CROCODILE SPECIALIST GROUP NEWSLETTER

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CROCODILE

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NEWSLETTER

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COVER PHOTOGRAPH: A large adult male Gharial (*Gavialis gangeticus*) captures a juvenile narrow-headed softshell turtle (*Chitra indica*). Rarely observed capturing prey other than fish, Gharial apparently feed on other vertebrates only rarely. Photograph: Pankaj Kumar (Gharial Ecology Project), taken on 19 August 2018 at the Chambal-Yamuna confluence.

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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

Sometimes some fantastic, "old-shool" crocodilian biological mysteries are solved. Sergio Balaguera-Reina has just reported that he and a small research team made an expedition to the Apaporiensis River in Colombia, and rediscovered the Apaporensis Caiman (*Caiman crocodilus apaporiensis*). Originally described by Fredrico Medem, one of the great crocodilian research pioneers, there had not been one seen in the wild for 42 years! Thanks to everyone who supported Sergio and the project! This is the seed of a great opportunity for future work by Sergio and with the samples collected there is going to be lots of exciting news in the future.

On a less scientific- or logic-based issue, the California Penal Code 653(o) banning trade in crocodilian products is raising its head again. Exemptions have been extended a number of times, to allow the sale of alligator and crocodile skins, parts and products in the state of California, but only up to 1 January 2020. If the Sunset Clause in Penal Code 653(o) is not extended beyond 1 January 2020, or the whole Code repealed, the ban on the sale of crocdilian products that are legal under both federal law (FWS, CFR 50 Special Rules) and the CITES Treaty governing all international trade in crocodilian species, will be re-imposed. The Louisiana Department of Wildlife and Fisheries, and the Louisiana Alligator Advisory Council, with the aid of contractor Matt Grey, are once again working to stop the ban coming into effect. It would clearly be detrimental to conservation prigrams based on sustainable use. It is seriously hard for outsiders to believe that advocates against the use of any animal can convince legislators to abandon conservation.

On 19-21 July, together with Rosie Cooney, Chair of the Sustainable Use and Livelhoods Specialist Group, I attended a meeting in Fiji of Oceania representatives of the Marine Turtle Specialist Group: "Conservation of Sea Turtles within the Cultural Context of Oceania - Possibilities Beyond Protection". Successful conservation efforts with sea turtles have not resulted in the ability of local people, with long traditions of use, being able to reintroduce even culturally appropriate uses - no trade - in many Pacific Islands. The CSG examples of crocodilian sustainable use, and the whole concept that "use" could be both responsible and beneficial, were of interest to many participants.

On 5-8 November 2018 I attended the CITES Livelihoods Workshop in Guangzhou, China, and presented a paper titled "CITES and Livelihoods: Lessons Learned from Crocodilians". Dan Natusch and Rosie Cooney were both present and confirmed use programs can be both responsible and beneficial to conservation, and to people's livelihoods. I'd like to take this opportunity to thank the many CSG members who submitted case histories to the workshop, which really did establish unequivocally that crocodilians do provide many excellent examples of successful programs, in which the livelihoods of local people are improved.

At the 25th CSG Working Meeting in Santa Fe it become obvious that the links between sustainable use and conservation are either poorly understood, or not prioritised, by some some elements of the crocodilian industry. My report on this issue is still in progreess because the issue is evolving continually. In early December, Chanel became the first luxury fashion house in the world to announce it was stopping the use of exotic animal skins such as snake, crocodilian, lizard and stingray. The company's head of fashion, Bruno Pavlovksy, said it had become difficult to source such skins "ethically" - cutting out the incomes of local people is obviously not considered unethical. Claims by designer Karl Lagerfeld that animal rights groups were not involved were hardly convincing. They are certainly claiming a victory! How nice it would be if some of these decision-makers had to live and survive with indigenous people for a week. It would make an educational "bonding" experience that might teach them much - espectially what "ethics" is all about.

The Summer CrocFest 2018 took place on 30 June 2018 at Wild Florida in Kenansville, Florida. It attracted some 200 attendees, who are seriously generous, and raised $US28,000! These funds provided much needed support for Sergio's Apaporensis expedition, among other things. An inaugural Croctoberfest Brew-at-the-Zoo evening was hosted by St. Augustine Alligator Farm Zoological Park on 28 September 2018. It raised over $US12,000 for Tomistoma field surveys. These are simply remarkable achievements. .

On 8 December, I personally attended the Winter CrocFest 2018 at Gatorama (Palmdale, Florida), which was the first fundraiser like this I have ever been to. Serious thanks due to Curt Harbsmeier and Colette Adams for making it all possible. Some 300+ people attended and I was seriously impressed by the diversity of people there with real interest and involvement with crocodilians. And then there was catch-up opportunities with Rom Whitaker, Jeff Lang, Christine Lippai and so many other CSG members. Around $US40,000 was raised for the Gharial work being driven by Jeff Lang, whose group is achieving remarkable results.

On the CITES front, Mexico is proposing to make a submission to CoP18 (Colombo, Sri Lanka, 23 May-3 June

2019) to transfer the Mexican population of the American crocodile (Crocodylus acutus) from Appendix I to Appendix II pursuant to Resolution Conf. 9.24 (Rev. CoP17). CSG was asked to provide comments on the draft proposal, which a group of members did.

The "2nd Forum on Crocodiles in the Philippines" is to be held at the University of the Philippines, Los Baños, Laguna, Philippines, on 6-8 March 2019 (see http://crocforumph.philippinecrocodile.com.ph/?i=1) (see below).

A CSG Sub-Regional Meeting organised largely by Marisa Tellez will be held in Belize on 26-29 June 2019 (see https://www.2019csgregionalmeeting.com/) (see below), just after the CITES CoP18 (23 May-3 June 2019).

Professor Grahame Webb, *CSG Chair.*

CSG Student Research Assistance Scheme

The Student Research Assistance Scheme (SRAS) provided funding to 7 students in the October-December 2018 quarter, and 5 further applications are currently under review/revision.

1. Kayla Du Plooy (South Africa): Electroencephalogram (EEG) assessment of brain activity after electrical stunning in the Nile crocodile (*Crocodylus niloticus*).

2. Adonika Spellen (Guyana): Assessment of the Appendix-II listing of Black Caiman (*Melanosuchus niger*) in Guyana.

3. Stephany del Rosario (Panama): Trophic ecology of the American crocodile (*Crocodylus acutus*) in coastal marine environments at Coiba Island, Panama.

4. Rigobert Akpamoli (Benin): Distribution of crocodile species in the Transboundary Biosphere Reserve in the Mono Delta of Benin.

5. Eréndrira Mejía Reyes (Mexico): Evaluation of reproductive effort as a survival factor in Morelet's crocodile (*Crocodylus moreletii*).

6. Nina Smalbrugge (Netherlands): The effect of climate change, human population growth and land cover change on the distribution of crocodilians in West and Central Africa.

7. Margaret Mosse (Kenya): Socio-ecological and institutional factors affecting the adoption and performance of Nile crocodile ranching in Kenya.

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

2nd Forum on Crocodiles in the Philippines (Los Baños, Philippines, 6-8 March 2019)

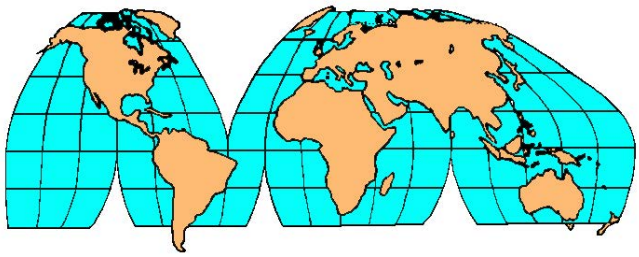
This 3-day Forum aims to highlight the plight of *Crocodylus porosus* and *C. mindorensis* in the Philippines, and to explore possibilities for furthering crocodile conservation and sustainable management in the country. The Forum is an affirmation of the continuous effort of the Filipino People to conserve their crocodilian species in their natural environments.

Papers may be submitted as oral or poster presentations, in the following themes: Natural History and Ecology; Husbandry, Veterinary and Health; Conservation Research and Management; and, Encouraging Human-Crocodile Coexistence of Crocodiles in the Philippines. All accepted presentations shall be peer-reviewed for subsequent publication in the Forum Proceedings. Details on the Forum are now available at: http://crocforumph.philippinecrocodile.com.ph.

CSG Regional Meeting (Placencia, Belize, 26-29 June 2019)

As reported in CSG Newsletter 37(3), the Belize Forest Department and the Crocodile Research Coalition is hosting a CSG Regional Meeting with the theme "*Fostering Regional Conservation through Collaboration*", in Placencia, Belize, on 26-29 June 2019. Marisa Tellez, CSG Regional Vice Chair for the Latin America and the Caribbean (LAC) region, with responsibility for the Central American & Caribbean (CAC) sub-region, is organising the meeting, with assistance from the LAC office and the host organisations. Details for the regional meeting are now available at: www.2019csgregionalmeeting.com.

Regional Reports



North America

USA

ALLIGATOR WORKING GROUP ESTABLISHED. In spring 2017, staff of the Louisiana Department of Wildlife and Fisheries (LDWF) were working to resolve numerous issues within the Alligator Research and Management Program, including problems with low wild alligator (*Alligator misssisssippiensis*) skin prices. This had led to difficulties with retaining nuisance alligator trappers, who

had been experiencing problems selling skins from their trapped alligators, which is their "payment" for providing this service to the citizens of the state. Additionally, concerns have long been present about imports of live alligators (predominantly hatchlings) between commercial alligator farms in southeastern states, and the possibility of disease introduction or transmission by this practice. As these issues involved management programs in several southeastern states, LDWF staff proposed to have an alligator-related meeting in conjunction with the annual conference of the Southeastern Association of Fish and Wildlife Agencies (SEAFWA) held in Louisville, Kentucky, to discuss options to find solutions for common problems in each state's management program.

The alligator session, held on 30 October 2017, was well attended. Representatives from several southeastern states participated, and follow up discussions were held with veterinary staff and the program directors to address possible requirements for veterinary health certificates and disease surveillance if import and export of live alligators were to be allowed between states.

In early 2018, plans were developed to formally establish an Alligator Working Group (AWG) under the Wildlife Resources Committee (WRC) of SEAFWA. This group was officially endorsed by SEAFWA in May 2018, with Amity Bass (LDWF) appointed as the Chair. Directors of wildlife agencies from Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee and Texas, appointed a designee for the group, and draft operational guidelines were prepared in June. Portions of these are excerpted below:

Mission

The AWG was established to support the WRC in fulfilling its mission and the overall purpose of the SEAFWA. Specifically, the AWG assists with state and regional, issues pertaining to the American alligator. The AWG assists the WRC by: identifying important regional issues and science-based management solutions; identifying collaborative, management-driven research needs and priorities; and, developing recommendations for wildlife resource policy, as needed and as requested by the WRC. Additionally, the AWG will provide opportunity for its members to collaborate and exchange information on matters relating to management of the alligators within the southeastern region.

Membership

The AWG shall consist of no more than one representative for each member state appointed at the discretion of the member state's WRC representative. Working group members should be member agency personnel who have agency duties related to alligator management or are uniquely qualified to function as the representative to the working group. Each working group member should be under clear instructions that participation on the working group is expected. More than one representative from a state member agency, or other interested persons, may participate in working group activities, but each member agency is limited to one official working group member and one vote. In the absence of an official member, another member from the same member agency may serve as proxy. Guests will be invited to attend annual meetings as deemed appropriate by working group members to provide specific expertise and to increase the group's knowledge base.

Meetings

The AWG shall meet annually to conduct business. This meeting will typically be held in late spring or summer, but should occur prior to the WRC's annual fall meeting held in conjunction with the Annual Conference of the SEAFWA. Working group members will rotate hosting of meetings, and final determination will be made at the annual meeting regarding the host for the next meeting.

Charges/Goals

1. Provide an opportunity to exchange ideas, methods, and approaches designed to effectively address challenges and opportunities associated with alligator management programs in the SEAFWA region.

2. Discuss important issues and needs facing alligator management programs in the SEAFWA region and bring recommendations for science-based management solutions to the WRC.

3. Identify collaborative, management-driven research needs and priorities, and develop recommendations for wildlife resource policy, as needed and as requested by the WRC.

4. Provide counsel to the WRC as requested with respect to alligators.

The AWG met on 22 October 2018 (along with the Alligator Program Leaders and Directors Meeting) at the recent SEAFWA Conference in Mobile, Alabama. Updates on several issues were discussed by various state representatives; focus was again on disease surveillance (especially *Mycoplasma* and *Chlamydia*) relative to import and export of live alligators between states, consideration of prohibition of this practice, and concerns with low skin prices for wild alligators.

The first meeting of the AWG not associated with the WRC's annual fall meeting held in conjunction with the annual SEAFWA conference, will hosted by LDWF in Louisiana, and is tentatively planned for February 2019, and will likely be in Lafayette or Baton Rouge. The next annual SEAFWA Conference where the group will again meet will be held on 27-30 October 2019 at Hilton Head, South Carolina; the alligator session is typically held on the Monday afternoon of the meeting. We invite all interested persons to attend these meetings and welcome any input on alligator management related issues.

