurred in the species.

D'Amore, D.C., Harmon, M., Drumheller, S.K. and Testin, J.J. (2019). Quantitative heterodonty in Crocodylia: assessing size and shape across modern and extinct taxa. PeerJ 7: e6485.

Abstract: Heterodonty in Crocodylia and closely related taxa has not

been defined quantitatively, as the teeth rarely have been measured. This has resulted in a range of qualitative descriptors, with little consensus on the condition of dental morphology in the clade. The purpose of this study is to present a method for the quantification of both size- and shape-heterodonty in members of Crocodylia. Data were collected from dry skeletal and fossil specimens of 34 crown crocodylians and one crocodyliform, resulting in 21 species total. Digital photographs were taken of each tooth and the skull, and the margins of both were converted into landmarks and semilandmarks. We expressed heterodonty through Foote's morphological disparity, and a principal components analysis quantified shape variance. All specimens sampled were heterodont to varying degrees, with the majority of the shape variance represented by a 'caniniform' to 'molariform' transition. Heterodonty varied significantly between positions; size undulated whereas shape was significantly linear from mesial to distal. Size and shape appeared to be primarily decoupled. Skull shape correlated significantly with tooth shape. High size-heterodonty often correlated with relatively large caniniform teeth, reflecting a prioritization of securing prey. Large, highly molariform, distal teeth may be a consequence of high-frequency durophagy combined with prey size. The slender-snouted skull shape correlated with a caniniform arcade with low heterodonty. This was reminiscent of other underwater-feeding tetrapods, as they often focus on small prey that requires minimal processing. Several extinct taxa were very molariform, which was associated with low heterodonty. The terrestrial peirosaurid shared similarities with large modern crocodylian taxa, but may have processed prey differently. Disparity measures can be inflated or deflated if certain teeth are absent from the tooth row, and regression analysis may not best apply to strongly slender-snouted taxa. Nevertheless, when these methods are used in tandem they can give a complete picture of crocodylian heterodonty. Future researchers may apply our proposed method to most crocodylian specimens with an intact enough tooth row regardless of age, species, or rearing conditions, as this will add rigor to many life history studies of the clade.

Salas-Gismondi, R., Moreno-Bernal, J.W., Scheyer, T.M., Sanchez-Villagra, M.R. and Jaramillo, C. (2018). New Miocene Caribbean gavialoids and patterns of longirostry in crocodylians. Journal of Systematic Palaeontology (http://dx.doi.org/10.1080/14772019.2018.1495275).

Abstract: Gavialoidea is a clade of slender- and long-snouted crocodylomorphs with a single living species, the Indian gharial *Gavialis gangeticus*. Because elongated snouts (longirostry) have evolved independently in several crocodylomorph clades, this head shape has been interpreted as an ecological adaptation. How this condition affected patterns of diversification and how longirostrineassociated cranial features changed through adaptive radiations remain poorly understood. Two new small gryposuchine gavialoids, *Dadagavialis gunai* gen. et sp. nov. (early Miocene, Panama) and *Aktiogavialis caribesi* sp. nov. (late Miocene, Venezuela), evidence remarkable Miocene diversification of longirostrine forms in the Neotropics and support transmarine biogeographical relations between northern South America, the Caribbean, and southernmost North America before the Isthmus of Panama was fully established. By integrating phylogenetics and geometric morphometrics, we focus on this gavialoid diversity to investigate patterns of longirostry across the crown group of crocodylomorphs (Crocodylia). Analyses revealed that the snout shape of gavialoids has occupied a small, distinct and almost invariable morphospace since the Cretaceous, in contrast with the morphologically labile snout shape of other crocodylians (crocodyloids and alligatoroids). Our results suggest iterative environmental shift occupations throughout gavialoid evolution without major changes in snout proportions, but involving conspicuous rearrangements of the circumorbital bones. The longirostrine gavialoid morphotype is a distinct adaptation for seizing small prey and typically includes short and wide premaxillae and enlarged 'caniniform' teeth only at the tip of the snout. In longirostrine crocodyloids (*Tomistoma*, *Crocodylus intermedius*), the conservation of powerful bites and 'caniniforms' closer to the jaw joints allowed them to exploit a wider range of prey sizes, which could explain their snout shape plasticity. Therefore, the Mio-Pliocene extirpation of gryposuchine gavialoids from the Caribbean by the arrival of *Crocodylus* is quite unlikely. The last gryposuchine survived throughout the Pliocene in the south-eastern Pacific, where *Crocodylus* has never been documented.

Hammerschlag, N., Schmitz, O.J., Flecker, A.S., Lafferty, K.D., Sih, A., Atwood, T.B., Gallagher, A.J., Irschick, D.J., Skubel, R. and Cooke, S.J. (2019). Ecosystem function and services of aquatic predators in the Anthropocene. Trends in Ecology and Evolution (https://doi.org/10.1016/j.tree.2019.01.005).

Abstract: Arguments for the need to conserve aquatic predator (AP) populations often focus on the ecological and socioeconomic roles they play. Here, we summarize the diverse ecosystem functions and services connected to APs, including regulating food webs, cycling nutrients, engineering habitats, transmitting diseases/parasites, mediating ecological invasions, affecting climate, supporting fisheries, generating tourism, and providing bioinspiration. In some cases, human-driven declines and increases in AP populations have altered these ecosystem functions and services. We present a social ecological framework for supporting adaptive management decisions involving APs in response to social and environmental change. We also identify outstanding questions to guide future research on the ecological functions and ecosystem services of APs in a changing world.

