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NEWSLETTER

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COVER PHOTOGRAPH: Training an adult male Mugger (*Crocodylus palustris*) at Madras Crocodile Bank Trust in 2009. Photograph: Akanksha Mukherjee. See pages 12-14 for related article.

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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

The primary mission of the CSG is to assist the SSC and IUCN to fulfill their missions with crocodilians. But while doing so, we benefit greatly from the camaraderie between members, the diverse experiences and knowledge so openly shared, and in many ways the open and transparent way in which we conduct business. None of us ever anticipated anything like the Covid-19 pandemic, which is by no means finished. It is the difference between "risk", which we know and can anticipate, and "uncertainty" - the unpredictable wild cards.

Amongst our large membership, some 670 members in 70 countries, there may well be members whose families, friends and colleagues have suffered directly. If so, be assured that all CSG members share your pain. Personally, living in Darwin, which is so isolated from everywhere, the "tyranny of distance" has for once been to our advantage. But this is not the case in many other countries.

As I see it, from a conservation perspective (https://www.iucn.org/news/commission-environmental-economic-and-social-policy/202006/covid-19-conservation-programs-and-crocodilians) Covid-19 is the experiment you could never afford to do. It has reaffirmed that conservation action is impossible without financial resources, and sustainability ultimately depends on ensuring funding can be sustained. The CSG has been able to build resources, so we can still function normally, but this is the exception rather than the rule.

The Covid-19 pandemic has caused the postponement of a series of important meetings, including the IUCN World Conservation Congress (7-15 January 2021), the 26th CSG Working Meeting (1-6 May 2021), the 23rd International Congress of Zoology (15-21 November 2021), and many more.

The postponement of the 26th CSG Working Meeting (Chetumal, Mexico) was necessary - but a serious constraint to CSG business. This is normally the time that the CSG Executive Committee and Steering Committee meet, to report on past activities and outline plans for the future.

The CSG Executive Committee had a "Zoom" meeting over 3 days (3-6 May 2020), and is preparing papers for distribution to the CSG Steering Committee. Some key recommendations from the meeting were that: (1) CSG needs a formal "Communication Strategy"; (2) the structure of the CSG Steering Committee needs to be revised; and, (3) a formal Future Leaders Program should replace the previous Future Leaders Working Group.

Since 21 April the CSG Latin America and the Caribbean Regional Office has been holding a series of virtual conferences ("Conference Cycle on Crocodilians"), moderated by Alejandro Larriera (CSG Deputy Chair) and Pablo Siroski (LAC regional Chair). To date 31 speakers have made presentations, and the program will continue until further notice (see page 4).

Under the guidance of Sally Isberg (Australia) and Pablo Siroski (Argentina), crocodilian case histories involving sustainable use are now being prepared for publication. It just seems so important that our pursuit of sustainable use is recognised nationally and internationally for its achievements.

On 15 June 2020, the lawsuit relating to California Penal Code 653o (ban on Alligator and Crocodile Trade Ban) was heard, but the judge did not make a final ruling, which may be weeks away.

A particularly sad piece of news was the death of Peter Beard. Perhaps unknown to many CSG members, Peter Beard was a photographer and highly innovative - perhaps eccentric - artist, who teamed up with Alistair Graham, a true pioneer in sustainable use, and together they created "Eyelids of Morning: The Mingled Destinies of Crocodiles and Men". This is simply a remarkable book, in terms of content and art, about crocodiles and people. It was well before its time. Peter Beard's photographs in his book "End of the Game", of protected elephants starving to death complete with tusks, because they had long exceeded carrying capacity, are simply incredible "spears in the ground", in a global debate that has long since been based on political expediency rather than science.

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

Professor Grahame Webb, *CSG Chair.*

CSG Student Research Assistance Scheme

The Student Research Assistance Scheme (SRAS) and Fritz Huchzermeyer Veterinary Science Student Research Assistance Scheme (FHVS-SRAS) provided funding to 7 students in the April-June 2020 quarter. Three further applications are currently under review.

1. Rayssa Santos (Brazil): Metal contamination and ecotoxicological effects on *Caiman latirostris* (Daudin, 1802) (Crocodylia, Alligatoridae) in lentic ecosystems of Atlantic forest in northeastern Brazil.

2. Jose Marcos Abreu (Brazil): Ecology and genetic diversity of *Paleosuchus palpebrosus* in the Cerrado biodiversity hotspot: Conservation of an iconic apex predator in rare aquatic environments in Central Brazil Highlands.

3. Milan Piva (USA): Magnetic Resonance Imagery (MRI) study of male crocodylian anatomy.

4. Florencia Valli (Argentina): Effects of maternal hormonal-epigenetic investment and climatic variables on sex determination of *Caiman latirostris*.

5. Sophie Tournier (France): Effects of visual separation on raising hatching Saltwater crocodiles (*Crocodylus porosus*).

6. Nicci Buys (South Africa): Associations between environmental contaminant exposure and DNA methylation in Nile crocodiles (*Crocodylus niloticus*).

7. Gabriela Gama (Brazil): Linking habitat protection, local communities livelihoods, and conservation of caimans in Brazilian northeast Atlantic forest.

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

26th CSG Working Meeting Postponed

Due to the current Covid-19 pandemic, the 26th CSG Working Meeting to be held in Chetumal, Quintana Roo, Mexico, has been postponed to 3-6 May 2021. It will be preceded by the veterinary, drone and taxonomy workshops on 1 May 2021, and a CSG Steering Committee meeting on 2 May 2021. Updated information is now available on the meeting website (www.biodiversidad.gob.mx/planeta/csg2020/index.html).

IUCN World Conservation Congress Postponed

The IUCN World Conservation Congress, to be held in Marseilles, France, has been postponed to 7-15 January 2021.

International Congress of Zoology Postponed

The 23rd International Congress of Zoology, to be held in Capetown, South Africa, has been postponed to 15-21 November 2021.

LAC Conference Cycle on Crocodilians

The Covid-19 pandemic has changed the way that most people are working, with many of us working out of home, with restrictions on field and laboratory work, and with face-to-face meetings being replaced with virtual meetings. Various virtual communication platforms, some new and some that have always been available to us, are now almost indispensable to how we currently "do business".

However, the ability to meet and socialise with colleagues in person and to present work, is considered very important, particularly for students, and to this end CSG Working Meetings have played a vital "communication" role. Many of us were planning, and looking forward to, attending the 26th Working Meeting (Mexico), and so its postponement, although necessary, left some of us in the LAC region with a sense of loss.

Lucia Fernandez, Alejandro Larriera and I pondered on whether a series of virtual conferences could strengthen and expand communication amongst CSG members, students, etc., in the region, and promote discussion on issues on crocodilian conservation, research and management of crocodilians. The "Ciclo de Conferencias sobre Crocodilianos" was born from these ponderings, and the LAC Regional Office presented the first speaker on 21 April (see below).

Participants can easily log in and watch live presentations on the LAC Facebook page (www.facebook.com/groups/148498038518765/media/videos), or watch the taped sessions later on the LAC Facebook page or the LAC Youtube channel (https://www.youtube.com/channel/UCzcOd-KG3QvTVWgOCZjhCvQ/featured). Although presented in Spanish, the majority of Powerpoint presentations are in English, allowing non-Spanish speakers to follow the themes.

At the time of writing, speakers had been drawn from Argentina, Belize, Bolivia, Brazil, Colombia, Costa Rica, Cuba, Guyana, Italy, Mexico, Panama, Switzerland, USA and Venezuela:

- 21 April - Alejandro Larriera: Sustainable use of crocodilians before and after Covid-19: The good and the bad.
- 23 April - Patricia Amavet, Gualberto Pacheco Sierra: Behind the genetic tracks of crocodilians.
- 28 April - Jon Paul Rodriguez (SSC): Conservation works.
- 30 April - Lucia Fernandez, Ricardo Adame Ojeda: Gods or demons? An analysis of the different relationships bewteen crocodilians and humans.
- 5 May - Juan Carlos Vasquez (CITES): Reflections on wildlife use in the post-coronavirus era.
- 7 May - Rafael Antelo, Omar Hernandez: The long walk in the conservation of the Orinoco crocodile.
- 12 May - Marisa Tellez: The good and the bad: The anthropogenic impact on the conservation of crocodilians.
- 14 May - Armando Rubio, Paulino Ponce Campos, Helios Hernandez Hurtado: Different visions on the conflict between humans and crocodiles.
- 19 May - Alvaro Velasco, Enrico Chiesa: The role of trade in the conservation of crocodilians.
- 21 May - Marco Lopez Luna, Paulo Braga Mascarenhas:

Crocodylia in the city.

- 26 May - Luis Bassetti, Augusto Kluczkovski: One health: Our role to clean a sick world and implications for management of crocodilians.
- 28 May - Natalia Rossi, Gustavo Sosa Rodriguez, Etiam Perez Fleitas: Conservation of crocodilian species in Cuba.
- 4 June - Miryam Venegas-Anaya, Pierre Charreau: Island crocodiles.
- 11 June - Luis Sigler: *Ex-situ* conservation of crocodilians.
- 18 June - Yhuri Nóbrega, Elizabeth Diaz, Josefa De La Torre, Miryam Venegas-Anaya: Environmental education programs in action.
- 25 June - Laura Porras, Paulino Ponce Campos: Human-Crocodile Conflict II.

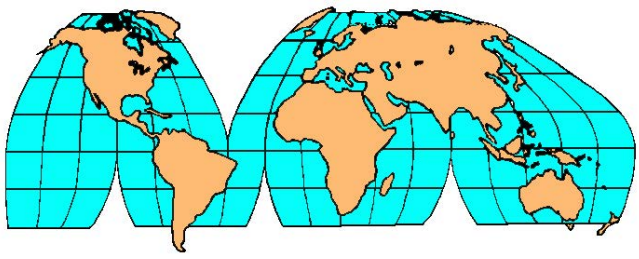
At this stage, presentations have been organised up until the end of July (see below), but the program will continue until further notice.

- 2 July - Carlos Piña: Drones.
- 9 July - Adonika Spellen, Alfonso Llobet: Crocodilian updates.
- 16 July - Gisela Poletta, Marisol Buenfil Rojas: Crocodilian ecotoxicology.
- 23 July - Pablo Siroski: Crocodilian conservation in Latin America and the Caribbean.

The virtual conferences have been very well received, with many people participating in the live presentations. But we have also recorded up to 1500 viewings of each presentation at a later date. This has proven to be an effective mechanism to stay connected with CSG members, students and crocodilian enthusiasts. Using some of these "user friendly" comunication platforms that are readily available, the LAC Regional Office is planning to continue with different kinds of virtual activities (eg personal interviews, "live" visits to interesting places). Our experiences could easily be adopted by other regions.

Pablo Siroski, *CSG Chair, Latin America and the Caribbean*.

Regional Reports



South Asia and Iran

India

MUGGER CROCODILE (*CROCODYLUS PALUSTRIS*) INTERACTIONS WITH DISCARDED RUBBISH IN CENTRAL GUJARAT, INDIA. The management of solid waste garbage, especially discarded plastic-based non-biodegradable materials, is a global problem - but is worse in developing countries like India. Over 700 marine species are affected through their interaction with plastic pollution (Gall and Thompson 2015), including marine mammals, sea turtles, sea birds, fish and invertebrates (NOAA Marine Debris Program 2014). However, the data on freshwater species such as crocodilians, is limited. Here, we present 7 years of data (January 2013 to December 2019) on interactions between Muggers (*Crocodylus palustris*) and discarded rubbish in Gujarat State, India.

The Mugger population in Gujarat faces various minor to major threats, including water pollution, habitat encroachment, development on river banks and the pet trade (Vyas 2010a). Recently two new threats were observed, namely the use of crocodile body parts for aphrodisiacs and crocodile-vehicle collisions (Vyas 2017; Vyas and Vasava 2019; Vyas *et al*. 2020).

Study Area

Information was gathered from various waterbodies in two regions (Fig. 1):

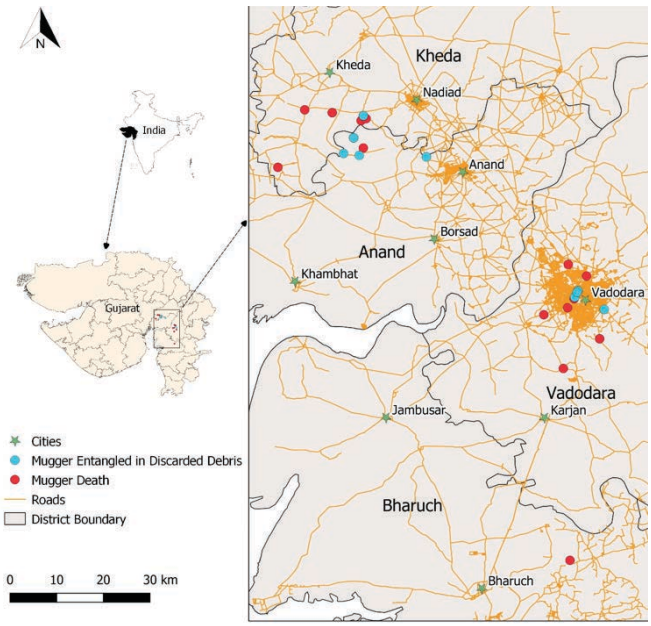


Figure 1. Locations of Muggers sighted with entangled/ discarded rubbish (blue dots) and dead Muggers (red dots) in Central Gujarat, India.

- Charotar: The Charotar region consists of parts of Anand and Kheda Districts. The region is located between the Sabarmati and Mahi Rivers in central Gujarat, and is well known for crops such as tobacco, pulses, rice and wheat. Large areas in this region are irrigated by the Mahi Irrigation Project, and therefore most waterbodies are interlinked and connected by an intensive irrigation canal network. This network of canals acts as the dispersal route for crocodiles. Most of the waterbodies contain Muggers, and the population in the region is known for co-existing with humans (Vyas 2013; Patel *et al*. 2014; Vasava *et al*.

2015).

- Vadodara: The Dhadhar-Vishwamitri River system is a minor system that flows in between two large perennial rivers, the Mahi and Narmada. Most of the river systems and along with other waterbodies are part of the district. Two water reservoirs have been constructed on this system, Sayaji Sarovar near Ajwa village on the Vishwamitri River, and Dev Dam on Dhadhar tributary, for drinking and irrigation purposes. Both reservoirs hold small Mugger populations. The Vishwamitri River flows through Vadodara City, so the sewage of the entire city and other industrial effluents are drained into it and making it very polluted. The water of the river turns reddish-black as it passes through the city. The Mugger population of the Vishwamitri River is a somewhat unique population in that it is found within a densely populated urban area of Vadodara City (Vyas 2010b, 2012, 2018).

Methodology

Information was collected from various sources, including personal observations, NGOs, wildlife enthusiasts and the Forest Department of Gujarat. Moreover, we took photographs and collected information on some of the cases by visiting the particular site and interviewing local people about the first sighting of animals. Where possible we freed animals from entangled debris with the help of local Forest Department personnel. We classified Muggers as juveniles and sub-adults (<180 cm TL) or adults (>180 cm TL) (Whitaker and Whitaker 1984; Mobaraki *et al*. 2013).

Results

Over the 7-year period, we recorded 16 cases of live Muggers entangled with human-discarded rubbish [Kheda 8, Anand 3, Vadadora (Vishwamitri River) 5; Table 1; Figs. 2-7]. Eleven cases involved adult Muggers (280-330 cm TL) and 5 cases involved juveniles/sub-adults (75-180 cm TL). We successfully removed entangled rubbish from 5 of the Muggers (Charotar 4, Vadodara 1; Table 1; Figs. 3 and 7) with the help of local NGO volunteers and Forest Department staff.

We noted six types of discarded rubbish in which Muggers were entangled; fishing net (N= 6; Figs. 2e, 3a, 3c and 7), plastic packing tape (N= 6; Figs. 2a-d, 2f and 3a), acrylic fibre (N= 2), plastic-fibre rope (N= 1), rubber tyre (N= 1), and barbed wire (N= 1; Fig. 3a). The discarded rubbish was considered non-biodegradable, with the exception of barbed wire.

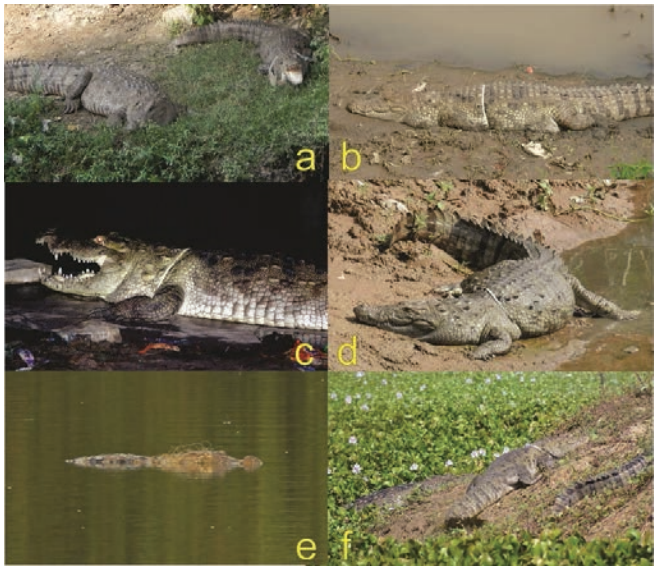


Figure 2. Plastic packing tape (a) around neck of adult Mugger at Bhimnath, Vishwamitri, Vadodara, (b) around belly of adult Mugger at Kalaghoda, Vishwamitri, Vadodara, (c) around neck of adult Mugger at Deva, Kheda, (d) near foreleg of adult Mugger at Bhimnath, Vishwamitri, Vadodara, (f) around neck of adult Mugger at Dabhau, Anand. (e) Adult Mugger entangled with fishing net at Deva, Kheda. Photographs: Rakesh Vadhavana (a, b, d), Vishal Mistry (c, e), Yuyutshu Bhattacharya (f).

Table 1. Details of 17 Muggers found entangled with discarded material. Size class: J= juvenile, SA= sub-adult, A= adult; TL is in cm. Source: VM= Vishal Mistry, MT= Manoj Thaker, RV= Rakesh Vadhavana, RK= Raju Kadam, AS= Ankit Soni, MP= Mehul Patel, AV= Anirudh Vasava. * = entangled materials successfully removed from the Mugger.

Date	Location	Class (TL)	Latitude/Longtitude	Entangled body part (debris)	Source
10 Jan 2013	Jol, Anand	A (300)	22°34.5650'N, 72°53.0232'E	Belly (tyre)*	VM
20 Jan 2015	Akota, Vishwamitri	A (320)	22°17.7578'N, 73°10.8858'E	Mouth (plastic-fibre rope)	MT
5 Mar 2015	Kapurai, Harinagar, Vadodara	J (100)	22°16.4007'N, 73°14.4532'E	Body (fishing net)*	RK
2 Dec 2015	Bhimnath, Vishwamitri (Fig. 2a)	A (310)	22°18.2970'N, 73°11.1602'E	Neck (plastic tape)	RV
5 Aug 2017	Kalaghoda, Vishwamitri (Fig. 2b)	A (290)	22°18.3323' N, 73°11.1678'E	Belly (plastic tape)	RV
14 Oct 2017	Deva, Kheda (Fig. 2c)	A (240)	22°37.2145'N, 72°44.0945'E	Neck (plastic tape)	AS, VM
26 Nov 2017	Vaso, Kheda (Fig. 3a)	J (90)	22°39.3900'N, 72°45.3198'E	Body (barb. wire/fishing net)*	MP
21 Mar 2018	Bhimnath, Vishvamitri (Fig. 2d)	A (280)	22°18.1678'N, 73°11.0645'E	Neck/forelegs (plastic tape)	RV
31 Jul 2018	Deva village	A (300)	22°37.2145'N, 72°44.0945'E	Body (fishing net)	VM
7 Jan 2019	Malataj, Anand	A (330)	22°34.8730'N, 72°44.9255'E	Neck (acrylic fibre)	VM
22 Feb 2019	Vaso, Kheda	SA (180)	22°39.3900'N, 72°45.3198'E	Body (fishing net)	VM
23 Feb 2019	Deva, Kheda (Fig. 2e)	A (305)	22°37.2145'N, 72°44.0945'E	Body (fishing net)	VM
8 May 2019	Vaso, Kheda (Fig. 3b)	A (210)	22°39.3900'N, 72°45.3198'E	Body (acrylic fibre)	VM
20 May 2019	Near Vaso, Kheda (Fig. 3c)	J (75)	22°39.0452'N, 72°45.0392'E	Body (fishing net)*	VM
3 Aug 2019	Vaso, Kheda	SA (120)	22°39.3900'N, 72°45.3198'E	Neck (plastic tape)*	VM
5 Jan 2020	Dabhou, Anand (Fig. 2f)	A (180)	22°35.0363'N, 72°43.0668'E	Neck (plastic tape)	AV

Table 2. Details of Muggers found dead in the study area. Size class: J= juvenile, SA= sub-adult, A= adult; Sex: M= male, F= female; TL is in cm. Source: FD= Forest Department, VM= Vishal Mistry, AV= Anirudh Vasava, KP= Kamlesh Parekh; PM= post-mortem.

Date	Location	Class/Sex (TL)	Latitude/Longtitude	Notes (Source)
10 Apr 2012	Deva, Kheda	A, F (210)	22°18.3323'N, 73°11.1678'E	PM conducted
27 May 2013	Heranj, Kheda (Fig. 4a)	A (225)	22°40.1360'N, 72°41.5268'E	Decomposed, floating in water (AV)
10 Feb 2014	Heranj, Kheda	A (190)	22°40.1360'N, 72°41.5268'E	Buried and reported by villagers
20 Jan 2015	Kalaghoda, Vadodara	A, M (300)	22°18.3323'N, 73°11.1678'E	Decomposed (FD)
18 Mar 2015	Deva, Kheda (Fig. 4b)	A, M (240)	22°37.2012'N, 72°44.0952'E	Decomposed, floating amongst vegetation
8 Sep 2016	Mujmhuda, Vadodara	SA, F (160)	22°17.0945'N, 73°10.2652'E	PM conducted
9 Mar 2017	Deva, Kheda (Fig. 4c)	A (300)	22°37.2012'N, 72°44.0952'E	Decomposed (VM)
10 Jul 2017	Dhanayavi, Vadodara	A, M (320)	22°13.1718'N, 73°13.9778'E	Decomposed, rope around neck
24 Jul 2017	Samiyala, Vadodara	J (120)	22°15.7110'N, 73° 7.2063'E	(FD)
9 Oct 2017	Deva, Kheda	A (300)	22°37.2012'N, 72°44.0952'E	(VM)
18 Nov 2017	Ram Sarovar, Vaso, Kheda	A (240)	22°39.0940'N, 72°45.0368'E	Animal with large anal tumour (VM)
25 Jan 2018	Vishwamitri R., Kalaghoda (Fig. 5)	A, M (330)	22°18.3323'N, 73°11.1678'E	Plastic debris found in stomach during PM
26 Feb 2018	Itola, Vadodara	A (220)	22° 8.4962'N, 73° 8.7420'E	Decomposed (FD)
4 Mar 2018	Vaso, Kheda	J (90)	22°39.3650'N, 72°45.3328'E	Dead due to entanglement in fishing net (VM)
20 Apr 2018	Junapora, Narmada (Vadodara)	A (210)	21°46.0222'N, 73°10.3830'E	Dead due to entanglement in fishing net
23 Apr 2018	Traj, Kheda	J (110)	22°38.2583'N, 72°39.7777'E	Fishing net found in stomach during PM (VM)
31 Jul 2018	Chhani, Vadodara	A, F (185)	22°21.8865'N, 73°10.1623'E	(FD)
2 Dec 2018	Dhaniyavi, Vadodara	A (370)	22°13.1582'N, 73°13.8912'E	Decomposed (FD)
18 Jan 2019	Heranj, Kheda (Fig 4d)	A (180)	22°40.1360'N, 72°41.5268'E	Decomposed, floating (AV)
24 Jun 2019	Vaso, Kheda	SA (150)	22°39.3900'N, 72°45.3198'E	Dead due to entanglement in fishing net (VM)
18 Aug 2019	Rozva, Kheda	SA (120)	22°54.5758'N, 73°19.7762'E	(KP)
22 Aug 2019	Canal, Vaso, Kheda (Fig. 6)	J (100)	22°37.6820'N, 72°44.7258'E	Fishing net found during PM (VM)
22 Aug 2019	Indravarna, Kheda,	SA (165)	22°33.2835'N, 72°34.6533'E	Dead 2-3 d old, plastic in stomach (VM)
27 Aug 2019	Vishwamitri, Sama, Vadodara	A (240)	22°20.3177'N, 73°12.3167'E	Decomposed
25 Dec 2019	Vishwamitri, Akota, Vadodara	A (300)	22°17.5850'N, 73°10.8192'E	Floating, unable to get to body
4 Jul 2019	Petli, Kheda	J (90)	22°35.8473'N, 72°45.3433'E	Decomposed, floating (VM)

During the study we also recorded 26 dead Muggers (Charotar 13, Vadodara 11; Table 2, Figs. 4-6), comprising 17 adults (220-370 cm TL) and 9 sub-adults or juveniles (160-75 cm TL). Death of 3 Muggers appeared to have been caused by entanglement in fishing nets. Most of the dead Muggers were badly decomposed/rotten (Fig. 4), however post-mortems were able to be carried out on 6 of them (Vadodara 2, Charotar 4). Four Muggers were found to have plastic material (Fig. 5) or fishing net in their stomachs (Fig. 6).

Rubbish was found in almost all the waterbodies available, including the Vishwamitri River and the 9 wetlands surrounding Vadodara City (Vyas 2018), and nearly 24 wetlands in Charotar that have populations of Muggers (Voluntary Nature Conservancy 2019). A similar situation exists in most wetlands, regardless of the presence of Muggers. The reported incidents of entanglement account for nearly 4% of the estimated total population of Muggers (Vyas 2018; Voluntary Nature Conservancy 2019).

Figure 3. (a) Juvenile Mugger from Vaso, Kheda, after removal of entangled barb wire and fishing net; (b) Plastic packing tape being removed from juvenile Mugger at Vaso, Kheda; (c) Juvenile Mugger entangled in discarded fishing net at Vaso, Kheda. Photographs: Mehul Patel (a), Vishal Mistry (b, c).

Figure 4. (a) Decomposed adult Mugger without posterior portion of tail at Heranj Village; (b) Decomposed adult Mugger entangled in vine vegetation at Deva Village; (c) Decomposed adult Mugger among invasive plants at Dev Village; (d) Decomposed adult Mugger at Heranj, Kheda. Photographs: Anirudh Vasava (a, d), Vishal Mistry (b, c).

Figure 5. Dead adult male Mugger (3 m TL) at Kalaghoda, Vishwamitri River, Vadodara and (inset picture) plastic debris found in stomach. Photograph: Raju Vyas.

Figure 6. Post-mortem being carried out by local veterinary personnel on juvenile Mugger found dead in a fishing net, and (inset pictures) fishing net found in its stomach. Photograph: Vishal Mistry.

Figure 7. Juvenile Mugger rescued from fishing net at Pali Ghat Chambal, Rajasthan. Photograph: Rudrapratap Singh Rajawat.

Discussion

In contrast to the numerous reports on reptiles such as marine turtles and snakes interacting with and ingesting discarded debris (Ivar do Sul 2011; Kapfer and Paloski 2011; Nelms *et al*. 2016; Ebert 2019; NOAA Marine Debris Program 2014), there is scant published information on entanglement of crocodilian species [eg *C. niloticus* (Hutton and Child 1989); *Gavialis gangeticus* (Hussain 1999; Sharma and Basu 2004; Bhatta 2009; Katdare *et al*. 2011); *C. porosus* (De Silva 2008; Gunn *et al*. 2010; Amarasinghe *et al*. 2015; Jennet 2020); *Tomistoma schlegelii* (Hassan *et al*. 2016); *C. palustris* (Vyas 2010b; Katdare *et al*. 2011)].

In India it is common practice among villagers and local urban authorities to dump various types of solid waste at the edge or banks of waterbodies, and sometimes factories may dump their waste in a similar fashion (Vyas 2010b). Most domestic waste and sewage of Vadodara City is discarded into the Vishwamitri River, and ponds in Charotar are also used for dumping of village waste. Most wetlands in our study area are used for fishing, and bits of fishing net are regularly discarded at/near these wetlands.

The risk of entanglement or ingestion by Muggers inhabiting these areas is thus high. Notwithstanding the low sample size (N= 6), that two-thirds of the dead Muggers examined in this study had non-biodegradable material in their stomachs (Table 2) supports this notion. However, it is not clear whether ingestion of of rubbish was responsible for the deaths of these Muggers. Captive adult *C. porosus* have died after ingesting plastic food (pie) wrappers (C. Manolis, pers. comm.), whereas a captive American alligator (*Alligator mississippiensis*) in Japan was found to have consumed more than 330 coins over decades, without any noticeable harmful effects (Fujita 2019). Many problem *C. porosus* in Sarawak, Malaysia, have been found to have plastic in their stomachs (B. Tisen, pers. comm.).

Likewise, with the 16 live Muggers observed to be entangled in some way with rubbish, it is difficult to ascertain with complete certainty whether that entanglement would have resulted in discomfort, injury or death of the animal. Severe entanglement in discarded (ghost) fishing nets (eg Fig. 7), however, is considered likely to have resulted in death of those animals eventually, as movement was restricted and/or their ability to feed impaired (Fig. 3). It is well established that fishing nets/traps, especially if made of monofilament (Butterworth *et al*. 2012), may threaten reptiles (eg Stuart *et al*. 2001; Sindha *et al*. 2020), including crocodilians (eg Stevenson and Whitaker 2010; Nair 2010; Sharma *et al*. 2011; Rajbhandari and Acharya 2015; Lang *et al*. 2019; Hutton and Child 1989).

The potential impact of plastics in the environment on wildlife is currently of great concern. Gonzalez-Jauregui *et al*. (2019) recently validated a stomach flushing method to ascertain its effectiveness in collecting microplastics from crocodilians. But our knowledge on the impact of macro-plastics and other non-biodegradable rubbish and litter in waterways on

crocodilians remains largely unknown. To some extent it is often difficult to separate the impact of other factors such as pollution (eg heavy metals, pesticides), which may also occur in the same areas. Discarded fishing nets in Gujarat and elsewhere appear to be an exception, with the potential to kill Muggers and other crocodilian species through entanglement.