Ruth Elsey *(relsey@wlf.la.gov)* and Jeb Linscombe *(jlinscombe@wlf.la.gov), LDWF, Louisiana, USA.*

WINTER CROCFEST 2018. Winter CrocFest 2018 took place on 8 December 2018 at Gatorama, in Palmdale, Florida, USA. Gatorama is one of Florida's few remaining "Original Roadside Attractions," and it is owned by Allen Register and his wife Patty. It features many species of crocodilian, including a large number of American alligators exceeding 3-4 m in length, and the largest group of American crocodiles in captivity.

Attendance exceeded 300 individuals, including world-famous conservationist Rom Whitaker from India, world-renowned crocodilian biologist Dr. Jeff Lang, long recognized for his groundbreaking work with Gharial, our own CSG Chairman and renowned conservationist Professor Grahame Webb! Also in attendance were crocodilian expert and Chairman of the AZA Crocodilian Advisory Group Dr. Kent Vliet, and crocodilian expert and head of the University of Florida's "Croc Docs" Dr. Frank Mazzotti. Additional CSG members in attendance included Allan "Woody" Woodward, Christine Lippai, Dr. Matt Shirley, Flavio Morrissiey, Frank Robb, Katie Anderson, Joe Wasilewski, Ed Metzger, Bruce Shwedick, Colette Adams and Curt Harbsmeier.

Figure 1. Professor Grahame Webb, CSG Chair, addresses participants at Winter CrocFest 2018.

The beneficiary of this installment of CrocFest is the Gharial, more specifically the Gharial Ecology Project (GEP) headed by Dr. Jeff Lang. All (100%) of funds raised will serve to continue the GEP's research with Gharial on the Chambal River, and recent expansion into Nepal. While pledges will be collected through the end of February 2019, Winter CrocFest has raised in excess of $US40,000 so far. CrocFest fundraisers have generated nearly $US400,000 for *in-situ* crocodilian conservation projects worldwide since 2010.

Thanks to everyone involved and/or associated with Winter CrocFest 2018. A full report will follow soon.

Curt Harbsmeier, Winter CrocFest *(charbsmeier@hdalaw.com)*.

East and Southeast Asia

Lao PDR

NOTES ON TRADITIONAL ECOLOGICAL KNOWLEDGE AND ETHNOHERPETOLOGY OF SIAMESE CROCODILES IN LAO PDR. The Siamese crocodile (*Crocodylus siamensis*) is regarded as one of the most critically endangered crocodilians in the world (Simpson and Bezuijen 2010). During the past 50 years, wild populations of *C. siamensis* throughout mainland Southeast Asia have plummeted in the wake of illegal hunting for skins and meat, Government-sponsored extermination programs, habitat loss, and over-collecting to stock commercial crocodile farms (Platt and Tri 2000; Platt *et al*. 2004, 2018a; Simpson *et al*. 2006; Simpson and Bezuijen 2010; Kanwatanakid-Savini *et al*. 2012; Guérin 2013). Fewer than 1000 adult *C. siamensis* now survive in the wild, and most populations are small, fragmented, and of questionable reproductive viability (Simpson and Bezuijen 2010).

The conservation situation is particularly acute in Lao PDR (hereafter referred to as Laos) where potentially viable, albeit fragmented populations of wild *C. siamensis* survive in Attapu, Khammouane, Salavan and Savannakhet Provinces (Stuart and Platt 2000; Thorbjarnarson *et al*. 2004; Bezuijen *et al*. 2013; Ziegler *at al*. 2015). Despite being legally protected as a "Prohibited Category I Species" (hunting and trade is strictly prohibited), Siamese crocodiles are threatened by deliberate killing for food and to protect people and livestock, collection of eggs for domestic consumption, incidental take in fishing gear, and most importantly, habitat loss (Simpson and Bezuijen 2010; Platt 2012; Bezuijen *et al*. 2013).

Recognizing that *C. siamensis* faced near-certain extinction in Laos unless immediate action was undertaken, the Wildlife Conservation Society-Lao Program, working together with the Lao Government, designed and implemented a long-term crocodile recovery plan in 2008 (Hedemark *et al*. 2009). As part of this plan, community-based conservation projects were implemented in villages adjacent to wetlands known to harbor crocodiles along the Champhone and Xangxoy Rivers (Kout Kaen, Xelat Kadan, Nong Maehang, Kout Mark Peo-Phai Cheo Reservoir Complex, Kout Kouang and Kout Koke) and Bang Fai River (Beung Hor and Beung Bua) in Savannakhet Province. Working together with local communities, site-specific management plans were prepared and village-based crocodile conservation teams (CCTs) established (Platt 2012; Platt *et al*. 2014a,b, 2018b). Each CCT consisted of 5-20 locally recruited villagers [primarily Lao Loum (Lowland Lao) with some ethnic Phouthai] tasked with monitoring crocodile populations, enforcing conservation regulations and searching for crocodile nests (Platt *et al*. 2014a).

Here, we report on the traditional ecological knowledge (defined as the cumulative body of knowledge concerning the relationship of organisms to one another and their environment, empirically acquired, and passed down by oral tradition; Berkes *et al*. 2000) and ethnoherpetology (defined as the relationships between human culture and

reptiles; Alves *et al*. 2012) of Siamese crocodiles in southern Laos. This information was obtained during both informal discussions and structured interviews of CCT members and rank-and-file villagers from 2011-2018 (Platt 2012, 2018; Platt *et al*. 2014a, 2018b). We also review other reports of indigenous ethnobiological knowledge provided by previous workers in Laos (eg Baird 2001; Thorbjarnarson *et al*. 2004; Bezuijen *et al*. 2013) and relate these to our findings. While often disparaged by western science (Huntington 2000), indigenous ethnobiological knowledge can provide insights into natural history and ecological relationships over-looked by academic investigators, utilitarian benefits in the form of novel pharmaceuticals and natural products, a greater understanding of biological and cultural diversity, and gateways to effective conservation strategies (Platt *et al*. 2018c and references therein).

The vernacular name ("folk taxa" of Berlin *et al*. 1966) applied by ethnic Lao to crocodiles is "Khea", which corresponds to the biological species recognized by western science as *C. siamensis*. As reported by Bezuijen *et al*. (2013), our informants likewise further classified crocodiles into two ichnotaxa (*sensu* Lockley 1999) - Khea Tin Pet (= Duck-footed Crocodile) and Khea Hia (= Monitor Crocodile) - based on differences in track morphology. The tracks of Khea Tin Pet are characterized by imprints of webbing between the toes, while those of Khea Hia are said to resemble the tracks of Monitors (*Varanus* spp.) and lack interdigital webbing. Rather than representing two different biological species, these ichnotaxa correspond to differences in hind- and forefoot morphology of *C. siamensis*. Our informants also described a third folk taxa known as Khea Nam Jout (= Freshwater Crocodile). The folk taxonomy of crocodiles in Laos is thus over-differentiated - that is, a single biological species is represented by multiple nonsynonymous folk species (Berlin *et al*. 1966). Over-differentiation of culturally or economically important species is common among traditional societies (Wilkie and Saridan 1999). In neighbouring Cambodia, where crocodile farming is an economically important rural industry in some areas (eg Tonle Sap), *C. siamensis* is over-differentiated into multiple folk taxa based on skin characteristics (Platt *et al*. 2004).

CCT members and villagers provided a number of interesting folk beliefs, including some with biological merit and potential conservation applications. Our informants stated that crocodiles vocalize during the wet season and attribute these bellows to mature males. Although many species of crocodilians are known to vocalize (Brazaitis and Watanabe 2011), we are unaware of any published reports specific to *C. siamensis*. According to our informants the sex of large juvenile and adult *C. siamensis* can be readily determined based on the external morphology of the cloaca; the opening of the female cloaca is said to be more oval than that of the male. Another common local belief pertains to nest site selection: if crocodiles select a soil substrate for nest construction (typically at the onset of the annual wet season in May-June; Platt 2012), this portends a wet season with below normal rainfall. Conversely, if crocodiles construct nests on floating mats of vegetation or other mesic microsites, a wet season with above normal rainfall is sure to follow.

Our informants also maintained that Siamese crocodiles display a dietary preference for domestic dogs. This preference is explained by a Lao folk story in which a dog, not wishing to swim a wide river, was transported across the water by a crocodile, and in return for this good deed, the dog defecated on the head of the crocodile before fleeing coward-like onto the riverbank. As a result of the dog's unappreciative and scornful behaviour towards the crocodile, the two species have been mortal enemies ever since. Interestingly, our informants described the body size of crocodiles based on mid-body girth rather than total length, and appear to have difficulty equating girth to total length. This practice is probably a legacy of past commercial skin-hunting when hides were measured in "Thuk", a 10-cm unit of ventral skin equivalent to the width of a person's hand (Bezuijen *et al*. 2013).

Some informants attributed magical and curative powers to certain parts of crocodile anatomy. A piece of skin removed from the tail of a crocodile is believed to increase the likelihood that an individual will win the lottery, and crocodile teeth and dried dung (see also Baird 2001) are regarded as lucky talismans and kept in houses to ward off malevolent spirits (Fig. 1). Because dogs and crocodiles are irreconcilable enemies (see above), this practice is believed to cause any dogs residing at the house to sicken and eventually die. A crocodile skin placed in a fallow rice field is thought to attract water buffalo and cattle which will defecate nearby and enrich the soil. Crocodile meat was eaten in the past (see also Bezuijen *et al*. 2013; Ziegler *et al*. 2015), as were eggs containing well-developed embryos. Until recently, the Lao Zoo found a ready market for both items among the visiting public, although the sale of wildlife products has since been discontinued. Dried crocodile dung is used to treat unspecified skin disorders and Bezuijen *et al*. (2013) reported that powdered crocodile teeth are considered an effective treatment for dog bites.

Figure 1. Fresh dung photographed at sacred wetland near Naonua Village in January 2018. Dried *C. siamensis* dung is considered an effective treatment for skin ailments and kept as a lucky talisman by rural villagers in Laos to ward off malevolent spirits. Photograph: Steven Platt.

Residents of several communities along the Champhone and Xangxoy Rivers participating in the conservation program venerate crocodiles as the incarnate embodiment of spirits from deceased ancestors. Crocodiles are thus considered powerful living talismans and treated with great respect. These beliefs are especially prevalent in Tansoum Village, adjacent to Kout Mark Peo-Phai Cheo Reservoir Complex, which harbors what is likely the single largest extant population of Siamese crocodiles in Laos (Platt 2018). Villagers believe that to molest or harm a crocodile will invite divine retribution to the transgressor in the form of misfortune, sickness, or even death.

Prior to collecting crocodile eggs for incubation as part of a head-starting project (Platt *et al*. 2014a), we were asked to participate in a ceremony to placate the ancestral spirits and assure them of our good intentions (Fig. 2). To our knowledge, this ceremony has not yet been described in the published literature. The ceremony was conducted by a well-known village shaman believed able to communicate directly with the crocodile spirits.

Figure 2. A shaman (in turban) from Tansoum Village conducting a ceremony to placate powerful ancestral spirits believed to reside within Siamese crocodiles. This ceremony was conducted before we ventured into the swamp to collect crocodile eggs as part of a head-starting project in the village in June 2012. Note offerings of sticky rice, cooked pork and rice whiskey. Photograph: Steven Platt.

Prior to the ceremony a young pig was killed and cooked, and together with other offerings, taken to the edge of a swamp where crocodiles dwell. Buddhist prayer candles and incense sticks were ignited and placed on the ground before the shaman, who proffered the cooked pig, sticky rice, and cigarettes to the spirits. Two bamboo vessels containing dried bamboo leaves and filled with potent, locally-brewed rice whiskey were placed among the other offerings, and additional alcohol was sprinkled in the ground. The shaman then began uttering incantations explaining our motives and reassuring the spirits of our good intentions, promising to return crocodile hatchlings to the swamp, and beseeching the crocodile spirits to protect and keep us safe as we collected crocodile eggs. Upon conclusion of the incantations, each participant drank a glass of whiskey and poured a small amount on the ground as a personal offering to the spirits. All present then consumed the boiled pork; the other offerings (prayer candles, sticky rice, and cigarettes) were left at the site after we departed.

Similar traditional beliefs were described by Baird (2001) in Naonua Village along the Bang Fai River where nearby wetlands (Beung Hor and Beung Bua) are considered sacred and thought to be protected by powerful spirits residing within crocodiles. According to villagers, the welfare of the community is closely linked to that of the crocodiles. Consequently, fishing is prohibited within the wetlands lest the crocodiles be deprived of a food source. A "sacred zone" surrounding the wetlands shelters a spirit house and a local shaman is responsible for placating and communicating with the spirits. Past transgressions have invariably led to misfortune for the community, most notably a well-remembered incident in 1966 when between 80 and 160 people died after a large fish was taken from the wetlands in violation of the taboos. Whenever a domestic animal is killed as part of a village ceremony, a portion of the carcass is offered to the crocodiles.