Cuff, A.R., Daley, M.A., Michel, K.B., Allen, V.R., Lamas, L.P., Adami, C., Monticelli, P., Pelligand, L. and Hutchinson, J.R. (2019). Relating neuromuscular control to functional anatomy of limb muscles in extant archosaurs. Journal of Morphology (doi: 10.1002/jmor.20973).

Abstract: Electromyography (EMG) is used to understand muscle activity patterns in animals. Understanding how much variation exists in muscle activity patterns in homologous muscles across animal clades during similar behaviours is important for evaluating the evolution of muscle functions and neuromuscular control. We compared muscle activity across a range of archosaurian species and appendicular muscles, including how these EMG patterns varied across ontogeny and phylogeny, to reconstruct the evolutionary history of archosaurian muscle activation during locomotion. EMG electrodes were implanted into the muscles of turkeys, pheasants, quail, guineafowl, emus (three age classes), tinamous and juvenile Nile crocodiles across 13 different appendicular muscles. Subjects walked and ran at a range of speeds both overground and on treadmills during EMG recordings. Anatomically similar muscles such as the lateral gastrocnemius exhibited similar EMG patterns at similar relative speeds across all birds. In the crocodiles, the EMG signals closely matched previously published data for alligators. The timing of lateral gastrocnemius activation was relatively later within a stride cycle for crocodiles compared to birds. This difference may relate to the coordinated knee extension and ankle plantarflexion timing across the swing-stance transition in Crocodylia, unlike in birds where there is knee flexion and ankle dorsiflexion across swing-stance. No significant effects were found across the species for ontogeny, or between treadmill and overground locomotion. Our findings strengthen the inference that some muscle EMG patterns remained conservative throughout Archosauria: for example, digital flexors retained similar stance phase activity and M. pectoralis remained an 'anti-gravity' muscle. However, some avian hindlimb muscles evolved divergent activations in tandem with functional changes such as bipedalism and more crouched postures, especially M. iliotrochantericus caudalis switching from swing to stance phase activity and M. iliofibularis adding a novel stance phase burst of activity.

Conner, J.L., Crossley, J.L., Elsey, R., Nelson, D., Wang, T. and

Crossley, D.A. II. (2019). Does the left aorta provide proton-rich blood to the gut when crocodilians digest a meal? Journal of Experimental Biology (doi: 10.1242/jeb.201079).

Abstract: Reptiles have the capacity to differentially perfuse the systemic and pulmonary vascular circuits via autonomic regulation of the heart and the vascular trees. While this aptitude is widely recognized, the role of "shunting" as a homeostatic mechanism to match convective transport with tissue demand remains unknown. In crocodilians, it has been hypothesized that a pulmonary vascular bypass of systemic venous blood, a right-to-left shunt (R-L), serves to deliver CO_2-rich blood with protons needed for gastric acid secretion during digestion. This hypothesis is partially based on the unique crocodilian vascular anatomy where a left aorta (LAo) arises from the right ventricle, and appears to preferentially supply the gastrointestinal system, whereas the right aorta emerges from the left ventricle. Recent theoretical considerations imply that a R-L shunt has minuscule effects on PCO_2 (Malte *et al*. 2017), but direct measurements of blood gases in both the right and left aortae or both the right and left atria in fed animals have not been conducted. For this reason, we measured blood parameters including PO_2, PCO_2, pH_e, $[HCO_3^-]$ in both aortae (right and left) as well as both atria following ingestion of a gavage feed standardized meal (5% body mass). Blood samples were withdrawn at 3, 6, 12, 24, 36 and 48 h into the digestive period to encompass the period of maximal gastric acid secretion. At no point did PCO_2 or pH differ between the left and right aortae, whereas PO_2 was significantly lower in the left aorta at several time points during digestion. Our findings do not support the hypothesis that a R-L shunt serves to deliver CO_2 for the gastrointestinal system after feeding in crocodilians.

Moustakas-Verho, J.E., McLennan, R., Spengler, J., Kulesa, P.M. and Cebra-Thomas, J.A. (2019). Manipulation of developmental function in turtles with notes on alligators. Methods in Molecular Biology 1920: 247-263.

Abstract: Reptiles have great taxonomic diversity that is reflected in their morphology, ecology, physiology, modes of reproduction, and development. Interest in comparative and evolutionary developmental biology makes protocols for the study of reptile embryos invaluable resources. The relatively large size, seasonal breeding, and long gestation times of turtles epitomize the challenges faced by the developmental biologist. We describe protocols for the preparation of turtle embryos for *ex ovo* culture, electroporation, in situ hybridization, and microcomputed tomography. Because these protocols have been adapted and optimized from methods used for frog, chick, and mouse embryos, it is likely that they could be used for other reptilian species. Notes are included for alligator embryos where appropriate.

Baker, C.J., Franklin, C.E., Campbell, H.A., Irwin, T.R. and Dwyer, R.G. (2019). Ontogenetic shifts in the nesting behaviour of female crocodiles. Oecologia (https://doi.org/10.1007/s00442-019-04382-4).