While there is little published information for India, there are some opportunistic observations of entanglement of *C. palustris* with rubbish from other areas of India [eg Panjim, Goa (Mathi 2013; Iyer 2010); Cauvery Wildlife Sanctuary, Karnataka (Skanda 2014; Kaggeeri 2016); Chambal River (Khandal 2015; Rudrapratap Singh Rajawat, pers. comm.; Fig. 7); Ranganathittu Bird Sanctuary, Mysore (Patra 2012; Vasant Joshi, pers. comm.)]. These support our contention that the extent of negative interactions between Muggers and rubbish could be more extensive than has been reported.

Further work is required to confirm the full extent of this problem, and to assess the long-term effect of human-induced plastics and other debris on the Mugger population, as well as other wildlife, in India. Regardless, public education and environmental awareness to reduce dumping in waterways is likely to be a critical action.

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EFFECTS OF ANTHROPOGENIC NOISE ON CROCODILIANS. Crocodilians have an acute sense of hearing, operating in the range 300 to 8000 Hz (Wever 1971; Higgs *et al*. 2002), and which is known to play a vital role in communication and social interactions (Reber 2018). The effects of anthropogenic noise on crocodilian species are severely understudied, yet important when considering protected area management and *ex-situ* breeding facilities for conservation of endangered species. Anthropogenic noise is defined as any sort of sound vibration created as a result of human activity. On land, large machinery, mining, blasting, drilling, vehicular traffic, construction and bass music produce vibrations that can impact natural crocodilian behaviour (McGregor *et al*. 2013).

Prolonged exposure to stressors such as noise can be severely detrimental. Immunosuppression, decreased fitness and accelerated aging are some of the documented effects of stressors on animals (Romero and Butler 2007). One of the earliest recorded impacts was construction blasting occurring 2 km from a South African *Crocodylus niloticus* farm causing the death of 26 juvenile females. Biochemistry values obtained from a stressed group of Nile crocodiles were characteristic of animals exposed to prolonged levels of stress (Watson 1990). Bevan *et al*. (2018) attributed behavioural displays such as lateral head movements, fleeing and complete submergence of *Crocodylus porosus* to stress, caused by exposures to noise (57.8-81 dB) and low frequencies (60-150 Hz) from aerial drones flying 50 m overhead.

Captive crocodilian species face additional threats, as visitors to zoos and parks can result in increased noise levels. Jakob *et al*. (2019) showed that animals in zoos can adapt to many sounds they hear on a regular basis, but unpredictable or intense noises cause chronic stress. Moreover, restricted movement, minimal retreat space and forced proximity to humans can further exacerbate the effects of noise. Juvenile crocodiles and hatchlings tend to immediately dive underwater or pile up on each other in the corners of an enclosure when exposed to stressors such as loud noises, fireworks, or large numbers of visitors (Huchzermeyer and Van Wyk 2003).

The impact of anthropogenic noise is an important issue, which needs to be actively studied and addressed. Due to the lack of data on crocodilian species, and the difficulty of isolating stressors in the wild, studying captive animals may be a feasible approach. This information could be used as a baseline for policy makers who can work to include zoos and conservation centres in "silent zones" or areas of restricted noise pollution. In natural environments, this information could influence approved levels of development and help to minimize the effects of habitat encroachment.

At the Madras Crocodile Bank Trust, we are working towards evaluating and mitigating the effects of increasing anthropogenic noise since the untimely death of one of our critically endangered Cuban crocodiles (*C. rhombifer*) in 2019. We are working in collaboration with the Indian Institute of Technology, Madras, to collect data during periods of elevated anthropogenic noise and using CCTVs to monitor animal behaviour during these exposures. This information will help us better understand the dangers of noise related stress in crocodilians and can also serve as a reference for all zoos and conservation centres that are facing similar challenges.

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TRAINING CROCODILIANS AT MADRAS CROCODILE BANK TRUST. Training of crocodilians is an effective management tool, particularly for captive crocodilians, helping to enrich environments, to modify behaviours, and to aid in husbandry. It is now well known that crocodilians are capable of learning, and several zoos have implemented training programs as part of their management regimes (see Rauhaus and Ploetz 2014; Raihaus and Ziegler 2020; Anon 2010, 2011; St Augustine Alligator Farm 2020; Thomson 2020). Such programs also provide a great opportunity to understand crocodilian "intelligence".

In my case, I began working with crocodiles in order to aid in their management, at Madras Crocodile Bank Trust (MCBT). The information contained here was presented as a poster at the 23rd CSG Working meeting in 2014, but only a short abstract appears in the Proceedings of that meeting (Mukherjee 2014). The details of this work were thus submitted to the CSG Newsletter so as to reach a larger audience.

Crocodilians in captivity often need to be captured and restrained for management tasks (eg enclosure cleaning and maintenance, medical intervention, etc.), and this can be a challenging activity with risks for both animal and handlers, particularly with large crocodilians.

Many tasks can be assisted by simply training crocodilians to comply on cue. Thus, the target behaviours in the initial sessions were directed towards that aim. The target behaviours of "come", "stay" and "open mouth" among others, were to help with visual physical examination of the animals without restraint. They allowed for sensitization during the "stay" command, and administration of medicines and supplements with "open your mouth" along with controlled hand-feeding as a reward action. Working with these basic commands allowed for a deeper understanding of their personalities and intelligence.

I then wanted to measure how quickly they learned and to see if the rate of learning differed between species. I knew that individual personalities played a role, but I wanted to see if age was also a factor to be considered.

Methods

I carried out an observational experiment at MCBT, and randomly selected 6 individuals of various species (5 not previous trained: *Caiman crocodilus*, *Melanosuchus niger*, *Crocodylus palustris*, *Crocodylus moreletii*, *Osteolaemus tetraspis* (cover photograph, Figs. 1 and 2); and one previously trained *Alligator mississippiensis*) (Figs. 3-5) for this purpose. I set up a behavioural goal for all and measured the time and the number of reinforcements used to achieve that target behaviour. The target behaviour for untrained crocodiles was in series of: responding to name, coming to a designated 'station', staying in said position until next cue, turning around and going into the water, and coming to a designated 'station' and get the reward.

The animal's participation, attitude and learning were scored per session. A color-coded bamboo pole was used as a guiding stick where the yellow end of the pole was used in case of positive events and the blue end was used for negative events. Behavioural training was carried out using reward based operant conditioning. Small chunks of beef were given as primary rewards and praise calls were used as secondary rewards for positive reinforcement. A vocal cue was used as a bridge command to mark target behaviour. Negative "punishments" for negative behaviour included relevant vocal cue with tap on snout with the blue end of the stick and time-outs ranging from 0.5 to 2 minutes and no rewards.

Seven sessions were conducted, with each session extending to a maximum of 15 minutes. Each session was videtaped for reference, personal learning and for demonstration

purpose. Safety protocols were exercised, and presence of an experienced spotter was mandatory during the entire process.

Figure 1. Left: 37-year-old Mugger (*Crocodylus palustris*). Right: 20-year-old Black caiman (*Melanosuchus niger*).

Figure 2. Left: 7-year-old Morelet's crocodile (*Crocodylus moreletii*). Right: 26-year-old Spectacled caiman (*Caiman crocodilus*).

Memory retention

"Allie", a 13-year-old *A. mississippiensis*, had previously undergone sessions with me from 2008 to 2010 as part of an enrichment training program. Her routine consisted of a total of 10 tasks, and had a set sequence.

In March 2014, 39 months since our last encounter, I investigated Allie's memory retention by testing the training routine of December 2010. I used the same routine for the first couple of times, and then I then jumbled up the task sequence in random orders to see if she remembered individual tasks separately or the routine as a whole. I gave her only one 15-minute session for this.

Figure 3. Allie (*A. mississippiensis*) performing "up" in 2010 (left) and 2014 (right).

Figure 4. Allie (*A. mississippiensis*) performing "jump" in 2010 (left) and "down" in 2014 (right).

Once the test of memory retention was completed, Allie was given a target behaviour that was completely random and novel.

Novel target behaviour

The target behaviour sequence for Allie was in series of: responding to name, coming to a designated area in the water pool and waiting for instruction, ringing a hanging cow-bell with her snout when instructed (Fig. 5), coming to a 'station' close to pools' edge for reward, turning around and going to another designated 'station' in the pool.

Figure 5. Allie (*A. mississippiensis*) ringing cow-bell.

Data

The following data were collected for all crocodilians per session:

- Species
- Start and Finish times
- No. of positive reinforcements
- No. of negative "punishments"
- Attitude score: 1 to 10 (1= not interested, 10= very interested)
- Participation score: 1 to 10 (1= no participation, 10= very participatory)

Results

All test subjects performed the target behaviour without flaws or slacks, three times in a row, within three training sessions. The average time to learn the target behaviour over the three sessions was 36.16 minutes (Fig. 6).

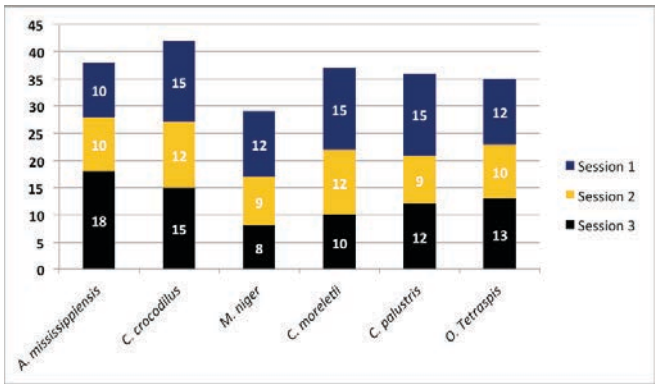

Figure 6. Time (in minutes) taken to achieve target behaviour.

The numbers of reinforcements used were a maximum of 41 for *C. crocodilus* and a minimum of 16 for *O. tetraspis* (Fig. 7). As the sessions progressed, an "eagerness" to learn more

tasks in order to get more food rewards was observed.

Memory retention was observed in *A. mississippiensis* as previously learned tasks were accurately executed. The subject remembered all the tasks and performed them flawlessly on vocal cues.

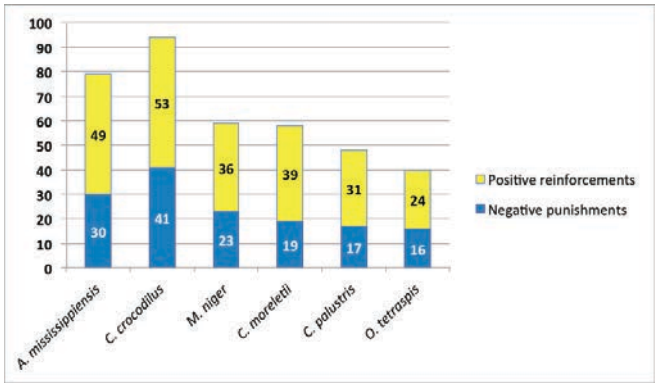

Figure 7. Number of reinforcements and punishments to achieve target behaviour.

Discussion

Crocodilians are extremely fast learners and appear to have have very good memory retention. Once the availability of reward for doing the right thing is established, they become more eager to participate and learn more tasks. They also appear to anticipate commands/instructions when a set sequence is routinely repeated.

I did not note any considerable difference in the rate of learning between the five species. Notwithstanding the small sample size, age did not seem to play any big role in training programs as the subjects were varied in age. All animals showed equal interest and enthusiasm once they deduced the reward system.

Figure 8. Observational learning in juvenile Mugger (2010).

Observational learning was seen in *C. crocodilus* when working in an enclosure with multiple animals. This was previously observed in *C. palustris* (Fig. 8) and *C. siamensis* during training sessions in 2008-2010 in communal enclosures. This may be true to some degree in all species. It shows they understand positive interactions that end with food rewards. The observer animal studies the interactions of the model animal for the first 3-4 days, after which they show keen interest in participating in similar interactions. Typically, they first try to mimic the behaviour they saw and learnt, and with some refining they learn routines faster than the original model animals.

The information gathered through these experiences indicates that crocodilians are able to be trained relatively quickly, and many zoos around the world are using this to assist in their captive management and husbandry.

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PRELIMINARY ASSESSMENT OF USE OF DORSAL SCUTE PATTERNS TO IDENTIFY WILD MUGGERS IN HUMAN-DOMINATED LANDSCAPES OF CENTRAL GUJARAT, INDIA. The Mugger crocodile (*Crocodylus palustris*) is a widely distributed crocodilian species in India (De Silva and Lenin 2010), which comes into conflict with humans on a consistent basis, particularly in central Gujarat (Vyas and Stevenson 2017). The intensity of conflict becomes more acute during the Mugger breeding season (Vyas and Stevenson 2017).

The ability to identify individual Muggers, particularly adults, can assist in the management of Muggers in human-dominated habitats and mitigate conflicts. Tagging of crocodilians (eg scute-clipping, cattle tags, transmitters, microchips) requires capture of the animal in the first instance, and possibly again later for identification purposes. Identification of individuals using non-invasive methods and morphological characteristics is becoming more widespread, although extension to crocodilians has been limited (*C. acutus*; Balaguera-Reina *et al*. 2017).

Digital photography, focusing on body patterns for identification of focal animals is popular, and has been used in various studies to understand biology, behaviour, ecology and threats [eg elephants (Vidya *et al*. 2014), zebra (Lahiri *et al*. 2011), tiger (Hiby *et al*. 2009). Traditionally such biometrics were created by manually entering data on patterns into a computer and then running a statistical model to identify the focal animal. For example in the case of elephants, Vidya *et al*. (2014) used a combination of ear shape, wear and tear of the ear, tusk shape and size, and tail brush pattern to identify focal elephants.

Using software for creating biometrics is becoming extremely popular nowadays, for both wild and domesticated animals. Photographic data on retinal identification, iris identification, nose print identification, body patterns (eg stripes, spots) have been analyzed through image processing using various software programs (eg MATLAB, PYTHON, SLOOP).

To identify focal Muggers (eg for a proposed study on reproductive hormone metabolites), we are constructing a biometrics system based on dorsal scute (osteoderm) patterns. The study is being undertaken in Central Gujarat, in collaboration with the Madras Crocodile Bank Trust (MCBT).

Figure 1. View of Mugger from drone.

A Digi-Phantom Drone, flying at 5-6 m height, was used to photograph Muggers from different angles (Fig. 1). Major obstacles to taking the images were vegetation cover and submerged crocodiles. A complete image of the dorsal scute pattern could not be taken for a submerged crocodile as only part of the body was visible. Muggers basking under shrubs were also difficult to photograph. We were able to obtain usable images for 10 Muggers (estimated size x-x m TL).

Manual counting of scutes was done from the images, with prominent scutes being coded as 1 and absence of scutes as 0. Scutes were counted on all transverse scute lines and longitudinal scute lines including up to three most prominent scutes present on each side of the vertebral axis, present on the dorsal body (Fig. 2).

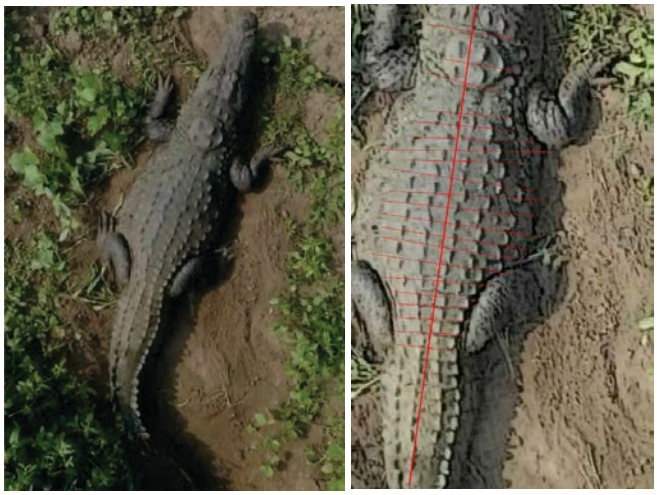

Figure 2. Manual coding of transverse scute lines and longitudinal scute lines (right) on *C. palustris* from drone images.

"Paint.Net", free image and photo editing software, was first used to edit the images of the Muggers, and different parameters were used to increase sharpness and visibility of the dorsal scutes. After this, MATLAB, with a multiple tool-box for image processing and pattern recognition, was selected as most appropriate for creating biometrics. It has been used for pattern recognition in humans (Masek 2003) and other species (Duyck *et al*. 2015; Silveira and Monteiro 2009; De and Ghoshal 2015). This software also allows use of extensions from other software, such as PYTHON.

Analysis using MATLAB software

Biometrics work on three important variables: pattern, colour and shape (Bugge *et al*. 2011). We used various feature detection and feature extraction tools to analyse the scute patterns.

1. Extraction of background was attempted initially, using an algorithm that is used to extract background for stained images [eg hematoxylin & eosin (H&E) stain] (Fig. 3). This algorithm converts a RGB (Red Green Blue) image into a L*a*b* colour space image, where L* is luminosity, a* is chromacity a layer, and b* is chromacity b layer. This algorithm classifies and separates 'a*b*' layer using

k-means clustering which helps in segmentation of H&E in the image, and in the end helps in extracting nuclei from the image. This algorithm did not work on the Mugger images due to the lack of contrast (camouflage; Stuart-Fox and Moussalli 2009). Other similar algorithms also failed to give usable results (Fig. 4), where animals had similar intensity of colour as its background environment.

Figure 3. Background extraction using H&E algorithm.

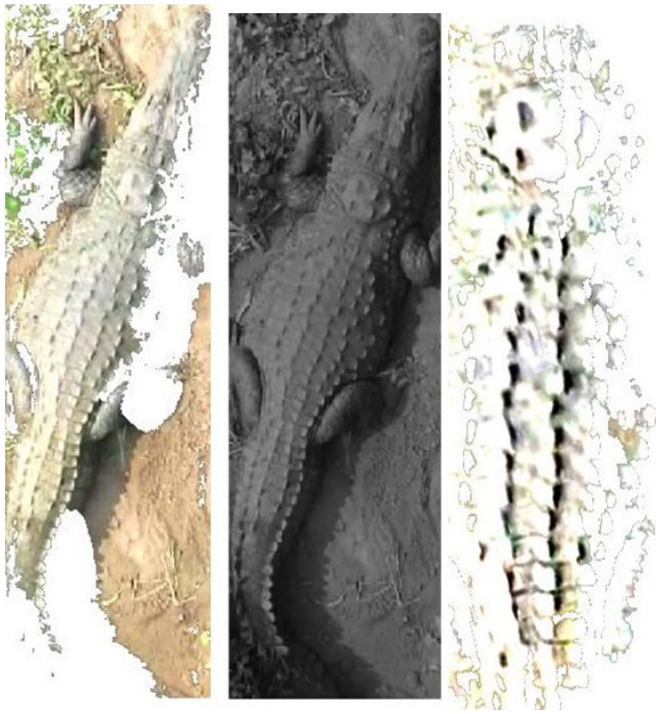

Figure 4. Background extraction using colour intensity algorithm.

2. RGB to gray scale and Otsu's method: Certain algorithms work on variables like shape and pattern, and color is not a strong detection variable. All Mugger images were converted from RGB into grayscale. Later the Otsu method (Otsu 1979) was used to segment the image into two pixels: black and white. This algorithm detects the threshold using automated global intensity threshold, and dividing the image into black and white pixels (Fig. 5). This image processing command is called the "graythresh command". This algorithm was useful in the detection of scutes in certain regions of the back, while in other regions the scutes were not detected because they were "burnt out" due to high luminosity. Overall, this method did not yield good results.

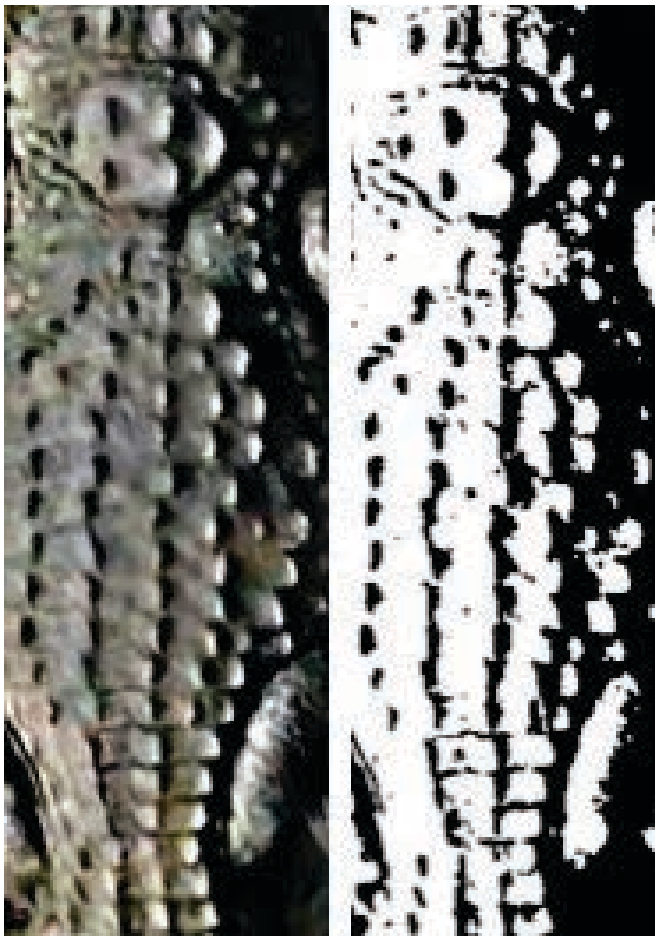

Figure 5. Otsu's method performs automatic image thresholding, and returns a single intensity threshold that separate pixels into two classes, foreground and background. .

3. Feature detection tool-box in MATLAB: Various feature detection tools (see below) were used to detect the scutes based on patterns and shapes (Fig. 6).

   - The Binary Robust Invariant Scalable Keypoint (BRISK) feature detects multiscale corner in the image.
   - The Maximally Stable Extremal Regions (MSER) is a blob detection feature which helps in detecting blobs, and stays nearly the same through a wide range of thresholds.
   - The Speeded Up Robust Feature (SURF) feature detects blob in the image after converting it in to 2D-grayscale image.
   - The Feature from Accelerated Segments Test (FAST) finds and marks all the corner points in the image.
   - The HARRIS feature uses computer vision HARRIS

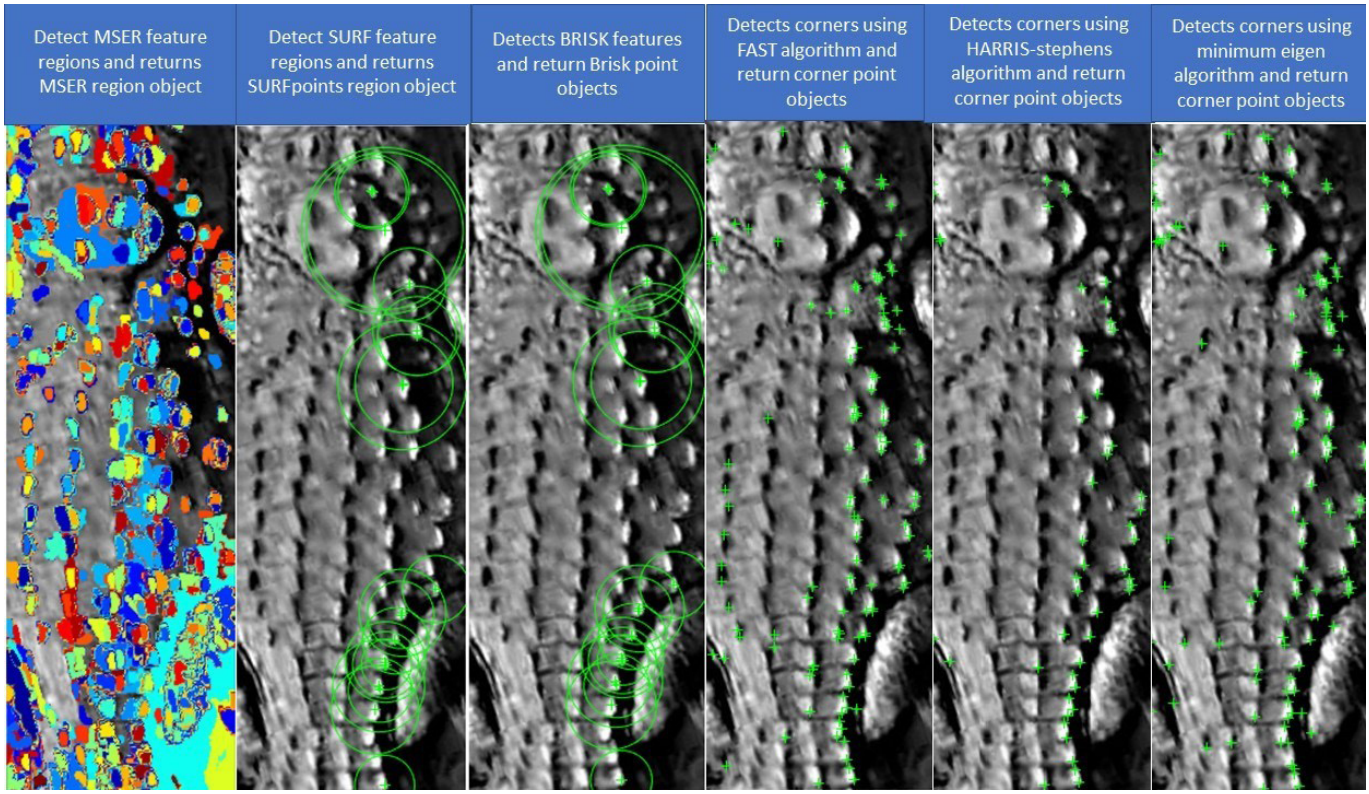

Figure 6. Algorithms run on Mugger image from feature detection tool-box of MATLAB.

algorithm to detect the inter feature corner points as well as extract them. It also gives the reason behind the collection.

- The MinEigen feature uses the Eigen value algorithm to detect the corner points in the image.

All theses feature-detection algorithms detected scutes, but only the MSER feature could detect scutes with high accuracy (Fig. 6). The other algorithms could not detect more than half of the scutes in the image.

Conclusion

The various algorithms used to detect scutes did not work effectively due to several reasons. The main reason for poor results was that it is extremely challenging to capture photos at the right angle, appropriate lighting, and sharpness using a drone. Very often the target crocodiles are not fully exposed and when they basking the intensity and angle of sunlight may not always give a good quality image. More image processing extensions from PYTHON need to be explored for increasing the accuracy.

Currently our image library has very few sample images, and hence there is a limited scope of experimenting with the software. Thus far, only the images taken during the drone surveys have been used since the objective is to apply this method to monitor wild crocodiles. However, it now appears that a much larger stock of sample images may be needed to be able to process all variables in the available software programs.

We aim to try other computer vision toolboxes and their algorithm on Mugger images to find the best fit for detecting scute pattern. Additional images will be collected from captive Muggers at MCBT to create a large data set for running machine learning and deep learning algorithms and to detect patterns in the scutes. Multiple combination of algorithm will be used making more specific to detect the scutes. Binary coding and grids will be used to make the biometric detection of scutes patterns for identifying focal animal.

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TALE OF A TAILLESS MUGGER (*CROCODYLUS PALUSTRIS*) FROM THE VISHWAMITRI RIVER, VADODARA, GUJARAT, INDIA. Mugger crocodiles (*Crocodylus palustris*) in the Vishwamitri River are an example of large carnivores living in an urbanised area with a human population (Vyas 2010, 2012, 2018). There are thus frequent occurrences of Muggers turning up in human settlements, causing fear and panic amongst locals. On 25 January 2020, a Mugger was spotted roaming the streets of the newly developed suburbs of Tarsali (22°15' 27.23" N; 73°13' 18.97" E), on the outskirts of Vadodara city. This locality is situated on the upstream portion of the Jambuwa River, a small tributary of the Vishwamitri River.

Volunteers from a local NGO, together with Forest Department staff, were able to rescue the animal (Fig. 1). On capture, it was noted to be an unusually large female Mugger, with almost all of its tail "missing" (Fig. 1). The Mugger measured 160 cm snout-vent length, and the tail was only 37 cm long. Assuming that snout-vent length makes up around half of total length, the Muggers total length, had the tail been complete, is estimated at around 3.2 m. That is, around 1.2-1.3 m of tail was missing. The animal had no signs of old wounds or injuries.

Figure 1. Figure 1. Tailless Mugger with team of rescuers.

Over the last 8 years (2012-2019), 542 Muggers of different sizes have been rescued/examined in Vadodara, of which 7 have were missing part of their tails (Vyas and Bhavsar 2009; Vyas 2014; Vyas and Vasava 2019; Vyas *et al*. 2020). In all of these cases, the absence of part of the tail was explicable, through:

- collision with train on railway tracks;
- tail being taken for "superstitious" practices. For example, practitioners of Unani medicine have been known to release crocodiles back to the wild after cutting off their tail. Such occurrences have been reported from remote areas of the state in the last few years, caused by the prevalent superstitious and aphrodisiac beliefs associated with crocodile tails (Vyas 2017)]; or,
- the result of intraspecific conflicts.

Close examination of the "tailless" Mugger indicated the posterior portion of the tail was covered with scales, together with well-formed osteoderms (= scutes) (Fig. 2), and there were no signs of scars suggestive of a healed wound. This led us to consider that the most likely explanation is that

this animal hatched without a tail - an abnormality that has been reported in other crocodilians (see below). However, although considered less probable, we cannot rule out that the animal lost its tail when it was very young (eg as a hatchling), a result of predation or intraspecific interaction.

Figure 2. Posterior aspect of the tail showing scales and osteoderms.

Crocodilian embryos incubated under sub-optimal conditions, particularly high temperatures, may hatch with serious deformities of the tail and/or spine, including absence of the tail (Huchzermeyer 2003). Researchers in Australia have observed healthy, tailless *C. porosus* hatchlings being produced from certain wild nests - also suggesting a genetic basis for the deformity (Webb and Manolis 1989). Huchzermeyer (2003) reports tailless *C. niloticus* and *Osteolaemus tetraspis* hatchlings.

Tailless crocodilians have been reported surviving in the wild (eg *C. porosus*, Zheng 2017; Kannadasan 2018) and in captivity (*Tomistoma schlegelii*, Kannadasan 2018; *Alligator mississippiensis*; Craven 2013; Anon 2020; *C. porosus*, C. Manolis, pers. comm.). In crocodilians, the tail plays an important role in swimming, feeding (eg prey capture), walking, and social behaviour and interactions (eg visual displays) (Willy *et al*. 2004). That an individual like the Mugger reported here appears to have survived in the wild for a considerable amount of time, without a tail, reflects the adaptability of crocodilians. Although tail tip amputations are common in many species of crocodilian, survival after loss of large portion/s of the tail appears to be more rare.