Our visits to Naonua Village during 2011-2018, suggest the continued persistence of these traditional beliefs. The community maintains the "scared zone" around the wetlands, restricts fishing, and protects wildlife. Every February the villagers make an offering on behalf of the community to the crocodiles; the value of the offering depends on what is being asked of the crocodiles. In the past Sambar (*Rusa unicolor*) or muntjac (*Muntiacus* sp.) meat was proffered, but with the local extinction of these mammals, chicken or buffalo is now substituted. In addition to formal offerings, villagers (often from other areas) visit the wetland and hoping to view a crocodile, construct small fires and burn hair-covered pigskin and roast chicken carcasses.

Odours emanating from the fire are said to attract a crocodile which is then fed the cooked items. This positive reinforcement has been so effective that merely igniting a small fire along the shoreline is now sufficient to lure the crocodile into view. The resident crocodile is also said to relish fresh watermelon. Villagers show no fear of crocodiles, and small children are allowed to swim in the lake even when a crocodile is in view.

According to Baird (2001), one or two crocodiles were present in Beung Hor and Beung Bua during 2000-01, and Thorbjarnarson *et al*. (2004) found a "very small group" of crocodiles inhabiting these wetlands during a site assessment in 2003. Our follow-up monitoring in 2011-13 could only confirm the presence of a single large female (ca. 2.9-3.0 m TL) which nested repeatedly, but deposited clutches of infertile eggs (Fig. 3; Platt 2018). Baird (2001) further remarked that villagers wished to increase the crocodile population by releasing a male to encourage reproduction. However, our offers to translocate a male crocodile from the Lao Zoo were rebuffed by villagers who feared the action would bode ill for their community by angering the spirits associated with the wetland.

Figure 3. Solitary female Siamese crocodile defending her nest at a sacred wetland near Naonua Village. Photograph: Steven Platt (July 2012).

The continued survival of *C. siamensis* in the densely populated agricultural landscape of Savannakhet Province (and probably elsewhere in Laos; see Bezuijen *et al*. 2013) has no doubt been abetted by the persistence of traditional beliefs which function as a *de facto* form of protection for crocodiles. However, although widespread in Savannakhet Province, these beliefs are not universal and illegal killing of crocodiles does occur on occasion (Fig. 4). Traditional taboos can be effective tools for biodiversity conservation when these beliefs are in concordance with conservation objectives (Luiselli 2003; Platt *et al*. 2003; Rudrud 2010; Sasaki *et al*. 2010; Ferronato and Cruzado 2013). Indeed, similar traditional beliefs are thought responsible for the survival of some populations of *C. siamensis* and *C. niloticus* in Cambodia (Sam *et al*. 2015) and Madagascar (Pooley 2016), respectively.

Figure 4. Investigating the illegal killing of a Siamese crocodile near Tansoum Village, that occurred in contravention of local traditional beliefs. Poachers who removed the tail for meat were later apprehended and fined. Photograph: Pakham Outhanekone (December 2012).

Although there is growing recognition that traditional beliefs can make significant contributions to conservation and should therefore be encouraged, beliefs alone may be insufficient to safeguard biodiversity because traditional systems often cannot compete with strong contemporary social and economic drivers (Sasaki *et al*. 2010). Moreover, there is a danger in over-reliance on traditional beliefs in any conservation program because belief systems can be expected to change over time, especially as traditional societies are eroded and modified by the dominant western paradigm. Nonetheless our experience in Laos suggests traditional beliefs are a viable near-term asset to stabilize populations and begin recovery of the Siamese crocodile.

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Latin America and the Caribbean

Mexico

V MEETING OF THE MEXICAN CROCODILIAN SPECIALIST GROUP (GEC-MEXICO). On 20-21 September 2018, the V Meeting of the Mexican Crocodilian Specialist Group (GEC-Mexico) was held at Chetumal, Quintana Roo, where around 70 crocodilian experts met to discuss several topics, including analysis of the current conservation status, trends and management in place for two of Mexico's endemic species: Morelet's crocodile (*Crocodylus moreletii*) and the American crocodile (*C. acutus*).

GEC-Mexico is comprised of experts from academia, federal and state Governments, civil society, producers, businessmen and local communities, among others. The V Meeting was coordinated by the National Commission for the Knowledge and Use of Biodiversity (CONABIO), the Secretariat of Agricultural, Rural and Fisheries Development (SEDARPE) of the Government of Quintana Roo, and the Farm Cocodrilia.

The event brought together the largest attendance of crocodilian specialists at these biannual GEC-Mexico meetings. Participants shared information and provided

Figure 1. Mexican Crocodilian Specialist Group (GEC-Mexico) during its V Meeting in Chetumal, Quintana Roo (top) and GEC-Mexico logo (bottom).

qualified guidance on the staus, trends and alternatives for the sustainable use of both Morelet's and American crocodiles. Some of the main agreements were:

- To continue the biannual monitoring of *C. moreletii* in permanent sites, considering the proposed prioritization criteria for management of financial resources; including geographic representation that ensures the genetic variability of the population, and information on habitat type and quality.

- To continue monitoring *C. moreletii* harvest sites in accordance with the Ranching Protocol, and continue including the outcomes in the centralized database hosted by CONABIO.

- To establish a Coordination Committee, composed of 5 sub-committees (logistics, contents, academic issues, communication, outings/excursions), for organization of the 26th Working Meeting of the CSG (Chetumal, Quintana Roo, 2020). Carlos Piña, who was directly involved in the organisation of the 25th CSG Working Meeting (Argentina, May 2018), was appointed as an external adviser for the event. The sub-committees are comprised of representatives of federal and state Governments, academia, civil society and the private sector.

- GEC-Mexico acknowledged that *C. acutus* populations in Mexico are no longer endangered, and agreed to prepare an amendment proposal to transfer the Mexican population to CITES Appendix II for consideration at CoP18 (Sri Lanka, May-June 2019).

The complete list of agreements from the meeting is at: http://www.conabio.gob.mx/internacionales/.

Hesiquio Benítez Díaz, *CSG Regional Vice Chair for Latin America and the Caribbean, with responsibility for Mexico (ac-cites@conabio.gob.mx).*

Cost Rica

COSTA RICAN UNIVERSITIES TRAIN RESCUE TEAMS IN CROCODILE MANAGEMENT. The American crocodile (Crocodylus acutus) is distributed along the Pacific coast from Mexico to northern Peru, while in the Caribbean it extends from Florida to Venezuela, including several of the Greater Antilles. The species is protected throughout its distribution, but as in other Range States, illegal hunting during the first half of the 20th century considerably reduced *C. acutus* populations in Costa Rica. In the 1970s the country's legislation began to protect the species and its habitats, primarily through the development of national parks and biological reserves. Over the next five decades, the crocodile population increased in numerous rivers and estuaries, especially in the Pacific coast, reaching values of more than 15 ind/km in rivers such as the Tempisque and Tarcoles.

At the same time, the human population of Costa Rica has almost doubled, reaching five million inhabitants in 2018. In addition to human population growth, the development of tourism and real estate activities in coastal areas has allowed significant exposure to crocodile habitat. Consequently, cases of humans-crocodile conflict have increased, particularly the number of attacks on residents and tourists in coastal communities. Over the last few years, Costa Rican authorities (firefighters, coastguards and park rangers) have been called to attend "emergencies" generated by crocodiles, and they are expected to resolve these conflicts. The fundamental problem is that these first-response groups do not have the experience or technical knowledge to adequately handle crocodiles, make decisions about their management, and deal effectively with situations involving by crocodiles.

For this reason, academic researchers with experience in crocodiles, at the Universidad Nacional and the Universidad de Costa Rica, the two largest public universities in the country, established a joint training program aimed at the humane management of crocodiles and the resolution of conflicts caused by them. The training includes both theoretical and practical aspects of crocodile biology, handling, and conservation, and focuses on the welfare of both animals and people. Over the last four years, more than 150 park rangers, firefighters and coastguards have received training, which has allowed them to acquire develop the skills to work correctly and safely with crocodiles. The importance of this training program was evident during floods caused by hurricanes and storms that hit Costa Rica recently. Currently, we are also working on an integrated management plan for *C. acutus* throughout the country.

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South Asia and Iran

India

GHARIAL MOTIFS (*GAVIALIS GANGETICUS*) AT SANCHI STUPA, INDIA. Sanchi Stupa, Madhya Pradesh, India, marks itself as one of the most significant Buddhist monuments, and thus an important pilgrim and tourist spots. Being a UNESCO World Heritage Site, this stupa is considered as one of the oldest and best conserved specimens. The overall landscape of the site includes this mound located on a relatively higher ground, with surrounding fertile plains forming between the Betwa and Halali Rivers. Interestingly, some rocks in and around this site are carved with motifs of animals such as fish, reptiles and birds. This note is elaborates the relevance of some noteworthy carvings which feature Gharial (*Gavialis gangeticus*), Mugger (*Crocodylus palustris*) and turtles (species?).

A particular motif of the Gharial is depicted on the frontal facade of the southern pillar of the Eastern Gate leading to the stupa. Out of the four panels on the pillar, the third panel depicts a Gharial carving with a typical riverine backdrop (Figs. 1 and 2). As per the narrative from 'Jataka Kathas' (tales with moral teachings of Buddha), the rock carving on the third panel is an account of Lord Buddha's miracle, while he walked along the banks of the Nairanjana River. As per the description and from the visuals, the Nairanjana River can be seen flooding, while Muni Kashyapa is found accompanied by a disciple and a boatman. Collectively, they are all rowing the boat towards Buddha to rescue him from the floods.

Below this pictorial narrative, one may find another glimpse of Lord Buddha, walking on the surface of the flooding river, with figures of Kashyapa and his disciple (twice repeated) in the foreground, now found on dry ground paying homage to the Master (represented by the throne at the right hand, bottom corner) (Longhurst 1979). A rock sculpture of Mugger and a turtle are present on the front face of the right pillar of the western gate of the stupa. Here, the fourth panel from the top depicts Gangetic riverine habitat along with the Mugger and turtle swimming in the water (Figs. 3 and 4).

Historically, the stupa at Sanchi (present day in Raisan District, Madhya Pradesh, India) dates back to the 3rd century BCE, when it was originally commissioned by Emperor Ashoka in order to propagate Buddhism. The nucleus is comprised of a simple hemispherical brick structure dome built over the relics of the Buddha (as it is believed). It was crowned by the chhatri, a parasol-like structure symbolizing high rank, which was intended to honor and shelter the relics.The stupawas located on a small hilland about 50 m from the Betwa River. The historic mention of the Nairanjana River pertains to a present-day river named Lilajan - also known as the Falgu or Phalgu River. This river originates in the Chhotanagpur Plateau through multiple small streams. It further meets another tributary Mohana (Lilajan) near Bodh Gaya, and merges to form a bigger river. It is after this confluence that the river is known as Phalgu. From Gaya, its course directs northeast, and finally vanishes in the Tal area.

This rock carving of Gharial at Sanchi Stupa suggests the erstwhile presence of a small Gharial population flourishing in the Falgu River. In the past, this river was once well connected with the Ganges River system. Over a passage of time, the Falgu may have disconnected from the Ganges and changed its course, due to geological and seismographic changes.

Present day, Gharials are found in the northern part of the Indian subcontinent. They historically inhabited four river systems [Indus (Pakistan), Ganges (India, Nepal), Mahanadi (India), Brahmaputra (Bangladesh, India, Bhutan), and may have also inhabited the Ayeyarwaddy River in Burma (Myanmar). Now, Gharials have become extinct in many areas which they formerly occurred (Whitaker and Basu 1983). The rock carving of Gharials at Sanchi Stupa further points to the presence of the species in the Falgu River basin, which also happens to be located between two other river basins, namely Son (a tributary of Ganges) and Mahanadi, both of which still have small populations of the species (Stevenson and Whitaker 2010).

Nonetheless, such rock carvings can not suffice as scientific evidence of species distribution in a particular area. However, this leaves us with some clues as to how old rock paintings, carvings, terracotta objects, mythological narratives and some traditional tales depict, support and interpret contextual flora, fauna, cultural and political occurrences of historically prevalent scenarios (Kadgaonkar 2015).

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Figure 1. Eastern gate of Sanchi stupa showing sculpture of Gharial with river habitat (see yellow arrow). Photograph: Kartik Upadhyay.