Abstract: Body size and age are crucial factors influencing reproductive capacity and success. As females grow, their reproductive investment and success often increase due to improved overall physiological condition and experience gained through successive reproductive events. While much of this work has been conducted on birds and mammals, surprisingly little is known on how body size affects nesting decisions in other long-lived vertebrates. We monitored the movements and nesting behaviour of 57 wild female estuarine crocodiles *Crocodylus porosus* over a 10-year period (and across consecutive nesting seasons) using externally mounted satellite tags, implanted acoustic transmitters and a network of submerged acoustic receivers. Applying Hidden Markov models to the telemetry-derived location data revealed that female nesting behaviours could be split into three distinct states: (i) ranging movements within home ranges and at nesting sites; (ii) migrations to and from nesting sites; (iii) and nesting/nest guarding. We found that during migration events, larger females migrated further and remained away from dry season territories for longer periods than smaller individuals. Furthermore, not only were migratory movements stimulated by increases in rainfall, larger females migrated to nest sites at lower rainfall thresholds than smaller females. We provide some of the first evidence of body size influencing nesting decisions in an ectothermic vertebrate, with shifts likely resulting from an increased willingness to invest in nest protection among larger and more experienced females.

Pritz, M.B. (2019). Thalamic reticular nucleus in *Caiman crocodilus*: Immunohistochemical staining. Brain, Behavior and Evolution (https://doi.org/10.1159/000496327).

Abstract: The thalamic reticular nucleus in reptiles, *Caiman crocodilus*, shares a number of morphological similarities with its counterpart in mammals. In view of the immunohistochemical properties of this nucleus in mammals and the more recently identified complexity of this neuronal aggregate in *Caiman*, this nucleus was investigated using a number of antibodies. These results were compared with findings described for other amniotes. The following antibodies gave consistent and reproducible results: polyclonal sheep anti-parvalbumin (PV), monoclonal mouse anti-PV, and polyclonal sheep anti-glutamic acid decarboxylase (GAD). In the transverse plane, this nucleus is divided into two. In each part, a compact group of cells sits on top of the fibers of the forebrain bundle with scattered cells among these fibers. In the lateral forebrain bundle, this neuronal aggregate is represented by the dorsal peduncular nucleus and the perireticular nucleus while, in the medial forebrain bundle, these parts are the interstitial nucleus and the scattered cells in this fiber tract. The results of this study are the following. First, the thalamic reticular nucleus of *Caiman* contains GAD(+) and PV(+) neurons, which is similar to what has been described in other amniotes. Second, the morphology and distribution of many GAD(+) and PV(+) neurons in the dorsal peduncular and perireticular nuclei are similar and suggest that these neurons colocalize these markers. Third, neurons in the interstitial nucleus and in the medial forebrain bundle are GAD(+) and PV(+). At the caudal pole of the thalamic reticular nucleus, PV immunoreactive cells predominated and avoided the central portion of this nucleus where GAD(+) cells were preferentially located. However, GAD(+) cells were sparse when compared with PV(+) cells. This immunohistochemically different area in the caudal pole is considered to be an area separate from the thalamic reticular nucleus.

Balme, J. and O'Connor, S. (2019). Bead making in Aboriginal Australia from the deep past to European arrival: Materials, methods, and meanings. PaleoAnthropology 2019: 177-195.

Abstract: This paper reviews the raw materials used by Indigenous Australians to make beads. It includes beads recovered from archaeological sites, as well as beads collected before 1940 held in museum collections, and those that are described in pre-1940 literature and other archival material. All three sources of information indicate that people were highly selective in their choice of materials for bead production and that availability and abundance only partly determined selection. Grass and reeds, the most widespread material represented in the museum and historic sources, if used in pre-European times, have not been preserved in archaeological sites. Beads made of highly iridescent or luminous shells, that historic sources suggest were regarded as imbued with powerful properties, were selected over other, more abundant colorful or patterned shells. Teeth of large macropod species were more commonly used than any other mammals despite other species being more readily available. On the other hand, dingo teeth, which were just as large and more robust than macropod teeth, were very rarely used, and this seems surprising given dingoes' ubiquitous presence in Aboriginal society. As dog teeth were commonly used as beads in personal adornments

by Melanesian people in Papua New Guinea, and the teeth of now locally extinct dogsized carnivores are found as beads in archaeological contexts, we suggest that the lack of dog teeth beads may reflect the high status of dogs in Aboriginal societies. Although the Australian archaeological bead assemblage is small, comparison with the historically documented beads indicates that the choice of raw material has remained relatively constant for thousands of years. The historical sources also describe human teeth and other bone relics as being worn as pendants for protection for the wearer. However these are often unmodified, being suspended by resin or other non-destructive techniques. This has implications for isolated human skeletal parts found in archaeological contexts.

Stein, K., Prondvai, E., Huang, T., Baele, J-M., Sander, P.M. and Reisz, R. (2019). Structure and evolutionary implications of the earliest (Sinemurian, Early Jurassic) dinosaur eggs and eggshells. Scientific Reports 9: 4424.