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ANOTHER GHARIAL NESTING IN THE YAMUNA RIVER, UTTAR PRADESH, INDIA. Gharials (*Gavialis gangeticus*) occur in the largest numbers in the Chambal River in Uttar Pradesh, India (Lang *et al*. 2019). The Chambal River is a tributary of the Yamuna River. During the 19th Century, Gharials were abundant in the lower Yamuna, as a number of well documented accounts attest (eg Hornaday 1885). But a century later, numbers had declined to such an extent that their presence was only sporadically reported (Singh

1979). Upstream of the Chambal confluence, the Yamuna is generally devoid of Gharials for most of the year (Tripathi *et al*. 2019). However, in the past decade, there have been two reports of Gharial nesting in the Yamuna River, one in 2011 (Chauhan 2011), and more recently, in 2019 (Tripathi *et al*. 2019).

The report in 2011 described nesting 12 km upstream in the Yamuna River, within the National Chambal Sanctuary (NCS), above the Yamuna-Chambal confluence. Nesting in 2019 was reported at 80 km above the confluence, at Yamuna Ghat, near the town of Etawah, about 40 km above the NCS boundary. Here we report on a nest located noted in 2020, near the village of Bhaupura, on the Yamuna River (26.788611° N, 78.87611° E), 21.5 km above the previously reported nesting in 2019, approximately 102 km above the Yamuna-Chambal confluence, and about 62 km above the NCS boundary.

During our February 2020 survey, no Gharial were seen in the Yamuna River up to Dibholi (NCS boundary), and there were no reports by villagers of any male Gharial in this stretch of river. However, on 15 June, hatchlings were sighted by volunteer Mr. Rajkumar, who recorded 41 live and 2 dead hatchlings at the site. The site was revisited on 19 June, at which time 28 hatchlings were present with a female Gharial, estimated to be 3 m TL. The female surfaced near the hatchlings at 10-15 minute intervals.

The excavated nest was located on the right bank when heading downstream, 7.2 m away from the shoreline, and 4 m above the water level. The whole sand bar is around 800 m long and 10-20 m wide. The sand at this site appears to be finer than that in the Chambal (Fig. 1).

Figure 1. View of upstream Yamuna River nest site located in 2020, showing excavated nest (center right) with recently opened eggshells. Photograph: Rajeev Chauhan.

Cattle disturbance was evident near the site, and adjoining areas serve as grazing grounds for cattle from nearby villages. Farmlands occupy the opposite bank, and villagers use nearby sand banks for bathing and domestic use. Signs of sand mining were also evident.

This report constitutes an extension of the recorded nesting by Gharials in the Yamuna River, above the protected area within the NCS, and nesting ocurring in successive years (2019 and 2020). This may be a consequence of better control over pollution in the waters of river in recent years, but more likely is due to further improvement in water quality resulting from an almost complete shutdown of industrial activity due to Covid-19 lockdowns over the last three months (March-May 2020), which coincided with the seasonal timing of Gharial nesting in this region (Lang and Kumar 2013, 2016).

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Nepal

GHARIAL TRAVELS MORE THAN 1000 KM FROM NEPAL TO INDIA. On 17 May 2020, a sub-adult Gharial (*Gavialis gangeticus*) was trapped in a fishing net in the Hooghly River, in the Raninagar area of Chakdah town in

West Bengal, India (Fig. 1). Fishermen informed local forestry officials, who transported the Gharial to the Bethuadahari Wildlife Sanctuary, where it was held in a pool.

Figure 1. Gharial captured by fishermen in the Hooghly River, West Bengal, India. Photograph: Subrat Kumar Behera (Wildlife Trust of India).

Examination of the Gharial revealed that it was in good condition, and had been scute-clipped. Both Nepal and India have engaged in head-starting programs over long periods of time, and many, if not most, of the Gharials released back into the wild, including areas upstream of this capture site in West Bengal, have been scute-clipped.

On 19 May 2020, B.C. Choudhury and his team from the Wildlife Trust of India sent photographs of the Gharial to me, and I was able to verify that the clipped tail scutes (6th on left of double row, 8th on right of double row, and 7th on single row; Fig. 2) matched those of a Gharial (ID= 687) that had originated from the Gharial Conservation and Breeding Center (GCBC) at Chitwan National Park (CNP), Nepal. As of March 2020, 1515 Gharials had been released from the GCBC into various rivers of Nepal, within the species' geographic range.

Figure 2. Position of clipped tail scutes of captured Gharial.

In the case of the Indian program, no systematic system of recording and/or archiving of scute-clipping patterns exists, and so it was not possible to check whether the Gharial originated from the Indian program.

Examination of GCBC records revealed that a female Gharial was scute-clipped with that sequence. It had hatched in June 2014, and been raised at GCBC until 17 March 2020, when it was released into the Rapti River, near Kasara (CNP headquarters). At the time of release it measured 2.06 m TL and 1.18 m SVL, and weighed 26 kg. The size of the Gharial captured in the Hooghly River was consistent with this 5.9-year-old Gharial.

Assuming that this Gharial originated in Nepal, and it had travelled in only one direction in the intervening 61-day period, the minimum distance travelled is estimated as 1062 km (Fig. 3). This comprises 22 km in the Rapti River, 612 km in the Narayani/Gandak River, 110 km in the Koshi River, and 318 km in the Hooghly River. Assuming that the animal had just arrived in the area of capture, then these data reflect a minimum average distance of 17.4 km travelled per day.

Figure 3. Presumed travel route of Gharial (ID 687) from the Rapti River in Nepal to the Hooghly River in India. The capture site was around 190 river km from the Bay of West Bengal to the southeast.

The movement in March-May occurred prior to the rainy season, but the Narayani/Gandak River is a massive, glacier-fed river so there is sufficient flow of water to assist the Gharial downstream, especially as the snowmelt begins upstream. Thus, movement could have involved the Gharial being passively carried downstream, or actively swimming. The "presumed" route from the Rapti River to the Hooghly River (Fig. 3) would have involved the Gharial navigating a number of major water structures/barriers (ie dams, barrages), which represent impediments to long-distance movements up and/or down rivers.

There have been around 10 marked Gharials captured in various rivers of West Bengal in 2020 (B.C. Choudhury, pers. comm. 2020), whose origins have yet to be verified through examination of scute clipping patterns. But they are suspected to be Nepalese in origin.

Other notable records of long distance movement and/or transborder crossings by Gharials, include:

- In 1981, a Gharial with an externally mounted radio-transmitter was reported 200 km downstream of the India-Nepal border (Maskey 1989), suggesting that the occasional downstream movement of Gharial from the Nepalese program has been occurring since the establishment of the GCBC.
- Choudhury *et al*. (2016) recorded a Nepalese Gharial in the Gandak River (= Indian portion of the Narayani River of Nepal) in March 2015.
- A radio-tracked Nepalese Gharial was recently identified on the other side of the India-Nepal border and the Tribeni Barrage, over 70 km from the release site (Griffith *et al*. 2020).
- A sub-adult Nepalese Gharial was killed by fishermen in Saran District, Bihar State, India (Sinha 2018), some 250+ km from the Rapti River in Nepal.
- A marked (scute-clipped) Gharial moved upstream, over the Tribeni Dam, from India into Nepal, along the Gandak/ Narayani River (Sinha 2018; Sinha, pers. comm.).
- In October 2015, a Gharial released in the Gandak River by the Bihar Forest Department (India) and WTI was captured by locals in the Mahananda River in West Bengal (Sinha 2018) - 234 days between release and capture, and sites about 1000 km apart.

Tracking of Gharial on the Chambal River in India has begun to shed light on movement patterns of the species. In Nepal, we are now investigating the movement of Gharial released from the GCBC, using radio-telemetry. Building on the data from the long-term scute clipping work and surveys, this study will provide a more detailed understanding of the movements of a subset of released Gharial, including how often movements into India might occur. Since 2019, the GCBC team, PhD student Phoebe Griffith and I have tagged 25 Gharial released from the GCBC using VHF and GPS transmitters. Post-release monitoring is continuing (see Griffith *et al*. 2020).

The long-distance journey made by this and other Gharials further exemplifies the need for co-operation and coordination between Nepal and India for Gharial conservation. For example, genetic sampling may be used to confirm the origin of Gharials, particularly in light of duplication of scute-clipping patterns between the two countries.

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GHARIAL TELEMETRY RESEARCH IN CHITWAN NATIONAL PARK - UPDATE 2019-2020. The sub-population of critically endangered Gharial (*Gavialis gangeticus*) in Chitwan National Park (CNP), Nepal, is one of six sub-populations that show recent recruitment, and is the largest population in Nepal (Bashyal *et al*. 2019; Lang *et al*. 2019). Since 1978, when the Gharial Conservation Breeding Centre (GCBC) was established, the focus of Gharial conservation in CNP has been a headstarting strategy based on eggs collected annually from the wild. Since the program began, 1515 Gharial have been released in Nepalese rivers (Khadka 2020b), the majority of them in the Rapti and Narayani River in CNP (Khadka, unpublished data).

The Gharial population in the Rapti and Narayani Rivers and their tributaries is estimated to be around 230 individuals, mostly juveniles and sub-adults (DNPWC 2019, unpublished data). This is an increase from a low of 34 in 2003 (Ballouard *et al*. 2010), but still not the "hundreds of Gharial observed on the lower Narayani River prior to the construction of the dam on the river near the Indo-Nepalese border in Triveni in 1964" (Maskey 1989).

There have recently been calls to shift the focus of Gharial conservation efforts in Nepal from an *ex-situ* to an *in-situ* approach (Lang 2017; Acharya *et al*. 2017). In response to the publication of the Department of National Parks and Wildlife Conservation (DNPWC) Gharial Conservation Action Plan for Nepal (2018-2022), and the need for an evidence base on which to enact *in-situ* conservation activities, telemetry research has been initiated to investigate movement, behaviour and survival of both wild-caught Gharial and captive-reared Gharial released from the GCBC at Kasara, CNP.

This research aims to identify critical riverine habitat to be recommended for protection to support the Gharial population, identify key areas for conservation action and protection both within and beyond CNP. The telemetry work will also inform the ongoing headstart program by providing an insight into why the release of such a substantial number of captive-reared Gharial has not led to an equally substantial increase in the resident Gharial population of CNP. Research on movements of Gharial in the National Chambal Sanctuary (India) has been investigated in depth by the Gharial Ecology Project, and has shown that adult Gharial make seasonal migratory movements of 200+ km (Lang and Kumar 2013, 2016). It is not known whether Gharial in Nepal undertake

similar movements, especially given the barrier (barrage at Triveni) on the India-Nepal border, and whether such movements would take them outside of protected river stretches.

Wild-Tagged Gharial. Following the successful tagging of five Gharials in November 2018, a further 15 resident Gharials in the Rapti River and its tributaries were permitted to be captured by CNP in November/December 2019. Gharials were tagged using VHF and/or GPS-GSM transmitters, and 95% of them had originated from the GCBC headstarting program. The team was made up of 10 catchers - all GCBC staff from the indigenous fishermen communities of Chitwan, whose traditional and personal knowledge of the river was instrumental to the success of the program.

Figure 1. Sub-adult male Gharial being prepared for release back into the river by the team (from left to right: Suka Maya Bote, Aitaram Bote, Kale Bote, Phoebe Griffith) after attachment of a radio-tracking device that will provide the GPS position of the Gharial 4 times per day. Photograph: Ranjana Bhatta.

Data from the tagged Gharial will inform conservation management of Gharial in CNP by addressing the following specific questions:

1. What is the extent of river usage by individual Gharial?
2. What is connectivity of the Gharial populations of the Rapti and Narayani Rivers?
3. What are the critical areas of habitat for protection?
4. To what extent do Gharial move outside protected stretches of river?
5. What are key threats and causes of mortality?

Among early findings, this year one of the tagged adult female Gharial travelled over 50 km to join a breeding group, and last monsoon a sub-adult Gharial travelled over 7 km outside of protected river stretches in agricultural areas during high water levels.

Head-Started Gharial. In March 2019, 20 Gharials due to be released from the GCBC, were tagged with VHF transmitters (see Fig. 2). In March 2020, a further 5 Gharials were tagged with GPS transmitters before work was suspended by the COVID-19 lockdown. Data from this telemetry work will:

1. Determine survival of a subset of Gharial from the GCBC for duration of battery life.
2. Identify causes of mortality.
3. Determine movement of Gharial post-release, and any extrinsic factors that lead to long-distance movement (eg Khadka 2020b).
4. Identify features of released Gharial that correlate with residency within the protected area such as size, sex, location of release and time since release.

Figure 2. Attachment of radio-tracking device to a juvenile Gharial at the GCBC, prior to release into the Rapti River. From left to right: Phoebe Griffith, Aitaram Bote, Bed Bahadur Khadka.

The importance of post-release monitoring is exemplified by the recent long-distance movement of a Gharial post-release (see Khadka 2020b). VHF follow-up by tracker Prakash Basnet is identifying which Gharial remain in Nepal, although at least one Gharial has moved further, having been identified on the other side of the Indian border and the Tribeni Barrage by Subrat Kumar Behera of the Wildlife Trust of India (WTI), over 70 km from the release site (Fig. 3).

Reproductive Ecology. The results of this telemetry study will provide vital information on the breeding of adult female Gharial in CNP, in particular the smallest size at which tagged Gharial breed and the extent of nesting in Nepal. Answering

Figure 3. Gharial from GCBC tagged with radio-tracking device, reported in India by the Wildlfe Trust of India. Photograph: Subrat Kumar Behera (WTI).

these questions will require two years of tracking data of adult-sized females, as well as identification of which tagged females are breeding and nesting through field observations and breeding surveys in conjunction with the ongoing work on reproductive ecology by EDGE Fellow Ranjana Bhatta. This will build on research into reproductive ecology carried out by Bed Bahadur Khadka, Assistant Conservation Officer, CNP (Khadka 2010, 2013, 2020a).

Project Partners. The ongoing telemetry research is a partnership between the DNPWC, CNP, the GCBC at CNP, National Trust for Nature Conservation (NTNC), Himalayan Nature, and the Zoological Society of London (ZSL) and ZSL Nepal Office. This research will be part of the PhD research of Phoebe Griffith (Wildlife Conservation Research Unit, Department of Zoology, University of Oxford).

Generous Support. Support for the ongoing fieldwork outlined in this update is generously provided by National Geographic, the Darwin Initiative, the UK Trust for Nature Conservation in Nepal, the CSG Student Research Assistance Scheme, the Satch Kranz Conservation Fund at Riverbanks Zoo and Garden, Idea Wild, Eddy Even and the British Herpetological Society. Special thanks to the invaluable assistance of the Gharial Ecology Project in loaning equipment and supplies, and providing training and advice. Phoebe Griffith also gives additional thanks to the National Environmental Research Council Environmental Research Doctoral Training Partnership at Oxford University and Brasenose College for their support of her PhD research.

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Latin America and the Caribbean

Venezuela

ABOUT THE SUPPOSED PRESENCE OF *MELANOSUCHUS NIGER* IN VENEZUELA. The presence of the Black Caiman (*Melanosuchus niger*) in Venezuela has long been the subject of speculation and controversy. The matter was raised by Medem (1963), who pointed out that *M. niger* was not found in the upper Orinoco River, which communicates with the Amazon basin through the Casiquiare

River. However, he suggested that the species could possibly occur in parts of Bolivar state that are within the Essequibo River basin (which originates in Guyana). Donoso-Barros (1966) referred to a specimen allegedly collected in Amazonas state, but the specimen may have originated from Brazil (Gorzula and Paolillo 1986). King (1991) claimed to have confirmed the presence of *M. niger* in Venezuela, based on the skin of a single specimen hunted by John H. (Jay) Wilson 23 years earlier (in March 1967) in an imprecise locality south of Puerto Ayacucho, the capital of Amazonas state.

More recently, Arteaga *et al*. (2018) suggested the presence of *M. niger* in Venezuela on the basis of a complete head and some osteoderms from the Botanamo River, Bolivar state. The main characteristic considered was skin colouration, but colour is a diagnostic characteristic of little value, given the wide variability shown by many crocodilian species. The authors also ruled out that the remains belonged to *Caiman crocodilus* because the calculated snout length/ width ratio (L/W) of 1.5 was higher than 1.3 - the latter is claimed to be established in the "CITES Identification Guide - Crocodilians" (Environment Canada 1995) as typical of *C. crocodilus*. However, the CITES Guide actually indicates a ratio of 1.2-1.5 for *C. crocodilius* and 1.6-1.9 for *M niger*. On this basis the specimen would more likely be *C. crocodilus* than *M. niger*. It is assumed that snout measurements taken by Arteaga *et al*. (2018) were as described in the CITES Guide (Fig. 1).

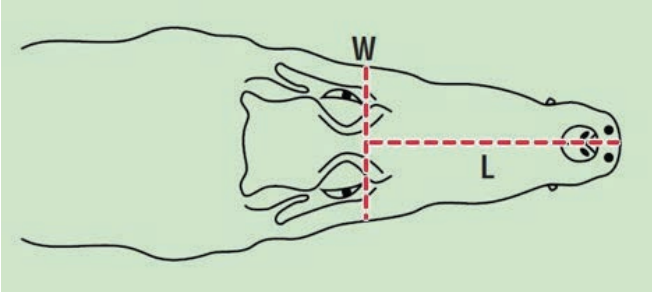

Figure 1. Snout length (L) and snout width (W) measurements as defined by the CITES Identification Guide - Crocodilians (Environment Canada 1995).

Using scale drawings of skulls in Medem (1983, 1984) and Donoso-Barros (1966), I derived L/W ratios for: *C. c. crocodilus* (1.22-1.83, mean= 1.58, N= 13); *C. c. apaporiensis* (1.78-2.13, mean= 1.93, N= 2); *C. c. fuscus* (1.22-1.28, mean= 1.26, N= 4); and, *M. niger* (1.16-1.35, mean= 1.26, N= 4). Notwithstanding potential differences between measurements on heads and skulls (from drawings), these data also suggest that the specimen reported by Arteaga *et al*. (2018) is more likley to be *C. crocodilus*. The significant difference in L/W ratio for *M. niger* skulls (1.16-1.35) versus the range reported in the CITES Guide (1.6-1.9) merits further examination, as the latter appear be incorrect.

The characteristics of the head described by Arteaga *et al*. (2018) also do not match the Brazaitis (1973) description for *M. niger* ("*The head is massive, wide, and high. Snout slightly pointed, slightly longer than the width at the base… four oblique elevations extend to the lateral margin of the snout* ". The oblique elevations do not seem to be present in the head reported by Arteaga *et al*. (2018). In addition, the specimen reported by Arteaga *et al*. (2018) was found in a river linked to the Essequibo River basin of Guyana, where the existence of *M. niger* has been verified. But this does not guarantee that the species will be present in all of its upstream tributaries within Venezuela.

Gorzula and Paolillo (1986) stated that "*Until now the existence of Melanosuchus niger has not been confirmed by us, despite field efforts invested for several years in the Federal Amazon Territory and in the Bolívar state, including watercourses such as Río Negro and Cuyuní, in which their presence could be presumed…*" (translated from Spanish). Discussions with professional herpetologists who have worked in Amazonas state over decades, have not revealed any evidence that *M. niger* occurs there. The overwhelming evidence points to the absence of *M. niger* in Venezuela.

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East and Southeast Asia

Indonesia

KALIMANTAN CROCODILE WORKSHOP: FIELD REPORTS.

Lamandau Nature Reserve

Immediately after the recent Kalimantan Crocodile Workshop (15-18 November 2019, Balikpapan, East Kalimantan; Stevenson *et al*. 2020), several workshop presenters obtained approval from BKSDA Kalimantan Tengah to visit Lamandau Nature Reserve (LNR), near Pangkalan Bun in Central Kalimantan. LNR is located adjacent to the Lamandau River, and about 41 km from Teringin Lama village, a location at which a 5-m long *Tomistoma schlegelii* was captured by the local community and opportunistically measured by Bruce Shwedick during a CSG Review Mission to Indonesia in September 2014 (Brien and Shwedick 2014). We were therefore interested in confirming the presence of *T. schlegelii* in LNR, and whether the reserve held a breeding population.

On 20 November 2019, Bruce Shwedick (BS) and Joe Wasilewski (JW) traveled from Balikpapan to Banjarmasin and then on to Pangkalan Bun. On 21 November we arrived at the BKSDA office in Pangkalan Bun and obtained a permit to visit LNR together with BKSDA staff. We also obtained permission to conduct an informal survey along the stretches of the river we would travel upon during our visit. While at the BKSDA office we were informed by staff that a juvenile *Crocodylus porosus* and a juvenile *Python reticulatus,* which had been captured in Pangkalan Bun after coming into contact with local residents, would be released in LNR at the same time.

We traveled from the BKSDA office using the BKSDA Wildlife Rescue vehicle to the Lamandau River, and then by motorized long boat from the Pangkalan Bun area to LNR. We entered the reserve at the Sungai Teringin Post, and were informed that LNR is also the location of an orangutan relocation and conservation project run by Orangutan Foundation-UK.

We continued on the Teringin River for approximately 15 km to Camp Gemini, whilst carrying out a daytime survey from 1300 h to 1430 h. One adult *T. schlegelii* (estimated at 4 m TL) was observed by JW and park staff member Setiawan, approximately 4 km from Sungai Teringin Post. No other sightings were made during this daytime survey. At Camp Gemini, we were allowed to assist with the release of the *C. porosus* and *P. reticulatus*. We were informed that 6 *C. porosus* (ranging in size from juveniles to 1.5 m TL) have been released in this area since March 2018. All of these animals had been captured in Pangkalan Bun by the BKSDA Wildlife Rescue team (Jhon Purba, pers. comm.).

We remained at Camp Gemini in the afternoon to observe feeding of orangutans being re-habituated to the wild in this area by Orangutan Foundation-UK. At 1600 h we traveled approximately 3 km upstream on the Teringin River, where we waited for nightfall. At 1800 h we began an informal spotlight survey [JW (spotter), Nasibah (spotter), BS (recorder) Jhon Purba, Setiawan] towards the Lamandau River. Water levels were relatively low (early wet season), with slow flow downstream, and overcast (no moon) conditions.

During the survey, three *C. porosus* were sighted, together with one eyeshine (believed to be *C. porosus*), over the 15 km stretch of the Teringin River (Table 1).

Table 1. Results of spotlight survey of Teringin River on 21 November 2019. TL= total length. Location refers to distance from start point of survey.

Location	Species	Estimated TL
1 km	*C. porosus*	1.2 m
3 km	*C. porosus*	0.6 m
5-6 km	Eyeshine	<1 m
7 km	*C. porosus*	1.2 m

Based on these observations, continued monitoring by BKSDA field staff would be useful in order to learn more about the status of both species, especially *T. schlegelii*, throughout the reserve. Due to its relatively easy accessibility, LNR could be an ideal location for an Indonesian university student to undertake a research project.

Tanjung Puting National Park

On 25 November 2019, BS arrived at the Tanjung Puting NP office in Pangkalan Bun, and obtained a permit to conduct an informal crocodilian survey on the Sekonyer and Sekonyer Kanan Rivers, from Tanjun Harapan Post to Camp Leakey. The main purpose of the survey was to continue to generate interest for the establishment of an annual monitoring program for *T. schlegelii* within the borders of the park. Tanjung Puting

NP has been identified in the CSG Tomistoma Action Plan as a high priority site for *T. schlegelii* conservation (Shaney *et al*. 2019).

After purchasing fuel and supplies, BS was transported by boat to the park by Mr. Ani, a member of the park's staff. Mr. Ani assisted previously during the visit to the park that was part of the CSG's Review Mission to Indonesia in 2014 (Brien *et al*. 2015). Upon arrival at Tanjung Harapan Post, BS was met by staff members (Mr. Dian, Mr. Sudiansyah and Mr. Bagas) assigned to assist him during this visit.

The survey team comprised: Mr. Bagas (lead spotter); BS (spotter and recorder); and, Mr. Dian (spotter and boat driver). At 1758 h we began our spotlight survey in a motorized long boat on the Sekonyer River, traveling at a very slow speed for 21 km from Tanjung Harapan Post to Muara Post. At 2232 h we began a spotlight survey on the Sekonyer Kanan River, continuing at a very slow speed for 7.6 km from Muara Post to Camp Leakey. Water levels were relatively high, current was slow, and conditions overcast. In the Sekonyer Kanan River the adjacent forest was flooded.

Three non-hatchling and 21 hatchling *T. schlegelii* were sighted during the survey (Table 2). The presence of hatchlings in both areas indicates successful hatching during the previous nesting season.

Table 2. Results of spotlight survey of Sekonyer and Sekonyer Kanan River on 25 November 2019. TL= total length, H= hatchling (one was caught and measured; 40 cm TL). All sightings were *T. schlegelii*.

Time	Estimated TL	Behaviour
Sekonyer R. (Tanjung Harapan Post to Muara Post; 21 km)		
1812 h	<1 m	submerged
1939 h	H	motionless/then submerged
1951 h	5 x H	motionless/then submerged
1955 h	H	motionless/then submerged
2000 h	2 x H	motionless/then submerged
2002 h	H	motionless/then submerged
2003 h	3 x H	motionless/then submerged
2007 h	H	motionless/then submerged
2021 h	1 m	submerged
2025 h	H	submerged
2040 h	H	submerged
2052 h	H	submerged
2059 h	H	motionless
Sekonyer Kanan R. (Muara Post to Camp Leaky; 7.6 km)		
2249 h	1 m	submerged
2327 h	H	motionless
2332 h	H	motionless
2354 h	H	motionless

On 26 November 2019, while returning from Camp Leakey during the day, a 2.5-m *T. schlegelii* was observed in the Sekonyer Kanan River by Mr. Dian. It was basking, then submerged. Later that afternoon, while BS was being returned to Kumai by park staff member Mr. Haderi, a 4-m *C. porosus* was observed in the Sekonyer River within 2 m of the park's entrance. It was swimming on the surface and then submerged.

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SUMATRA CROCODILE WORKSHOP: FIELD REPORTS. Following the Sumatra Crocodile Workshop on the medical management, conflict management and conservation of crocodiles, held in Medan, Indonesia, on 24-27 November 2017 (Stevenson 2017), several of the workshop presenters were invited by the Nature Conservancy of Sumatra to visit Way Kambas National Park (Lampung Province) and Berbak National Park (Jambi Province).

Way Kambas National Park

On 28 November 2017, Joe Wasilewski (JW), Adam Britton (AB) and Bruce Shwedick (BS) traveled from Medan to Bandar Lampung, and then on to the base camp of the Kegiatan Tim Elephant Response Unit located near the southern border of Way Kambas NP. During the first evening of our visit we were allowed to travel with Tri Sulistiyono and several other mahouts on one of their routine elephant patrols. Elephants are used by Mr. Sulistiyono and his team to monitor the park's borders and occasionally to drive wild elephants back into the park after they leave it in search of food on nearby farms. Three such teams operate along the perimeter of the park. They also conduct outreach programs

with their local communities in order to mitigate human/elephant conflict (Tri Sulistiyono, pers. comm.).

On 29 November 2017, we visited the park and arranged to travel by power boat with Mr. Sulistiyono and several park rangers along the Way Kanan River, from the Seksi I Wilayah Resort to Temba Tamu Field Station. While there, Heri and Turgino shared their recent observations of crocodiles in the area. They reported having seen both *Tomistoma schlegelii* and *Crocodylus porosus*. Of interest was that they used the name "buaya muara" to describe *T. schlegelii*, a name used in many other parts of Indonesia to describe *C. porosus*. The name they used for *C. porosus* was "buaya kali", a common name with which we were not familiar.

We waited for nightfall and then conducted an informal spotlight survey along the 9 km of river back to the Seksi I Wilayah Resort [BS (spotter), JW (spotter), AB (recorder, spotter), Heri and Turgino (boat crew)]. The survey was considered "informal" as observations were made incidentally during a visit to the National Park by invitation. Water levels were relatively low (early-mid wet season), with slow flow downstream, and overcast (no moon) conditions.

Ten (10) sightings was recorded, comprising: 3 *C. porosus*; one eyeshine (believed to be *C. porosus*); one *T. schlegelii*; one individual believed to be *T. schlegelii*; and, 4 crocodiles for which species could not be confirmed (Table 1).

Formal surveys conducted in 2002 were unable to confirm if *T. schlegelii* was still present in Way Kambas NP (Bezuijen *et al*. 2002a). However, the presence of a breeding population of *C. porosus* was confirmed and it was suggested that the park may serve as an important site for the species' recovery in southern Sumatra (Bezuijen *et al*. 2002a).

Based upon our observations, formal surveys of Way Kambas NP would be useful in order to learn more about the status of both species, especially *T. schlegelii*, throughout the park. Due to its relatively easy accessibility, Way Kambas NP could be an ideal location for an Indonesian university student to undertake a research project.

Berbak National Park

On 1 December 2017, JW and BS traveled from Bandar Lampung to Jambi City. On 2 December 2017 we were met by staff members of Berbak NP and transported to their office. While there we examined the skull (65 cm head length) of an adult *T. schlegelii* that had been collected in the park by Kyle Shaney and Dr. Amir Hamidy during their surveys in 2015 (Shaney *et al*. 2016).

From the office we traveled to the Kumpe River, where a field team was assembled. It consisted of Saryono (Park Ranger), Irfan Cayhad (UNDP Tiger Project) Adelino Gomes (Park Manager), Bobby Sandra (Technical Manager), Basri (Park Guide), Kasno (Park Guide) and Zainul (boat operator). We traveled by motorized long boat for approximately 10 km to the entrance of the national park, and then continued for an additional 18 km via a canal. We reached the Simpang T., a tributary of the Air Hitam Laut River, after a total journey of 5 hours. Our trip required portaging the boats 6 times over log dams that have been constructed as a part of a peat swamp rehydration project. From there we traveled a short distance to a section of the Simpang T., named "As Buaya" (Crocodile Path) and made plans to spend the night at the Long Camp fishing camp. Access to this portion of the park is allowed to a limited number of fishermen from the nearby local communities each year (Saryono, pers. comm.).

That evening we were divided into two teams and conducted informal spotlight surveys upstream and downstream from the camp. Water levels were high, and the areas of surrounding forest were flooded. One eyeshine was observed (estimated to be an adult) in very close proximity to Long Camp.

On 3 December 2017, we traveled the length of As Buaya to a remote fishing camp. One adult *T. schlegelii* was observed along our route. For a map of the area, we traveled in Berbak NP, please refer to Shaney *et al*. (2016).

Table 1. Results of spotlight survey of the Way Kanan River [from Temba Tamu Field Station (Camp D1) to Seksi I Wilayah Resort boat ramp (upstream)] on 29 November 2017. Cp= *Crocodylus porosus*; Ts= *Tomistoma schlegelii*; ES= eyeshine; TL= total length Mobile telephone GPS used, so location accuracy is at best considered to be "approximate" (WGS84 assumed). Latitudes/longitudes in italics are likely to be inaccurate because the GPS did not update from the previous fix.