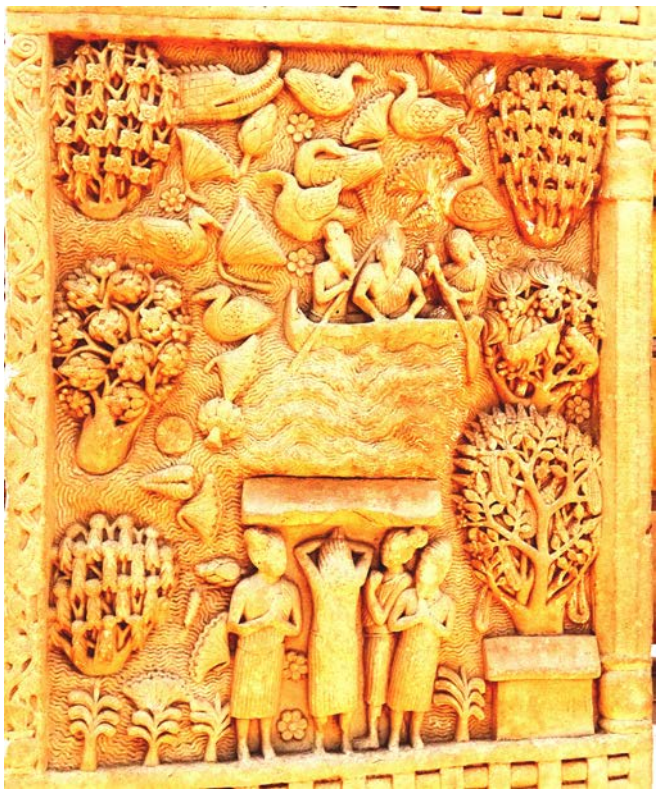

Figure 2. Third panel, showing a detailed carving of front part of Gharial along with river life and habitat. Photograph: Kartik Upadhyay.

Figure 3. Western gate of Sanchi stupa showing sculpture of Mugger and river habitat (see yellow arrow). Photograph: Kartik Upadhyay.

Figure 4. Top fourth panel, showing detailed carving of river habitat along with Mugger, turtle and fish. Photograph: Kartik Upadhyay.

GHARIAL ECOLOGY PROJECT - UPDATE 2018-2019. The Gharial Ecology Project (GEP) has finished its 11th field season, since its initiation in 2008, immediately following the mass die-off of Gharial (*Gavialis gangeticus*) in the winter of 2007-08. To date, our research approach has been productive, and has been sustained by strong support from the international zoo community, and concerned NGOs. In particular, little was known about Gharial reproductive behaviours, and the species is one of the most desired for exhibit, because of its unusual appearance and unique position as the only living member of its crocodilian subgroup. Gharials in captivity have the reputation of being very difficult to breed, and only recently has a North American zoo facility, St. Augustine Alligator Farm, been able to successfully breed and produce a hatchling. Within India, captive Gharial have bred since the 1980s, but seldom have other facilities been successful with captive reproduction. International zoos have taken the lead in providing range state conservation funds. And there is sustained interest among crocodilian conservationists to foster field research and conservation efforts on the remaining extant populations.

The GEP has as its ultimate goals: 1) to develop a comprehensive assessment of Gharials in the National Chambal Sanctuary (NCS); 2) to identify and protect the species' critical riverine habitats; and, 3) to reduce threats and challenges to the species' continued survival. Gharials are listed as Critically Endangered (CR) on the IUCN Red List, with an estimated 650-700 mature adults globally; 500+ are resident in the NCS. Project activities are conducted by a small core staff (3-4) of Indian biologists/naturalists, under the banner of the Madras Crocodile Bank Trust (in south India, near Chennai, Tamil Nadu), and with inputs from the Senior Scientific Advisor, Professor Jeff Lang.

Over the last decade (2008-2018), the GEP has produced a detailed description of Gharial behavioural ecology in the bottom third of the 625-km NCS. Adult Gharials make seasonal migratory movements of 200+ km and exhibit complex social interactions at large crèches of hatchlings [Lang and Kumar 2013, 2016; summarized in Lenin (2018) and Sohn (2018)].

Comprehensive Surveys. In February 2017 and 2018, the GEP team partnered with Madhya Pradesh Forest Department (MPFD) staff and other researchers based at the Deori EcoCentre near Morena to survey the Gharial population within the NCS (bottom 425 km, from Pali to Pachnada). In 2018, the total number of Gharial counted and estimated in the NCS was ~1675 individuals. Adjusted for accuracy in size categories, these counts included 75 mature males (with ghara), 464 reproductive females plus 52 "near reproductive" females, 462 sub-adults, 366 juveniles and 208 yearlings. In 2017, comparable counts were lower, totaling 1300+ Gharial, with an estimated 415 nests laid. In 2018, a total of 443 nests at 37 sites was documented, of which 318 nests hatched and 115 were lost. Survey details and comparable data are presented for 2017 and for 2018 in GEP (2018).

The relative importance of the Chambal Gharial population cannot be overstated. Now, with realistic size estimates of the other sub-populations, totaling approximately 650-700 adults globally, the NCS population comprises 85% of the global total (550/650). It also represents ~90% (450/500) of the global annual nesting. Importantly, the Chambal population is the ONLY self-sustaining population living in an open river, protected habitat. Major threats are, in order of importance: a) dams and river-linking; b) water extraction; c) sand mining; and, d) net fishing.

Red List Reassessment. Together with co-authors Subir Chowfin and J. Perran Ross, and substantive inputs from many knowledgeable colleagues, a reassessment of Gharial for the IUCN Red List was completed (June 2018), and is "in press" (Lang *et al*. 2019). Today, Gharial are limited to only 14 widely spaced, restricted localities in north India and in lowland Nepal. Only 5 sub-populations (4 in India; 1 in Nepal) exhibit recent reproduction/recruitment. In approximate rank order of importance (from high to low), these are: Chambal, Katerniaghat, Chitwan, Gandak, Corbett; a sixth locality, Babai River in Bardia National Park (BNP-Nepal) is potentially another breeding population, but recent evidence of nesting/hatching is absent.

The updated CR status of Gharial is based on: 1) a 94% exponential decline in adult numbers, within 3 generations (using 25 y/generation, from 1943), from >20,000 adults historically (based on 1 Gharial/river km) to 650 adults today; and, 2) a 94% exponential decline in occupancy area from 80,000 km^2 historically to 4400 km^2 today. Continuing major threats include dams/barrages, water extraction/irrigation, river inter-linking, fishing net mortality, sand/boulder mining and introduced species. Conservation actions have included captive breeding and head-starting in past decades, but now require smart, site-specific programs with local river communities to reduce multiple threats *in-situ*.

Gharial in Nepal. In early 2018, an updated Nepalese Action Plan for Gharial was outlined by the Nepalese Department of National Parks and Wildlife Conservation, and was reviewed upon request by the CSG. In brief, the revised plan for Gharial in Nepal refocuses attention on *in-situ* versus *ex-situ* conservation strategies, including an emphasis on an evidence-based program, informed by science. Phoebe Griffith, an Oxford University PhD student, has initiated a comprehensive series of studies, from telemetry of wild resident Gharials to "local ecological knowledge" surveys in riverside communities surrounding Chitwan National Park (CNP) (Figs. 1-3). To date, 5 wild resident Gharial have been outfitted with VHF and/or GSM transmitters, and are being tracked successfully in CNP.

The GEP has been instrumental in assisting the Nepal telemetry study by loaning equipment and supplies, as well as sharing capture and tagging methodologies. Phoebe joined GEP staff on the Chambal in late February and early March during the Gharial breeding season. In November, she assisted with capture, tagging and tracking resident wild Gharial living near our Garhaita base near Etawah, Uttar Pradesh.

Figure 1. From left - Ashish Bashyal, Phoebe Griffith and Jailabeen A. AB and JA are ZSL EDGE Fellows to be appointed in 2019-2021 starting their projects in March. Photograph: GEP.

Figure 2. From left - Ravi Singh, Phoebe Griffith, Deepu, Ashish Bashyal and Jailabdeen A. Photograph: GEP.

Figure 3. From left - Anil, Shiv, Ravi Singh, Jeff Lang, Jailabdeen A, Phoebe Griffith and Ashish Bashyal. Photograph: GEP.

EDGE Conservation Fellows. In early 2019, three young conservation biologists (one in India; two in Nepal) working with Gharial will begin funded projects as EDGE Fellows for 2019-2020. These are competitive, 2-year awards from the Zoological Society of London (ZSL) to benefit Critically Endangered species in their natural habitats. The EDGE Fellows working with Gharial are Jailabdeen A. (India-Chambal) (Fig. 1), Ranjana Bhatta (Nepal-Chitwan) and Ashish Bashyal (Nepal-Bardia) (Fig. 1). Ranjana will coordinate her project with Phoebe's project in CNP, and Ashish will continue his research on the Babai River sub-population (the sixth ranked "breeding" population). It is indeed fortunate to have 3 EDGE Fellows focusing on Gharial, and there will be opportunities to work together and collaborate, amongst themselves and with other Gharial researchers. For example, in November, Ashish joined Phoebe and Jailabdeen in the joint capture/tag operation near our Chambal base, and did some tracking.

Upstream Initiative. Jailabdeen A and our expert tracker and naturalist Pankaj Kumar, are the core GEP team, together with manager and driver Deepu. They will extend the GEP behavioural and telemetry studies of Gharial to the upstream of the NCS (Dholpur to Pali; ~205-km river stretch, including the upstream tributaries). In marked contrast to the downstream section (studied since 2008), little is known about Gharial ecology in the NCS upstream. Present surveys (2017 and 2018) indicate a robust Gharial population (>450) and at least one third of the total nesting (143/443) in this top stretch of 200+ river km where Gharial reside.

These findings highlight two critical questions: 1) where are the upstream adults during the seasonal monsoon months, when the river is in flood; and, 2) why are there so few young Gharials encountered in upstream sections? In short, by extending observations and tracking to Gharial living upstream, a better understanding of how the relatively large number of Gharials are using resources in the entire NCS and how best to protect and conserve the last large breeding population through appropriate actions. Our studies will concentrate initially on: 1) a detailed reconnaissance of riverine habitats, and eventually, later in 2019; on, 2) tracking of upstream residents during 2019-2021, using proven field methodologies pioneered in the lower Chambal.

Acoustic monitoring is now available for behavioural studies because Jailabdeen A, GEP Project Coordinator, is studying Gharial communication, using hydrophones to remotely record acoustic signals. Each individual male produces a "signature" popping signal by which it may be recognized and distinguished from every other male. Communication in Gharial, previously unstudied, is now known to involve acoustic "pops" performed only by large males with big gharas, and subtle "clicks" produced by hatchlings and nesting females. Jailabdeen's acoustic studies have been presented in three meetings/publications to date, and will be part of his PhD research at Bharathidasan University (Tiruchirappalli, Tamil Nadu).

Research Collaborations. We are regularly in touch with Indian researchers, and have an active collaboration with Laboratory for Conservation of Endangered Species

(LaCONES) at the Centre for Cellular and Molecular Biology (CCMB) in Hyderabad. Ravi Singh (Figs. 2 and 3) is another PhD student who is conducting a genetic study of creche participants, as well as characterizing the Chambal population, using microsatellite markers, and next generation sequencing to reveal how guardian adults at the creches are related to hatchlings, and how the Chambal Gharial population is genetically structured. One surprising preliminary result of Ravi's studies to date indicate that certain markers are specific to the Chambal population, and show little/no variation. Ravi's studies are designed to reveal the genetic relatedness among crèche participants, including large, big ghara male guardians, some of which exhibit "alloparental care" of hatchlings likely fathered by other males. Another collaboration with Dr. Karthik Vasudevan, in the same laboratory, focuses on stable isotope analyses to understand food webs in Chambal Gharials, as the apex predators in this river ecosystem.

In early 2018, the GEP collaborated with the MPFD on a radio-telemetry study to determine patterns of survival and residency in head-started Gharial, raised from eggs hatched in captivity, after these have been released in the wild. In mid-February, 9 juvenile Gharial (1.2 m total length) which had been reared in captivity were radiotagged and subsequently tracked after release. Within 3 months, only a few of these were found close to the release sites. After six months, only 3 radios were recovered (one was inside a sub-adult Mugger crocodile for three weeks). Importantly, none of the 9 gharial could be found in the vicinity of the releases, and no radios could be found. In late 2018, this exercise was repeated. Fifteen head-started juvenile Gharial from Deori were radiotagged and released in a stretch of lower Chambal. In the same area, we caught and tagged 8 wild resident Gharial, matched for size and sex. As of the end of December, 7 resident and 13 head-started Gharial were trackable - the study will continue into 2019.

Generous Support. As an overall part of the GEP activities, but outside the scope of this update, our community programs in riverside communities, and capacity building workshops for teachers and frontline Forest Department staff are conducted throughout the NCS periodically. Major support for the GEP has been provided by the City of Prague/Prague Zoo annually since 2013, and other contributors include the St. Augustine Alligator Farm, Berlin Zoo, Butterfly World UK, Eddy Even, Wildlife Conservation Society, Los Angeles County Zoo, San Diego Zoo, and a host of other agencies and NGOs. Special thanks for support are extended to Winter CrocFest 2018, held at Gatorama (Palmdale, Florida, USA) and attended by CSG Chair Grahame Webb and Rom Whitaker, Croc Bank founder, and organized by Curt Harbsmeier, Colette Adams and Flavio Morrissiey (see page 6). Joe Wasilewski ran a very successful auction.