Abstract: One of the fossil record's most puzzling features is the absence of preserved eggs or eggshell for the first third of the known 315 million year history of amniote evolution. Our meagre understanding of the origin and evolution of calcareous eggshell and amniotic eggs in general, is largely based on Middle Jurassic to Late Cretaceous fossils. For dinosaurs, the most parsimonious inference yields a thick, hard shelled egg, so richly represented in the Late Cretaceous fossil record. Here, we show that a thin calcareous layer ($\leq$100 μm) with interlocking units of radiating crystals (mammillae) and a thick shell membrane already characterize the oldest known amniote eggs, belonging to three coeval, but widely distributed Early Jurassic basal sauropodomorph dinosaurs. This thin shell layer strongly contrasts with the considerably thicker calcareous shells of Late Jurassic dinosaurs. Phylogenetic analyses and their Sinemurian age indicate that the thin eggshell of basal sauropodomorphs represents a major evolutionary innovation at the base of Dinosauria and that the much thicker eggshell of sauropods, theropods, and ornithischian dinosaurs evolved independently. Advanced mineralization of amniote eggshell ($\geq$150 μm in thickness) in general occurred not earlier than Middle Jurassic and may correspond with a global trend of increase in atmospheric oxygen.

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.

Bittencourt, P.S., Campos, Z., de Lima Muniz, F., Marioni, B., Campos Souza, B., Da Silveira, R., de Thoisy, B., Hrbek, T. and Pires Farias, I. (2019). Evidence of cryptic lineages within a small South American crocodilian: the Schneider's dwarf caiman *Paleosuchus trigonatus* (Alligatoridae: Caimaninae). PeerJ 7: e6580.

Abstract: Schneider's dwarf caiman *Paleosuchus trigonatus* is one of the smallest living crocodilians. Due to its broad distribution, cryptic behavior, and small home range, the species is well suited for the study of phylogeographic patterns on a continental scale. Additionally, this species is under threat due to habitat loss, trade and harvest, but is considered at low conservation risk by the IUCN. In the present study we test the hypothesis that *P. trigonatus* is comprised of geographically structured lineages. Phylogenetic reconstructions of the mitochondrial cytochrome b gene and single locus species discovery methods revealed the existence of two well-supported lineages within *P. trigonatus* - an Amazonian and Guianan lineage. Fossil calibrated divergence of these lineages was estimated to have occurred in the Late Miocene (7.5 Ma). The hypothesis that the Atlantic coast drainages might have been colonized from the southeast or central Amazon is supported by demographic metrics and relatively low genetic diversity of the Coastal and upper Branco populations when compared to the Amazon basin populations. The Amazon basin lineage is structured along an eastwest gradient, with a sharp transition in haplotype frequencies to the east and west of the Negro and Madeira Rivers. These lineages are already under anthropogenic threat and, therefore, are conservation dependent. Recognition of these lineages will foster discussion of conservation future of *P. trigonatus* and these lineages.

Lessner, E.J., Gant, C.A., Hieronymus, T.L., Vickaryous, M.K. and Holliday, C.M. (2019). Anatomy and ontogeny of the mandibular symphysis in *Alligator mississippiensis*. The Anatomical Record (https://doi.org/10.1002/ar.24116).

Abstract: Crocodylians evolved some of the most characteristic skulls of the animal kingdom with specializations for semi-aquatic and ambush lifestyles, resulting in a feeding apparatus capable of tolerating high biomechanical loads and bite forces and a head with a derived sense of trigeminal-nerve-mediated touch. The mandibular symphysis accommodates these specializations being both at the end of a biomechanical lever and an antenna for sensation. Little is known about the anatomy of the crocodylian mandibular symphysis, hampering our understanding of form, function, and evolution of the joint in extant and extinct lineages. We explore mandibular symphysis anatomy of an ontogenetic series of *Alligator mississippiensis* using imaging, histology, and whole mount methods. Complex sutural ligaments emanating about a midline-fused Meckel's cartilage bridge the symphysis. These tissues organize during days 37-42 of *in ovo* development. However, interdigitations do not manifest until after hatching. These soft tissues leave a hub and spoke-like bony morphology of the symphyseal plate, which never fuses. Interdigitation morphology varies within the symphysis suggesting differential loading about the joint. Neurovascular canals extend throughout the mandibles to alveoli, integument, and bone adjacent to the symphysis. These features suggest the *Alligator* mandibular symphysis offers compliance in an otherwise rigid skull. We hypothesize a fused Meckel's cartilage offers stiffness in hatchling mandibles prior to the development of organized sutural ligaments and mineralized bone while offering a scaffold for somatic growth. The porosity of the dentaries due to neurovascular tissues likely allows transmission of sensory and proprioceptive information from the surroundings and the loaded symphysis.

Mazzotti, F.J., Smith, B.J., Squires, M.A., Cherkiss, M.S., Farris, S.C., Hackett, C., Hart, K.M., Briggs-Gonzalez, V. and Brandt, L.A. (2019). Influence of salinity on relative density of American crocodiles (*Crocodylus acutus*) in Everglades National Park: Implications for restoration of Everglades ecosystems. Ecological Indicators 102: 608-616.