ID	Time	Latitude	Longtitude	Species	Est. TL	Notes
1	1918 h	-5.02000	105.82195	Cp	1.5 m	Confirmed by head and tail markings
2	1936 h	-5.02417	105.81220	?	0.6 m	Too far for species ID, but head length fairly clear
3	1942 h	-5.02250	105.80810	Cp	0.8 m	Confirmed by photograph
4	1949 h	*-5.02250*	*105.80810*	?	2 m	Too far for species ID, but head length fairly clear
5	1955 h	*-5.02250*	*105.80810*	Cp	0.6 m	Confirmed by photograph
6	2008 h	-5.02222	105.80310	Cp?	ES	
7	2011 h	-5.02556	105.79190	Ts?	1.5 m	Almost certainly Ts, but dived before confirmation
8	2016 h	-5.02000	105.79330	?	0.7 m	Too far for species ID, head length estimate
9	2032 h	*-5.02000*	*105.79330*	Ts	1 m	Confirmed at close range
10	2040 h	*-5.02000*	*105.79330*	?	>1 m	Too far for species ID, size based on rough head size

At the camp, the park staff interviewed a local fisherman about recent fishing activities, and we were able to enquire about recent interactions with crocodilians. We were informed: by the fisherman that they do not experience conflict with crocodilians in this area; by park staff that helicopters were being used by Government and nearby oil palm plantations to control peat swamp fires within the borders of the national park; that Berbak NP has a sister park relationship with the Great Dismal Swamp National Wildlife Refuge in Suffolk, Virginia, USA, and that staff members from both parks are sharing information on peat swamp rehydration and eco-tourism; that a tree planting project was underway in areas previously damaged by fires and that plans were being made to create access to a remote portion of the park for eco-tourism purposes. That access could also provide opportunities for continued investigations of the status and ecology of *T. schlegelii*.

Acknowledgements

We would like to express our appreciation to: BKSDA Aceh; the Nature Conservancy of Sumatra; the Kegiatan Tim Elephant Response Unit; Way Kambas NP; Berbak NP; the Indonesian Department of National Parks; and, the Indonesian Institute of Sciences.

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East and Southern Africa

Madagascar

BUILDING PUBLIC AWARENESS ABOUT NEW HUNTING REGULATIONS IN MADAGASCAR. The Madagascar Crocodile Conservation and Sustainable Use Program (MCCSUP) was launched in 2014 to assist Madagascar with its management and conservation of Nile crocodiles (*Crocodylus niloticus*). MCCSUP was established in close collaboration with the Malagasy CITES Management Authority (Direction Générale des Eaux et Forêts; DGEF), and a series of activities were designed to provide opportunities for stakeholders, including an extensive artisinal industry, to become active, legal, sustainable and verifiable players on the national and international market.

MCCSUP fulfilled a key role in Madagascar, providing technical and financial assistance to a dedicated Crocodile Management Unit (CMU) and facilitating national and international experts to carry out research on Madagascar's Nile crocodile population (eg population surveys, research into human-crocodile conflicts). The program has also supported capacity building in Madagascar and provided guidance on best practices in crocodile conservation, management, and sustainable use.

Developing a public education program was a key activity identified through MCCSUP for the CMU to undertake. Efforts were directed at "hotspots" for HCC and hunting in the west and northwest of the country. Working with a professional film production company, Digital Development Communications (DDC), a storyline was developed that addresses the conservation and sustainable use of crocodiles in Madagascar, and is presented as a cartoon-style film targeting the northwest of Madagascar (where crocodiles are more prevalent). The voices in the film include local dialect, music, folklore and wildlife. The film can be viewed at (https://www.youtube.com/watch?v=D2Tev_v0fpc&feature=youtu.be). Accompanying the film, the DDC also produced and published a colouring book and a colour poster ("Living with the Crocodile") that highlights the new regulations on hunting size limits.

Figure 1. Screenshots from public awareness film.

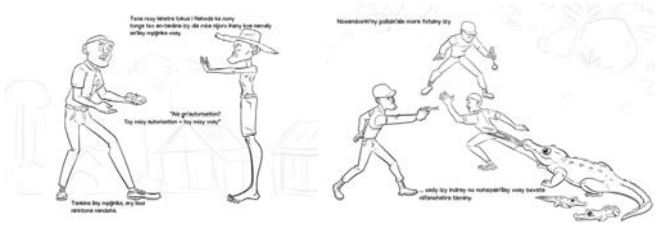

Figure 2. Pages from "Living with the Crocodile" colouring book, featuring: (left) city man offering villager money for crocodiles, and the villager saying "No permit - no crocodiles"; and, (right) city man being arrested by forest rangers for attempting to illegally catch crocodiles.

The film was launched in Madagascar by the Director General at the Ministry of Environment and Sustainable Development and has aired on national television. A large donation of colouring crayons was received from children at the Pinecrest Preparatory Middle-High School, a public charter school (6-12) in Miami, Florida, USA. All of the products were put onto USB sticks to make distribution easier across the target region (and nationally), and Gatorama, an alligator farm and visitor attraction in Palmdale, Florida, USA, donated USB sticks for this purpose. Thank-you to all who provided this generous support!

Figure 3. Public awareness poster "Living with the Crocodile".

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Recent Publications

Eniang, E.A., Akani, G.C., Dendi, D., Fa, J.E. and Luiselli, L. (2020). People's perceptions of crocodiles in Nigeria. Herpetological Journal 30: 112-116.

Abstract: Throughout Africa, feelings towards crocodiles vary according to the danger or fear experienced by communities living alongside them. Crocodile conservation programs must therefore be based on reliable assessments of cultural attitudes towards these reptiles. In this study, we interviewed a random sample of 300 persons in six states in southern Nigeria to determine their perception of crocodiles. Our results revealed that most respondents were very familiar with crocodiles, with animals being regularly sighted but only in small numbers. Most interviewees were aware of just two crocodile types, consistently describing the Dwarf crocodile (*Osteolaemus tetraspis*) and the West African Nile crocodile (*Crocodylus* [*niloticus*] *suchus*); only a minority of respondents reporting they were aware of the West African Slender-snouted crocodile (*Mecistops cataphractus*).

Kosch, J.C.D. (2020). Sampling Impacts the Assessment of Tooth Growth and Replacement Rates in Archosaurs: Implications for Paleontological Studies. MSc thesis, North Carolina State University, Raleigh, North Carolina, USA.

Abstract: Dietary habits in extinct species cannot be directly observed; thus, in the absence of extraordinary evidence, the dietary ecology of extinct species must be reconstructed with a combination of morphological proxies. Such proxies often include information on dental organization and function such as tooth formation time (TFT) and replacement rate (TRR). In extinct organisms, TFT and TRR are calculated, in part via extrapolation of the space between incremental lines in dental tissues representing daily growth (von Ebner Line Increment Width; VEIW). Tooth formation times and replacement rates in extinct species are becoming regularly calculated; however, to date, little work has been conducted testing assumptions about the primary data underpinning these calculations, specifically, the potential impact of differential sampling and data extrapolation protocols. To address this, we tested a variety of intradental, intramandibular, and ontogentic sampling effects on calculations of mean VEIW, TFT, and TRR using histological sections and CT reconstructions of a growth series of three specimens of the extant archosaurian *Alligator mississippiensis*. We find transect position within the tooth and orientation with respect to VELs to have the greatest impact on calculations of mean VEIW - a maximum number of VEIW measurements should be made as near to the central axis as possible. Measuring in more crowded regions of the tooth off the central axis can reduce mean VEIW by 36%, causing inflated TFT calculations. We find little demonstrable impact to calculations of mean VEIW from the practice of subsampling along a transect, or from using mean VEIW derived from one portion of the dentition to extrapolate TFT and TRR for other regions of the dentition. Subsampling along transects contributes only minor variation in mean VEIW calculations (<12%) that are dwarfed by the standard deviation of mean VEIW. Moreover, variation in VEIW with distance from the pulp cavity likely reflects idiosyncratic patterns related to life history, which are difficult to control for; however, we recommend increasing raw VEIW data to minimize this effect. Our data reveal only a weak correlation between mean VEIW and body length, suggesting minimal ontogenetic impacts for the calculations of TFT and TRR. Finally, we provide a relative standard deviation of mean VEIW for *Alligator* of 29.94%, which can be used by researchers to create data-driven error bars for TFTs and TRRs in fossil taxa with small sample sizes. We caution that small differences in mean VEIW calculations resulting from nonstandardized sampling protocols, especially in a comparative context, will produce inflated error in TFT estimations that intensify with crown height. The same holds true for applications of our relative SD to TFT calculations in extinct taxa, which produce highly variable maximum and minimum TFT estimates in large-toothed taxa (eg 718-1331 days in *Tyrannosaurus*).

Burghardt, G.M. (2020). Insights found in century-old writings on animal behaviour and some cautions for today. Animal Behaviour (https://doi.org/10.1016/j.anbehav.2020.02.010).

Abstract: An appreciation of the diverse roots of animal behaviour study is essential for informed teaching and stimulating current research and scholarship. Insights by early seminal authors

are often ignored, insights that may have avoided subsequent controversies or spawned productive research. Even with internet access now available for much early work, historical perspectives are increasingly being lost. Animal behaviour textbooks are often misleading and simplistic on historical matters. In this paper, I document how four authors writing 100 or more years ago greatly influenced my research on nonavian reptile behaviour. These four authors, which merit serious re-reading by students of virtually any taxa and topic, are Jakob von Uexküll, Margaret Floy Washburn, James Mark Baldwin and Wallace Craig. There are also current and upcoming challenges and risks impacting animal behaviour research that may affect how today's research will be viewed in historical perspectives 50, 100 or more years from now.

Fago, A., Natarajan, C., Pettinati, M., Hoffmann, F.G., Wang, T., Weber, R.E., Drusin, S.I., Issoglio, F., Martí, M.A., Estrin, D. and Storz, J.F. (2020). Structure and function of crocodilian hemoglobins and allosteric regulation by chloride, ATP, and CO_2. American Journal of Physiology - Regulatory Integrative Comparative Physiology 318: R657-R667.

Abstract: Hemoglobins (Hbs) of crocodilians are reportedly characterized by unique mechanisms of allosteric regulatory control, but there are conflicting reports regarding the importance of different effectors, such as chloride ions, organic phosphates, and CO_2. Progress in understanding the unusual properties of crocodilian Hbs has also been hindered by a dearth of structural information. Here, we present the first comparative analysis of blood properties and Hb structure and function in a phylogenetically diverse set of crocodilian species. We examine mechanisms of allosteric regulation in the Hbs of 13 crocodilian species belonging to the families Crocodylidae and Alligatoridae. We also report new amino acid sequences for the - and -globins of these taxa, which, in combination with structural analyses, provide insights into molecular mechanisms of allosteric regulation. All crocodilian Hbs exhibited a remarkably strong sensitivity to CO_2, which would permit effective O_2 unloading to tissues in response to an increase in metabolism during intense activity and diving. Although the Hbs of all crocodilians exhibit similar intrinsic O_2-affinities, there is considerable variation in sensitivity to Cl^- ions and ATP, which appears to be at least partly attributable to variation in the extent of NH_2-terminal acetylation. Whereas chloride appears to be a potent allosteric effector of all crocodile Hbs, ATP has a strong, chloride-independent effect on Hb-O_2 affinity only in caimans. Modeling suggests that allosteric ATP binding has a somewhat different structural basis in crocodilian and mammalian Hbs.

Fitri, W.N., Wahid, H., Rinalfi, P.T., Raj, D., Donny, Y., Qayyum, L. and Malek, A.A.A. (2020). Spermatozoa morphometry and ultrastructure in estuarine crocodile (*Crocodylus porosus*). Asian Pacific Journal of Reproduction 9(2): 104-108.

Abstract: To evaluate normal spermatozoa morphometry and ultrastructure in estuarine crocodile (*Crocodylus porosus*). Four adult male crocodiles aged between 12-15 years, with an average snout to tail length of (3.15 ± 0.01) m were selected for this study. Manipulation of the phallus digitally from the base of the penis was performed on four adult male crocodiles to facilitate the flow of semen to the sulcus. Semen was collected from all individuals for spermatozoa morphometry and ultrastructure study. Morphometry analysis was performed from eosin-nigrosin stained spermatozoa sample. Scanning electron microscopy was conducted to observe the surface ultrastructure of spermatozoa. The morphology of crocodile spermatozoa was made up of acrosome, head, and tail which corresponded to (5.55 ± 1.20) µm, (12.74 ± 1.57) µm and (70.67 ± 4.40) µm, respectively. The total length of spermatozoa in estuarine crocodile was measured at (88.96 ± 0.52) µm. The most common spermatozoa abnormalities found in the samples were cytoplasmic droplets. Normal morphology, morphometry of spermatozoa in estuarine crocodile which are vermiform shaped-head with a long tail along with questionably high cytoplasmic droplets count are described in this study.

Salighehzadeh, R., Sharifiyazdi, H., Akhlaghi, M. and Soltanian, S. (2020). Serotypes, virulence genes and polymorphism of capsule gene cluster in *Lactococcus garvieae* isolated from diseased rainbow trout (*Oncorhynchus mykiss*) and mugger crocodile (*Crocodylus palustris*) in Iran. Iranian Journal of Veterinary Research 21(1): 26-32.

Abstract: *Lactococcus garvieae* causes lactococcosis in rainbow trout in many parts of the world. This study was conducted for the existence of the virulent factors and differentiation of the two serotypes in *L. garvieae*. Twenty-two strains of *L. garvieae* isolated from diseased rainbow trout from farms in different regions and mugger crocodile of Iran, were investigated. In order to rapidly detect the presence of the hly1, hly2, hly3, NADH oxidase, sod, pgm, adhPsaA, eno, LPxTG-3, adhCI, and adhCII virulence genes, two multiplex polymerase chain reaction (PCR) assays were developed. Also, simplex PCR method was used to identify the bacterial serotypes, CGC, LPxTG-2, Adhesion, and adhPav virulence genes using the specific primer. All varieties of *L. garvieae* contained the hly1, hly2, hly3, NADH oxidase, pgm, adhPav, LPxTG-3, sod, eno, adhPsaA, adhCI, and CGC virulence genes. Also, adhCII gene was present in all strains except one of the isolates originated from mugger crocodile. In addition, LPxTG-2 gene was only present in one of the isolates belonging to mugger crocodile. Adhesion gene was not present in all the strains. Interestingly, all the 22 strains originated from both hosts were identified as belonging to the serotype I. Based on the phylogenetic sequences of the capsule gene cluster, group all fish isolates into a cluster together with one isolate obtained from mugger crocodile. Further studies are recommended to investigate the role of virulence genes in *L. garvieae* and evaluate their pathogenicity to rainbow trout.

Paintsil, E. (2020). COVID-19 threatens health systems in sub-Saharan Africa: The eye of the crocodile. Journal of Clinical Investigation (https://doi.org/10.1172/JCI138493).

Abstract: The threat of Coronavirus Disease 2019 (COVID-19) to health systems in sub-Saharan Africa (SSA) can be compared metaphorically to a lake in Africa infested with a bask of crocodiles and the saying: "the eye of the crocodile." In the lake, only the eyes of the crocodile appear on the surface while the rest of the body is submerged in water. In this Viewpoint, the eyes and the body of the crocodile represent the public health preparedness and health systems, respectively, in SSA.

Galoppo, G.H., Tavalieri, Y.E., Schierano-Marottia, G., Osti, M.R., Luque, E.H. and Muñoz-de-Toro, M.M. (2020). Long-term effects of *in ovo* exposure to an environmentally relevant dose of atrazine on the thyroid gland of *Caiman latirostris*. Environmental Research (https://doi.org/10.1016/j.envres.2020.109410).

Abstract: The increased incidence of human thyroid disorders, particularly in women, suggests that the exposure to endocrine-disrupting compounds (EDCs) together with sex-related factors could play a role in thyroid dysregulation. Since the herbicide atrazine (ATZ) is an environmental EDC suspected to behave as a thyroid disruptor, and *Caiman latirostris* is a crocodilian species highly sensitive to endocrine disruption that can be exposed to ATZ, this study aimed to describe the histoarchitecture and sexually dimorphic features of the thyroid gland of *C. latirostris*, and to determine the long-term effects of *in ovo* exposure to an environmentally relevant dose of ATZ (0.2 ppm) on its thyroid gland and growth. Control caimans showed no sexual dimorphisms. In contrast, ATZ-exposed caimans showed altered embryo growth but an unaltered temporal pattern of development and a sexually dimorphic response in the body condition index growth curves postnatally, which suggests

a female-related increase in fat storage. Besides, both male and female exposed caimans showed increases in the size of the thyroid stromal compartment, content of interstitial collagen, and follicular hyperplasia, and decreases in the expression of androgen receptor in the follicular epithelium. ATZ-exposed females, but not males, also showed evidences of thyroid enlargement, colloid depletion, increased follicular epithelial height and increased presence of microfollicular structures. Our results demonstrate that prenatal exposure of caimans to ATZ causes thyroid disruption and that females were more vulnerable to ATZ than males. The effects were organizational and observed long after exposure ended. These findings alert on ATZ side-effects on the growth, metabolism, reproduction and development of non-target exposed organisms, particularly females.

Srimangkornkaew, P., Praduptong, A., Siruntawineti, J., Chaeychomsri, S. and Chaeychomsri, W. (2020). Acute oral toxicity of *Crocodylus siamensis* bile in Sprague Dawley rats. Bulletin of the Department of Medical Sciences 62(1): 16-25.

Abstract: Crocodile bile is consisted of coprocholic acid, coprochenodeoxycholic acid, cholestanol, and other derivatives. In many countries, bile of animals has been used as an ingredient of traditional medicine. Although usage of *Crocodylus siamensis* (Siamese crocodile) bile has been used for treatment of various symptoms, toxicological studies of crocodile bile have not been evaluated. This study was to determine acute oral toxicity of *C. siamensis* bile in Sprague Dawley rats. Our study was conducted in a stepwise procedure and used fixed dose of *C. siamensis* bile at 300 and 2000 mg/kg body weight according to OECD Guidelines for the testing of chemicals 420, Acute Oral Toxicity-Fixed Dose Procedure. The results showed that no mortality of rats orally given dried *C. siamensis* bile at the dose of 300 mg/kg body weight. In contrast, the dose of 2000 mg/kg body weight demonstrated mortality within 24 hours after testing. The results suggested that *C. siamensis* bile is classified in Globally Harmonized System for Classification and Labeling of Chemicals as category 4 (300 mg/kg <LD50 ≤2000 mg/kg).

Montefeltro, F.C., Lautenschlager, S., Godoy, P.L., Ferreira, G.S. and Butler, R.J. (2020). A unique predator in a unique ecosystem: modelling the apex predator within a Late Cretaceous crocodyliform-dominated fauna from Brazil. Journal of Anatomy (doi: 10.1111/joa.13192).

Abstract: Theropod dinosaurs were relatively scarce in the Late Cretaceous ecosystems of southeast Brazil. Instead, hypercarnivorous crocodyliforms known as baurusuchids were abundant and probably occupied the ecological role of apex predators. Baurusuchids exhibited a series of morphological adaptations hypothesized to be associated with this ecological role, but quantitative biomechanical analyses of their morphology have so far been lacking. Here, we employ a biomechanical modelling approach, applying finite element analysis (FEA) to models of the skull and mandibles of a baurusuchid specimen. This allows us to characterize the craniomandibular apparatus of baurusuchids, as well as to compare the functional morphology of the group with that of other archosaurian carnivores, such as theropods and crocodylians. Our results support the ecological role of baurusuchids as specialized apex predators in the continental Late Cretaceous ecosystems of South America. With a relatively weak bite force (~600 N), the predation strategies of baurusuchids likely relied on other morphological specializations, such as ziphodont dentition and strong cervical musculature. Comparative assessments of the stress distribution and magnitude of scaled models of other predators (the theropod *Allosaurus fragilis* and the living crocodylian *Alligator mississippiensis*) consistently show different responses to loadings under the same functional scenarios, suggesting distinct predatory behaviors for these animals. The unique selective pressures in the arid to semi-arid Late Cretaceous ecosystems of southeast Brazil, which were dominated by crocodyliforms, possibly drove the emergence and evolution of the biomechanical features seen in baurusuchids, which are distinct from those previously reported for other predatory taxa.

Cossette, A.P. (2020). A new species of *Bottosaurus* (Alligatoroidea: Caimaninae) from the Black Peaks Formation (Palaeocene) of Texas indicates an early radiation of North American caimanines. Zoological Journal of the Linnean Society (https://doi.org/10.1093/zoolinnean/zlz178).

Abstract: Morphological and molecular data suggest a close relationship for alligators and caimans. The first fossil appearances combined with phylogenetic hypotheses suggest a divergence of the groups near the Cretaceous-Palaeogene boundary, but the early fossil record of Caimaninae is incomplete, and large gaps exist between the earliest representatives of the group. A new caimanine from lower Palaeocene (Tiffanian) deposits in the Black Peaks Formation of Brewster County, Texas is established upon two specimens of different size that bear similarities to *Bottosaurus harlani* from the uppermost Cretaceous and lowermost Palaeogene of New Jersey. The larger individual consists of a partial skull and lower jaw in addition to postcranial material. The smaller individual preserves a snout and posterior portions of the skull. Both specimens suggest an animal with a comparatively short, flat, broad snout. Species of *Bottosaurus* share diagnostic morphological character states but are differentiated in meaningful ways. Phylogenetic analysis shows that the new species is sister to *B. harlani*, indicates an early radiation of North American caimanines and elucidates a more complicated biogeographical history than previously hypothesized. A growing body of evidence suggests that Caimaninae may be diagnosed by ancestral characters, potentially drawing basal alligatoroids crownwards in phylogenetic trees.

Meseguer, A.S. and Condamine, F.L (2020). Ancient tropical extinctions at high latitudes contributed to the latitudinal diversity gradient. Evolution (https://doi.org/10.1111/evo.13967).

Abstract: Global biodiversity currently peaks at the equator and decreases toward the poles. Growing fossil evidence suggest this hump-shaped latitudinal diversity gradient (LDG) has not been persistent through time, with similar diversity across latitudes flattening out the LDG during past greenhouse periods. However, when and how diversity declined at high latitudes to generate the modern LDG remains an open question. Although diversity-loss scenarios have been proposed, they remain mostly undemonstrated. We outline the 'asymmetric gradient of extinction and dispersal' framework that contextualizes previous ideas behind the LDG under a time-variable scenario. Using phylogenies and fossils of Testudines, Crocodilia and Lepidosauria, we find that the hump-shaped LDG could be explained by (1) disproportionate extinctions of high-latitude tropical-adapted clades when climate transitioned from greenhouse to icehouse, and (2) equator-ward biotic dispersals tracking their climatic preferences when tropical biomes became restricted to the equator. Conversely, equivalent diversification rates across latitudes can account for the formation of an ancient flat LDG. The inclusion of fossils in macroevolutionary studies allows revealing time-dependent extinction rates hardly detectable from phylogenies only. This study underscores that the prevailing evolutionary processes generating the LDG during greenhouses differed from those operating during icehouses.

Moore, B.C., Francis, R., Foster, A., Kelly, D.A., Does, M., Kim, D.K., Groenewald, H.B. and Myburgh, J.G. (2020). Morphological changes associated with Nile crocodile (*Crocodylus niloticus*) phallic glans inflation. Journal of Morphology (doi: 10.1002/jmor.21126).

Abstract: The crocodylian phallic glans is the distal inflatable structure that makes the most direct contact with the female cloacal

and associated reproductive tract openings during copulation. Therefore, its form and function directly impact female tissue sensory interactions and insemination mechanics. Compared to mammals, less is known about glans functional anatomy among other amniotes, including crocodylians. Therefore, we paired an *ex vivo* inflation technique with magnetic resonance imaging 3D-reconstructions and corresponding histological analyses to better characterize the morphological glans restructuring occurring in the Nile crocodile (*Crocodylus niloticus*) at copulation. The expansion of contiguous inflatable spongiform glans tissues is variably constrained by adjacent regions of dense irregular collagen-rich tissues. Therefore, expansion shows regional differences with greater lateral inflation than dorsal and ventral. Furthermore, this enlargement elaborates the cup-like glans lumen, dorsally reorients the glans ridge, stiffens the blunt and bifid glans tip, and putatively works to seal the ventral sulcus spermaticus semen conduit groove. We suggest how these dynamic male structures may interact with structures of the female cloacal urodeum and how these morphological changes, in concert with the varying material properties of the structural tissue compartments visualized in this study, aid copulatory gamete transfer and resulting fecundity.

Da Silva Lacerda, M.B., Lucy Gomes de Souza, L., Lobo, L.S., Schaefer, C.E.G.R. and Romano, P.S.R. (2020). New outcrop with vertebrate remains from Solimões Formation (Eocene-Pliocene), Southern Solimões Basin, Acre State, Northern Brazil. Journal of South American Earth Sciences (https://doi.org/10.1016/j.jsames.2020.102588).

Abstract: Here we describe fossil vertebrate remains from a new Solimões Formation (Eocene-Pliocene) locality, near the highway BR 364 at Sena Madureira municipality (Acre, Brazil). The findings comprise more than 44 isolated fragments from which twenty-three specimens could be properly identified anatomically and systematically. The materials include at least three different Caimaninae genera (*Caiman*, *Melanosuchus*, and *Mourasuchus*), two distinct side-necked turtles (*Chelus* and Podocnemididae) and one mammal (Toxodontidae). The studied fossils could be systematized into two taphonomic classes based on their preservational status, indicating a sinuous fluvial meandering paleoenvironment. This new locality seems to be relevant regarding not only its fossil vertebrate diversity but also because of its geographic position: on a highway side, which allows access at any season of the year, as contrary to most common riverine outcrops from Solimões Formation, which are restricted to collections during the dry seasons.

Johnson, M.M., Young, M.T. and Brusatte, S.L. (2020). Emptying the wastebasket: a historical and taxonomic revision of the Jurassic crocodylomorph *Steneosaurus*. Zoological Journal of the Linnean Society (https://doi.org/10.1093/zoolinnean/zlaa027).

Abstract: Teleosauroidea is a clade of ancient crocodylomorphs that were integral components of coastal marine environments throughout the Jurassic. For nearly two centuries, one of the most familiar genera of teleosauroids has been *Steneosaurus*, encompassing nearly every teleosauroid species at some point. However, no type species has been designated for *Steneosaurus* under ICZN Code rules; the type specimen of the presumed type species *S. rostromajor* Geoffroy Saint-Hilaire, 1825 (MNHN.RJN 134c-d) is a chimera that has been largely neglected in the literature. Moreover, there is confusion as to which teleosauroid species it pertains to, and the genus *Steneosaurus* is often recovered as paraphyletic or polyphyletic in phylogenetic analyses. As such, the validity of *Steneosaurus* is uncertain. Here we formally designate *S. rostromajor* as the type species of *Steneosaurus*, designate a lectotype and re-evaluate MNHN.RJN 134c-d. We compare it with several well-known teleosauroids, including *Lemmysuchus* and '*S.*' *edwardsi*. Due to lack of autapomorphic characters, poor preservation and a tortured taxonomic history, we find MNHN.RJN 134c-d to be an undiagnostic and unreliable specimen. Thus, we consider *S. rostromajor* as a *nomen dubium* and propose that the genus *Steneosaurus* is undiagnostic. This has profound implications for teleosauroid phylogenetics, which we will clarify in an upcoming paper.

Staniewicz, A.M. (2020). Acoustic Communication of Rare and Threatened Crocodilians and its Use for Population Monitoring. PhD thesis, University of Bristol, UK.

Abstract: Freshwater animal populations can be more vulnerable to human impact than those in terrestrial and marine ecosystems, but may receive less conservation investment, often due to limited availability of information. In this thesis I explore strategies for the conservation monitoring of crocodilians, an iconic group of apex predators that play a key role in tropical freshwater ecosystem regulation, but are unfortunately vulnerable to human activities. Population assessments, crucial in developing conservation programs, require robust methodologies that take advantage of our knowledge of organismal biology and ecology. Traditional crocodile survey techniques that rely on spotlight or aerial counts are well established for the more conspicuous species, but can provide limited information when applied to species that are shy or difficult to access. These hard-to-survey species are also often the ones that are most vulnerable to habitat modification, and are consequently of greater conservation concern. Crocodiles are the most vocal of reptiles, which opens up the potential for novel methods of surveying. Here I provide baseline information on general ecology and acoustic communication in three threatened crocodilian genera in Africa and Southeast Asia - *Mecistops*, *Osteolaemus*, and *Tomistoma* - and then go on to test how the crocodile vocalisations can be exploited in a monitoring and survey context. I find that: (i) sympatric African crocodiles are highly partitioned in their habitat preferences, and so monitoring methods need to be tailored to individual species ecology, even when species are found in close proximity; (ii) West African slender-snouted crocodiles, *Mecistops cataphractus*, of all size classes produce distress calls and will respond to pre-recorded calls of their own species, but while the calls produced by small individuals attract conspecifics of all size classes, calls emitted by adults tend to repel them; (iii) spotlight surveys incorporating playback of *Mecistops* distress calls show greater detection rates compared to spotlight-only surveys; (iv) spotlight-only surveys detect a greater number of *Mecistops* than passive acoustic monitoring; (v) adult Central African dwarf crocodiles, *Osteolaemus tetraspis*, produce four distinct vocalisation types previously unreported in crocodylids, and are readily detected during passive acoustic monitoring; (vi) adult Sunda gharials, *Tomistoma schlegelii*, produce a range of previously-unreported underwater acoustic signals, but these appear restricted only to direct mating activities, therefore limiting utility of acoustic monitoring for their population assessment. This research provides an insight into the diversity of crocodilian acoustic repertoires, offers potential for acoustic-based survey methodologies in conservation, and opens up exciting new directions in reptile behavioural ecology.

Klassen, M., Adams, J., Cramberg, M., Knoche, L. and Young, B.A. (2020). The narial musculature of *Alligator mississippiensis*: Can a muscle be its own antagonist? Journal of Morphology (doi: 10.1002/jmor.21124.

Abstract: The crocodilian naris is regulated by smooth muscle. The morphology of this system was investigated using a combination of gross, light microscopic, and micro-CT analyses, while the mechanics of narial regulation were examined using a combination of Hall Effect sensors, narial manometry, and electromyography. *Alligator mississippiensis*, like other crocodilians, routinely switches among multiple ventilatory mechanics and does not occlude the nares during any portion of the ventilatory cycle. In a complex that is unique among vertebrates, a single block of smooth muscle functions in dilation when active, and in constriction when passive. The alligator nares may include one of the best examples of a muscle

that functions in "pushing" as well as "pulling." The central muscle for narial regulation, the *dilator naris*, can legitimately be viewed as its own antagonist.