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RESULTS OF ANNUAL CENSUS OF ESTUARINE CROCODILES (*CROCODYLUS POROSUS*) IN RIVER SYSTEMS OF BHITARKANIKA WILDLIFE SANCTUARY, ODISHA, INDIA. The annual census conducted in the river systems of Bhitarkanika Wildlife Sanctuary/National Park from 6 to 14 January 2019 resulted

in counts of 1742 Estuarine crocodiles (619 hatchlings, 347 yearlings, 273 juveniles, 178 sub-adults and 325 adults). The crocodile population has increased significantly over time, from 0.87/km in 1976 to 13.4/km in 2019.

With the initiation of the Government of India/FAO/UNDP Project "Crocodile Breeding and Management", the Crocodile Conservation and Research Project was launched in different states of the country in early 1975. The Estuarine Crocodile Conservation and Research Programme, implemented in the State of Odisha has been a great success. At a national level, it is on top so far as the "rear and release" and building up the depleted wild population is concerned. The crocodile population in Bhitarkanika has gradually built up with over the last 43 years, with a 15+ times increase since 1976. More than 101 female *C. porosus* (both released and wild) have bred successfully in the wild. This is a 14 times increase in nesting compared to the mid-1970s.

Areas such as the main Bhitarkanika River from Khola to Pathasala, Thanapati, Mahinsamada and Suhajore Creeks, Baunsagada River, Kalibhanjadia, etc., have higher concentrations of crocodiles, since they satisfy all the basic requirements for survival and propagation of the species in this mangrove ecosystem. Bhitarkanika holds the largest population of wild crocodiles in India, and comprises an estimated 75% of the total population in the country.

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Nepal

CROCODILIANS AS MODELS TO TEACH SCIENTIFIC METHOD TO HIGH SCHOOL STUDENTS IN BARDIA NATIONAL PARK OF NEPAL. Scientific method is a critical component of science education and a proper way to involve students in scientific phenomenon (Lederman and O'Malley, 1990). However, research have shown that school science does not help much to students to develop their scientific literacy as majority of science curricula are traditional and largely lecture based (Lederman and O'Malley 1990). In high school (1st to 10th grade) educational system in Nepal, course curriculums for 'Science' classes are largely lecture based and provide very limited exposure to students to scientific method and experiments. Although, schools in developed regions of Nepal may provide some hands-on learning opportunities, the issue is more prevalent in remote areas such as the buffer zone of the Bardia National Park (hereafter referred to as BNP; Fig. 1) where students barely receive such opportunities.

We designed this workshop to address the lack of understanding of scientific method in high school students from various schools in the buffer zone of BNP using crocodilians as models. The overarching goal of this workshop was to enable those students to learn and apply scientific method using threatened species of crocodilians as models. The BNP situated in Bardia district of Province-5 in southwestern Nepal comprises of pristine habitat of diverse ecological zones and harbors many endangered species and as such provides an ideal natural laboratory setting to test scientific hypotheses. The BNP is also home to two species of crocodilians - the 'Critically Endangered' Gharial (*Gavialis gangeticus*) (Choudhury *et al*. 2007) and the 'Vulnerable' Mugger crocodile (*Crocodylus palustris*) (Choudhury and De Silva 2013) (Fig. 2).

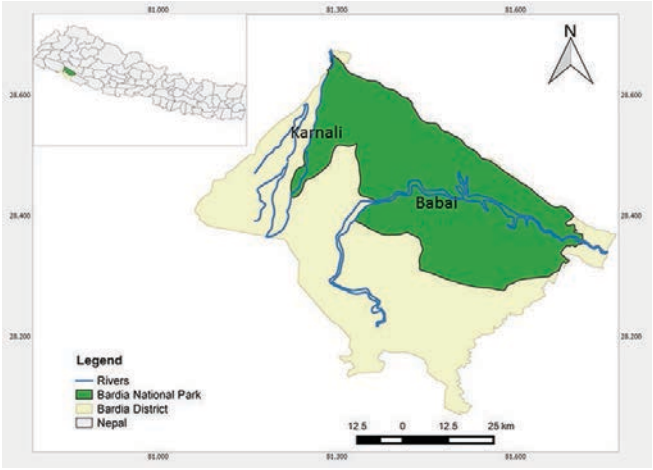

Figure 1. Bardia National Park.

Figure 2. Gharials and Muggers basking on a sandy bank in the Babai River. Photograph: Ashish Bashyal.

Morphology, behaviour and ecology of these crocodilians provide ample opportunities to test scientific hypotheses to students. During our ongoing long-term ecological research on crocodilians in the BNP, we have generally observed lack of knowledge and occasional negative attitude towards crocodilians in locals including students. Therefore, we expected that teaching scientific methods to students using crocodilians as models will create a win-win situation by equipping students with scientific knowledge as well as encouraging and involving them in conservation of crocodilians.

Material and Methods

a. Study area: The BNP (28°15' to 28°35.5' N and 80°10' to 81°45' E) is situated in Bardia district of Province-5 in southwestern Nepal and covers an area of 968 km^2.

Table 1. Training workshop syllabus.

Course Title: Crocodilians as Models to Teach Scientific Method to Students

Course Objective: The overarching goal of this project is to enable students from various schools in the buffer zone of Bardia National Park of Nepal, to learn and apply scientific method using threatened species of crocodilians as models.

Expected Learning Outcomes:

Upon completion of this course, students should have obtained:
a. A working knowledge of basic concepts of scientific method.
b. A working knowledge of biology and ecology of crocodilians.
c. A working knowledge of designing and executing hypothesis-driven project.
d. Hands-on experience of using research equipment.
e. Hands-on experience in analyzing data set using data obtained in the field.
f. Hands-on experience in preparing scientific report and present it effectively.

Course Modules: This course has been divided into seven modules as follows:

Module 1: Scientific Method
Objective: To introduce students to the process of scientific method via series of lectures and activities.

Activities: Students perform 'chewing gum lab' exercise and 'Black Box' activity. In 'chewing gum lab' students will work in a group of two to determine if mass of chewing gum will increase or decrease if they chew it for 10 minutes, using scientific method. Similarly, in 'Black Box' activity students work in a group of two to find out what is inside the black box without opening it.

Module 2: Biology and Ecology of Crocodilians
Objective: To introduce students to general ecology and biology of Gharials (*Gavialis gangeticus*) and Muggers (*Crocodylus palustris*) via a series of lectures and video clips.

Activities:
a. Students draw crocodilians using provided drawing instructions.
b. Students share their experience with crocodilians.

Module 3: Project Design
Objective: To facilitate students to develop hypotheses-driven research projects on various aspects of biology and ecology of crocodilians.

Activities:
a. Students work in group to develop a hypothesis driven project on either Gharials or Mugger crocodiles.
b. Students develop a strategy for executing project and design data sheet for recording field observations.

Module 4: Field Work and Data Collection
Objective: To provide first-hand experience to students on conducting field survey to study crocodilians.

Activities:
a. Students learn to use research equipment such as hand-held GPS unit, binoculars, DLSR camera, etc.
b. Students conduct field survey to study population and habitat ecology of crocodilians.

Module 5: Data Analysis
Objective: To introduce students to fundamentals of data analysis and provide first-hand experience on analyzing their data set from the field survey.

Activities:
a. Students learn to use software such as MS Excel and qGIS.
b. Students analyze their data set and prepare tables, charts and maps.

Module 6: Scientific Report Preparation
Objective: To introduce students to fundamentals of preparing scientific report.
Activities: Students work in groups to prepare a scientific report under instructor's guidance.

Module 7: Final Presentations
Objective: To build student's communication capacity.

Activities:
a. Students present their findings to other students and instructors in sessions.
b. Students fill out course evaluation form.

Bardia is one of the least developed districts of Nepal, with an adult literacy rate of 56.5% and per capita income of $US1086. The BNP is drained by two major rivers - the Karnali in the west and Babai in the east (Bhuju *et al*. 2007). The BNP is surrounded by a buffer zone of 328 km^2 and over 60% of the population in the buffer zone is from an indigenous Tharu community. Local communities are primarily engaged in subsistence farming, cattle rearing and fishing.

b. Target group: Two high schools located in the buffer zone of the BNP were selected for the workshop. Shree Jagadamba High School is an exemplary governmental school where Nepali is the primary language for teaching, and BBAS Memorial High School is a privately run school where English is the primary language for teaching. Governmental schools charge nominal fees, whereas private schools are costly and as such students with marginal socio-economic background are bound to attend the former. We deliberately chose these two schools to represent two different educational systems in Nepal. Each school was requested to provide five students from Grade 9 and 10 with representation of students of diverse ethnicity, socio-economic background and sex. Throughout the duration of workshop, the pool of students from both schools was mixed to allow interaction and sharing of knowledge among them.

c. Workshop: We designed a syllabus (Table 1) for our workshop, which comprised of seven modules as described below.

- Module 1 - Scientific Method: We used multi-media aided lecture with student friendly educational materials to introduce participating students (Fig. 3) to the process of scientific method, critical thinking skills as well as basic ecological principles. Similarly, students were also introduced to and allowed to perform the 'Black Box' activity and other fun scientific experiments (Table 1) to further strengthen their understanding of science and scientific method.

- Module 2 - Biology and Ecology of Crocodilians: In this module, we introduced students to various aspects of ecology and biology of two crocodilian species (Gharial and Mugger) using photographs and video clips.

- Module 3 - Project Design: We sequentially guided students to develop projects on two thematic research areas (population ecology and habitat ecology) on crocodilians. Students designed projects by strictly adhering to the process of scientific method and for testing hypotheses which were both scientifically testable and feasible (both timewise and financially). One group developed a project on Gharial and another group on Mugger.

- Module 4 - Field Survey: We guided students to conduct a survey in the Parewaodar section of the Babai River. This site in right below the bridge on east-west highway and has some resident Gharials and Muggers which can be spotted throughout the year. The entire stretch of Parewaodar was thoroughly surveyed using binoculars. Students took photographs of basking crocodilians using a telephoto zoom lens attached to Nikon D3100 camera, and geotagged all crocodilians using a hand-held Global Positioning System (GPS) device (Garmin GPSMAP 64). Similarly, locations where crocodilians and their nests were spotted were classified as mixed bank, rock bank, sand bank, steep bank, muddy bank or sandy island (Maskey *et al*. 1995).

Figure 3. Workshop participants during the field survey. Photograph: Ashish Bashyal.

- Module 5 - Data analysis: We statistically analyzed all quantitative data in MS Excel 2007 (for ease of learning for students) using descriptive statistics (mean, standard deviation, percentage). Similarly, we conducted spatial analysis in QGIS2.10.1' (QGIS Development Team 2016) using GPS co-ordinates taken in the field. We presented results in bar diagrams, frequency tables, pie charts and high resolution maps, as appropriate.

- Module 6 - Scientific report writing: We introduced students to basic techniques of writing a scientific report. Students then worked in a group to prepare a report based on their project on population and habitat ecology of crocodilians.

- Module 7 - Final presentation: We trained students in range of communication skills including public speaking. Students then presented their findings via oral presentation.

Major Accomplishments of the Workshop

a. Capacity Building: Though this workshop, we were able to build the capacity of 10 participating students in: (a) process of scientific method and critical thinking skills, (b) designing hypothesis-driven research/experiment, and (c) designing, executing and reporting science project/ research. More importantly, we were also able to raise

awareness level in students on role and importance of crocodilians as a keystone species in aquatic ecosystems. Follow up conducted after two months of workshop suggested that majority of students had retained most of the knowledge gained during the workshop. They were able to discuss scientific method in their classroom and meetings of eco clubs. Similarly, students were able to advocate and promote crocodilian conservation in their class rooms, eco-clubs and home.

b. Syllabus: We developed a syllabus for this workshop. We believe this syllabus is replicable in any part of the world to include any crocodilian species. Additionally, the syllabus is flexible and can easily be tailored to fit the educational level of the target participants.

We consider our project to be important for two different yet interrelated reasons. First and foremost, our project contributed in capacity-building of high school students from one of the remote areas of Nepal by providing them an opportunity to learn and apply scientific method using crocodilians as models. Secondly, in this learning process students are expected to start appreciating crocodilians and develop positive attitude towards them which is critical to ensure long-term conservation of these globally threatened crocodilians. Based on the feedback on the workshop received from participating students and principals from both schools, this workshop appeared to a simple yet effective approach to build scientific knowledge in students and promote crocodilian conservation.

Acknowledgements

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Zoos

USA

SUCCESSFUL REPRODUCTION OF THE SUNDA GHARIAL (*TOMISTOMA SCHLEGELII*) AT AUDUBON ZOO. Despite being kept by many zoological parks over the past century (Niekisch 2010; Stuebing *et al*. 2015), successful captive reproduction in the Sunda Gharial (*Tomistoma schlegelii*) has been rare, occurring at only a handful of zoological parks and crocodile farms in North America, Europe and Asia (Lilleor *et al*. 1995; Shwedick 2000, 2006; Shwedick and Sommerlad 2000; Whitaker 2000; Sommerlad and Baur 2004; Brazaitis and Abene 2008; Kardon and Muscher 2008; Matthew *et al*. 2010; Anon 2013; Stevenson 2017). As a long-time participant of the Association of Zoos and Aquariums' (AZA) Species Survival Plan for the species, *T. schlegelii* has been a flagship species of Audubon Zoo's Herpetology Department since the species was first acquired in 1986. After experiencing many years of producing non-viable eggs from a single pair of adults (ages unknown, but male and female have been in captivity for at least 45 and 44 years, respectively) maintained outdoors year-round at its reptile house, viable eggs with developing embryos were first received by the zoo in 2010 when one egg hatched prematurely - the hatchling perished in the incubator.