Abstract: The status of the American crocodile (*Crocodylus acutus*) has long been a matter of concern in Everglades National Park (ENP) due to its classification as a federal and state listed species, its recognition as a flagship species, and its function as an ecosystem indicator. Survival and recovery of American crocodiles has been linked with regional hydrological conditions, especially freshwater flow to estuaries, which affect water levels and salinities. We hypothesize that efforts to restore natural function to Everglades ecosystems by improving water delivery into estuaries within ENP

will change salinities and water levels which in turn will affect relative density of crocodiles. Monitoring ecological responses of indicator species, such as crocodiles, with respect to hydrologic change is necessary to evaluate ecosystem responses to restoration projects. Our objectives were to monitor trends in crocodile relative density within ENP and to determine influences of salinity on relative density of crocodiles. We examined count data from 12 years of crocodile spotlight surveys in ENP (2004-2015) and used a hierarchical model of relative density that estimated relative density with probability of detection. The mean predicted value for relative density (λ) across all surveys was 2.9 individuals/km (95% CI: 2.0-4.2); relative density was estimated to decrease with increases in salinity. Routes in ENP's Flamingo/Cape Sable area had greater crocodile relative density than routes in the West Lake/Cuthbert Lake area and Northeast Florida Bay areas. These results are consistent with the hypothesis that restored flow and lower salinities will result in an increase in crocodile population size and provide support for the ecosystem management recommendations for crocodiles, which currently are to restore more natural patterns of freshwater flow to Florida Bay. Thus, monitoring relative density of American crocodiles will continue to be an effective indicator of ecological response to ecosystem restoration.

Kettler, L. and Carr, C. (2019). Neural maps of interaural time difference in the American alligator: a stable feature in modern archosaurs. Journal of Neuroscience (https://doi.org/10.1523/JNEUROSCI.2989-18.2019).

Abstract: Detection of interaural time differences (ITD) is crucial for sound localization in most vertebrates. The current view is that optimal computational strategies of ITD detection depend mainly on head size and available frequencies, although evolutionary history should also be taken into consideration. In archosaurs, which include birds and crocodiles, the brainstem nucleus laminaris (NL) developed into the critical structure for ITD detection. In birds, ITDs are mapped in an orderly array or place code, whereas in the mammalian medial superior olive, the analog of NL, maps are not found. As yet, in crocodilians topographical representations have not been identified. However, non-topographic representations of ITD cannot be excluded due to different anatomical and ethological features of birds and crocodiles. Therefore, we measured ITD-dependent responses in the NL of anesthetized American alligators of either sex and identified the location of the recording sites by lesions made after recording. The measured extracellular field potentials, or neurophonics, were strongly ITD tuned and their preferred ITDs correlated with the position in NL. As in birds, delay lines, which compensate for external time differences, formed maps of ITD. The broad distributions of best ITDs within narrow frequency bands were not consistent with an optimal coding model. We conclude that the available acoustic cues and the architecture of the acoustic system in early archosaurs led to a stable and similar organization in today's birds and crocodiles although physical features, like internally coupled ears, head size or shape, and audible frequency range, vary among the two groups.

Gonçalves Augusta, B. and Zaher, H. (2019). Enamel dentition microstructure of *Mariliasuchus amarali* (Crocodyliformes, Notosuchia), from the Upper Cretaceous (Turonian-Santonian) of the Bauru Basin, Brazil. Cretaceous Research (https://doi.org/10.1016/j.cretres.2019.03.013).

Abstract: Advanced notosuchians represent a diverse clade of highly heterodont crocodyliforms that were endemic to the South American landmass during the Cretaceous. *Mariliasuchus amarali* is an advanced notosuchian from the Upper Cretaceous (Turonian-Santonian) of the Bauru Basin, south-central Brazil, and it is known from several well-preserved specimens in distinct ontogenetic stages. Previous functional analyses of the dentition of *M. amarali* suggested generalist feeding habits. However, microscopic patterns of the enamel, such as crystallite micromorphology and microwear variation along the dental series, have not been investigated in detail so far. Our results evidence that *M. amarali* enamel is unique among crocodyliforms, and that heterodonty in this species is even more complex than previously thought. External crown morphology, macrowear position, microwear orientation, and enamel crystallite micromorphology support the recognition of four tooth morphotypes, each of these presenting a combination of features never seen before. *M. amarali* is the first described reptile bearing both true and false denticles in the same tooth, a condition up to now autapomorphic for the taxon that supports its classification into a distinct dental category (ziphomorph). Ontogenetic trends of dentition reveal that heterodonty was kept through the entire life of *M. amarali*, and that adults and juveniles occupied very similar ecological niches. Hypothesis of *M. amarali* presenting omnivorous feeding habits, with the inclusion of hard items in its diet, is supported here. The unique combination of dental features in the taxon could have provided an important adaptive advantage in a low resource environment, as it has been postulated for the Bauru Basin.

Cidade, G.M., Souza-Filho, J.P., Schmaltz Hsiou, A., Brochu, C.A. and Riff, D. (2019). New specimens of *Mourasuchus* (Alligatorioidea, Caimaninae) from the Miocene of Brazil and Bolivia and their taxonomic and morphological implications, Alcheringa: An Australasian Journal of Palaeontology (doi: 10.1080/03115518.2019.1566495).