Choe, Y. and Schuett, M.A. (2020). Stakeholders' perceptions of social and environmental changes affecting Everglades National Park in South Florida. Environmental Development (https://doi.org/10.1016/j.envdev.2020.100524).

Abstract: Urban sprawl and population growth have altered the landscape in the U.S in recent decades. Protected areas and development are compatible lenses, yet stakeholders' involvement in decision-making is often missing from environmental governance. Knowing how managers and stakeholders work together is also necessary to capture the meanings and feelings that local communities and various groups might have about a park and its ecosystem. The purpose of this study was to examine how stakeholders living and working in proximity to Everglades National Park (EVER) perceive environmental and social changes to the park and community relations. Data collection involved 41 interviews with stakeholders who have interacted with EVER, eg consumers, NGOs, federal agencies, state/local governments, businesses, and scientists. The in-person, semi-structured interviews were conducted using snowball sampling. These data were generated using three methods: field notes, audio recordings, and transcripts. An analysis of the interview data generated six research themes: loss of native species, urban development, a shortage and contamination of water, hurricanes, climate change, and increased recreation use. The results of this study add to the literature by providing a better understanding of the relationships stakeholders have with national parks. The results will provide useable knowledge that may help stakeholders and public land managers design strategies for sustainable plans for the park and its surrounding communities.

Rossi, N.A., Menchaca-Rodriguez, A., Antelo, R., Wilson, B., McLaren, K., Mazzotti, F., Crespo, R., Wasilewski, J., Alda, F., Doadrio, I., Barros, T.R., Hekkala, E., Alonso-Tabet, M., Alonso-Giménez, Y., Lopez, M., Espinosa-Lopez, G., Burgess, J., Thorbjarnarson, J.B., Ginsberg, J.R., Vliet, K.A. and Amato, G. (2020). High levels of population genetic differentiation in the American crocodile (*Crocodylus acutus*). Research Square (doi: 10.21203/rs.2.16265/v1).

Abstract: The American crocodile (*Crocodylus acutus*) is a widely distributed species across coastal and brackish areas of the Neotropical region of the Americas and the Greater Antilles. Available information on patterns of genetic differentiation in *C. acutus* shows a complex structuring influenced by interspecific interactions (mainly hybridization) and anthropogenic actions (mostly historical hunting, recent poaching and unintentional translocation of individuals). Moreover, recent work suggests *C. acutus* as a complex of cryptic species with preliminary proposals for taxonomic reassignment. Until recently, most population genetics research has primarily focused on present hybrid zones with other new world crocodilians . In this study, we used data on mitochondrial DNA control region and 11 nuclear polymorphic microsatellite loci to assess the degree of population structure of *C. acutus* in South America, North America, Central America and the Greater Antilles. We used traditional genetic differentiation indices, Bayesian clustering and multivariate methods to create a more comprehensive picture of the genetic relationships within the species across its range. Analyses of mtDNA and microsatellite loci show evidence of strong population genetic structure in the American crocodile, with unique populations in each sampling locality. Our results support previous findings showing large degrees of genetic differentiation between the continental and the Greater Antillean *C. acutus*. We report three new haplotypes unique to Venezuela, which are considerably less distant from the Central and North American haplotypes than to the Greater Antillean ones. Our findings reveal genetic population differentiation between Cuban and Jamaican *C. acutus* and offer the first evidence of strong genetic differentiation among the populations of Greater Antillean *C. acutus*. The information generated here is crucial for local and regional planning and conservation of the species, and contributes to the ongoing discussion on potential taxonomic revision for *C. acutus*.

Kassie, A. and Bekele, A. (2020). Diversity, distribution and habitat of Herpetofauna around Gambella Zuria District, West Ethiopia. International Journal of Zoology and Applied Biosciences 5(2): 68-78.

Abstract: Herpetofauna is the least studied group of vertebrates in general in the world and in particular in Ethiopia. This study was carried out to describe the species composition, diversity, distribution and species richness of amphibians and reptiles in Gambella Zuria District, Gambella National Regional State, Western Ethiopia. The study was conducted in 2018. Pitfall traps along with drift fence and Visual encounter survey methods were used to capture the amphibians and reptiles for visual estimation. Herpetofauna was investigated in three habitat types such as wetland, agricultural land, and house and riverine forest. A total of 95 amphibian individuals categorized under 9 species, belonging to 6 genera in 6 families were recorded. In addition to amphibians, a total number of 17 reptile species belonging to 3 orders, 11 different families, and 13 genera were recorded. Out of which, 5 species were snakes, 10 species of lizards, one species of turtle and one species of crocodile. *Ptychadena nilotica* was the most abundant amphibian species while *Agama finchi* was highest from reptile species in the study area. Tedia riverine forest (H= 1.81; D= 5.02) was the most amphibian species-rich and diverse among the four habitat types. Agricultural land and house had the lowest diversity index (H= 0.64; D= 1.8) compared to other habitat types. Karmi riverine forest (H=2.03) was the most reptile species-rich and diverse among the four habitat types followed by Agricultural land and house (H= 1.69). Jenena wetland had the lowest diversity index (H= 1.09) compared to other habitat types. This study showed that Gambella Zuria District is rich in amphibian and reptile species. A further extended molecular study should be carried out to obtain detailed information on the abundance and population structure of herpetofauna for better understanding and develop conservation strategies in Gambella Zuria District riverine forests and wetland areas.

Schwab, J.A., Young, M.T., Neenan, J.M., Walsh, S.A., Witmer, L.M., Herrera, Y., Allain, R., Brochu, C.A., Choiniere, J.N., Clark, J.M., Dollman, K.N., Etches, S., Fritsch, G., Gignac, P.M., Ruebenstahl, A., Sachs, S., Turner, A.H., Vignaud, P., Wilberg, E.W., Xu, X., Zanno, L.E. and Brusatte, S.L. (2020). Inner ear sensory system changes as extinct crocodylomorphs transitioned from land to water. Proceedings of the National Academy of Sciences of the United States of America (https://doi.org/10.1073/pnas.2002146117).

Abstract: Major evolutionary transitions, in which animals develop new body plans and adapt to dramatically new habitats and lifestyles, have punctuated the history of life. The origin of cetaceans from land-living mammals is among the most famous of these events. Much earlier, during the Mesozoic Era, many reptile groups also moved from land to water, but these transitions are more poorly understood. We use computed tomography to study changes in the inner ear vestibular system, involved in sensing balance and equilibrium, as one of these groups, extinct crocodile relatives called thalattosuchians, transitioned from terrestrial ancestors into pelagic (open ocean) swimmers. We find that the morphology of the vestibular system corresponds to habitat, with pelagic thalattosuchians exhibiting a more compact labyrinth with wider semicircular canal diameters and an enlarged vestibule, reminiscent of modified and miniaturized labyrinths of other marine reptiles and cetaceans. Pelagic thalattosuchians with modified inner ears were the culmination of an evolutionary trend with a long semiaquatic phase, and their pelagic vestibular systems appeared after the first changes to the postcranial skeleton that enhanced their ability to

swim. This is strikingly different from cetaceans, which miniaturized their labyrinths soon after entering the water, without a prolonged semiaquatic stage. Thus, thalattosuchians and cetaceans became secondarily aquatic in different ways and at different paces, showing that there are different routes for the same type of transition.

Fontenot, N. and Bourke, J.M. (2020). Abnormal nasal passage morphology in an adult Gharial (*Gavialis gangeticus*) implications for airflow and nasal septum development in longirostrine crocodylians. The FASEB Journal (https://doi.org/10.1096/fasebj.2020.34.s1.06287).

Abstract: Gharials are unique among extant crocodylians for their extremely longirostrine skull morphology. The extensively elongate rostrum in this group is comprised of contributions from the premaxillae, maxillae, palatines, vomers and pterygoids. Unlike some brevirostrine crocodylian taxa, the vomers do not support the nasal septum throughout its course, but terminate approximately 1 cm distal to the prefrontal-maxillary suture. Nasal septum integrity is maintained via a septal sulcus produced by the sharp ventral dip along the midline of the two maxillae as they join together to form the floor of the nasal cavity. In other longirostrine crocodylians such as *Alligator* and *Crocodylus*, this septal sulcus is pronounced and holds the septum in place for most of the nasal passage. However, in *Gavialis* the septal sulcus is weakly developed and the septum largely rests on the suture-line of the maxillae instead. Here we describe a unique case of a large adult female gharial with an extensively deviated septum. Deviation of the nasal septum produced a strong sigmoidal shape to the nasal passage rostral to the orbit. Segmentations and 3D renderings made in Avizo 7.1 (Thermo Fisher Scientific) and Computational Fluid Dynamic analysis using ANSYS Fluent (ANSYS Inc.) were run on this deviated airway to better determine the effects this wavy septum had on airflow. Results revealed a slightly elevated resistance in nasal airflow with the production of a few, small vortices within the bends of the nasal passage. These secondary flow patterns were not enough to induce turbulent flow and the majority of the nasal passage maintained laminar flow pattern similar to other crocodylians. Our results suggest that in spite of the heavily deviated septum, this animal was able to breathe with little extra effort. We compared this specimen to two other *Gavialis* specimens and discovered similar, albeit weaker developed, deviations of the nasal septum in these specimens as well. We suspect that weak development of the septal sulcus in *Gavialis* leaves this species susceptible to septal deviations and this type of developmental abnormality may be fairly common for this species and potentially other species of crocodylians with extensively elongated rostra.

Dubansky, B., Raney, J. and Dubansky, B. (2020). Mode of Ossification and extracellular fiber characterization of osteoderm matrix in the American alligator (*Alligator mississippiensis*) and comparisons to inherited and acquired heterotopic ossification disorders. The FASEB Journal (https://doi.org/10.1096/fasebj.2020.34.s1.06694).

Abstract: Osteoderms are bones that form in the dermis of several reptilian species and have been a source of scientific curiosity since at least the 1800s. Though there are several hypotheses for their function, a consensus has not yet emerged. The function of osteoderms is further obscured, since there is little histomorphological information on these structures. Indeed, understanding the cellular and molecular events that initiate and drive osteoderm development may clarify the functional significance of these structures. Dubansky & Dubansky (2018) conducted the first histological description of the development of the osteoderm in the American alligator, and identified discrete developmental stages based on the organization of collagen fibers and contributing cell mediators, as well as the degree of mineralization of the matrix. However, questions remain regarding the type of collagen and the identity of the cell precursors that are involved at different stages, as well as the existence of a hyaline cartilage model. In this study, differential staining techniques characterized changes in the fibrous component of the developing matrix of the osteoderm, and investigated whether ossification proceeds via an endochondral mechanism. Early stage osteoderms exhibit an extensive reticulin (type III collagen) fiber scaffold, which is replaced by disorganized, thick type I collagen fibers in mineralizing maturing matrix, and highly organized, thin type I collagen at the proliferating edge of the matrix. Despite morphological similarities to cartilage in some areas, staining showed that hyaline cartilage was absent and, therefore, the mode of ossification more resembled intramembranous ossification, than endochondral ossification. Osteoderm development resembles Heterotopic Ossification (HO) disorders in humans and is being used as a model to study several forms of this pathology. Based on this study, osteoderm histomorphology most closely resembles the inherited disorder Progressive Osseous Heteroplasia, in which pathological bone formation is restricted to the dermis and superficial fascia and proceeds via intramembranous ossification. Documenting similarities and differences among the various types of HO lesions and osteoderms may provide insights into the disease progression and future therapeutic strategies.

Tsai, H.P. (2020). The development of appendicular joint cartilages in *Alligator mississippiensis*: Evolutionary and biomechanical implications for Archosauria. The FASEB Journal (https://doi.org/10.1096/fasebj.2020.34.s1.00377).

Abstract: Crocodylians and birds are the two surviving lineages within Archosauria, a clade of morphologically and ecologically diverse vertebrates that evolved highly disparate locomotor postures. The appendicular joints of crocodylians and birds differ substantially, thus complicating inferences of ancestral morphology and evolutionary transitions. Recent studies have indicated that the American alligator, an extant crocodylian, use a wide spectrum of cartilaginous and other connective tissues to construct the hip joint. However, little is known about the distribution and use of cartilage throughout other appendicular joints, as well the ontogenetic transition of the crocodilian chondro-osseous interface during early development. In particular, the hyaline cartilage on the proximal femur of late embryonic alligators possesses a convex, cone-like extension that inserts deep into the metaphysis. This morphology is not seen in juvenile and adults, but is superficially similar to the cartilage cone-metaphyseal trough articulation inferred in early members of multiple archosaurian groups. The method by which alligators and other archosaurs reduced the cartilage cone during ontogeny and evolution, as well as the functional significance of the cartilage cone itself, are poorly understood. This study examined the ontogenetic transitions of proximal appendicular joints in the American alligator, spanning from in ovo stages to the first year of life. We used dissection, histology, and imaging techniques to assess the articular soft tissue anatomy at the chondro-osseous junction of the proximal- and distal epiphyses of the femur and humerus. Additionally, osteological correlates for joint cartilage were identified on fully skeletonized limb bone elements and compared with bony morphology seen in fossil archosauromorphs. At the onset of hatching, the alligator did not reduce the cartilage cone via decreasing the “depth” of cartilaginous extension into the metaphysis, as inferred for early archosaurs. Instead, neonatal alligators regress the cartilage cone via multiple invasion fronts of trabecular bones, such that the subchondral growth plate of hatchlings presents a convex surface perforated by numerous cartilage canals, similar to those found in young birds. These results suggest that the ontogenetic loss of cartilage cone in the alligator is different from the evolutionary loss of cartilage cone hypothesized for early archosaurs. Instead, the role of cartilage thinning, fibrocartilage sleeve development and calcified epiphyseal cartilage may be highly associated within different sauropsid lineages in response to evolutionary changes in joint loading regimes.

Xu, C., Palade, J., Fisher, R.E., Smith, C.I., Clark, A.R., Sampson,

S., Bourgeois, R., Rawls, A., Elsey, R.M., Wilson-Rawls, J. and Kusumi, K. (2020). Comparative anatomy and histology reveal the American alligator (*Alligator mississippiensis*) exhibits regenerative capacity of the tail. The FASEB Journal (https://doi.org/10.1096/fasebj.2020.34.s1.00441).

Abstract: Reptiles are the only amniotes that maintain the capacity to lose and regrow entire appendages. Among reptiles, tail regeneration has been extensively studied in Lepidosauria, the subclass that includes lizards, but this study presents the first anatomical and histological evidence of tail regeneration in an archosaur, the American alligator (*Alligator mississippiensis*). All animals were wild caught juveniles or sub-adults with an average total body length of 133.4 ± 29.2 cm (n= 3). Although the duration of tail regrowth is unknown, the average length of the regenerated tail was 15.7 ± 7.3 cm. The regenerated tail was externally distinct from the original tail. The scales were compacted and lacked organization as well as dorsal scutes. Gross dissection, radiographs, and magnetic resonance imaging revealed that the caudal vertebrae were replaced by a ventrally-positioned, unsegmented endoskeleton. This contrasts with lepidosaurs, where the regenerated tail is radially organized around a central endoskeleton, but shares commonality with urodele amphibians that regrow a tail with a clear dorsal-ventral axis. Immunohistochemistry confirmed that this alligator structure was composed of cartilage, which formed a hollow rod with foramina distributed along the proximal-distal axis. Furthermore, in contrast to the original tail, the regenerated tail lacked skeletal muscle and instead featured adipose and fibrous connective tissue supplied by a dense network of newly established axons and blood vessels. Despite substantial regrowth of the tail, the deposition of extensive connective tissue is reminiscent of mammalian wound healing or fibrosis. Using Herovici's stain, it was shown that the regenerated tail is composed of both type I and type III collagen fibers. The lack of muscle contrasts with the lepidosaurs, which regrow functional skeletal muscle groups, but shares similarities with regenerated limbs in Xenopus adult frogs, which have a cartilaginous endoskeleton surrounded by connective tissue, but lacking skeletal muscle. Overall, this study of regeneration in the alligator identifies a distinct pattern of regrowth with features in common with lepidosaurs, amphibia, and wound repair in mammals. Further analysis will help to shed light on the conservation of regeneration in amniote vertebrates.

Drumheller, S.K. (2020). Incorporating trace fossils when exploring the interplay of form and function in the crocodyliform feeding apparatus. The FASEB Journal (https://doi.org/10.1096/fasebj.2020.34.s1.00379).

Abstract: Many crocodylians, both living and extinct, fill the semi-aquatic ambush predator niche, and their prey preferences roughly can be predicted based on a combination of snout shape, tooth morphology, and body size. Among extant crocodylians, slender-snouted taxa such as *Gavialis gangeticus* and *Tomistoma schlegelii* generally prefer smaller-bodied prey, whereas the broader-snouted taxa divide into generalists like *Crocodylus niloticus* and macro-generalists like *Alligator mississippiensis*, who will eat a diversity of prey items including animals that are as big or even bigger than themselves. Large-bodied members of these generalist ecomorphotypes generate the highest bite forces observed in modern taxa and are often apex predators in their ecosystems. The availability of a robust phylogenetic hypothesis for crocodylians makes them an excellent clade with which to explore these types of ecomorphological hypotheses, which link form and function in the feeding apparatus within an evolutionary framework. The resulting synthesis of extant and extinct datasets has provided both exciting new insights, but also some complications. The addition of extinct taxa into studies of morphological disparity, both within the crown group and deeper in the crocodyliform evolutionary tree, introduce a diverse array of snout shapes and associated niches that are not represented in the surviving members of the clade (eg fully marine, fully terrestrial, durophagous, omnivorous, and even possibly herbivorous forms). Though hypotheses regarding diet in these diverse groups are based on craniodental morphology, indirect evidence, in the form of trace fossils, provides an independent means of testing those predictions. Gut contents are extremely rare in this clade because of the highly destructive digestion of crocodyliforms, and coprolites, though comparatively common, contain remains that are so degraded as to be largely unidentifiable and uninformative. Isotopic and dental microwear studies can provide broad patterns of diet. However, for detailed, direct evidence of crocodyliform feeding, bite marks are a particularly useful source of direct evidence with which to explore patterns of diet in this clade. A recent, concentrated effort to characterize modern crocodylian bite marks has resulted in the identification of novel patterns and diagnostic traces associated with feeding behavior in that clade. These trace fossils provide critical insights into diet, feeding strategy, and even intraspecific competition in crocodyliforms and their extinct relatives. By integrating these ichnological data with traditional dietary hypotheses based on morphology and phylogeny of extinct groups, a more complete, and oftentimes more complex and realistic, concept of past ecosystems and trophic structures can be explored.

Rashid, D.J., Bradley, R., Bailleul, A.M., Surya, K., Woodward, H.N., Wu, P., Wu, Y.-H., Menke, D.B., Minchey, S.G., Parrott, B., Bock, S.L., Merzdorf, C., Narotzky, E., Burke, N., Horner, J.R. and Chapman, S.C. (2020). Distal spinal nerve development and divergence of avian groups. Scientific Reports 10: 6303.

Abstract: The avian transition from long to short, distally fused tails during the Mesozoic ushered in the Pygostylian group, which includes modern birds. The avian tail embodies a bipartite anatomy, with the proximal separate caudal vertebrae region, and the distal pygostyle, formed by vertebral fusion. This study investigates developmental features of the two tail domains in different bird groups, and analyzes them in reference to evolutionary origins. We first defined the early developmental boundary between the two tail halves in the chicken, then followed major developmental structures from early embryo to post-hatching stages. Differences between regions were observed in sclerotome anterior/posterior polarity and peripheral nervous system development, and these were consistent in other neognathous birds. However, in the paleognathous emu, the neognathous pattern was not observed, such that spinal nerve development extends through the pygostyle region. Disparities between the neognaths and paleognaths studied were also reflected in the morphology of their pygostyles. The ancestral long-tailed spinal nerve configuration was hypothesized from brown anole and alligator, which unexpectedly more resembles the neognathous birds. This study shows that tail anatomy is not universal in avians, and suggests several possible scenarios regarding bird evolution, including an independent paleognathous long-tailed ancestor.

Austin, B.B. and Milnes, M.R. (2020). Validation of antibodies for the immunolocalization of germ cells in alligator gonads. Poster presentation, Knowledge Box, Georgia College (https://kb.gcsu.edu/src/2020/poster_presentations/5/).

Abstract: Previous studies of alligators from pesticide-contaminated lakes have shown decreased fertility in comparison to less polluted reference populations. Our research is focused on elucidating potential mechanisms of decreased reproductive success in alligators exposed to environmental contaminants during critical developmental periods. The localization and identification of germ cells during development can provide critical information in assessing future reproductive capability. Germ cells are the unique precursors of gametes, more commonly referred to as eggs and sperm. Specific cell types can be localized through immunohistochemistry (IHC), which involves the use of labeled antibodies to identify specific molecules present in the cells of interest. In this study we used standard IHC protocols to test two antibodies for use as potential biochemical markers of germ cells in hatchling alligator gonads. We ran parallel procedures on mouse gonads as a positive control for the validation of our techniques.

Because the process of germ cell maturation is generally conserved among vertebrates, antibodies intended to identify germ cells in mice may bind to homologous antigens in alligator germ cells. Our results indicate that a polyclonal antibody to DDX4 binds to putative germ cells in mice and alligators. DDX4 is an RNA helicase expressed in germ cells and is thought to be expressed in all stages of germ cell development up to late meiosis. We also tested an antibody to SCP3, a gene involved in the stabilization of homologous chromosomes during prophase I. Our monoclonal antibody recognized germ cells in prophase I in mice, but it did not bind homologous antigens in the alligator. By identifying germ cells at various developmental stages, we can determine if contaminants affect development of alligator gonads in a way that would compromise future fertility. Further research will involve the validation of antibodies that identify germ cells in specific stages of meiosis.

Ortega-León, A.M., Santos-Morales, A.H., Zamora-Abrego, J.G. and Pérez-Mendoza, H.A. (2020). Analysis of the population dynamics of the endangered American crocodile, *Crocodylus acutus* in Paramillo National Natural Park. Marine and Freshwater Research (https://doi.org/10.1071/MF19026).

Abstract: Few studies have been conducted on the population dynamics of crocodiles, especially in the Neotropics. This is the first study to provide data on the population dynamics of the threatened American crocodile (*Crocodylus acutus* Cuvier, 1807)) in Paramillo National Natural Park. Twenty-four survey routes of 22 km each were studied, and a total of 733 sightings was recorded. During the study period (from October 2014 to March 2016), the population remained stable and experienced slight growth ($\lambda = 1.049 \pm 0.428$). Offspring production by the adults II stage was the most sensitive contribution (17.05), whereas the permanence of this adult stage was the demographic process that contributed the most to population growth (0.653). However, an 18% decrease in adults II would jeopardise long-term population viability and lead to a high probability of quasi-extinction, with under 300 individuals over the next 30 years. Thus, despite the apparent stability of this population, we suggest that it be considered a key target for future conservation efforts. Additionally, we recommend that this species continue to be listed as endangered in Colombia and not be modified in the CITES Appendix I.

Sachs, S., Young, M.T. and Hornung, J.J. (2020). The enigma of *Enaliosuchus*, and a reassessment of the Lower Cretaceous fossil record of Metriorhynchidae. Cretaceous Research (https://doi.org/10.1016/j.cretres.2020.104479).

Abstract: *Enaliosuchus macrospondylus* Koken, 1883 was one of the first thalattosuchian taxa from the Cretaceous to be described. The type series includes an atlas-axis complex, remnants of three post-axial cervical vertebrae, several dorsal vertebrae, a caudal vertebra, an incomplete femur and a fragmentary sacral rib from the upper Valanginian of northern Germany. Additionally, two isolated, non-thalattosuchian, tooth crowns from the uppermost Valanginian to lowermost Hauterivian of different localities in northern Germany were tentatively assigned to *E. macrospondylus* by Koken. The taxon was established for the distinctive the atlas-axis morphology, in particular the apparent lack of an axis parapophysis. *Enaliosuchus macrospondylus* has been considered a valid taxon in recent studies, based upon a largely complete metriorhynchid specimen from the Valanginian of France that had been referred to this taxon, an assignment that has never been questioned. Here we provide a detailed re-description of the *E. macrospondylus* holotype specimen and determine whether it is diagnostic, and if a referral of the French specimen to *E. macrospondylus* is justified. We also discuss whether *E. macrospondylus* and another metriorhynchid specimen from the Valanginian of northern Germany, described as *Enaliosuchus schroederi*, are conspecific. Finally, we provide an overview of the current knowledge of metriorhynchid diversity during the Cretaceous.

Truter, C. (2020). Temperature - something not to take lightly by crocodile farmers. ELRC Niloticus News, March 2020.

Swan, G. (2020). Electrical stunning - an essential management tool for crocodile farmers. ELRC Niloticus News, April 2020.

Aguilar-Olguín, S., Rivera-Rodríguez, M.C., Hernández-Hurtado, H., González-Trujillo, R. and Ramírez-Martínez, M.M. (2020). Effect of vegetation and abiotic factors on the abundance and population structure of *Crocodylus acutus* (Cuvier, 1806) in coastal lagoons of Colima, Mexico. Amphibian & Reptile Conservation 14(1): 174-182.

Abstract: Crocodile populations are affected by their environment, and disturbance of that environment leads to changes in their physiology and behavior. Using nocturnal spotlight counts, the infuences of vegetation type and several abiotic factors on populations of *Crocodylus acutus* were evaluated in Colima, Mexico. Six interconnected lagoons with a known presence of crocodiles were selected, and the largest (Laguna de Cuyutlan) was divided into four sections. Differences in crocodile density and size classes among these lagoons were determined, and the effects of abiotic factors and vegetation type on the density and distribution of crocodiles were identifed. Salinity could infuence the crocodile populations, since low crocodile densities were observed in lagoons with high salinity. Average densities of crocodiles of 0.2-8.3 individuals/km and 0-5.9 ind/km were recorded during the rainy and dry seasons, respectively. The average densities of crocodiles of size classes I, II, and III ranged from 0.3-1.7 ind/km, whereas those of size classes IV and V ranged from 0.1-1.8 ind/km. Population densities of crocodiles were associated with factors such as salinity (<1%), and since the hatchlings and juveniles are the most vulnerable to conditions of high salinity, they are drawn to sites of lower salinity, such as those with aquatic and mangrove vegetation. This suggests that *C. acutus* can fnd refuge and food in the mangrove vegetation and water at ambient temperatures of 3.9-6.3ºC. Variations observed in both the water and ambient temperatures probably did not affect the normal thermoregulation processes of the crocodiles, since they can adopt a strategy of thermoconformity in response to even minor variations in temperature. There were significant differences ($P<0.05$) among the lagoons in terms of salinity, aquatic and mangrove vegetation, and water and ambient temperatures. The coastal lagoons of Colima provided suitable habitats for crocodile distribution, but increased salinity led to the movement of crocodiles towards areas supplied with fresh water.

Untari, D., Hardjanto, H., Nugroho, B. and Soekmadi, R. (2020). Patterns and Trends of Crocodile Trade from Tanah Papua, Indonesia. Forest and Society 4(1): 209-224.

Abstract: *Crocodylus porosus* and *C. novaeguineae* are two protected and tradable crocodile species in Indonesia. Therefore, precautionary principles are needed in their utilization to ensure sustainability. Although the commodity from these species is traded domestically and internationally, the broader picture of its use in Indonesia is less known. The objectives of the study were to: (1) analyze the domestic trade of crocodiles, and (2) analyze the international trade of crocodiles. The analysis was conducted using data of direct utilization sourced from the wild in the form of skin and hatchlings, data on domestic transport permits, CITES export permits, and the CITES trade database. The study suggested that the harvest of crocodile hatchlings and skin do not represent the actual condition since the skin recorded were only those sent outside of the province. Determining zero harvest quotas of *C. porosus* did not stop species harvest for domestic trade. The dominant source of *C. porosus* skin export was captive breeding, while *C. novaeguineae* was sourced from the wild. Ranch-sourced skin of both species for export were very low.

Rose, A., Fukuda, Y. and Campbell, H.A. (2020). Using environmental DNA to detect estuarine crocodiles, a cryptic-ambush predator of humans. Human-Wildlife Interactions 14(1).

Abstract: Negative human-wildlife interactions can be better managed by early detection of the wildlife species involved. However, many animals that pose a threat to humans are highly cryptic, and detecting their presence before the interaction occurs can be challenging. We describe a method whereby the presence of the estuarine crocodile (*Crocodylus porosus*), a cryptic and potentially dangerous predator of humans, was detected using traces of DNA shed into the water, known as environmental DNA (eDNA). The estuarine crocodile is present in waterways throughout southeast Asia and Oceania and has been responsible for >1000 attacks upon humans in the past decade. A critical factor in the crocodile's capability to attack humans is their ability to remain hidden in turbid waters for extended periods, ambushing humans that enter the water or undertake activities around the waterline. In northern Australia, we sampled water from aquariums where crocodiles were present or absent, and we were able to discriminate the presence of estuarine crocodile from the freshwater crocodile (*C. johnstoni*), a closely related sympatric species that does not pose a threat to humans. Further, we could detect the presence of estuarine crocodiles within an hour of its entry and up to 72 hours after the crocodiles were removed from aquariums. We conclude that eDNA could be a valuable tool for reducing human-wildlife conflict through early detection of the species.

Faiaz, S.A., Coetzer, T.H.T. and Goldring, J.P.D. (2020). Isolation of Nile crocodile (*Crocodylus niloticus*) serum immunoglobulin M and Y (IgM and IgY). Journal of Immunological Methods (doi: 10.1016/j.jim.2019.112724).

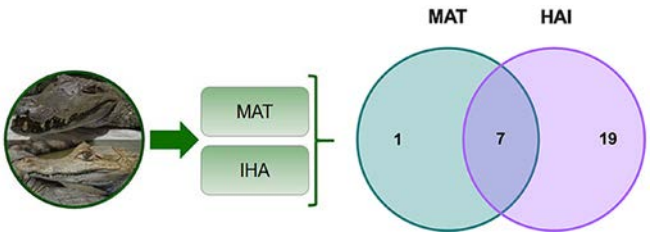
Abstract: Crocodile immunity has not been fully characterised with more studies on crocodile innate immunity than cell-mediated or humoral immunity. Crocodile immunoglobulin genes have been described but immunoglobulin proteins have not been isolated or studied biochemically. Two large proteins proposed to be crocodile IgM and IgY were isolated and purified from *Crocodylus niloticus* sera using two different protocols. A 50% (w/v) ammonium sulfate and a 15% (w/v) polyethylene glycol precipitation step was followed by Cibacron blue F3GA affinity- and Sephacryl-S300 gel filtration chromatography. An alternate purification protocol, with only two steps, involved thiophilic affinity- and Sephacryl-S300 gel filtration chromatography. The purified crocodile IgM resolved on reducing SDS-PAGE with an apparent mass of 180 kDa. Purified crocodile IgY resolved at 180 kDa alongside chicken IgY on a non-reducing SDS-PAGE gel, and is deduced to consist of two 66 kDa heavy and two 23 kDa light chains under reducing conditions. The thiophilic/gel filtration two-step protocol gave three-fold higher yields of isolated protein than the four-step precipitation/chromatography protocol. Antibodies against the isolated crocodile IgM and IgY were raised in chickens and affinity purified. The chicken antibodies differentiated between crocodile IgM and IgY and have the potential for use in the diagnosis of crocodile infections. The purified crocodile antibodies can be biochemically characterised and compared to mammalian and avian antibodies to give a better understanding of crocodile humoral immunity.