Over the last decade, several husbandry changes were made that are believed to have helped achieve and improve breeding success. Diets were modified to include more whole prey items and less muscle meat, and the male's weight was reduced to help improve fertility and aid with copulation. Additionally, incubation temperatures were increased and the handling of eggs during incubation was reduced. The first successful hatching of the species at Audubon Zoo

occurred in 2014 when two live offspring were produced. Subsequently, one hatching was produced in 2016 and two hatchlings in 2017. Most recently in September 2018, 7 *T. schlegeilii* were hatched from a clutch of 21 eggs, making this the fourth successful hatching event for this species at the zoo and the greatest number of offspring produced there to date.

A total of 21 eggs were laid by the female in a nest mound comprised predominantly of live oak leaf litter on 25 June 2018. The following day, 10 eggs were retrieved by staff and set up for artificial incubation at 32.7°C. Approximately one month later, on 2 August 2018, an additional four eggs were retrieved from the nest and transferred to the same incubator. The remaining seven eggs were left to incubate naturally within the nest. Eggs retrieved from the nest (N= 14) averaged 8.4 cm (range 7.9 to 9.3 cm) in length by 4.9 cm (range 4.5 to 5.7 cm) in width and had an average mass of 165 g (range 140 to 180 g).

Figure 1. First pipped *T. schlegelii* hatchling.

The first egg in the incubator pipped on 18 September 2018 after 84 days of incubation (Fig. 1), followed by an additional four eggs over the next four days. The hatchlings took 1-3 days to emerge from their eggs after pipping, and although all five individuals did show signs of some residual abdominal yolk, the degree of their abdominal distension was substantially less than what had been observed in previous years' offspring. Live hatchlings from these artificially incubated eggs averaged 104 g (100 to 106 g) in weight, 14.3 cm (13.5 to 14.7 cm) snout-vent length (SVL) and 29.8 cm (29.2 to 30.4 cm) total length (TL). Artificially incubated eggs that did not hatch deteriorated and were discarded at various stages throughout incubation, with five of these revealing dead embryos and other signs of development upon dissection.

While excavating the nest on 11 October 2018, to determine the fate of the eggs left to incubate naturally, two live hatchlings were discovered in the exhibit with the adults. These animals were leaner in appearance than their artificially-incubated siblings and did not show any of the same signs of residual abdominal yolk, averaging 100 g in mass (92 to 108 g), 16.0 cm SVL (15.4 to 16.5 cm) and 32.7 cm TL (30.7 to 34.7 cm). Original plans to study the parental behavior of *T. schlegelii* with offspring hatched naturally within the nest were suspended due to increased aggression observed between the male and female that began just days before the hatchlings were discovered on exhibit. All seven offspring were transferred to an off-exhibit enclosure where they are currently being reared together as a group. No aggression between siblings has been observed to date.

Together with recent hatchings at San Antonio Zoo (San Antonio, USA) in 2016, and Crocodiles of the World (Brizenort, UK; Stevenson 2017) and Zoo Miami (Miami, USA) in 2017, successful hatchings of *T. schlegelii* at Audubon Zoo over the past several years represent a continuing trend of successful captive reproduction of this species in zoological parks which follows decades of marginal and inconsistent breeding success. At the institutional level, this recent hatching event represents a marked increase in egg viability and hatch rates. Most notably, this event may represent the first time that *T. schlegelii* eggs have successfully been hatched naturally outside of the species' range states. A more detailed and thorough report describing the history, husbandry and reproduction of *T. schlegeilii* at Audubon Zoo is forthcoming.

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Europe

3RD EUROPEAN CROC NETWORKING MEETING.The 3rd European Croc Networking Meeting was held on 5-7 October 2018 at La Planète des Crocodiles in Civaux, France. With the backdrop of a nuclear power plant and sky walks over crocodile-filled ponds, it was a location to remember. We had 49 participants from 11 countries, representing husbandry, research, fashion and industry, as well as hobbyists and enthusiasts.

Key talks in husbandry covered the first captive Gharials hatched in Europe (Mira Procházka) and the Chinese alligator status in Europe and China (Eddy Even). We followed up with research being conducted by Paris Zoo in French Guiana (Oliver Marquis), PhD work on Gharials in Nepal (Phoebe Griffith), how fossil Gavialids diversified (Polly Russell), and a quick overview of the diversity of crocodilian research (Ashley Pearcy).

The speed dating was unique as always, giving the participants a further opportunity to mingle and exchange ideas. We brought forth opportunities in Europe and around the globe for internships, volunteer and graduate programs. If any of you would like to be added to our ever-growing list, please feel free to contact us.

We also had our first poster session, which we hope will expand. Congratulations again to Cedric Orlando for winning our best student poster on the morphometrics of the inner ear. He made an additional request for inner ears when doing autopsies or dissecting animals. Please email him for the protocol (cedric.orlando@hotmail.fr). We try to promote collaboration wherever possible- your help would be really appreciated.

The 4th European Croc Networking Meeting will be held at the National Reptile Zoo in Kilkenny, Ireland, on 4-6 October 2019! We hope to see you all there!

Ashley Pearcy, Agata Staniewicz and David Oudjani - *The 2018 Organizing Team*.

Submitted Publications

Observations of deep-diving in Nile crocodiles (*Crocodylus niloticus*) in Lake Tanganyika, Tanzania

Over the course of two 10-month filming expeditions to Lake Tanganyika in 1990 and 1992, stationed on the shores of Mahale National Park, Tanzania, the authors observed adult Nile crocodiles (*Crocodylus niloticus*) diving to depths in excess of 30 m, and recorded a tethered juvenile diving to a depth of at least 60 m. On several occasions, white polypropylene net floats used to mark cichlid nest sites were found punctured in the recesses of underwater caves on a boulder slope at depths of 15-25 m. The puncture marks were consistent with bites from 2-4 m long *C. niloticus*.

On at least 3 occasions divers encountered individual Nile crocodiles (3-4 m TL) underwater at Lubugwe, a deep-water inlet where depths of 100 m exist within 30 m of the shore. A crocodile, estimated at 4 m TL, was observed motionless with its head in a small cave at a depth of 15 m on the north side of the inlet. On two subsequent occasions when trying to film crocodiles on the south side of the inlet, 3-4 m long individuals dived actively into deep water and were recorded swimming rapidly down at a depth of 30 m, before divers lost sight of them.

These observations prompted an experiment in which a captive juvenile (0.8 m TL) Nile crocodile was fastened in a lightweight nylon harness, tethered to 25 kg test monofilament line, and released with a maximum recording depth gauge (Oceanic, analogue, 0-200 feet) attached to it, in around 75 m of water (checked with depth sounder) (at 6° 10’ 04.08”S, 29° 44’ 21.92”E). On release the crocodile headed down and then remained motionless for 40 min. It was then retrieved, alive and very active, with the depth gauge indicating a depth attained of at least 60 m - the gauge’s limit.

It is hoped these limited observations will stimulate further study into deep-diving in crocodilians.

Mark Deeble, *Old Coastguards, Gurnards Head, St. Ives, TR26 3DE UK (mark@deeblestone.com)* and Norbert Rottcher, *PO Box 24525, Karen 00502, Kenya (Norbert.Rottcher@gmail.com)*.

Recent Publications

Sun, H., Zuo, X., Sun, L., Yan, P., Zhang, F., Xue, H., Li, E., Zhou, Y., Wu, R. and Wu, X. (2018). Insights into the seasonal adaptive mechanisms of Chinese alligators (*Alligator sinensis*) from transcriptomic analyses. Australian Journal of Zoology (https://doi.org/10.1071/ZO18005).

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

Boukens, B.J.D., Kristensen, D.L., Filogonio, R., Carreira, L.B.T., Sartori, M.R., Abe, A.S., Currie, S., Joyce, W., Conner, J., Opthof, T., Crossley, II, D.A., Wang, T. and Jensen, B. (2018). The electrocardiogram of vertebrates: Evolutionary changes from ectothermy to endothermy. Progress in Biophysics and Molecular Biology (https://doi.org/10.1016/j.pbiomolbio.2018.08.005).

Abstract: The electrocardiogram (ECG) reveals that heart chamber activation and repolarization are much faster in mammals and birds compared to ectothermic vertebrates of similar size. Temperature, however, affects electrophysiology of the heart and most data from ectotherms are determined at body temperatures lower than those of mammals and birds. The present manuscript is a review of the effects of temperature on intervals in the ECG of ectothermic and endothermic vertebrates rather than a hypothesis-testing original research article. However, the conclusions are supported by the inclusion of original data (Iguana iguana, N= 4; *Python regius*, N= 5; *Alligator mississippiensis*, N= 4). Most comparisons were of animals of approximately 1 kg. Compared to mammals and birds, the reptiles at 35-37°C had 4 fold lower heart rates, 2 fold slower atrial and ventricular conduction (longer P- and QRS-wave durations), and 4 fold longer PR intervals (atrioventricular delay) and QT intervals (total ventricular repolarization). We conclude that the faster chamber activation in endotherms cannot be explained by temperature alone. Based on histology, we show that endotherms have a more compact myocardial architecture. In mammals, disorganization of the compact wall by fibrosis associates with conduction slowing and we suggest the compact tissue architecture allows for faster chamber activation. The short cardiac cycle that characterizes mammals and birds, however, is predominantly accommodated by shortening of the atrioventricular delay and the QT interval, which is so long in a 1 kg iguana that it compares to that of an elephant.

Baier, D.B., Garrity, B.M., Moritz, S. and Carney, R.M. (2018). Alligator (*Alligator mississippiensis*) sternal and shoulder girdle mobility increase stride length during high walks. Journal of Experimental Biology (doi: 10.1242/jeb.186791).

Abstract: Crocodilians have played a significant role in evolutionary studies of archosaurs. Given that several major shifts in forelimb function occur within Archosauria, forelimb morphologies of living crocodilians are of particular importance in assessing locomotor evolutionary scenarios. A previous X-ray investigation of walking alligators revealed substantial movement of the shoulder girdle, but since the sternal cartilages do not show up in X-ray, the source of the mobility could not be conclusively determined. Scapulocoracoid movement was interpreted to indicate independent sliding of each coracoid at the sternocoracoid joint; however, rotations of the sternum could also produce similar displacement of the scapulocoracoids. Here, we present new data employing marker-based XROMM (X-ray Reconstruction of Moving Morphology), wherein simultaneous biplanar X-ray video and surgically implanted radio-opaque markers permit precise measurement of the vertebral axis, sternum, and coracoid in walking alligators. We found that movements of the sternum and sternocoracoid joint both contribute to shoulder girdle mobility and stride length, and that the sternocoracoid contribution was less than previously estimated. On average, the joint contributions to stride length (measured with reference to a point on the distal radius, thus excluding wrist motion) are as follows: thoracic vertebral rotation 6.2 ± 3.7%, sternal rotation 11.1 ± 2.5%, sternocoracoid joint 10.1 ± 5.2%, glenohumeral joint 40.1 ± 7.8%, and elbow 31.1 ± 4.2%. To our knowledge this is the first evidence of sternal movement relative to the vertebral column (presumably via rib joints) contributing to stride length in tetrapods.

Young, B.A., Adams, J., Segal, S. and Kondrashova, T. (2018). Hemodynamics of tonic immobility in the American alligator (*Alligator mississippiensis*) identified through Doppler ultrasonography. Journal of Comparative Physiology A, Neuroethology, Sensory, Neural, and Behavioral Physiology (doi: 10.1007/s00359-018-1293-x).

Abstract: American alligators (*Alligator mississippiensis*) held inverted exhibit tonic immobility, combining unresponsiveness with flaccid paralysis. We hypothesize that inverting the alligator causes a gravitationally promoted increase in right aortic blood flowing through the foramen of Panizza, with a concurrent decrease in blood flow through the primary carotid, and thereby of cerebral perfusion. Inverting the alligator results in displacement of the liver, post-pulmonary septum, and the heart. EKG analysis revealed a significant decrease in heart rate following inversion; this decrease was maintained for approximately 45 s after inversion which is in general agreement with the total duration of tonic immobility in alligators (49 s). Doppler ultrasonography revealed that following inversion of the alligator, there was a reversal in direction of blood flow through the foramen of Panizza, and this blood flow had a significant increase in velocity (compared to the foraminal flow in the prone alligator). There was an associated significant decrease in the velocity of blood flow through the primary carotid artery once the alligator was held in the supine position. Tonic immobility in the alligator appears to be a form of vasovagal syncope which arises, in part, from the unique features of the crocodilian heart.

Silliman, B.R., Hughes, B.B., Gaskins, L.C., He, Q., Tinker, M.T., Read, A., Nifong, J. and Stepp, R. (2018). Are the ghosts of nature's past haunting ecology today? Current Biology 28(9): R532-R537.