Abstract: *Mourasuchus* is one of the most peculiar crocodylians of all time, showing an unusual 'duck-faced' rostrum with thin, gracile mandibles. It includes four species restricted to the South American Miocene. Here, we describe ten late Miocene specimens of *Mourasuchus*, nine from the Solimões Formation of Brazil and one from Bolivia. All specimens are assigned to *M. arendsi*, but this assignment may change as the diversity and relationships within *Mourasuchus* are better understood. We also discuss several issues pertinent to the morphology of *Mourasuchus*: the presence of a braincase neomorph (the laterocaudal bridge), hypotheses about sexual dimorphism, the function of the squamosal 'horns' the presence of possible thermoregulatory functions in the genus. Additionally, the paleogeographic distribution of *Mourasuchus* in the Miocene of South America is also discussed.

Morris, Z.S., Vliet, K.A., Abzhanov, A. and Pierce, S.E. (2019). Heterochronic shifts and conserved embryonic shape underlie crocodylian craniofacial disparity and convergence. Proceedings of the Royal Society B 286: 20182389.

Abstract: The distinctive anatomy of the crocodylian skull is intimately linked with dietary ecology, resulting in repeated convergence on blunt- and slender-snouted ecomorphs. These evolutionary shifts depend upon modifications of the developmental processes which direct growth and morphogenesis. Here we examine the evolution of cranial ontogenetic trajectories to shed light on the mechanisms underlying convergent snout evolution. We use geometric morphometrics to quantify skeletogenesis in an evolutionary context and reconstruct ancestral patterns of ontogenetic allometry to understand the developmental drivers of craniofacial diversity within Crocodylia. Our analyses uncovered a conserved embryonic region of morphospace (CER) shared by all non-gavialid crocodylians regardless of their eventual adult ecomorph. This observation suggests the presence of conserved developmental processes during early development (before Ferguson stage 20) across most of Crocodylia. Ancestral state reconstruction of ontogenetic trajectories revealed heterochrony, developmental constraint, and developmental systems drift have all played essential roles in the evolution of ecomorphs. Based on these observations, we conclude that two separate, but interconnected, developmental programmes controlling craniofacial morphogenesis and growth enabled the evolutionary plasticity of skull shape in crocodylians.

Cullen, T.M., Longstaffe, F.J., Wortmann, U.G., Goodwin, M.B., Huang, L. and Evans, D.C. (2019). Stable isotopic characterization of a coastal floodplain forest community: a case study for isotopic reconstruction of Mesozoic vertebrate assemblages. Royal Society Open Science 6: 181210.

Abstract: Stable isotopes are powerful tools for elucidating ecological trends in extant vertebrate communities, though their application to Mesozoic ecosystems is complicated by a lack of extant isotope data from comparable environments/ecosystems (eg coastal floodplain forest environments, lacking significant C4 plant components). We sampled 20 taxa across a broad phylogenetic, body size, and physiological scope from the Atchafalaya River Basin of Louisiana as an environmental analogue to the Late Cretaceous coastal floodplains of North America. Samples were analysed for stable carbon, oxygen and nitrogen isotope compositions from bioapatite and keratin tissues to test the degree of ecological resolution that can be determined in a system with similar environmental conditions, and using similar constraints, as those in many Mesozoic assemblages. Isotopic results suggest a broad overlap in resource use among taxa and considerable terrestrial-aquatic interchange, highlighting the challenges of ecological interpretation in C3 systems, particularly when lacking observational data for comparison. We also propose a modified oxygen isotope-temperature equation that uses mean endotherm and mean ectotherm isotope data to more precisely predict temperature when compared with measured Atchafalaya River water data. These results provide a critical isotopic baseline for coastal floodplain forests, and act as a framework for future studies of Mesozoic palaeoecology.

Mannion, P.D., Chiarenza, A.A., Godoy, P.L. and Cheah, Y.N. (2019). Spatiotemporal sampling patterns in the 230 million year fossil record of terrestrial crocodylomorphs and their impact on diversity. Palaeontology (https://doi.org/10.1111/pala.12419).

Abstract: The 24 extant crocodylian species are the remnants of a once much more diverse and widespread clade. Crocodylomorpha has an approximately 230 million year evolutionary history, punctuated by a series of radiations and extinctions. However, the group's fossil record is biased. Previous studies have reconstructed temporal patterns in subsampled crocodylomorph palaeobiodiversity, but have not explicitly examined variation in spatial sampling, nor the quality of this record. We compiled a dataset of all taxonomically diagnosable non-marine crocodylomorph species (393). Based on the number of phylogenetic characters that can be scored for all published fossils of each species, we calculated a completeness value for each taxon. Mean average species completeness (56%) is largely consistent within subgroups and for different body size classes, suggesting no significant biases across the crocodylomorph tree. In general, average completeness values are highest in the Mesozoic, with an overall trend of decreasing completeness through time. Many extant taxa are identified in the fossil record from very incomplete remains, but this might be because their provenance closely matches the species' present-day distribution, rather than through autapomorphies. Our understanding of nearly all crocodylomorph macroevolutionary 'events' is essentially driven by regional patterns, with no global sampling signal. Palaeotropical sampling is especially poor for most of the group's history. Spatiotemporal sampling bias impedes our understanding of several Mesozoic radiations, whereas molecular divergence times for Crocodylia are generally in close agreement with the fossil record. However, the latter might merely be fortuitous, ie divergences happened to occur during our ephemeral spatiotemporal sampling windows.