Bock, S.L., Lowers, R.H., Rainwater, T.R., Stolen, E., Drake, J.M., Wilkinson, P.M., Weiss, S., Back, B., Guillette, L. and Parrott, B.B. (2020). Spatial and temporal variation in nest temperatures forecasts sex ratio skews in a crocodilian with environmental sex determination. Proceedings of the Royal Society B 287: 20200210.

Abstract: Species displaying temperature-dependent sex determination (TSD) are especially vulnerable to the effects of a rapidly changing global climate due to their profound sensitivity to thermal cues during development. Predicting the consequences of climate change for these species, including skewed offspring sex ratios, depends on understanding how climatic factors interface with features of maternal nesting behaviour to shape the developmental environment. Here, we measure thermal profiles in 86 nests at two geographically distinct sites in the northern and southern regions of the American alligator's (*Alligator mississippiensis*) geographical range, and examine the influence of both climatic factors and maternally driven nest characteristics on nest temperature variation. Changes in daily maximum air temperatures drive annual trends in nest temperatures, while variation in individual nest temperatures is also related to local habitat factors and microclimate characteristics. Without any compensatory nesting behaviours, nest temperatures are projected to increase by 1.6-3.7°C by the year 2100, and these changes are predicted to have dramatic consequences for offspring sex ratios. Exact sex ratio outcomes vary widely depending on site and emission scenario as a function of the unique temperature-by-sex reaction norm exhibited by all crocodilians. By revealing the ecological drivers of nest temperature variation in the American alligator, this study provides important insights into the potential consequences of climate change for crocodilian species, many of which are already threatened by extinction.

Batista Ferreira, F., Gomes de Macêdo-Júnior, A., Salomão Lopes, C., Vieira Silva, M., Pires Ramos, E.L., Ferreira Júnior, A., Netto Vitaliano, S., Santiago, F.M., Quagliatto Santos, A.L., Mineo, J.R. and Patriarca Mineo, T.W. (2020). Serological evidence of *Toxoplasma gondii* infection in *Melanosuchus niger* (Spix, 1825) and *Caiman crocodilus* (Linnaeus, 1758). International Journal for Parasitology: Parasites and Wildlife (https://doi.org/10.1016/j.ijppaw.2020.04.008).

Abstract: *Toxoplasma gondii* is a protozoan with worldwide prevalence, known to affect a large variety of warm-blooded hosts. However, its ability to induce long-lasting infections in cold-blooded animals remains unclear. The most likely source of infection is through consumption of meat containing tissue cysts or by ingestion of food or water contaminated with oocysts. The current global climate change trend and the progressive degradation of natural habitats are prone to alter the distribution of ectotherm populations over a short period of time, which may favor contact between these animals and the protozoan. In association, alligator meat is considered a delicacy in many regions and its consumption has been previously related to a diversity of foodborne diseases. In that sense, we proposed in this study to search for specific antibodies against *T. gondii* in serum samples of two common species of alligators from the Brazilian fauna (*Melanosuchus niger* and *Caimam crocodilus*). We obtained the serum samples from 84 alligators from the Araguaia region, which were tested by agglutination assays that do not require species-specific secondary antibodies (Modified Agglutination Test - MAT; Indirect Hemagglutination Assay - IHA). From the 84 samples tested, eight (9.5%) were positive by MAT. From those, seven (87.5% of MAT+, 8.3% of the total) were also positive by IHA, reassuring a probable exposure of these animals to the parasite. Direct parasite detection in muscle fragments of one serologically reactive alligator did not yield positive results. Our results provide serological evidence that Brazilian alligators may be exposed to *T. gondii* and further studies should be performed to elucidate whether alligators are natural hosts of this ubiquitous protozoan parasite.



Malgora, S., Gibelli, D., Floridi, C., Martinenghi, C., McKnight, L., Ikram, S., Elias, J., Milani, C., Oliva, G. and Cellina, M. (2020). CT examination and 3D analysis of Egyptian animal mummies.

La Radiologia Medica (doi: 10.1007/s11547-020-01192-0 PMID: 32279159).

Abstract: Aim: To report our experience on CT investigation of animal mummies, focusing on the practical and radiological aspects of the study, the acquisition parameters and the different reconstruction techniques. Materials and Methods:Thirteen mummies underwent CT examination on the same CT scanner (Siemens sensation) with the following acquisition parameters: 120 kV; 140 mAs; slice thickness: 1 mm; reconstruction interval: 0.7 mm; and rotation time: 0.75 s. All datasets were reconstructed with both bone and soft tissue algorithms and archived on our picture archiving and communication system using their catalogue number as an identifier. Images were then transferred on IntelliSpace Portal (Philips Healthcare) for post-processing multiplanar and 3D reconstructions. The acquired data were submitted to anthropological analysis. Results: CT enabled the identification of the bundles content: four cats with complete skeleton, one upper part of a cat mummy, one lower part of a cat mummy, one cat head with four cervical vertebrae, two crocodiles, two raptors, skeletons from one or more snakes and one mummy with dog appearance, containing long bones. All cats and hawks showed cervical fractures; in one cat, the skull was collapsed inwards, and in another cat, the head was turned backwards; one cat presented a skeleton more radiopaque than normal with evidence of cracks related to the use of the resins for mummification that were poured directly over the corpse. Conclusions: CT is a valuable noninvasive technique to study Egyptian mummies, enabling in-depth analysis while preserving the integrity of the mummy bundles, ensuring protection of a valuable archaeological resource.

Guastalla, M.G. (2020). Fatores determinantes para a presença de *Caiman latirostris* (Crocodylia: Alligatoridae) em lagoas no Sudeste de Goiás. MSc thesis, Instituto Federal Goiano, Urutai, Brazil.

Abstract: The loss and fragmentation of habitats has caused major changes in behavior, movement patterns, and population dynamics of crocodilians. Such an effect is shown more visible in species that occur near areas with greater population density human, such as the broad-snoutedcaiman (*Caiman latirostris*). It is a generalist species of habitat with high capacity for colonization of artificial environments. Thus, the study had as an objective to evaluate how environmental variables can influence the occurrence and abundance of the species in artificial lagoons created in pastures in southeastern Goias, Brazil. The work was developed in the Environmental Preservation Area of Limoeiro, in Cumari, where 30 artificial lagoons were selected to count adult individuals of broad-snouted-caiman. The temperature and humidity of the air were measured before and after the period of lagoon sampling. Lagoons were visited at night, with six visits in each season (dry and rainy). Models of occupation and abundance were made through the package unmarked software R, correlating sightings to variables: swamp presence, lagoon area (m^2), lagoon type (perennial/ seasonal) and distance from the river. Between 2018 and 2019, after 264 visits, 86 sightings of broad-snouted-caiman were made. Temperature positively influenced the detection of alligators, while humidity negatively influenced the detection of individuals in both seasons. Variables such as area lagoon (m^2), and the presence of swamp better explained the occupation and abundance of alligators adults in ponds during the rainy season; and distance from the Paranaíba River in the dry season. It was possible to identify that air temperature and humidity interfere with species detectability. In addition, the variables river distance, lagoon area and swamp presence were significant for the occurrence and abundance of broad-snouted-caiman. This project was supported by a grant from the Federal Institute of Goiás.

Platt, S.G., Rainwater, T.R., Elsey, R.M., Bishop, N.D. and McMurry, S.T. (2020). On the occurrence of runt eggs in Morelet's crocodile. Caribbean Naturalist. 75: 1-10.

Abstract: Runt (abnormally small) eggs are widely reported in the avian literature, but the few reports available for crocodilians are ambiguous. From 1992 to 2000, we examined 3015 *Crocodylus moreletii* (Morelet's Crocodile) eggs from 117 nests in northern Belize; 9 of these eggs met the criterion for runt eggs. Runt eggs occurred at frequencies (per egg and per clutch) comparable to those reported for wild birds, appeared to be deposited in no particular order within the clutch, and were seemingly viable in some cases. Most runt eggs appeared to be associated with small female body size. In comparison to those of birds, crocodilian runt eggs probably impose minimal energetic costs on females because the maternal investment can be partially recouped by consuming those that fail to hatch.

Cartagena-Otálvaro, V.M., Páez, V.P., Alzate-Estrada, D. and Bock, B.C. (2020). Demography and habitat use of *Caiman crocodilus* in two contrasting channels in the middle Magdalena River drainage, Colombia. Herpetological Conservation and Biology 15(1): 49-60.

Abstract: A rigorous monitoring project provides a means for guaranteeing the conservation or sustainable use of a population, allowing the quantification of changes in its demographic parameters and associating them with spatial and temporal variation in environmental factors. We present the results of a monitoring project of a population of Spectacled caiman (*Caiman crocodilus*) conducted from 2013 to 2018 in two contrasting channels in the middle Magdalena River drainage in Colombia. We employed three monitoring methods: nocturnal counts, capturemark-recapture study, and N-mixture models. Although nocturnal counts and N-mixture models are comparable methods, the estimates of population size and of detection probabilities that they provided were different. Both methods, however, agreed in general by indicating that detection probabilities were low and population sizes were large, in comparison to similar estimates from other populations. In the deeper channel with more riparian vegetation and less fishing activity, relative densities were 3.3 orders of magnitude greater than in the other channel, and had a population comprised of a larger proportion of subadult and adult individuals. Low recapture rates precluded estimation of population sizes, survivorship rates, or detection probabilities with the capture-markrecapture data; however, this method provided a more reliable summary of the size distribution of individuals, population sex ratios, and patterns of habitat use. Water depth was the only covariable that significantly influenced detection probabilities. This study is the first application of N-mixture models to estimate population size and detection probabilities in a *Caiman* population.

Clarke, G.S., Hudson, C.M. and Shine, R. (2020). Encounters between freshwater crocodiles and invasive cane toads in north-western Australia: does context determine impact? Australian Zoologist (https://doi.org/10.7882/AZ.2020.015).

Abstract: The potent defensive chemicals of cane toads (*Rhinella marina*) protect them against predators that lack coevolved physiological tolerance to those toxins. That relative invulnerability may explain why major injuries (such as limb loss) appear to be rare in cane toads from most of their global range; however, we noted frequent predator-induced injuries (>4% of adults) in samples from within the toad's native range (in French Guiana) and from a site (Lake Argyle) in north-western Australia. Toads at Lake Argyle enter the edge of the lake at night to rehydrate, exposing them to foraging freshwater crocodiles (*Crocodylus johnstoni*). Crocodiles rarely consume toads, but the attacks often result in loss of a limb. Because limbs contain relatively little toxin, attacks to the limbs expose a crocodile to nauseating but non-lethal amounts of toxin; and hence, facilitate taste aversion learning by the predator. The context of the encounters, such as differences in geography, may help to explain why the invasion of cane toads has not significantly impacted on crocodile populations at this site, in contrast to heavy impacts reported from nearby riverine systems.

Kay, J.C., Elsey, R.M. and Secor, S.M. (2020). Modest regulation of digestive performance is maintained through early ontogeny for the American alligator, *Alligator mississippiensis*. Physiological and Biochemical Zoology (https://doi.org/10.1086/709443).

Abstract: With regards to the digestive physiology of crocodilians. several previous studies documented postprandial metabolic responses. A study on the Broad-nosed caiman (Starck *et al*. 2007) described postprandial changes in small intestinal histology and in the size of several organs. Tracy *et al*. (2015) compared intestinal histology, intestinal hydrolase activity, and paracellular transport of the small intestine between the American alligator and Saltwater crocodile. Eme *et al*. (2019) examined the body mass scaling of organ masses for hatchling (<500 g) female alligators. In this paper we quantify and compare among three age classes (neonate, juvenile, and sub-adults) of the American alligator their postprandial responses in metabolic rate, organ masses, intestinal histology, digestive enzyme activities, and intestinal nutrient uptake. We demonstrate age and size effects on specific dynamic action and capacities for pancreatic enzyme activity and intestinal nutrient uptake. This study also documented regional variation throughout the gut in luminal pH and effects of digestion on gut pH. By addressing hypotheses on the regulation of digestive peformance and ontogenetic shifts in regulatory capacities, we found that American alligators modestly regulate digestive performance with feeding and fasting, that among these age classes they do not experience an ontogenetic shift in the magnitude of regulation, and that metabolism, organ mass, and intestinal performance scale allometrically with body mass.

Thiendedsakul, P., Boonsoongnern, P., Jara, P. and Tulayakul, P. (2020). Comparative liver metabolic enzyme activity of cytochrome P450 and glutathione-S-transferase in crocodile (*Crocodylus siamensis*) and livestock. Comparative Biochemistry and Physiology Part C. Toxicology & Pharmacology (https://doi.org/10.1016/j.cbpc.2020.108784).

Abstract: This study aimed to compare the metabolism of detoxification liver enzymes activity of CYP1A2, CYP2E1, the GST enzymes activity for class pi, mu, alfa, and the universal GST between crocodile and livestock, plus the relationship of these two enzyme activities in the crocodile. Interestingly, the CYP1A2 and CYP2E1 were existent in the freshwater crocodile livers microsomal enzyme activities, and these two enzymes could be determined in both pig and chicken. Also, the universal GST, alpha, mu, and pi class of phase II were presented in the crocodile liver cytosolic fractions, and these three enzymes could also be found in pig and chicken. The kinetic activity (Vmax/Km ratio) of GST activity towards CDNB was higher in the crocodile than chicken, and pig; 80.02, 57.80 and 45.25 ml/min/mg protein, respectively. The Vmax/Km ratio GST activity towards t-PBO was highest in crocodile. In contrast, the GST activity towards EA was highest in pig, chicken and crocodile in this order. However, the Vmax/Km ratio GST activity towards CHP was very low in all species. The crocodile liver microsome fraction could metabolites AFB1 to AFM1, suggesting that the CYP1A2 activity was actively presented. The kinetic enzyme activity of crocodile liver towards CDNB revealed the highest velocity compared with other livestock species; this indicates that crocodile liver enzyme activities were very active for the detoxification function towards all xenobiotic, especially for GST activity, towards carcinogenic agent when compared with other livestock.

Ezat, M., Naguib, M. and van Langevelde, F. (2020). Home range and long-range movements of the Nile crocodile in relation to the anthropogenic pressure, Lake Nasser, Egypt. Pp. 76 *in* Proceedings of Wias Annual Conference 2020: Frontiers in Animal Sciences. WIAS: The Netherlands.

Abstract: Movements of animals determine and reflect home ranges and social interactions, provide insights into resource requirements and habitat usage, and allow to make predictions about individual and population responses to disturbances. The size, location and shape of a home range reflects an animals' behavioural decisions as it searches for food, nesting sites, shelter and mates. Understanding movement behaviour and social structures is seen as prerequisite for effective conservation and management actions, particularly for apex predators with large home ranges because of their influence on lower trophic levels. The Nile crocodile *Crocodylus niloticus* is the second world's largest reptile and the most iconic animal along the Nile. The Nile crocodile inhabits threatened wetlands and it is an important indicator species of environmental conditions. Lake Nasser in Egypt is the largest man-made lake world-wide and contains a large, but decreasing population providing unique opportunities to study their ecology and behaviour under fully free ranging conditions.However, despite its remote location, the crocodiles of Lake Nasser compete with local fishermen. Local crocodile populations become therefore increasingly threatened as many individuals are killed every year, often by local fishermen. Yet, little is known about the behaviour and ecology of Nile crocodile and consequently local conservation programs lack information on the spatial distribution of crocodiles and whether they indeed consume fish in the same areas in which fishermen harvest their fish. Home ranges of Nile crocodiles generally centre around suitable basking sites in winter and expand to include favourable breeding (mating and nesting) and foraging sites in summer. However, these long-range movement are only anecdotally described and without determining factors that could explain these movements, eg the anthropogenic pressures in the lake. The aim of this PhD project is thus is to obtain fundamental insights into the distribution and movements of fully free ranging GPS tagged Nile crocodiles by determining their home ranges and long-range movements. In particular, determining seasonal changes in habitat use and movements to and from nesting sites is important to also understand the ecological requirements and to understand where and when crocodiles are exposed to threats by,for instance fishermen or changing water levels that effects the availability of the nesting habitat.

Fernandez dumont, M.L., Bona, P., Pol, D. and Apesteguía, S. (2020). New anatomical information on *Araripesuchus buitreraensis* with implications for the systematics of Uruguaysuchidae (Crocodyliforms, Notosuchia). Cretaceous Research (https://doi.org/10.1016/j.cretres.2020.104494).

Abstract: *Araripesuchus* (Uruguaysuchidae) is a gondwanan mesoeucrocodylian genus that includes several species, distributed in the Cretaceous of Niger (*A. wegeneri* and *A. rattoides*), Madagascar (*A. tsangatsangana*), Brazil (*A. gomesii*), and Argentina (*A. patagonicus* and *A. buitreraensis*). The two Argentinean species came from different localities of the lower Cenomanian of Patagonia. Here, we present a complete cranial description of *A. buitreraensis* and explore its phylogenetic relationships, based on new as well as previously reported specimens. We studied the skulls of eight specimens of *A. buitreraensis*, almost all represented by partial cranium and mandible, adding new autapomorphies to the original diagnosis of this taxon. A comparison between the new specimens also reveals some discrepant features, which are interpreted as ontogeny or as intraspecific variation. We present revised scorings of several uruguaysuchid species (*A. buitreraensis*, *A. gomesii*, and *Uruguaysuchus aznarezi*) from a published morphological dataset and conduct a phylogenetic analysis to test the phylogenetic position of *A. buitreraensis*. As in resent phylogenetic proposals, this taxon was recovered as the basalmost member of a clade, which clusters all uruguaysuchids from South America. A revision of the diagnosis and a new phylogenetic definition of Uruguaysuchidae is also presented.

Bauso, J., Simoncini, M.S., Chiani, Y., Schmeling, M.F., Larriera, A., Vanasco, N.B. and Piña, C.I. (2020). Presence of *Leptospira* spp. in *Caiman latirostris* (Crocodylia, Alligatoridae) populations in Santa Fe, Argentina. Heliyon 6: e03837.

Abstract: Leptospirosis is a disease caused by pathogenic spirochetes of the genus *Leptospira*, transmitted by wild and domestic animals. Rodents play a fundamental role in the transmission cycle of this zoonosis but the function of reptiles is unknown. For example, crocodilians could play an important role in the transmission of this disease by living in ideal environments (bodies of shallow water and high temperatures) for the colonization of this bacterium. However, few studies have documented the presence of zoonotic diseases in caiman populations. Our objective was to assess the prevalence of antibodies to leptospira and the presence of *Leptospira* spp. in wild and captive *Caiman latirostris*. Blood samples were taken from 45 individuals (20 wild and 25 captive). Before extraction, we cleaned each caiman's neck in order to prevent contamination of samples. We determined the presence of antibodies in serum by microscopic agglutination test (MAT) and polymerase chain reaction (PCR) to detect DNA of the bacteria. We excluded 9 of the 45 samples analyzed by MAT because 5 had lipemic serum and 4 were contaminated (colonized by other organisms). Of the 36 caimans studied by microscopic agglutination test (MAT), 56% (20/36) were considered reactive (titers 50). In 74% (14/19) of captive samples and 35% (6/17) of wild samples, antibodies to leptospira were detected by MAT. The serogroup with highest occurrence was Pyrogenes (85%, n ¼ 17/20), presenting coagglutinations with Icterohaemorrhagiae (25%, n ¼ 5/20). One sample from a captive animal was positive for PCR, and we could not isolate leptospires because of agar contamination. Of the 45 blood agar media, 17.8% were contaminated and the rest were negative. This work determined the presence of *Leptospira* spp. in one caiman and a high prevalence of antibodies in captive caiman relative to wild individuals.

Beal, E.R. (2020). American Alligator (*Alligator mississippiensis*) Ecology Within Human-Dominated Landscapes. MSc thesis, University of North Florida, Florida, USA.

Abstract: Urbanization is an ever-increasing threat to wildlife and their habitats, yet research has been limited to a small number of taxa. The American alligator (*Alligator mississippiensis*) is an apex predator that has surprisingly received minimal attention within urban areas. To investigate the potential effects of urban land use on spatial ecology, we conducted surveys of relative alligator abundance in nine tributaries surrounding the St. Johns River. We used these data to explore the potential effects of urban development on alligator spatial distribution and habitat selection. At the coarse scale, we found no correlation between percent developed land and relative alligator abundance. Instead, salinity is the primary driver of relative abundance. At the fine scale, we found that alligators prefer habitats characterized by more open water and highly vegetated shorelines and avoid anthropogenic structure. Only one out of 93 sighted individuals was an adult, and recent data suggests that adults are relatively rare in our study area. Thus, juveniles still occupy urban habitats because they are not being targeted and they face virtually no competition from adults. To investigate the potential effects of land development on trophic ecology, we performed gut content analysis on golf course alligators found on Jekyll Island, Georgia. We made comparisons with alligators found in more natural areas on Sapelo Island, Georgia. Percent index of relative importance values reveal that there may be functional differences in prey choice or availability, but analysis of similarity, non-metric multidimensional scaling, and simplified Morisita index analyses show no significant difference. Further land development and increasing human activity may therefore degrade available habitat and limit the distribution of breeding adult alligators in once suitable areas and possibly shift diets toward reliance on prey items usually of lesser importance. These potentially interacting spatial and trophic effects could lead to local population declines.

Beal, E.R. and Rosenblatt, A.E. (2020). What do alligators eat on golf courses? 2020 SOARS Virtual Conference Poster (https://digitalcommons.unf.edu/soars/2020/spring_2020/13/).

Abstract: Urbanization is an ever-increasing threat to wildlife and their natural habitats, yet research has been limited to a small number of taxa and very few large predator species. The American alligator (*Alligator mississippiensis*) is an apex predator across the southeast USA and has surprisingly received minimal attention within urban areas. To investigate the potential effects of land development on alligator trophic ecology, we performed gut content analysis on golf course alligators found on Jekyll Island, Georgia. We then made comparisons with alligators found in more natural areas on Sapelo Island, Georgia. In total, we collected stomach content samples from 25 alligators on Jekyll Island golf courses, of which only one had an empty stomach. Data provided from Sapelo Island consisted of 93 alligators within our alligator size range, of which only one had an empty stomach. While analysis of similarity, non-metric multidimensional scaling, and simplified Morisita index analyses show no significant difference in diets between the two areas (possibly because of a low sample size from Jekyll Island), %IRI values for prey items reveal that there may be functional differences in prey choice or availability. Further land development and increasing human activity may therefore shift diets toward reliance on prey items usually of lesser importance. These trophic effects could possibly lead to local population declines, if paired with habitat degradation or other stressors.

Brown, G.J., Forbes, P.B.C., Myburgh, J.G. and Nöthling, J.O. (2020). Calcium and phosphorus in unbanded eggs of the Nile crocodile (*Crocodylus niloticus*). Aquaculture Research (https://doi.org/10.1111/are.14675).

Abstract: Unbanded crocodilian eggs do not form an opaque band around their lesser circumference, indicating fertilization failure or early embryonic death. Assuming they represent fertile eggs prior to the onset of embryonic metabolism, the concentration and content of calcium (Ca) and phosphorus (P) in each component (shell, shell membrane, yolk and albumen) of unbanded farm-laid Nile crocodile (*Crocodylus niloticus*) eggs were described. The grouping effect of clutch (clutch effect) on each component's Ca and P concentration and content were assessed. Using regression models, the clutch size, clutch laying date, pond of origin, component mass and component Ca and P concentration were evaluated for an effect on each component's Ca and P content. Eggshell made by far the greatest contribution to total egg Ca whilst contributing no measurable P. Yolk contributed by far the greatest quantity of P and a significant quantity of Ca. Albumen contributed variable, but generally very low quantities of Ca and P to the egg. A strong clutch effect existed for shell Ca content and yolk Ca and P concentration and content. A very weak clutch effect existed for shell Ca concentration, and albumen Ca and P concentration. Shell membrane was an unreliable sample type in this study, likely reflecting issues with processing. Shell Ca and yolk Ca and P content were influenced primarily by component mass, and secondarily by element concentration. Albumen Ca and P content was principally influenced by element concentration. These descriptive findings will guide sample selection for future research.

Angelici, F.M. and Rossi L. (2020). The need and relevance of the book: Problematic wildlife and the modern world. *In* Problematic Wildlife II, ed. by F. Angelici and L. Rossi. Springer: Cham.

Abstract: In the second volume of Problematic Wildlife, we explore relevant topics related to the ecology of the planet and the inevitable overlap between ecosystems, habitats, wildlife conservation, and human activities. The book is divided into six parts. The first is devoted to the species that can pose a danger to human health and safety, the second is about the urban wildlife and its related conflicts with humans, and the third is about hunting and ecotourism as possible tools for conservation. The fourth part of the book is devoted to the major problem of species extinction, while the fifth part consists in a broad collection of works about the debated role of the zoos for conservation, animal welfare, and animal rights. Finally, the last part of the book covers specific cases related to humans and

herpetofauna convivence and conflicts.

Ouedraogo, I., Ouedraogo, I., Kpoda, N.W., Oueda, A., Bance, V., Kabore, J. and Kabre, G.B. (2020). Impact of road construction on the distribution of *Crocodylus suchus* (Étienne Geoffroy Saint-Hilaire 1807) in urban park Bangr-Weoogo (Burkina Faso). International Journal of Biological and Chemical Sciences 14(2): 390-401.

Abstract: In contrast to other anthropogenic activities, little is known about impact of road construction on reptile distribution in urban areas. Therefore, the present study aimed at quantifying impact of road construction on *C. suchus* distribution. It was conducted from February 2016 to May 2018, in the urban Park Bangr-weoogo. *C. suchus* populations were counted day by used binoculars pairs and night by spotlight. The different observations were carried on foot. Every time, we observed crocodile, we visually estimate its size class. When we couldn't appreciate the size of an individual, it was just noted as eyes only. About road works, direct observations have been done and noted. To have mapping of the dynamics of crocodile habitats in the park, aerial shots were taken during road construction. We used QGIS version 2.18.2 to establish map distribution of crocodiles. A total of 145 crocodiles including 10.34% of hatchlings, 17.93% of juveniles, 31.03% of sub-adults and 24.14 of adults were counted before road works. While during road work, 202 crocodiles were counted, whose 5.45% of hatchlings, 19.8% of juveniles, 30.69% of sub-adults and 37.62% of adults. Road work has led to a loss of crocodile habitat.

Young, B.A., Potter, J., Blanchard, J., Knoche, L. and Kondrashova, T. (2020). Cardiac response to stimulation and stress in the American alligator (*Alligator mississippiensis*). Amphibia-Reptilia (https://doi.org/10.1163/15685381-bja10013).

Abstract: Previous descriptions of the direction (tachycardia versus bradycardia), magnitude, and duration of the cardiac stimulation/stress response of the American alligator (*Alligator mississippiensis*) have been contradictory. Superficial EKG leads were used to quantify heart rate while presenting a graded series of stimuli to a cohort of 5 sub-adult alligators. Only tachycardic responses were recorded. Stress (manual restraint and transport) induced a nearly 3-fold increase over the resting heart rate (~17 bpm), which decreased only 7 bpm over 40 minutes in a stimulus-free environment. Lower-level stimulation (ie exposure to room light) produced a significantly smaller response than did higher-level stimulation (ie physical contact), both responses were transitory, lasting approximately 120 s.

Hone, D., Mallon, J.C., Hennessey, P. and Witmer, L.M. (2020). Ontogeny of a sexually selected structure in an extant archosaur *Gavialis gangeticus* (Pseudosuchia: Crocodylia) with implications for sexual dimorphism in dinosaurs. PeerJ 8:e9134.

Abstract: Despite strong evidence for sexual selection in various display traits and other exaggerated structures in large extinct reptiles, such as dinosaurs, detecting sexual dimorphism in them remains difficult. Their relatively small sample sizes, long growth periods, and difficulties distinguishing the sexes of fossil specimens mean that there are little compelling data on dimorphism in these animals. The extant gharial (*Gavialis gangeticus*) is a large and endangered crocodylian that is sexually dimorphic in size, but males also possesses a sexually selected structure, the ghara, which has an osteological correlate in the presence of a fossa associated with the nares. This makes the species a unique model for potentially assessing dimorphism in fossil lineages, such as dinosaurs and pterosaurs, because it is a large, slow-growing, egg-laying archosaur. Here we assess the dimorphism of *G. gangeticus* across 106 specimens and show that the presence of a narial fossa diagnoses adult male gharials. Males are larger than females, but the level of size dimorphism, and that of other cranial features, is low and difficult to detect without a priori knowledge of the sexes, even with this large dataset. By extension, dimorphism in extinct reptiles is very difficult to detect in the absence of sex specific characters, such as the narial fossa.

Brochu, C.A. and Sumrall, C.D. (2020). Modern cryptic species and crocodylian diversity in the fossil record. Zoological Journal of the Linnean Society (https://doi.org/10.1093/zoolinnean/zlaa039).

Abstract: Advances in molecular biology and genetics are revealing that many recognized crocodylian species are complexes of two or more cryptic species. These discoveries will have a profound impact on interpretation of the crocodyliform fossil record. Our understanding of ranges of intraspecific variation in modern crocodylian morphology may be based on multiple species and thus express both intraspecific and interspecific variation. This raises questions about our ability to recognize modern species in the fossil record, and it also indicates that specimens from disparate localities or horizons may represent not single widespread species, but multiple related species. Ranges of variation in modern species require a thorough re-evaluation, and we may have to revisit previous perceptions of past crocodyliform diversity, rates of evolution or anagenetic lineages in stratigraphic succession. These challenges will not be unique to those studying crocodyliforms and will require sophisticated approaches to variation among modern and fossil specimens.

Criscitiello, M.F., Kraev, I., Petersen, L.H. and Lange, S. (2020). Deimination protein profiles in *Alligator mississippiensis* reveal plasma and extracellular vesicle-specific signatures relating to immunity, metabolic function, and gene regulation. Frontiers in Immunology 11: 651.