Abstract: Humans have decimated populations of large-bodied consumers and their functions in most of the world's ecosystems. It is less clear how human activities have affected the diversity of habitats these consumers occupy. Rebounding populations of some predators after conservation provides an opportunity to begin to investigate this question. Recent research shows that following long-term protection, sea otters along the northeast Pacific coast have expanded into estuarine marshes and seagrasses, and alligators on the southeast US coast have expanded into saltwater ecosystems,

habitats presently thought beyond their niche space. There is also evidence that seals have expanded into subtropical climates, mountain lions into grasslands, orangutans into disturbed forests and wolves into coastal marine ecosystems. Historical records, surveys of protected areas and patterns of animals moving into habitats that were former hunting hotspots indicate that - rather than occupying them for the first time - many of these animals are in fact recolonizing ecosystems. Recognizing that many large consumers naturally live and thrive across a greater diversity of ecosystems has implications for setting historical baselines for predator diversity within specific habitats, enhancing the resilience of newly colonized ecosystems and for plans to recover endangered species, as a greater range of habitats is available for large consumers as refugia from climate-induced threats.

Bosco-Lauth, A.M., Hartwig, A.E. and Bowen, R.A. (2018). Reptiles and amphibians as potential reservoir hosts of Chikungunya Virus. The American Journal of Tropical Medicine and Hygiene 98(3): 841-844.

Abstract: Chikungunya virus is an emerging arbovirus of significant human-health concern. Little is known about its sylvatic cycle, including whether ectothermic vertebrates are permissive to infection. In this study, individuals from 10 species of reptiles and amphibians were inoculated with chikungunya virus and samples of blood were tested to characterize viremia and seroconversion. Viremia was not detected in cane toads, house geckos, or American alligators, but most of the green iguanas, red-eared sliders, ball and Burmese pythons, leopard frogs, Texas toads, and garter snakes developed viremia. Peak virus titers in serum of up to 4.5, 4.7 and 5.1 log10 plaque-forming units per milliliter were observed for garter snakes, ball pythons, and Texas toads, respectively. These results add to those of other studies that have suggested a possible role for ectothermic vertebrates in the ecology of arbovirus maintenance and transmission in nature.

Tavalieri, Y.E., Galoppo, G.H., Canesini, G., Truter, J.C., Ramos, J.G., Luque, E.H. and Muñoz-de-Toro, M. (2018). The external genitalia in juvenile *Caiman latirostris* differ in hormone sex determinate-female from temperature sex determinate-female. General and Comparative Endocrinology (https://doi.org/10.1016/j.ygcen.2018.10.003).

Abstract: The broad-snouted caiman (*Caiman latirostris*) is a crocodilian species that inhabits South American wetlands. As in all other crocodilians, the egg incubation temperature during a critical thermo-sensitive window (TSW) determines the sex of the hatchlings, a phenomenon known as temperature-dependent sex determination (TSD). In *C. latirostris*, we have shown that administration of 17-β-estradiol (E2) during the TSW overrides the effect of the male-producing temperature, producing phenotypic females (E2SD-females). Moreover, the administration of E2 during TSW has been proposed as an alternative way to improve the recovery of endangered reptile species, by skewing the population sex ratio to one that favors females. However, the ovaries of E2SD-female caimans differ from those of TSD-females. In crocodilians, the external genitalia (ie clitero-penis structure or phallus) are sexually dimorphic and hormone-sensitive. Despite some morphological descriptions aimed to facilitate sexing, we found no available data on the *C. latirostris* phallus histoarchitecture or hormone dependence. Thus, the aims of this study were: (1) to establish the temporal growth pattern of the phallus in male and female caimans; (2) to evaluate histo-morphological features and the expression of estrogen receptor alpha (ERα) and androgen receptor (AR) in the phallus of male and female pre-pubertal juvenile caimans; and (3) to determine whether the phallus of TSD-females differs from the phallus of E2SD-females. Our results demonstrated sexually dimorphic differences in the size and growth dynamics of the caiman external genitalia, similarities in the shape and spatial distribution of general histo-morphological compartments, and sexually dimorphic differences in innervation, smooth muscle fiber distribution, collagen organization, and ERα and AR expressions. The external genitalia of E2SD-females differed from that of TSD-females in many histological features and in the expression of ERα and AR, resembling patterns described in males. Our results alert on the effects of estrogen agonist exposure during TSW and suggest that caution must be taken regarding the use of E2SD as a procedure for wildlife population management.

Ascari, S.H., Njau, J.K., Sauer, P.E., Polly, P.D. and Peng, Y. (2018). Fossil herbivores and crocodiles as paleoclimatic indicators of environmental shifts from Bed I and Bed II times of the Olduvai Gorge, Tanzania. Palaeogeography, Palaeoclimatology, Palaeoecology (https://doi.org/10.1016/j.palaeo.2018.09.021).

Abstract: The radiation and extinction of East African vertebrate fauna have been linked to key climatic changes that occurred around 2.8, 1.7 and 0.5 Ma. This study tests whether vegetation and diet changes were linked to these climatic fluctuations, focusing on the climatic event at 1.7 Ma, by analyzing the stable isotope composition of fossil herbivore teeth from the Olduvai Gorge's stratigraphic units Upper Bed I, Lower Bed II, and Upper Bed II, which span ~1.83-1.33 Ma, in order to detect shifts in herbivore diets from C3 to C4 plants in conjunction with their drinking water isotope geochemistry. C4 grass expansion is known to be favored by drier conditions, and this study tests whether herbivore diets permanently changed to being C4 dominant at this key time period. Crocodile teeth are also tested to determine if they may be used as paleoclimatic indicators, since large crocodiles prey on terrestrial herbivores in wetland settings. Vertebrate bioapatite carbon and oxygen isotope compositions are found to show similar trends as those of pedogenic carbonates (carbonate nodules, or concretions), which reflect a drying environment that was changing from C3 woodland dominated habitats to mixed woodlands and grasslands from Bed I to Lower Bed II times. While a return to more humid conditions in Upper Bed II might be expected to lead to a reversal to C3 plants, herbivores in this study retained mostly the drought-resistant C4 plant diet. These results indicate that vegetation and ecosystems passed through a threshold to C4 domination that did not revert to C3 despite partial reversals in climate that occurred later. Crocodile teeth were not useful in tracking C4 plant expansion, but the oxygen isotopes from modern crocodiles are able to show seasonal cycles from wet to dry seasons, and Bed I crocodiles indicate a degree of annual seasonal changes during that time as well.

Li, C., Wu, X. and Rufolo, S. (2018). A new crocodyloid (Eusuchia: Crocodylia) from the Upper Cretaceous of China. Cretaceous Research (https://doi.org/10.1016/j.cretres.2018.09.015).

Abstract: *Jiangxisuchus nankangensis* gen. et sp. nov. is described on the basis of a nearly complete skull and mandible from the Upper Cretaceous of China. It is the only representative of the Crocodyloidea truly known in the Cretaceous of China on the basis of a set of cranial features, such as the palatine not extending significantly beyond the anterior end of the suborbital fenestra and the fronto-parietal suture making modest entry into the supratemporal fenestra at maturity. Within the Crocodyloidea, *J. nankangensis* is one of the basal forms and differs from other crocodyloids mainly in the following features: the nasals entering the single external naris; the interfenestral region of the skull roof narrow, about half the width of the interorbital region; the medial margin of the supratemporal fossa rimmed; the squamosal and quadrate entering the dorsal margin of the infratemporal fenestra; the supraoccipital exposed on the skull roof; the maxilla excluded from the large incisive foramen; the palatine shorter than the suborbital fenestra in length; the internal choana divided by a septum; the splenial not entering into the mandibular symphysis; and diastemata present at the premaxillary-maxillary suture, between the seventh and eighth maxillary teeth, and between the ninth and tenth dentary teeth. The

discovery of *J. nankangensis* not only expands the paleogeography of the Crocodylia into Asia during the Cretaceous, but also provides new information for understanding the early history of the group.

Garcia, L.I. (2018). The Mayan gods: An explanation from the structures of thought. Journal of Historical Archaeology & Anthropological Sciences 3(1): 00071.

Abstract: This article explains the existence of the Classic and Post-classic Mayan gods through the cognitive structure through which the Maya perceived and interpreted their world. This structure is none other than that built by every member of the human species during its early ontogenesis to interact with the outer world: the structure of action. When this scheme is applied to the world's interpretation, the phenomena in it and the world as a whole appears as manifestations of a force that lies behind or within all of them and which are perceived similarly to human subjects. This scheme, which finds application in the Mayan worldview, helps to understand the personality and character of figures such as the solar god, the rain god, the sky god, the jaguar god and the gods of Venus. The application of the cognitive schema as driving logic also helps to understand the Maya established relationships between some animals, such as the jaguar and the rattlesnake and the highest deities. The study is part of the pioneering work that seeks to integrate the study of cognition development throughout history to the understanding of the historical and cultural manifestations of our country, especially of the PreHispanic cultures.

Barrientos-Lara, J.I., Alvarado-Ortega, J. and Fernandez, M.S. (2018). The marine crocodile *Maledictosuchus* (Thalattosuchia, Metriorhynchidae) from the Kimmeridgian Deposits of Tlaxiaco, Oaxaca, southern Mexico. Journal of Vertebrate Paleontology (https://doi.org/10.1080/02724634.2018.1478419).

Abstract: Metriorhynchidae is a family of highly specialized, extinct marine crocodylomorphs that inhabited the Paleopacific Ocean and the Tethys Sea during the Jurassic and the Early Cretaceous. Numerous metriorhynchid fossil specimens have been recovered from European and South American localities, but North American records of this family are still scarce. Here, we describe a recently recovered Kimmeridgian metriorhynchid from the Sabinal Formation, Tlaxiaco Basin, Oaxaca, Mexico, that is attributable to the genus *Maledictosuchus*. This genus was known previously from a single species, *M. riclaensis*, from the Middle Jurassic of Spain. The characteristics of this Mexican specimen support its identification as a new species, *Maledictosuchus nuyivijanan*, sp. nov. The two species differ in dental and skull-roof morphology. The frontal of *M. nuyivijanan*, sp. nov., has a wide, rounded anterior end that extends rostrally to the same level of the anterior end of the prefrontal, whereas the frontal of *M. riclaensis* has a narrow anterior end that is located posterior to the anterior end of the prefrontal. Additionally, the teeth of *M. nuyivijanan*, sp. nov., exhibit bicarinated crowns, a smooth labial surface, and a lingual surface ornamented with longitudinal ridges, whereas those of *M. riclaensis* lack carinae and the labial and lingual surfaces are covered with considerably more conspicuous ridges. The North American occurrence of *M. nuyivijanan*, sp. nov., suggests a wider temporal and geographic distribution for the genus *Maledictosuchus* across the Tethys Sea than previously thought: from the Callovian in Europe to the Kimmeridgian in southern North America.

Brackhane, S., Xavier, F.M.E., Gusmao, M. and Fukuda, Y. (2018). Habitat mapping of the Saltwater crocodile (*Crocodylus porosus*) in Timor-Leste. Herpetological Review 49(3): 439-441.

Groffen, J., Van Der Ploeg, J., Telan, S.P. and Van Weerd, M. (2018). *Rhinella marina* (cane toad). Predation by a crocodile. Herpetological Review 49(3): 520-521.

Kiladze, A.B. (2018). Angle of mouth gaping of the Nile crocodile *Crocodylus niloticus* at basking. Biology 9(75): 103-105.

Abstract: One of the aspects of the behavioral thermoregulation of the Nile crocodile *Crocodylus niloticus* Laurenti, 1768 (Crocodylidae, Crocodylia) under the conditions of a crocodile farm in Djerba Explore Park (Djerba Island, Tunisia) was considered. Observation of the basking was carried out for 12 adult individuals on June 3, 2018, in the daytime at an air temperature of +29°C. It was established that the degree of mouth gaping during basking was determined by the angle between the open jaws, which on average was 26 ± 1°, varying from 18° to 32°.

Ren, S., Chen, M., Yang, L. and Liu, Z. (2018). 5-Hydroxytryptamine and Dopamine neurons in the cerebellum of the new-hatching Yangtze Alligator *Alligator sinensis*. The Anatomical Record (doi: 10.1002/ar.23982.).

Abstract: Nissl and immunohistochemical staining methods were used to morphologically characterize the cerebellum of the new-hatching Yangtze alligator, and the cerebellar histological structure and the distribution profiles of 5-hydroxytryptamine (5-HT) and dopamine (DA) neurons were investigated for the first time. The results of cerebellar histological structure showed that there was a ventriculus cerebelli in the cerebellum of the new-hatching Yangtze alligator, the surface of the cerebellar cortex was not very smooth, the cerebellar cortex could be divided into four layers which include external granular layer, molecular layer, Purkinje cell layer and granular layer, Purkinje cell layer could be characterized specially by multilayer, two cerebellar nuclei termed as the nucleus cerebelli lateralis and the nucleus cerebelli medialis were found in the cerebellar medulla. 5-hydroxytryptamine-immunoreactive (5-HT-IR) and dopamine-immunoreactive (DA-IR) neurons and fibers distributed widely in the cerebellum. The structures and profiles of 5-HT-IR and DA-IR neurons and fibers in the cerebellum of the Yangtze alligator were similar to that reported in other reptiles, but also had some specific features. The abundance of 5-HT and DA in cerebellum suggested that these highly conserved neurotransmitters would play important roles in motor control.