Mastrantonio, B.M., Baczko, M.B. von, Desojo, J.B. and Schultz, C.L. (2019). The skull anatomy and cranial endocast of the pseudosuchid archosaur *Prestosuchus chiniquensis* from the Triassic of Brazil. Acta Palaeontologica Polonica 64(1): 171-198.

Abstract: *Prestosuchus chiniquensis* is the most famous "rauisuchian" described by Friedrich von Huene, eight decades ago, and several specimens have been assigned to this taxon since then. In the present contribution, we provide the first detailed description of a complete and very well preserved skull (including the braincase) assigned to *Prestosuchus chiniquensis* from the *Dinodontosaurus* Assemblage Zone of the Santa Maria Supersequence of southern Brazil. The detailed description of the skull of *Prestosuchus chiniquensis*, besides increasing the knowledge about this taxon, may help elucidate the taxonomic relationships of pseudosuchians even further, since most of the characters used in phylogenetic analyzes are cranial. The presence of the subnarial fenestra, a controvertial extra opening on the skull of "rauisuchians", is thoroughly discussed considering the evidence provided by this new specimen. We consider that the small slit-opening between the premaxilla and the maxilla in *Prestosuchus chiniquensis*, can not safely be considered a true fenestra, but indicates more likely the existence of some degree of cranial kinesis between these elements which can result in different relative positions of the bones after definitive burial and fossilization, so that the size and shape of this opening is taphonomically controlled. Complementarily, the digital reconstruction of its cranial endocast was developed both from the observation of the preserved braincase and from CT scan images, which resulted in obtaining the first endocast known for a "rauisuchian". The endocast of *Prestosuchus chiniquensis* exhibited some remarkable convergences with that of theropod dinosaurs, which could be a reflection of the similar niches they occupied, since "rauisuchians" were the top predators at the end of the Late Triassic, before the extinction of all non-crocodylomorph pseudosuchians.

Nixon, B., Johnston, S.D., Skerrett-Byrne, D.A., Anderson, A.L., Stanger, S.J., Bromfield, E.G., Martin, J.H., Hansbro, P.M. and Dun, M.D. (2019). Modification of crocodile spermatozoa refutes the tenet that post-testicular sperm maturation is restricted to mammals. Molecular & Cellular Proteomics (https://doi.org/10.1074/mcp.RA118.000904).

Abstract: Competition to achieve paternity has contributed to the development of a multitude of elaborate male reproductive strategies. In one of the most well-studied examples, the spermatozoa of all mammalian species must undergo a series of physiological changes, termed capacitation, in the female reproductive tract before realizing their potential to fertilize an ovum. However, the evolutionary origin and adaptive advantage afforded by capacitation remains obscure. Here, we report the use of comparative and quantitative proteomics to explore the biological significance of capacitation in an ancient reptilian species, the Australian saltwater crocodile (*Crocodylus porosus*). Our data reveal that exposure of crocodile spermatozoa to capacitation stimuli elicits a cascade of physiological responses that are analogous to those implicated in the functional activation of their mammalian counterparts. Indeed, among a total of 1119 proteins identified in this study, we detected 126 that were differentially phosphorylated (± 1.2 fold-change) in capacitated versus, noncapacitated crocodile spermatozoa. Notably, this subset of phosphorylated proteins shared substantial evolutionary overlap with those documented in mammalian spermatozoa, and included key elements of signal transduction, metabolic and cellular remodeling pathways. Unlike mammalian sperm, however, we noted a distinct bias for differential phosphorylation of serine (as opposed to tyrosine) residues, with this amino acid featuring as the target for ~80% of all changes detected in capacitated spermatozoa. Overall, these results indicate that the phenomenon of sperm capacitation is unlikely to be restricted to mammals and provide a framework for understanding the molecular changes in sperm physiology necessary for fertilization.

Roamcharern, N. Payoungkiattikun, W., Anwised, P., Mahong, B., Jangpromma, N., Daduang, S. and Klaynongsruang, S. (2019). Physicochemical properties and oxygen affinity of glutaraldehyde polymerized crocodile hemoglobin: The new alternative hemoglobin

source for hemoglobin-based oxygen carriers. Artificial Cells Nanomedical Biotechnology 47(1): 852-861.

Abstract: Hemoglobin-based oxygen carriers (HBOCs) are modified stroma-free hemoglobin molecules used in developing a blood substitute for therapeutic usage. In order to prevent hemoglobin dissociation, glutaraldehyde (GTA) was used to generate high-molecular weight heterogeneous crocodile hemoglobin (Poly-cHb). This work, Poly-cHb was created using various GTA concentrations, ranging from 0.025-0.150% (v/v). Physicochemical properties were investigated that were comparable GTA polymerized human hemoglobin (Poly-hHb). This study has revealed that GTA polymerization increases the molecular size of Native-cHbs from 14.10 nm over a range from 16.31 to 54.27 nm. Moreover, this polymerization alters the secondary structure and heme environment by decreasing the helicity ratio from 1.00 to 0.95 at the highest condition and exhibits hypochromic shift of the Soret band to be 0.88 times lower than the native. However, all Poly-cHbs still possessed higher oxygen affinity than that of Poly-hHbs with average P50 values of 13 and 21 mmHg, respectively. Although, polymerization affected the overall Poly-cHb structure slightly, but compensated by decreasing the denaturation level to lower than 10%. Thus, it is interesting to note that Poly-cHb may advantageously provide effective oxygen carriage and ability for pasteurization, which may benefit the search for new alternative hemoglobin sources for HBOC development.