Abstract: Alligators are crocodilians and among few species that endured the Cretaceous-Paleogene extinction event. With long life spans, low metabolic rates, unusual immunological characteristics, including strong antibacterial and antiviral ability, and cancer resistance, crocodilians may hold information for molecular pathways underlying such physiological traits. Peptidylarginine deiminases (PADs) are a group of calcium-activated enzymes that cause posttranslational protein deimination/citrullination in a range of target proteins contributing to protein moonlighting functions in health and disease. PADs are phylogenetically conserved and are also a key regulator of extracellular vesicle (EV) release, a critical part of cellular communication. As little is known about PAD-mediated mechanisms in reptile immunology, this study was aimed at profiling EVs and protein deimination in *Alligator mississippiensis*. Alligator plasma EVs were found to be polydispersed in a 50-400-nm size range. Key immune, metabolic, and gene regulatory proteins were identified to be posttranslationally deiminated in plasma and plasma EVs, with some overlapping hits, while some were unique to either plasma or plasma EVs. In whole plasma, 112 target proteins were identified to be deiminated, while 77 proteins were found as deiminated protein hits in plasma EVs, whereof 31 were specific for EVs only, including proteins specific for gene regulatory functions (e.g., histones). Gene Ontology (GO) and Kyoto Encyclopedia of Genes and Genomes (KEGG) enrichment analysis revealed KEGG pathways specific to deiminated proteins in whole plasma related to adipocytokine signaling, while KEGG pathways of deiminated proteins specific to EVs included ribosome, biosynthesis of amino acids, and glycolysis/gluconeogenesis pathways as well as core histones. This highlights roles for EV-mediated export of deiminated protein cargo with roles in metabolism and gene regulation, also related to cancer. The identification of posttranslational deimination and EV-mediated communication in alligator plasma revealed here contributes to current understanding of protein moonlighting functions and EV-mediated communication in these ancient reptiles, providing novel insight into their unusual immune systems and physiological traits. In addition, our findings may shed light on pathways underlying cancer resistance, antibacterial and antiviral resistance, with translatable value to human pathologies.

Moreno-Arias, R.A. and Ardila-Robayo, M.C. (2020). Journeying to freedom: The spatial ecology of a reintroduced population of Orinoco crocodiles (*Crocodylus intermedius*) in Colombia. Animal Biotelemetry (https://doi.org/10.1186/s40317-020-00202-2).

Abstract: The Orinoco crocodile (*Crocodylus intermedius*) is the largest crocodile and the most threatened by extinction in the Neotropics due to overexploitation for the skin trade during the early-middle twentieth century. Knowledge of their ecology is poor in Colombia because long-term armed conflict has restricted fieldwork. In 2015, we reintroduced four captive-reared adult crocodiles, each equipped with a Sirtrack KiwiSat 202 satellite transmitter and monitored their movements from 2015 to 2018. Seasonal movements were as far 177 km in males and 115 km in females. Home ranges were as large as 55 km^2 for males and 16 km^2 for females for a single year and 178 km^2 and 21 km^2, respectively, for males and females over 2 years. Spatial ecological patterns changed drastically by season, with males increasing their home range and females reducing home range during the wet season. We confirmed that daily activity patterns defined as measure by number of locations across the day were not influenced by season. We believe that seasonal changes in the size and shape of home ranges were associated with patrolling or exploratory behaviors after release, while daily activity behavior was independent of season, sex or size of the animal.

Dridi, J. (2020). A new crocodylomorph tooth assemblage from the Tataouine Basin and comments on the stratigraphic context of the Douiret Formation. Annales de Paléontologie (https://doi.org/10.1016/j.annpal.2020.102424).

Abstract: A new crocodylomorph tooth assemblage from the Lower Member of the Douiret Formation (uppermost Jurassic-lowermost Cretaceous) in southeastern Tunisia is described. These teeth have been grouped into five morphotypes based on their diagnostic morphological features. The sample includes teeth, which have not been reported until now, such as non-Machimosaurini teleosauroid teeth, and labiolingually compressed tooth crowns with cutting edges devoid of serrations. Certain minor morphometric differences have been interpreted as ontogenetic or being possibly related to the position of the teeth in the jaws. Three trophic entities have subsequently been defined on the basis of the morphological characteristics of the teeth, and a possible niche partitioning between at least three crocodylomorph taxa is highlighted for the first time in the Tataouine Basin. On the other hand, the stratigraphic context of the Douiret Formation is thoroughly discussed in order to show how stratigraphic uncertainties could significantly impact previous attempts at reconstructing the macroevolutionary history of Crocodylomorpha. The latter should be treated with caution when the stratigraphic context of the fossil bearing formation remains a subject of debate.

Hilveski, S. and Velasco, A. (2020). Status and conservation of *Crocodylus acutus* at a naval base in Aragua State, Venezuela. Journal of Herpetology 54(2): 183-188.

Abstract: We present the conservation status and ecological characteristics (distribution, habitat preference, reproduction, population size, and structure) of an American crocodile (*Crocodylus acutus*) population associated with the naval base "TN Tomas Vega" in Turiamo Bay, Aragua state, Venezuela. The sheltered coastal habitats, with freshwater or brackish water, as San Miguel River of Turiamo Bay, provide essential nursery habitats for hatchling American crocodiles. During the breeding season, we looked for signs of nesting activity; however, because of continuous military exercises in the area, it is currently not known where nesting occurs. Based upon spotlight surveys of 6.7 km of survey routes, the resident American crocodile population of Turiamo Bay was estimated at 38 American crocodiles. Of this population, 6 sightings were classified as eyeshine only, 11 as class I, 14 as class II, 6 as class III, and 1 as class IV, exhibiting differential habitat association according to the size class. Encounter rates were highest in the brackish lagoon and low in the west coast and the San Miguel River, possibly because of the activities of the naval base causing evasive behavior by American crocodiles. Our results indicate the *C. acutus* population in Turiamo Bay has been relatively stable in the past few years. However, it is important to accurately estimate the population size of *C. acutus* and protect the nesting and nursery habitats. Therefore, we recommend continuation of the population studies and involvement of environmental organizations to regulate anthropogenic activities in Turiamo Bay.

Charruau, P., Oceguera-Figueroa, A., Cedeño-Vázquez, J.R. and Pérez-Rivera, S.D. (2020). Record of *Haementeria acuecueyetzin* (Oceguera-Figueroa, 2008) in Morelet's crocodiles from Quintana Roo, Mexico. Comparative Parasitology 87(1): 89-92.

Abstract: Herein, we present the first Mexican record of Morelet's crocodile, *Crocodylus moreletii*, as a host for the proboscis-bearing leech, *Haementeria acuecueyetzin*. From November 2004 to October 2017, we captured 111 crocodiles during spotlight surveys in lagoons of the Dziuché ejido, municipality of José María Morelos, Quintana Roo, Mexico. Twenty-one (18.9%) individuals had leeches identified as *H. acuecueyetzin*. It is the first report of *H. acuecueyetzin* for the State of Quintana Roo, Mexico, and the northernmost record of the species. This is also the second case of leech parasitism in *C. moreletii*. *Haementeria acuecueyetzin* likely parasitize a large array of vertebrates, and its role as a potential vector of blood parasites in *C. moreletii* requires further investigation.

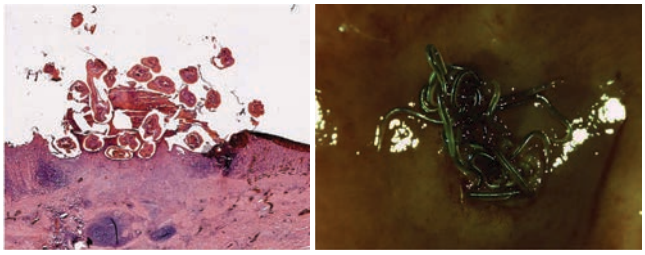
López-Luna, M.A., González-Soberano, J., González-Jáuregui, M., Escobedo-Galván, A.H., Suárez-Domínguez, E.A., Rangel-Mendoza, J.A. and Morales-Mávil, J.E. (2020). Nest-site selection and nest size influence the incubation temperature of Morelet's crocodiles. Journal of Thermal Biology (https://doi.org/10.1016/j.jtherbio.2020.102624).

Abstract: In oviparous tetrapods, the nesting-site selection by females is related to the habitat characteristics, which influences nest incubation temperature. Females can directly influence the incubation temperature by choosing certain construction materials or by building nests of different sizes. There are few studies focusing on these aspects in crocodilians that build mound nests. The aim of this study was to determine whether the nest size, its exposure to solar radiation, and the environmental temperature influence the incubation temperature of Morelet's crocodile (*Crocodylus moreletii*) nests. Artificial nests of two sizes (small and large) were constructed with similar characteristics to natural nests and placed in two locations differing in exposure to solar radiation (shaded and sunny). We used temperature and relative humidity data loggers to record the incubation temperature inside each nest every hour during the species' natural nesting period. Likewise, we recorded the ambient temperature every hour where the experiments were set up with temperature data loggers. We found that nest size and its exposure to solar radiation affected the incubation temperature, with smaller nests in shaded locations having lower incubation temperatures than larger nests in sunny locations. We discuss the importance of nest-site selection and maintenance behaviour of the mound nest by female crocodiles on the incubation temperature of the nest.

Yesudas, R. and Young, B. (2020). Histopathological impact of nematodes on the gastric mucosa of the American alligator (*Alligator mississippiensis*). The FASEB Journal (https://doi.org/10.1096/fasebj.2020.34.s1.03564).

Abstract: Nematodes are adapted to inhabit a vast array of niches. They have evolved tremendous strategies to survive and succeed in a variety of hosts and host tissues. Intestines represent an ideal habitat

for a large number of parasites, compared to the stomach. In the present study we examined the stomach of 14 sub-adult, wild-caught American alligators (*Alligator mississippiensis*) from the coastal region of Louisiana. Nematodes were found in four of the alligators (~29%). Two different parasites were found; *Dujardiascaris waltoni* (Nematoda: Heterocheilidae) and *Ortleppascaris* sp.? (Nematoda: Ascaridoidea). *D. waltoni* was found loose among the stomach contents, whereas *Ortleppascaris* sp.? was found embedded in the stomach wall. *Ortleppascaris* was associated with multifocal lesions in the gastric mucosa. These lesions were roughly 4 mm in diameter and housed multiple parasites. The lesions caused a clearly visible penumbra of mucosal damage. As the parasites invaded the gastric mucosa, they induced a granulomatous inflammation of the mucosa and submucosa. There was a marked eosinophilic necrosis, a cellular response that produces the penumbra around the invasive nodules. The impacted worms burrowed into the mucosa, and were surrounded by an eosinophilic exudation, resulting in an elevated nodule of worms and mucosa. This presumably represent proliferating host mucosal tissue responding to the parasitic challenge. Alligators have "typical" vertebrate gastric pits and glands in the stomach mucosa. Mucosal burrows of the nematodes led to a loss of the gastric pits in the infected zone and digestive efficiency of the host. Previous studies have described keratitis and enteritis associated with nematode infections in crocodilians, but similar reports are lacking from *Alligator mississippiensis*. Alligators and crocodiles have remarkably effective immune systems, which enable them to fight against microbial infections and allow quick wound healing. We hope to expand our understanding of host-parasite relations in this important species.



Left: Host response/eosinophil exudation in infected gastric mucosa. Right: Nematodes burrowed in to the stomach mucosa.

Wang, X., Zhao, L., Wang. R.-W. and Fang, S.-G. (2020). Mate success affects sex ratio strategies in structured population. Ecological Modelling 429: (https://doi.org/10.1016/j.ecolmodel.2020.109104).

Abstrsct: In this model, we considered the population density effect based on the evolutionary maintainable strategy (EMS) for optimal sex ratio strategy analysis, instead of the evolutionary stable strategy (ESS) under the population equilibrium. We used a cellular automaton model to simulate population dynamics using the birth-death process to monitor the effect of space structure on the optimal sex ratio in EMS.The simulation showed that when the whole population was a panmixia, the optimal sex ratio would be 1:1 (male/female), which conforms to the Fisher's theory prediction. However, in a structured population, the ratio favoured a female-bias sexratio, which conforms to the local mate competition theory prediction. With the decreased dispersal range, the sex ratio strategy tended towards a higher male proportion, which is similar to the local resource competition prediction.The predictions of our model partly conformed to classical theories and explained some gaps in the ESS model. However, the driving force differed from the classical sex ratio model.The sex ratio was selected by population fitness rather than mother's fitness. The optimal sex ratio strategy for a population is to guarantee mating success, indicating that population survival may provide a complementary explanation for the sex ratio evolution.

Grajal-Puche, A., Murray, C.M., Kearley, M., Merchant, M., Nix, C., Warner, J.K. and Walker, D.M. (2020). Microbial assemblage dynamics within the American alligator nesting ecosystem: A comparative approach across ecological scales. Microbial Ecology (doi: 10.1007/s00248-020-01522-9).

Abstract: Understanding the ecological processes that shape species assemblage patterns is central to community ecology. The effects of ecological processes on assemblage patterns are scale-dependent. We used metabarcoding and shotgun sequencing to determine bacterial taxonomic and functional assemblage patterns among varying defined focal scales (micro-, meso-, and macroscale) within the American alligator (*Alligator mississippiensis*) nesting microbiome. We correlate bacterial assemblage patterns among eight nesting compartments within and proximal to alligator nests (micro-), across 18 nests (meso-), and between 4 geographic sampling sites (macro-), to determine which ecological processes may drive bacterial assemblage patterns within the nesting environment. Among all focal scales, bacterial taxonomic and functional richness (α-diversity) did not statistically differ. In contrast, bacterial assemblage structure (β-diversity) was unique across all focal scales, whereas functional pathways were redundant within nests and across geographic sites. Considering these observed scale-based patterns, taxonomic bacterial composition may be governed by unique environmental filters and dispersal limitations relative to microbial functional attributes within the alligator nesting environment. These results advance pattern-process dynamics within the field of microbial community ecology and describe processes influencing the American alligator nest microbiome.

Hocknull, S.A., Lewis, R., Arnold, L.J., Pietsch, T., Joannes-Boyau, R., Price, G.J., Moss, P., Wood, R., Dosseto, A., Louys, J., Olley, J. and Lawrence, R.A. (2020). Extinction of eastern Sahul megafauna coincides with sustained environmental deterioration. Nature Communications 11: 2250 (doi: 10.1038/s41467-020-15785-w).

Abstract: Explanations for the Upper Pleistocene extinction of megafauna from Sahul (Australia and New Guinea) remain unresolved. Extinction hypotheses have advanced climate or human-driven scenarios, in spite of over three quarters of Sahul lacking reliable biogeographic or chronologic data. Here we present new megafauna from north-eastern Australia that suffered extinction sometime after 40,100 (±1700) years ago. Megafauna fossils preserved alongside leaves, seeds, pollen and insects, indicate a sclerophyllous forest with heathy understorey that was home to aquatic and terrestrial carnivorous reptiles and megaherbivores, including the world's largest kangaroo. Megafauna species diversity is greater compared to southern sites of similar age, which is contrary to expectations if extinctions followed proposed migration routes for people across Sahul. Our results do not support rapid or synchronous human-mediated continental-wide extinction, or the proposed timing of peak extinction events. Instead, megafauna extinctions coincide with regionally staggered spatio-temporal deterioration in hydroclimate coupled with sustained environmental change.

Mendoza-Roldan, J.A., Modry, D. and Otranto, D. (2020). Zoonotic parasites of reptiles: A crawling threat. Trends in Parasitology (https://doi.org/10.1016/j.pt.2020.04.014).

Abstract: Reptiles are reservoirs of a wide range of pathogens, including many protozoa, helminths, pentastomids, and arthropod parasitic species, some of which may be of public health concern. In this review we discuss the zoonotic risks associated with human-reptile interactions. Increased urbanization and introduction of exotic species of reptile may act as drivers for the transmission of zoonotic parasites through the environment. In addition, being a part of human diet, reptiles can be a source of life-threatening parasitoses, such as pentastomiasis or sparganosis. Finally, reptiles kept as pets may represent a risk to owners given the possibility of parasites transmitted by direct contact or fecal contamination. Awareness of reptile-borne zoonotic parasitoses is important to advocate control,

prevention, and surveillance of these neglected diseases.

Learmonth, M.J. (2020). The matter of non-avian reptile sentience, and why it "matters" to them: A conceptual, ethical and scientific review. Animals 10: 901 (doi:10.3390/ani10050901).

Abstract: The concept of sentience, how it is characterised and which non-human animals possess it have long been of contention in academic and intellectual debates. Many have argued that there is no way to empirically know that animals have conscious experiences. Yet others argue that consciousness, awareness and sentience in non-human animals can be quite obvious, and can indeed be measured empirically. Most modern declarations of animal sentience from official organisations and governments now include all vertebrate animals as sentient beings, including reptiles and fish. Some declarations also include some invertebrate species. This conceptual, ethical and scientific review first focuses on conceptual components and definitions of consciousness, awareness and sentience. It then specifically discusses how cognitive, neurobiological, ethological and comparative psychological research in non-avian reptiles over the last century has evidenced many capacities that historically were denied to this class of animals. Non-avian reptiles do indeed possess all of the necessary capacities to be declared as sentient beings, at least in the small proportion of reptile species that have actually been empirically investigated so far. It is suggested that much innovative future research will continue to uncover evidence of capabilities linked to sentience within a wide range of species, including non-avian reptiles, fish and invertebrates.

Brochu, C.A. (2020). Pliocene crocodiles from Kanapoi, Turkana Basin, Kenya. Journal of Human Evolution 140 (https://doi.org/10.1016/j.jhevol.2017.10.003).

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

Groh, S.S., Upchurch, P., Barrett, P.M. and Day, J.J. (2020). The phylogenetic relationships of neosuchian crocodiles and their implications for the convergent evolution of the longirostrine condition. Zoological Journal of the Linnean Society 188(2): 473-506.

Abstract: Since their origin in the Late Triassic, crocodylomorphs have had a long history of evolutionary change. Numerous studies examined their phylogeny, but none have attempted to unify their morphological characters into a single, combined dataset. Following a comprehensive review of published character sets, we present a new dataset for the crocodylomorph clade Neosuchia consisting of 569 morphological characters for 112 taxa. For the first time in crocodylian phylogenetic studies, quantitative variation was treated as continuous data (82 characters). To provide the best estimate of neosuchian relationships, and to investigate the origins of longirostry, these data were analysed using a variety of approaches. Our results show that equally weighted parsimony and Bayesian methods cluster unrelated longirostrine forms together, producing a topology that conflicts strongly with their stratigraphic distributions. By contrast, applying extended implied weighting improves stratigraphic congruence and removes longirostrine clustering. The resulting topologies resolve the major neosuchian clades, confirming several recent hypotheses regarding the phylogenetic placements of particular species (eg *Baryphracta deponiae* as a member of Diplocynodontinae) and groups (eg Tethysuchia as non-eusuchian neosuchians). The longirostrine condition arose at least three times independently by modification of the maxilla and premaxilla, accompanied by skull roof changes unique to each longirostrine clade.

Simulundu, E., Ndashe, K., Chambaro, H.M., Squarre, D., Reilly, P.M., Chitanga, S., Changula, K., Mukubesa, A.N., Ndebe, J., Tembo, J., Kapata, N., Bates, M., Sinkala, Y., Hang'ombe, B.M., Nalubamba, K.S., Kajihara, M., Sasaki, M., Orba, Y., Takada, A. and Sawa, H. (2020). West Nile virus in farmed crocodiles, Zambia, 2019. Emerging Infectious Diseases 26(4): 811-814.

Abstract: We detected West Nile virus (WNV) nucleic acid in crocodiles (*Crocodylus niloticus*) in Zambia. Phylogenetically, the virus belonged to lineage 1a, which is predominant in the northern hemisphere. These data provide evidence that WNV is circulating in crocodiles in Africa and increases the risk for animal and human transmission.

Kondrashova, T., Blanchard, J., Knoche, L., Potter, J. and Young, B.A. (2020). Intracranial pressure in the American alligator (*Alligator mississippiensis*): reptilian meninges and orthostatic gradients. Journal of Comparative Physiology A 206: 45-54.

Abstract: The cranial meninges of reptiles differ from the more widely studied mammalian pattern in that the intraventricular and subarachnoid spaces are, at least partially, isolated. This study was undertaken to investigate the bulk flow of cerebrospinal fluid, and the resulting changes in intracranial pressure, in a common reptilian species. Intracranial pressure was measured using ocular ultrasonography and by surgically implanting pressure cannulae into the cranial subarachnoid space. The system was then challenged by: rotating the animal to create orthostatic gradients, perturbation of the vascular system, administration of epinephrine, and cephalic cutaneous heating. Pressure changes determined from the implanted catheters and through quantification of the optic nerve sheath were highly correlated and showed a significant linear relationship with orthostatic gradients. The catheter pressure responses were phasic, with an initial rapid response followed by a much slower response; each phase accounted for roughly half of the total pressure change. No significant relationship was found between intracranial pressure and either heart rate or blood flow. The focal application of heat and the administration of epinephrine both increased intracranial pressure, the latter influence being particularly pronounced.

Delene, K., Lemma, A. and Fesseha, H. (2020). Major diseases of Nile crocodile (*Crocodylus niloticus*) with focus on current status in Arba Minch Crocodile Ranch, Ethiopia. Online Journal of Animal and Feed Research 10(3): 98-110.

Abstract: *Crocodylus niloticus* is found in 26 African countries including Ethiopia, the largest recorded specimen measuring 17.0 feet, an animal from the Gambela Upeno River in 1969. Its presence and absence also depend on the climatic conditions and the environment (ie the landscape for basking and feeding). In Ethiopia, Nile crocodiles have a mating period during September to

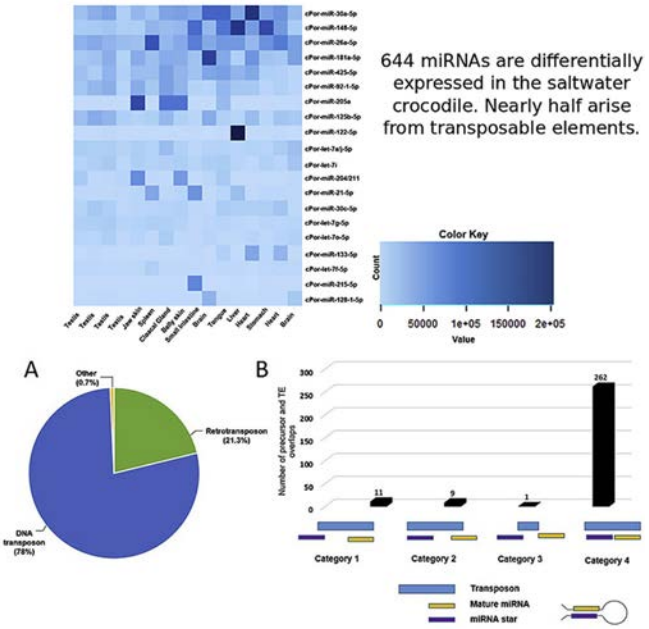
October, Nesting occurs in the dry season December to January, and hatchling takes place at the onset of the rainy season (March/April). Over the period of 2007-2016 an average of 201,000 *C. niloticus* skins were exported globally per year, with an increasing trend over the period 2009-2016. Besides the management problems, at Arba Minch Crocodile Ranch, Nile crocodiles are suffering from nutritional abnormalities and health problems. The diseases of the Nile crocodile are classified as infectious (transmissible) and non-infectious (non-transmissible). A transmissible crocodile disease includes bacterial, viral, fungal, protozoan, and parasitic diseases; non-transmissible crocodile diseases are nutritional, toxic poisonings and metabolic disorders; other diseases like nutritional bone diseases and skin lesions are the major health problems at Arba Minch Crocodile Ranch. The main aim of this review is to highlight the major diseases and management status of *C. niloticus* in Arba Minch ranches, Ethiopia. In conclusion, the Arba Minch Crocodile Ranch should exercise care and caution when introducing hatchlings from the wild into the ranch and enhance its husbandry methods to reduce the occurrence of infection and disease. It must also work with professionals and research groups.

Pozo, R.A., LeFlore, E.G., Duthie, A.B., Bunnefeld, N., Jones, I.L., Minderman, J., Rakotonarivo, S. and Cusack, J.J. (2020). A multispecies assessment of wildlife impacts on local community livelihoods. Conservation Biology (https://doi.org/10.1111/cobi.13565).

Abstract: Conflicts between the interests of agriculture and wildlife conservation are a major threat to biodiversity and human wellbeing globally. Addressing such conflicts requires a thorough understanding of the impacts associated with living alongside protected wildlife. Despite this, most studies reporting on human-wildlife impacts and the strategies used to mitigate them focus on a single species, thus over-simplifying often complex systems of human-wildlife interactions. In this study, we characterize the spatiotemporal patterns of impacts by multiple co-occurring species on agricultural livelihoods in the eastern Okavango Delta Panhandle in northern Botswana. Using a database of 3264 wildlife incidents recorded between 2009 and 2015 by the Department of Wildlife and National Parks, we show that a total of 8 species - African elephant, hippopotamus, cheetah, crocodile, leopard, lion, spotted hyena and African wild dog - appear on incident reports, of which 56.5% are attributed to elephants. Most species were associated with only one type of damage (ie either damage to crops or livestock loss). Carnivores were primarily implicated in incident reports related to livestock loss, particularly towards the end of the dry season (May-October). In contrast, herbivores were associated with crop loss incidents during the wet season (November-April). Our study illustrates how local communities can face distinct livelihood challenges from different species at different times of the year. Such a multi-species assessment has important implications for the design of conservation interventions aimed at addressing the costs of living with wildlife, and thereby mitigating the underlying conservation conflict. Our spatiotemporal, multi-species approach is widely applicable to other regions where sustainable and long-term solutions to conservation conflicts are needed for local communities and biodiversity.

Ghosh, A., Platt II, R.N., Vandewege, M.W., Tabassum, R., Hsu, C-Y,. Isberg, S.R., Peterson, D.G., Finger Jr., J.W., Kieran, T.J., Glenn, T.C., Gongora. J. and Ray, D.A. (2020). Identification and characterization of microRNAs (miRNAs) and their transposable element origins in the saltwater crocodile, *Crocodylus porosus*. Analytical Biochemistry (doi: 10.1016/j.ab.2020.113781).

Abstract: MicroRNAs (miRNAs) are 18-24 nucleotide regulatory RNAs. They are involved in the regulation of genetic and biological pathways through post transcriptional gene silencing and/or translational repression. Data suggests a slow evolutionary rate for the saltwater crocodile (*Crocodylus porosus*) over the past several million years when compared to birds, the closest extant relatives of crocodilians. Understanding gene regulation in the saltwater crocodile in the context of relatively slow genomic change thus holds potential for the investigation of genomics, evolution, and adaptation. Utilizing 11 tissue types and 16 small RNA libraries, we report 644 miRNAs in the saltwater crocodile with > 78% of miRNAs being novel to crocodilians. We also identified potential targets for the miRNAs and analyzed the relationship of the miRNA repertoire to transposable elements (TEs). Results suggest an increased association of DNA transposons with miRNAs when compared to retrotransposons. This work reports the first comprehensive analysis of miRNAs in *Crocodylus porosus* and addresses the potential impacts of miRNAs in regulating the genome in the saltwater crocodile. In addition, the data suggests a supporting role of TEs as a source for miRNAs, adding to the increasing evidence that TEs play a significant role in the evolution of gene regulation.



Hitchens, R.T. and Blakeslee, A.M.H. (2020). Trends in illegal wildlife trade: Analyzing personal baggage seizure data in the Pacific Northwest. PLoS ONE 15(6): e0234197.

Abstract: The illegal import of wildlife and wildlife products is a growing concern, and the U.S. is one of the world's leading countries in the consumption and transit of illegal wildlife and their derivatives. Yet, few US studies have analyzed the illegal wildlife trade (IWT) on a national or local scale. Moreover, to our knowledge, no studies have specifically examined the trends associated with IWT moving through personal baggage. This work aimed to better understand the magnitude of illegal wildlife importation into U.S. ports of entry by determining trends associated with illegal wildlife products from personal baggage seizures, using the Pacific Northwest (PNW) as a specific case study. To identify the most influential factors determining the numbers and types of personal baggage seizures into PNW, we analyzed 1731 records between 1999 and 2016 from the Fish and Wildlife Service's (FWS) Law Enforcement Management Information System (LEMIS) database. We found five significant contributors: taxonomic classification of wildlife, categorical import date, wildlife product, source region, and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) status. While wildlife seizures across taxonomic categories have generally decreased in the PNW since 2008, other findings provide a reason for concern. More specifically, mammals were identified as the largest animal group of seized wildlife, and temporal trends indicate increases in seizures for this and several other taxonomic groups. Many of the seizures originated from overseas, with East Asia serving as the largest source. Our PNW case study can be a model for how large-scale geographical

seizure data can be used to inform about the major factors that have historically and presently contribute to IWT, with conservation implications globally.

Huang, J., Chen, H., Zhou, Y., Wang, S., Ren, Q., Fang, Z., Li, H., Zheng, K., Liu, X., Gu, Y. and Li, W. (2020). The first report of *Cryptosporidium testudinis* in Chinese alligators (*Alligator sinensis*) in China. Parasitology Research (https://doi.org/10.1007/s00436-020-06733-0).

Abstract: Several *Cryptosporidium* species that infect reptiles, especially squamates, are well described, but there is limited data about *Cryptosporidium* species infecting crocodilians. In this study, we assess the occurrence of intestinal parasites using traditional microscopic examination and describe the prevalence and *Cryptosporidium* species in captive-bred Chinese alligators (*Alligator sinensis*) in eastern China using molecular methods. The results of microscopic examination showed that no intestinal parasites were detected among the 491 fecal samples examined from the Chinese alligators. The overall prevalence for *Cryptosporidium* was 0.41% (2/491) by PCR detection using the SSU rRNA locus. Sequence and phylogenetic analysis of the SSU rRNA, COWP, and actin genes revealed the presence of *Cryptosporidium testudinis*, which has been isolated primarily from chelonians. This is the first detection of the specific DNA of *C. testudinis* in the feces of the Chinese alligator. This study expands our knowledge of the *Cryptosporidium* species involved in crocodiles, and more extensive studies are necessary to confirm the validity of *C. testudinis* in crocodiles.

Drake, N. (2020). Swamp Thing: Alligators, Symbolism, and the Meaning of Animals in the American South. PhD thesis, Mississippi State University, Mississippi, USA.

Abstract: Humans form lasting and unique relationships with the natural world and, by extension, the organisms and animals who have for millennia carved out niche environments. Scholars and general observers agree - at least in principle - that human beings have actively shaped (for better and for worse) the habitats, behaviors, and population of the Earth's creatures. In turn, those spaces and animals have influenced not only how humans think of the natural world, but also of humanity itself. Animals, in other words, help humans understand themselves. This dissertation is a history of the American alligator. A study of human interactions with alligators can reveal not only how humans viewed the animal, but also how they created, recreated, and utilized those representations to meet their own ends. Much of what humans attached to alligators - either positive, negative, or oscillating between - were the results of an internal process of dialogue, culture, and human psychology. In simpler terms, this research investigates how human beings understand themselves and how a particular species fits within human understandings of the "natural" world. A large literature exists on the study of species and, in addition, southern wildlife and ecology.

Mishra, B., Akhila, M.V., Thomas, A., Benny, B. and Assainar, H. (2020). Formulated therapeutic products of animal fats and oils: Future prospects of zootherapy. International Journal of Pharmacological Investigation 10(2): 112-116.

Abstract: In the traditional system of practices, animal fats and its oil gained acceptance in healing various ailments. Fats are chemically triglycerides in which glycerol is esterified with three fatty acids. The fats are generally obtained from animal by rendering methods. The main difference between fat and oil is that they are solid and liquid at room temperature respectively. Fatty acid composition present in oil is determined by GC-MS analysis. And it mainly includes oleic acid, palmitic acid, stearic acid, linoleic acid and linolenic acid. This composition plays an important role in antimicrobial, anti-inflammatory, antibacterial activities. The therapeutic products from the animal's fat and oils are presenting the tremendous acceptability for human, while used by various route of administrations for various internal and external therapeutic indications. This merit of the animal's fat and oils make it an exceptional choice for using them as a drug. The key fatty acid present in the oil are mainly responsible for the therapeutic activity. The different types of fat obtained from varieties of animal include crocodile, turtle, lizard, sheep, cobra, shark, python etc. Lack of scientific evidence for the traditional healing practice using animal fats or its oils make researches to scientifically prove the therapeutic activity and this may lead to the new era for the development of a variety of novel formulations. Animal based products are also gained importance along with animal based medicines. This article focuses on various animal fats, its traditional uses and some of the formulations developed recently by using these.

Kim, K.S., Lockley, M.G., Lim, J.D., Bae, S.M. and Romilio, A. (2020). Trackway evidence for large bipedal crocodylomorphs from the Cretaceous of Korea. Scientific Reports 10: 8680.

Abstract: Large well-preserved crocodylomorph tracks from the Lower Cretaceous (? Aptian) Jinju Formation of South Korea, represent the well-known crocodylomorph ichnogenus *Batrachopus*. The Korean sample includes multiple, narrow-gauge, pes-only trackways with footprint lengths (FL) 18-24 cm, indicating trackmaker body lengths up to ~3.0 m. Surprisingly, the consistent absence of manus tracks in trackways, with well-preserved digital pad and skin traces, argues for bipedal trackmakers, here assigned to *Batrachopus grandis* ichnosp. nov. No defnitive evidence, either from pes-onmanus overprinting or poor track preservation, suggests the trackways where made by quadrupeds that only appear bipedal. This interpretation helps solve previous confusion over interpretation of enigmatic tracks of bipeds from younger (? Albian) Haman Formation sites by showing they are not pterosaurian as previously inferred. Rather, they support the strong consensus that pterosaurs were obligate quadrupeds, not bipeds. Lower Jurassic *Batrachopus* with foot lengths (FL) in the 2-8 cm range, and Cretaceous *Crocodylopodus* (FL up to ~9.0 cm) known only from Korea and Spain registered narrow gauge trackways indicating semi-terrestrial/terrestrial quadrupedal gaits. Both ichnogenera, from ichnofamily Batrachopodidae, have been attributed to *Protosuchus*-like semi-terrestrial crocodylomorphs. The occurrence of bipedal *B. grandis* ichnosp. nov. is evidence of such adaptations in the Korean Cretaceous.

Marschang, R.E., Bogan, J. and Bradford, C.M. (2020). What's new in the scientific literature? Infectious diseases of reptiles and amphibians: Peer-reviewed publications, July 2019-December 2019. Journal of Herpetological Medicine and Surgery 30(2): 54-62.

Young, M.T., Sachs, S., Abel, P., Foffa, D., Herrera, Y. and Kitson, J.J.N. (2020). Convergent evolution and possible constraint in the posterodorsal retraction of the external nares in pelagic crocodylomorphs. Zoological Journal of the Linnean Society, 189(2): 494-520.

Abstract: Amongst Mesozoic marine reptiles, metriorhynchid

crocodylomorphs were unique in evolving into pelagically adapted forms with little-to-no posterodorsal retraction of the external nares. Narial retraction is a common adaptation seen in sustained swimmers, notably occurring during cetacean evolution. Mesosaurids and the basalmost known members of ichthyosauriforms, thalattosaurians, saurosphargids, sauropterygians, pleurosaurids and mosasauroids had the external nares divided by an ossified bar, bound by multiple cranial bones and were positioned back from the tip of the rostrum. However, metriorhynchids evolved from taxa with a single external naris bound solely by the premaxilla, and positioned near the tip of an elongate rostrum. We posit that metriorhynchids were uniquely disadvantaged in evolving into sustained swimmers. Herein we describe three Late Jurassic metriorhynchid cranial rostra that display differing degrees of narial retraction. In our new phylogenetic analyses, the backwards migration of the narial fossa posterior margin occurred independently at least four times in Metriorhynchidae, whereas the backwards migration of the anterior margin only occurred twice. Although Rhacheosaurini share the backwards migration of the anterior and posterior narial margins, posterodorsal retraction occurred differently along three lineages. This culminated in the Early Cretaceous, where a rhacheosaurin evolved nares bound by the premaxilla and maxilla, and significantly posterodorsally retracted.

Łukaszewicz, A. (2020). Horus and Seth revisited. An incident on the Nile described by a Roman poet. Pp. 105-110 *in* Ex Oriente Lux. Studies in Honour of Jolanta Młynarczyk. Wydawnictwa Uniwersytetu Warszawskiego: Warsaw.

Abstract: In their descriptions of Egypt, ancient writers mention conflicts inspired by religious differences. Strabo writes that the inhabitants of Tentyra (Dendera) differ from the rest of Egyptians, since they hate the crocodile most of all the animals. Juvenal states that in his time, during a conflict between two neighbouring towns, Tentyra and Ombos, one of the Tentyritae was captured by the enemy party and eaten raw. The aggressors were the Tentyritae. They were defeated by the inhabitants of Ombos and lost one of their fellow citizens. It seems that the Ombitae, who by the second century AD no longer practiced human sacrifice, found in the battle an opportunity to commit a cruel act of ritual cannibalism. The struggle between the worshippers of Seth (Ombos) and those of Horus (Dendera) seems to be inspired by the legend of the assassination of Osiris by Seth who dismembered his brother's body, and the vengeance of Osiris' son Horus. Horus had an important place in the religious life of Dendera. The Ombitae were worshippers of the crocodile, the animal of Seth. Horus appears in Egyptian iconography in various forms, including Harpocrates ("Horus the infant"). In the Roman period Seth is often represented as a crocodile. An echo of the mythical struggle between the Egyptian deities still survives in some modern works of art. In a square of the city of Warsaw there is a sculpture by Stanisław Jackowski (1887-1951) showing a little boy fighting with a crocodile, which should be interpreted as Harpocrates, the young Horus, in a struggle with Seth in his animal form

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Roberto, I.J., Bittencourt, P.S., Muniz, F.L., Hernandez Rangel, S.M., Nobrega, Y.C., Avila, R.W., Souza, B.C., Alvarez, G., Mirando-Chumacero, G., Campos, Z., Farias, I.P. and Hrbek, T. (2020). Unexpected but unsurprising lineage diversity within the most widespread Neotropical crocodilian genus *Caiman* (Crocodylia, Alligatoridae). Systematics and Biodiversity (https://dx.doi.org/10.1080/14772000.2020.1769222).

Abstract: Species discovery methods utilizing coalescent-based approaches are powerful tools for detecting cryptic lineages within morphological conservative groups, thus being an important methodology of integrative taxonomic research. Crocodilians are a classic example of morphologically conserved group where coalescence-based species delimitation analyses resulted in the discovery of cryptic lineages and potentially new species. In this study, we used several single locus species discovery methods to analyze the phylogenetic diversity of the most widespread alligatorid genus of the Neotropics, the genus *Caiman*. We analyzed 479 specimens representing all named taxa, with the exception of *Caiman crocodilus apaporiensis*, and known geographic distribution of these taxa. We observed high lineage diversity within the *Caiman crocodilus*/*yacare* complex, ranging from 7 to 10 lineages, and three lineages within *Caiman latirostris*. We also provide a new dated phylogeny for all the delimited lineages. Oligocene and Miocene events triggered the diversification of the major lineages, with latter Pleistocene events influencing the final diversification of the genus. We demonstrate that the discovered lineages within the *Caiman* complex are compatible with being species and as such are candidates for an integrated taxonomic analysis. However, it is important to highlight that independent of the future recognition of these lineages as species, it is extremely important to protect these cryptic lineages as unique evolutionary entities, many of which are highly threatened by habitat loss from dam construction projects, tailing dam collapses, mining, agriculture and agricultural run-off across all of South America.

Lin, J.Q., Huang, Y.Y., Bian, M.Y., Wan, Q.H. and Fang, S.G. (2020). A unique energy-saving strategy during hibernation revealed by multi-omics analysis in the Chinese alligator. iScience 23(6) (doi: 10.1016/j.isci.2020.101202).

Abstract: Many ectotherms hibernate in face of the harsh winter conditions to improve their survival rate. However, the molecular mechanism underlying this process remains unclear. Here, we explored the hibernation mechanism of Chinese alligator using integrative multi-omics analysis. We revealed that (1) the thyroid hormone biosynthesis, nutrition absorption and metabolism, muscle contraction, urinary excretion and immunity function pathways are overall downregulated during hibernation; (2) the fat catabolism is completely suppressed, contrasting with the upregulation of hepatic fatty-acid-transporter CPT1A, suggesting a unique energy-saving strategy that differs from that in hibernating mammals; (3) the hibernation-related genes are not only directly regulated by DNA methylation but also controlled by methylation-dependent transcription networks. In addition, we identified and compared tissue-specific, species-specific, and conserved season-biased miRNAs, demonstrating complex post-transcriptional regulation during hibernation. Our study revealed the genetic and epigenetic mechanisms underlying hibernation in the Chinese alligator and provided molecular insights into the evolution of hibernation regulation.

Thomas, A. (2020). The Use of Forensic Gellifters to Collect Human DNA Off Trafficked Animal Specimens. (see https://experiment.com/projects/can-gelatine-lifters-collect-human-dna-off-trafficked-animal-specimens).

Abstract: Overexploitation is a leading threat to species worldwide, with 72% of threatened and nonthreatened species suffering from its pressures. The illegal wildlife trade (IWT) is worth millions of dollars fuelled by demand acrossinternational and domestic markets in traditional medicines, the exotic pet trade, consumption and luxury goods. Up until now use of forensics in tackling the IWT has been focused on the animals, seeking to identify the species and geographical origins of seized goods. This study has identified a gap in the research where collection and analysis of human based evidence in IWT cases is being overlooked. Using black gellifters, a common and inexpensive forensic tool for fingerprint lifting, this study attempted to collect and analyse trace levels of human DNA from fingerprints deposited on three commonly trafficked animal specimens, ivory, a feather and crocodile skin. Comparisons were made between specimens and analysis was carried out to see if the scanning process involved in imaging fingerprints from gellifters impacted DNA recovery. Results showed failure to recover DNA in quantities needed for successful profiling in any samples, with average DNA concentrations of <1pg/μl. Fingerprints collected

from ivory had the highest average DNA concentrations at 0.241 pg/μl fingerprints from feather and crocodile skin had averages of 0.218 pg/μl and 0.209 pg/μl respectively. Human DNA concentrations retrieved between specimens were not found to be significantly different. Scanning of the gels resulted in significantly lower average DNA concentrations compared to not scanning (p-value= 0.00198). Removal and replacement, after fingerprint collection, of the gellifter's protective acetate layer and possibly gellifter composition were discussed as likely contributors to overall low DNA concentrations. The wavelengths of light used, and supplementary removal and replacement of the acetate required, during the scanning process were the two factors concluded as contributing to the significantly lower DNA concentrations retrieved from scanned samples. This study shows in theory that collection of human trace DNA from fingerprints left on ivory, feathers and crocodile skin is possible using black gellifters, but the protocol used is not efficient and further research is needed to improve upon it.

Stein, M.D., Hand, S.J., Archer, M., Wroe, S. and Wilson, L.A.B. (2020). Quantitatively assessing mekosuchine crocodile locomotion by geometric morphometric and finite element analysis of the forelimb. PeerJ 8: e9349.

Abstract: Morphological shifts observed in the fossil record of a lineage potentially indicate concomitant shifts in ecology of that lineage. Mekosuchine crocodiles of Cenozoic Australia display departures from the typical eusuchian body-plan both in the cranium and postcranium. Previous qualitative studies have suggested that these crocodiles had a more terrestrial habitus than extant crocodylians, yet the capacity of mekosuchine locomotion remains to be tested. Limb bone shape, such as diaphyseal cross-section and curvature, has been related to habitual use and locomotory function across a wide variety of taxa. Available specimens of mekosuchine limbs, primarily humeri, are distinctly columnar compared with those of extant crocodylians. Here we apply a quantitative approach to biomechanics in mekosuchine taxa using both geomorphic morphometric and finite element methods to measure bone shape and estimate locomotory stresses in a comparative context. Our results show mekosuchines appear to diverge from extant semi-aquatic saltwater and freshwater crocodiles in cross-sectional geometry of the diaphysis and generate different structural stresses between models that simulate sprawling and high-walk gaits. The extant crocodylians display generally rounded cross-sectional diaphyseal outlines, which may provide preliminary indication of resistance to torsional loads that predominate during sprawling gait, whereas mekosuchine humeri appear to vary between a series of elliptical outlines. Mekosuchine structural stresses are comparatively lower than those of the extant crocodylians and reduce under high-walk gait in some instances. This appears to be a function of bending moments induced by differing configurations of diaphyseal curvature. Additionally, the neutral axis of structural stresses is differently oriented in mekosuchines. This suggests a shift in the focus of biomechanical optimisation, from torsional to axial loadings. Our results lend quantitative support to the terrestrial habitus hypothesis in so far as they suggest that mekosuchine humeri occupied a different morphospace than that associated with the semi-aquatic habit. The exact adaptational trajectory of mekosuchines, however, remains to be fully quantified. Novel forms appear to emerge among mekosuchines during the late Cenozoic. Their adaptational function is considered here; possible applications include navigation of uneven terrain and burrowing.

Powell, S., Versluys, T.M., Williams, J.J., Tiedt, S. and Pooley, S. (2020). Using environmental niche modelling to investigate abiotic predictors of crocodilian attacks on people. Oryx (doi:10.1017/S0030605319000681).

Abstract: Crocodilians are distributed widely through the tropics and subtropics, and several species pose a substantial threat to human life. This has important implications for human safety and crocodilian conservation. Understanding the drivers of crocodilian attacks on people could help minimize future attacks and inform conflict management. Crocodilian attacks follow a seasonal pattern in many regions, but there has been limited analysis of the relationship between attack occurrence and fine-scale contemporaneous environmental conditions. We use methods from environmental niche modelling to explore the relationships between attacks on people and abiotic predictors at a daily temporal resolution for the Nile crocodile *Crocodylus niloticus* in South Africa and Eswatini (formerly Swaziland), and the American alligator *Alligator mississippiensis* in Florida, USA. Our results indicate that ambient daily temperature is the most important abiotic temporal predictor of attack occurrence for both species, with attack likelihood increasing markedly when mean daily temperatures exceed 18°C and peaking at 28°C. It is likely that this relationship is explained partially by human propensity to spend time in and around water in warmer weather but also by the effect of temperature on crocodilian hunting behaviour and physiology, especially the ability to digest food. We discuss the potential of our findings to contribute to the management of crocodilians, with benefits for both human safety and conservation, and the application of environmental niche modelling for understanding human-wildlife conflicts involving both ectotherms and endotherms.

Whiting, E.T. and Head, J.J. (2020). Neogene crocodylians from the Central Great Plains: spatiotemporal histories and relationships with regional climatic and environmental changes. Journal of Paleontology (https://doi.org/10.1080/02724634.2020.1764007).

Abstract: Crocodylian fossils are well documented from Upper Cretaceous and lower to middle Paleogene deposits in the mid-high latitudes of the Western Interior, whereas the only extant North American taxon, *Alligator mississippiensis*, is restricted to the lower-latitude wetlands of the southeastern United States. The departure of crocodylians from the Western Interior has been inferred to represent a major shift from more equable, warmer, wetter climates in the Paleogene to more seasonal, cooler, drier climates in the Neogene. The timing of further geographic range shifts during the Neogene, including the local extinction (extirpation) of crocodylians from the Great Plains, is poorly constrained. We document the Neogene crocodylian fossil record of the Central Great Plains (CGP) in order to constrain the timing of mid-continental crocodylian extinctions against a backdrop of climatic and environmental changes. The Neogene CGP crocodylian fossil record consists of mostly incomplete specimens, likely referable to the extant genus *Alligator*, and appears to document multiple latitudinal range shifts that are spatiotemporally consistent with regional climatic and environmental changes inferred from independent proxy evidence. The last appearance datum (LAD) for crocodylians in the CGP is ~6 Ma, which suggests that climatic and environmental conditions in the region were unfavorable to crocodylians after this time. In general, Neogene crocodylian fossils throughout the Great Plains are not abundant. Barring taphonomic biases or sampling issues, this could imply low population densities, and/or that the fossil-bearing areas in this region were close to the northernmost limits of crocodylian (cf. *Alligator*) distributions during the Neogene.

Stainback, G.A., Lai, J.H., Pienaar, E.F., Adam, D.C., Wiederholt, R. and Vorseth, C. (2020). Public preferences for ecological indicators used in Everglades restoration. PLoS One 15(6): e0234051.

Abstract: The Everglades is one of the largest wetland ecosystems in the world covering almost 18,000 square miles from central Florida southward to Florida Bay. Over the 20th century, efforts to drain the Everglades for agriculture and development severely damaged the ecosystem so that today roughly 50% of the historic flow of water through the Everglades has been diverted elsewhere. In an attempt to restore the Everglades, the U.S. Congress authorized the Comprehensive Everglades Restoration Plan (CERP) in 2000, expected to cost over $16 billion and to take several decades

to complete. We used the results from a stated preference choice experiment (SPCE) survey of Florida households to estimate the willingness to pay for several ecological attributes related to CERP performance indicators likely to be impacted by Everglades restoration. We also used a latent class model (LCM) to explore preference heterogeneity among respondents. On average, survey respondents were willing to pay for improvements in all of the attributes included in the survey, namely increased populations of wading birds, American alligators, endangered snail kites, and spotted seatrout, and reduced polluted discharges from Lake Okeechobee to the Caloosahatchee and St. Lucie Rivers. Willingness to pay was highest for reduced polluted discharges from Lake Okeechobee.

Martin, J.D. (2020). Scales and balances. Pp. 53-61 *in* Between Making and Knowing, ed. by J.D. Martin and C.C.M. Mody. World Scientific: Singapore.

Abstract: In Ancient Egyptian mythology, entry into the afterlife was secure only after the weighing of the heart. The gods would place the deceased's heart on a scale opposite the feather of Maat, symbolizing the seven cardinal virtues of truth, justice, propriety, harmony, balance, reciprocity, and order. Those whose hearts were in equilibrium with Maat could pass into the afterlife; hearts heavy with misdeeds would be devoured by Ammut - a chimerical, crocodile-headed goddess - consigning the soul of the deceased to oblivion.

Wang, X., Huang, J., Wang, P., Wang, R., Wang, C., Yu, D., Ke, C., Huang, T., Song, Y., Bai, J., Li, K., Ren, L., Miller, R.D., Han, H., Zhou, X. and Zhao, Y. (2020). Analysis of the Chinese alligator TCRα/δ loci reveals the evolutionary pattern of atypical TCRδ/TCRμ in tetrapods. Journal of Immunology (doi: 10.4049/jimmunol.2000257).

Abstract: Atypical TCRδ found in sharks, amphibians, birds, and monotremes and TCRμ found in monotremes and marsupials are TCR chains that use Ig or BCR-like variable domains (VHδ/Vμ) rather than conventional TCR V domains. These unconventional TCR are consistent with a scenario in which TCR and BCR, although having diverged from each other more than 400 million years ago, continue to exchange variable gene segments in generating diversity for Ag recognition. However, the process underlying this exchange and leading to the evolution of these atypical TCR receptor genes remains elusive. In this study, we identified two TCRα/δ gene loci in the Chinese alligator (*Alligator sinensis*). In total, there were 144 V, 154 Jα, 9 Jδ, 8 Dδ, 2 Cα, and 5 Cδ gene segments in the TCRα/δ loci of the Chinese alligator, representing the most complicated TCRα/δ gene system in both genomic structure and gene content in any tetrapod examined so far. A pool of 32 VHδ genes divided into 18 subfamilies was found to be scattered over the two loci. Phylogenetic analyses revealed that these VHδ genes could be related to bird VHδ genes, VHδ/Vμ genes in platypus or opossum, or alligator VH genes. Based on these findings, a model explaining the evolutionary pattern of atypical TCRδ/TCRμ genes in tetrapods is proposed. This study sheds new light on the evolution of TCR and BCR genes, two of the most essential components of adaptive immunity.

Marquis, O., Mathevon, N., Aubin, T., Gaucher, P. and Lemaire, J. (2020). Observations on breeding site, bioacoustics and biometry of hatchlings of *Paleosuchus trigonatus* (Schneider, 1801) from French Guiana (Crocodylia: Alligatoridae). Herpetology Notes 13: 513-516.

Reed, D.M. (2020). What It Means To Wade. Thesis, College of Charleston, Charleston, South Carolina, USA.

Abstract: "What It Means to Wade: is a lyric essay structured in numbered sections of prose poetry. Composed in alternating anecdotal vignettes, inclusions of scientific research, and lyrical moments of contemplation, this essay explores the relationship between human and animal, between the self and one's space, both physical and emotional. The essay contains a set of narratives that dance around each other: the speaker tells a story through slowly emerging fragments of her experience moving into a historically haunted house, while also revealing the years of alligator-related nightmares she's experienced since. Relying heavily on associative leaps, the essay shifts back and forth between past and present, between the palpable and the imagined. Scientific research and Egyptian mythology relating back to alligators and crocodiles are incorporated throughout the piece, grounding the essay in fact while simultaneously posing rhetorical philosophical questions which arise from the uncovered information. From the desert-dwelling owner of a rattlesnake museum to American serial killer Joe Ball, from folklore's Bluebeard to her own father, the speaker interrogates male figures and their potential for inciting fear or love, or sometimes both. In a seamless weaving together of personal and collective experiences, "What It Means to Wade" examines what it means to be a woman and what it means to move forward in spite of what recurs and what may lie ahead.

Tavalieri, Y.E., Galoppo, G.H., Canesini, G., Luque, E.H. and Muñoz de Toro, M.M. (2020). Effects of agricultural pesticides on the reproductive system of aquatic wildlife species, with crocodilians as sentinel species. Molecular and Cellular Endroncrinology (https://doi.org/10.1016/j.mce.2020.110918).

Abstract: Agricultural pesticides represent a significant class of endocrine-disrupting chemicals (EDCs) to which non-target organisms around the world are constantly exposed. Laboratory studies have found strong evidence showing the endocrine-disruptive potential of these pesticides at environmentally relevant exposure levels. Since the field of endocrine disruption continues to grow in richness and complexity, this review aims to provide an update on the effects of two agricultural pesticides that act as EDCs: atrazine and endosulfan. We will focus mainly on the effects on crocodilians due to their worldwide occurrence in tropical and sub-tropical wetland ecosystems and their ecological and physiological features, which render them vulnerable to exposure to pesticides with endocrine-disrupting action at all life stages. The results here reviewed provide important insights into the effects of hormonally active agricultural pesticides at cellular, tissue, and organ levels in the reproductive system of crocodiles. A better understanding of the effects of exposure to environmentally relevant doses of EDCs on the reproductive system of crocodilians will contribute to protect and improve the health of both wildlife species and humans.

Azevedoa, L.P., Dos Santos Ferraz, R.H., Lopes de Magalhães, M.R., Oliveira, A.P., Cogliati, B., Scalon Lemos, L.M., Branco, P.C., De Abreu Sousa, D., Machado Cunha da Silva, J.R. and Nogueira Pressinotti, L. (2020). Healing potential of *Caiman yacare* (Daudin, 1802) visceral fat oil. Wound Medicine (https://doi.org/10.1016/j.wndm.2020.100195).

Abstract: *Caiman yacare* visceral fat oil was extracted, analyzed, and tested for healing potential. In vivo assays were performed by excisional wounds in rats and treated topically daily with Caiman oil for 10 days. The positive and negative controls were, respectively, with Dersani® (Essential Fatty Acids - EFA, reference substance) and saline solution (SS). The scattered area was measured daily, and at 3rd and 10th days the rats were euthanized and samples were processed for histological analyses. The cytotoxicity was evaluated by the MTT assay in non-tumor retinal pigment epithelium cells. The Caiman oil composition was 42.95 ± 1.03% of saturated fatty acids and 43.74 ± 0.74% of unsaturated ones. After 10 days of excisional wounds, the Caiman oil-treated animals present a larger scarred area than the negative control ones. Caiman oil and EFA treated animals present significantly more epidermal papillae than in SS-treated ones

on day 10. Caiman oil treated animals, at 10th day, present a relative increased area of collagen fibers, as well as an elevated number of fibroblasts and monomorphonuclear cells in the wound region in comparison to both SS and EFA treated ones. The oil showed no significant cytotoxicity up to 500 μg/mL. Taken together, Caiman oil, extracted as a by-product of the *C. yacare* zootechnical disposal, demonstrated wound healing properties equal to the commercial available solution, subsidizing its ethnoknowledge.

Rossi, N.A., Menchaca-Rodriguez, A., Antelo, R., Wilson, B., McLaren, K., Mazzotti, F., Crespo, R., Wasilewski, J., Alda, F., Doadrio, I., Barros, T.R., Hekkala, E., Alonso-Tabet, M., Alonso-Giménez, Y., Lopez, M., Espinosa-Lopez, G., Burgess, J., Thorbjarnarson, J.B., Ginsberg, J.R., Vliet, K.A. and Amato, G. (2020). High levels of population genetic differentiation in the American crocodile (*Crocodylus acutus*). PLoS One 15(7): e0235288.

Abstract: The American crocodile (*Crocodylus acutus*) is a widely distributed species across coastal and brackish areas of the Neotropical region of the Americas and the Greater Antilles. Available information on patterns of genetic differentiation in *C. acutus* shows a complex structuring influenced by interspecific interactions (mainly hybridization) and anthropogenic actions (mostly historical hunting, recent poaching, habitat loss and fragmentation, and unintentional translocation of individuals). In this study, we used data on mitochondrial DNA control region and 11 nuclear polymorphic microsatellite loci to assess the degree of population structure of *C. acutus* in South America, North America, Central America and the Greater Antilles. We used traditional genetic differentiation indices, Bayesian clustering and multivariate methods to create a more comprehensive picture of the genetic relationships within the species across its range. Analyses of mtDNA and microsatellite loci show evidence of a strong population genetic structure in the American crocodile, with unique populations in each sampling locality. Our results support previous findings showing large degrees of genetic differentiation between the continental and the Greater Antillean *C. acutus*. We report three new haplotypes unique to Venezuela, which are considerably less distant from the Central and North American haplotypes than to the Greater Antillean ones. Our findings reveal genetic population differentiation between Cuban and Jamaican *C. acutus* and offer the first evidence of strong genetic differentiation among the populations of Greater Antillean *C. acutus*.

Ssebugere, P., Sillanpää, M., Matovu, H., Wang, Z., Schramm, K-W., Omwoma, S., Wanasolo, W., Chelangat Ngeno, E. and Odongo, S. (2020). Environmental levels and human body burdens of Per- And Poly-Fluoroalkyl substances in Africa: A critical review. Science of the Total Environment 739: (doi: 10.1016/j.scitotenv.2020.139913).

Abstract: Per- and polyfluoroalkyl substances (PFASs) are known organic pollutants with adverse health effects on humans and the ecosystem. This paper synthesises literature about the status of the pollutants and their precursors, identifies knowledge gaps and discusses future perspectives on the study of PFASs in Africa. Limited data on PFASs prevalence in Africa is available because there is limited capacity to monitor PFASs in African laboratories. The levels of PFASs in Africa are higher in samples from urban and industrialized areas compared to rural areas. Perfluorooctane sulfonic acid (PFOS) and perfluorooctanoic acid (PFOA) are the dominant PFASs in human samples from Africa. Levels of PFOS and PFOA in these samples are lower than or comparable to those from industrialized countries. PFOA and PFOS levels in drinking water in Africa are, in some cases, higher than the EPA drinking water guidelines suggesting potential risk to humans. The levels of PFASs in birds' eggs from South Africa are higher, while those in other environmental media from Africa are lower or comparable to those from industrialized countries. Diet influences the pollutant levels in fish, while size and sex affect their accumulation in crocodiles. No bioaccumulation of PFASs in aquatic systems in Africa could be confirmed due to small sample sizes. Reported sources of PFASs in Africa include municipal landfills, inefficient wastewater treatment plants, consumer products containing PFASs, industrial wastewater and urban runoff. Relevant stakeholders need to take serious action to identify and deal with the salient sources of PFASs on the African continent.

Goedert, J., Amiot, R., Berthet, D., Fourel, F., Simon, L. and Lécuyer, C. (2020). Combined oxygen and sulphur isotope analysis - A new tool to unravel vertebrate (paleo)-ecology. Naturwissenschaften 107(2):(doi: 10.1007/s00114-019-1664-3).

Abstract: Reconstructing the living environment of extinct vertebrates is often challenging due to the lack of proxies. We propose a new proxy to the living environment based on the combined oxygen and sulphur stable isotope analysis of vertebrate hydroxyapatite. We tested this isotopic proxy to 64 biogenic apatite (bones) samples that represent a wide spectrum of the extant vertebrate phylogenetic diversity including crocodiles, snakes, turtles, mammals, birds, lizards, fish and amphibians. We show that the combination of these two isotopic systems allows the living environment of all these vertebrates to be unambiguously distinguished between freshwater (aquatic vs semi-aquatic), seawater (aquatic vs semi-aquatic) and terrestrial. The main goal of this study is to provide a present-day isotopic reference frame and to discuss methodological issues that will serve to interpret future oxygen and sulphur isotope results obtained either from fossil or modern skeletal material. This new isotopic approach of combined oxygen and sulphur isotope analysis will be particularly useful to document major aquatic-terrestrial transitions in the fossil record but also to better constrain the living environment of some present-day species.

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