Wu, X., Zhang, X., Jin, Z., Song, Y., Luan, F. and Xue, X. (2019). Strontium isotope analysis of Yangtze alligator remains from Late Neolithic North China. Archaeological and Anthropological Sciences 11(3): 1049-1058.

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."

Donoso, C.H. (2018). Assessment of mangroves identified as *Crocodylus porosus* habitat in Del Carmen Siargao Islands. Journal of Science and Technology 4(1).

Abstract: The study aimed to assess the species composition, abundance, distribution, as well as the zonation pattern of mangrove species identified as the nesting habitat of *Crocodylus porosus*. A total of three transect lines and 30 quadrats were used. The mangrove area had five true mangrove species belonging to 4 families; namely, *Sonneratia alba*, *Avicennia marina*, *Rhizophora mucronata*, *R. apiculata* and *Ceriops tagal* and one associate mangrove, *Nypa fruticans*. *Sonneratia alba* and *Avicennia marina* were the most abundant in the area, and were found in seaward zone. *Rhizophora apiculata* and *R. mucronata* were in the middle zone whereas *N. fruticans* and *C. tagal* were found in landward zone. In terms of ecological status, the mangrove area of Del Carmen, Siargao Islands, Philippines can be rated as 3.0 using a rating scale of 1-no impact and 5.0-having impact. This means that the area was disturbed. The number of mangrove saplings and seedlings were quite low. Destruction of the habitat was observed. The cutting of trees and the use of the area as berthing site for boats is most observed in the mangrove area. Active community active participation on mangrove conservation and crocodile bio-physical monitoring should be strengthened for a sustainable management of their wetland resources.

Sun, H., Zuo, X., Sun, L., Yan, P., Zhang, F., Xue, H., Li, E., Zhou, Y., Wu, R. and Wu, X. (2019). Insights into the seasonal adaptive mechanisms of Chinese alligators (*Alligator sinensis*) from transcriptomic analyses. Australian Journal of Zoology 66(2): 93-102.

Abstract: The Chinese alligator (*Alligator sinensis*) is an endemic and rare species in China, and is considered to be one of the most endangered vertebrates in the world. It is known to hibernate, an energy-saving strategy against cold temperatures and food deprivation. Changes in gene expression during hibernation remain largely unknown. To understand these complex seasonal adaptive mechanisms, we performed a comprehensive survey of differential gene expression in heart, skeletal muscle, and kidney of hibernating and active Chinese alligators using RNA-Sequencing. In total, we identified 4780 genes differentially expressed between the active and hibernating periods. GO and KEGG pathway analysis indicated the likely role of these differentially expressed genes (DEGs). The upregulated DEGs in the active Chinese alligator, *CSRP3*, *MYG* and *PCKGC*, may maintain heart and skeletal muscle contraction, transport and storage of oxygen, and enhance the body's metabolism, respectively. The upregulated DEGs in the dormant Chinese alligator, *ADIPO*, *CIRBP* and *TMM27*, may improve insulin sensitivity and glucose/lipid metabolism, protect cells against harmful effects of cold temperature and hypoxia, regulate amino acid transport and uptake, and stimulate the proliferation of islet cells and the secretion of insulin. These results provide a foundation for understanding the molecular mechanisms of the seasonal adaptation required for hibernation in Chinese alligators, as well as effective information for other non-model organisms research.

Cedillo-Leal, C.N., Requena-Lara, G., Martínez-González, J.C., Vázquez-Loya, D.A. and Cienfuegos-Rivas, E.G. (2019). Distribution of *Crocodylus moreletii* Dumeril & Bibron in Tamaulipas, Mexico. Agroproductividad 12(1): 59-64.

Abstract: Objective: Determine and evaluate the current status of the swamp crocodile in the state of Tamaulipas, Mexico. Design/methodology/approach: Maps of spatial distribution were made as a contribution to the management and conservation plans of crocodile. Hundred and twenty-three documents were reviewed, and 41 were selected (nine books, 12 scientific articles, three theses, five official pages, four project reports and eight documents from specialist groups). Field visits were carried out with the support of the fire department and civil protection to monitor the population of crocodiles in the area. Geo-referenced maps were prepared with the documented records and sightings in the distribution area. Results: It was found that *C. moreletii* has expanded its distribution to the north of the State and in the south region there are sightings in 14 new bodies of water where they had not been reported. The above could be an indicator that the crocodile population is recovering, and conservation plans should be proposed before the conflict with the human population has a negative effect on this species so important for aquatic ecosystems. Limitations on study/implications: In the State of Tamaulipas there is not enough information about the presence and location of crocodiles in the different bodies of water in the region. The capture of animals is difficult due to the proximity to the human population and due to the insecurity prevailing in the region. Findings/conclusions: The crocodile population is expanding to bodies of water where they were not documented within the registered distribution for this species.

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