Tellez, M. and Boucher, M. (2018). The lessons of history and the future of American crocodile conservation in Belize. Herpetological Review 49(3): 492-498.

Dubansky, B.H. and Dubansky, B.D. (2018). Alligator osteoderm development resembles the pathogenesis of heterotopic ossification. The FASEB Journal 32(1).

Abstract: Adaptive phenotypes that model human disease states are rare. However, such evolutionary model organisms have the potential to be powerful representations of pathologic processes, since they occur independent of laboratory manipulation. It was hypothesized that dermal ectopic bone (osteoderms) produced naturally in the skin of alligators is such an evolutionary model for studying heterotopic ossification (HO), a spectrum of soft tissue mineralization disorders. Indeed, striking similarities between inherited types of HO in humans and the ontogeny of osteoderms in early life stage alligators were identified. Classical histological staining and immunohistochemistry showed that osteoderms develop via intramembranous ossification of the dermis, similar to the inherited HO disorder Progressive Osseous Heteroplasia (POH). Osteoderm development shared other mechanistic similarities with another inherited HO disorder, Fibrodysplasia Ossificans Progressiva (FOP), namely the derivation of osteoblasts from endothelial cell precursors via endothelial-to-mesenchymal transition. A detailed mapping of the morphological, cellular, and genetic overlap between osteoderm development and HO lesion formation is ongoing, and it is predicted that alligators will emerge as a tractable model organism through which to study many different types of HO, both inherited and acquired.

Brooke H. Dubansky, B.H. and Close, M. (2018). A review of alligator and snake skin morphology and histotechnical preparations. Journal of Histotechnology (https://doi.org/10.1080/01478885.2018 .1517856).

Abstract: The anatomy, biochemistry, biomechanics, and evolution of reptile integument have been topics of intense interest in the scientific community for at least two centuries. As such, histological techniques were, and still are, employed to provide a comprehensive understanding of the relationships between tissue structure, function, and the evolution of reptile integument. However, histotechnical preparations of reptile skin present many challenges related to the unique microanatomical configuration of the integument in these animals. Reptilian epidermal scales may be thick and corneous and are often not penetrated well by either processing fluids or embedding media. The reptile dermis is a composite of several different tissue types with a range of biophysical properties creating many problems with tissue processing, sectioning, and staining. Further, lepidosaurs (snakes, lizards, and tuataras) exhibit epidermal modifications associated with the shedding cycle (ie ecdysis) that may also create histotechnical artifacts. Here, this study reviews the general skin morphology from crocodilians (alligators, crocodiles, and gharials) and lepidosaurs. Common difficulties encountered while preparing this organ for histological examination are explained and highlighted, and technical solutions and protocols are provided that mitigate these problems.

Yaney-Keller, A.M. (2018). Using Unmanned Aerial Vehicles (UAVS) and Automatic Camera Traps to Assay Mangrove Estuaries and Tropical Dry Forest on the Pacific Coast of Costa Rica. MSc thesis, Purdue University, Indiana, USA.

Abstract: The northwestern coast of Costa Rica is a landscape defined by a complex mixture of biodiverse habitats, agriculture, urban development, and popular tourist destinations. This rugged coast contains two of the world's most endangered forest types, mangrove estuaries and tropical dry forests. However, many of these important habitats have been degraded or destroyed, and what is left resides largely in national parks or remote places. Due to their small size and ambiguous conservation value, habitats in remote regions often fall to the wayside in conservation planning and management effort, and many basic attributes of these fragmented forests remain unknown. One such region lies to the south of Santa Rosa National Park and north of the Papagayo peninsula,an area of the Gulf of Papagayo best known by its popular local beach, Playa Cabuyal. Sparsely inhabited, this area contains a mixture of pasture land, fragmented tropical dry forest, and two small sized ($\leq$1 km^2) mangrove estuaries. As one of the last sections of north Pacific coast outside of a national park without significant development, gaining basic inventory knowledge of this area is critical for determining base lines about the flora and fauna that persists in this increasingly fragmented region. Rapid biological assessment technologies have become increasingly popular and available to biologists and managers who wish to study biodiversity in remote regions, none more so than unmanned aerial vehicles (UAVs) and automatic camera traps. These two technologies have been adapted for biological assays in the past decade at a rapid pace, and have pushed the boundaries of our understanding of difficult to access habitats and their inhabitants. They present a promising solution to this problem, and so were chosen to determine the mangrove forest structure and terrestrial vertebrate biodiversity of this remote and wild region. A UAV equipped with a commercially available normalized difference vegetation index (NDVI) sensor was used to assess two mangrove estuaries using aerial photography at both 10 cm and 100 cm resolution during both dry and wet seasons. Structural parameters such as mean and maximum canopy height, percent canopy coverage, and species were then compared to field-based 2 measurements on canopy mangrove trees ($\geq$5 cm DBH) from 22 14-m diameter circular plots spread throughout the forests. UAV-derived measurements at both resolutions of plot maximum canopy height and canopy coverage showed no statistical difference from plot measurements. NDVI measurements revealed distinctions between red (*Rhizophora racemosa*) and black (*Avicennia germinans*) mangroves during dry season measurements. Additionally, I used 13 automatic camera traps to assess the terrestrial vertebrate species assemblage over a period of 1498 trap days. Seventy species from 42 families in 27 orders were detected, including several vulnerable and near threatened species such as great curassow (*Crax rubra*), American crocodile (*Crocodylus acutus*) and jaguar (*Panthera onca*). Tropical dry and mangrove forests had the highest avian diversity, while edge habitat had the highest mammalian diversity. Herpetofaunal diversity was greatest in the mangrove habitat. The findings of this study suggest a surprising complexity and wealth of biodiversity within this remote and fragmented region of the Gulf of Papagayo. Overall, these results indicate a need for further study and protection of both the animals and habitats that make up the region.

Von Baczko, M.B. (2018). Rediscovered cranial material of *Venaticosuchus rusconii* enables the first jaw biomechanics in Ornithosuchidae (Archosauria: Pseudosuchia). Ameghiniana 55(4): 365-379.

Abstract: During the Triassic period, pseudosuchians presented a broader variety of feeding habits than those seen nowadays, including herbivorous and omnivorous as well as carnivorous diets. Based on their general anatomy, ornithosuchids have been historically proposed to be either hunters or scavengers. The rediscovered cranial materials of the ornithosuchid *Venaticosuchus* herein described in detail enabled the reconstruction of its jaw musculature and a geometric biomechanical analysis to study the possible feeding habits of ornithosuchids. The muscles were reconstructed based on inferences of their osteological correlates seen in their closest living relatives, such as *Caiman*, *Alligator* and *Iguana*. Consequently, the jaws were considered a third-class lever system and the moment arms were calculated for the adductor and depressor musculature. The study of the three species of ornithosuchids (*Ornithosuchus*, *Venaticosuchus* and *Riojasuchus*) revealed greater similarities between ornithosuchids and aetosaurs, in spite of their different feeding habits, than between ornithosuchids and crocodylians. The relative bite force of *Venaticosuchus* resulted higher than that of other ornithosuchids, aetosaurs and Alligator. The elevated bite force identified for ornithosuchids together with their low bite speed and the morphology of their constricted snouts, suggest features more compatible with scavenging feeding habits. Ornithosuchids were not the apex predators of the Late Triassic continental communities but were more likely regarded to have scavenged or preyed on small animals such as procolophonids, sphenodontians, juvenile aetosaurs, erpetosuchids, cinodonts, and dicynodonts that did not exceed them in size.

Kidder, K., Falconi, R. and Merchant, M. (2018). Characterization of chitotriosidase enzyme activity in the serum of the American alligator (*Alligator mississippiensis*). Advances in Biological Chemistry 8: 81-90.

Abstract: Chitotriosidase (ChT) is an endoglucosaminidase enzyme that cleaves chitinous substrates and has been strongly associated with innate immune activity and the ability to identify non-selftissues. This enzyme activity was detected and characterized the serum from the American alligator (*Alligator mississippiensis*) using a fluorometric probe. Alligator serum exhibited volume-dependent activity, with activity (2.1 $\pm$ 0.3 µmol/min) observed at dilutions as low as a 1:150, and maximum activity (5.2 $\pm$ 0.6 µmol/min) measured at a dilution of 1:30. Alligator serum ChT showed linear activity for approximately 20 min, at which time activity decreased exponentially, presumably due to the depletion of substrate. In addition, the ChT activity in alligator serum was temperature-dependent with low activity at 5˚C, a sharp increase from 10˚C-30˚C, and maximal activity from 30˚C-40˚C. The activity was inhibited in the presence of water-soluble chitin, but not mannan, indicating the specificity of the enzyme. The presence of ChT in alligator serum

is likely to be partially responsible for the potent innate immune system of these crocodylians, and particularly antifungal activities.

Shirley, M.H., Carr, A.N., Nestler, J.H., Vliet, K.A. and Brochu, C.A. (2018). Systematic revision of the living African Slender-snouted crocodiles (*Mecistops* Gray, 1844). Zootaxa 4504(2): 151-193.

Abstract: Molecular and morphological evidence has shown that the African slender-snouted, or sharp-nosed, crocodile *Mecistops cataphractus* (Cuvier, 1824) is comprised of two superficially cryptic species: one endemic to West Africa and the other endemic to Central Africa. Our ability to characterize the two species is compromised by the complicated taxonomic history of the lineage and overlapping ranges of variation in distinguishing morphological features. The name *M. cataphractus* was evidently originally based on West African material, but the holotype is now lost. Although types exist for other names based on the West African form, the name *M. cataphractus* is sufficiently entrenched in the literature, and other names sufficiently obscure, to justify retypification. Here, we designate a neotype for *M. cataphractus* and restrict it to West Africa. We resurrect *M. leptorhynchus* as a valid species from Central Africa and identify exemplary referred specimens that, collectively, overcome the obscurity and diagnostic limits of the extant holotype. We additionally indicate suitable neotype material in the event the holotype is lost, destroyed, or otherwise needing replacement, and we rectify the previously erroneous type locality designation. We provide a revised diagnosis for crown *Mecistops*, and revise and update previous descriptions of the two living species, including providing both more complete descriptions and discussion of diagnostic characters. Finally, we provide considerable discussion of the current state of knowledge of these species' ecology, natural history, and distribution.

Balaguera-Reina, S.A., Venegas-Anaya, M.D., Rivera-Rivera, B., Morales Ramírez, D.A. and Densmore III, L.D. (2018). How to estimate population size in crocodylians? Population ecology of American crocodiles in Coiba Island as study case. Ecosphere (10): e02474.

Abstract: Reliable estimates of crocodylian population size are desirable for both understanding the ecology and natural history of species and developing sound conservation and management plans. However, choosing appropriate methods to estimate population numbers can be difficult due to the paucity of comprehensive analyses regarding their effectiveness, robustness, and applicability. We estimated the American crocodile population size in the southern tip of Coiba Island, Panama, using both spotlight surveys (Messel's and King's visible fraction estimations) and mark-recapture (POPAN formulation-superpopulation) methods. We assessed and compared the outcomes of these methods with the overall capture record for the study area from 2009 to 2013, evaluating their applicability, accuracy, strengths, and limitations. Using historical and current capture data, we defined a minimum population size of ~112 non-hatchling animals in our study area, which was larger than both Messel's (19.00 ± 7.50 individuals) and King's (25.71 ± 7.25 individuals) population size estimates, revealing that these latter approaches clearly underestimate population numbers. We estimated a total population size that range between 147 and 257 individuals based on POPAN formulation grouping the data by sex and age groups as the most plausible population size of the American crocodile population in this area at the time. We analyzed and discussed sources of bias in population size estimations for all methods used in the present study, providing recommendations to minimize errors and improve estimations. Finally, we analyzed and compared population ecology attributes obtained in our study with what have been reported in other insular and coastal areas across the American crocodile range, increasing knowledge about the ecology of the species.

García-Grajales, J. and Buenrostro-Silva, A. (2018). Crocodile attacks in Oaxaca, Mexico: An update of its incidences and consequences for management and conservation. Acta Universitaria (doi: https://doi.org/10.15174/au.2018.1924).

Abstract: Human-crocodile conflicts in Mexico often have a political dimension due to public safety. The aim of this work was to update analyses of the incidence of crocodile attacks on humans in Oaxaca and to identify patterns or trends that could have relevance to future conflict mitigation. We compiled attack records from 2004 to 2017. The highest proportion of attacks (64%) and deaths (12%) occurred on the northwest coast in two periods of the year related with the nesting and rainy seasons. No differences existed between the seasons in the number of crocodile attacks and the mean number of attacks between years. The attacks were related with fishing activity (40%); male victims (92%) were more common than female, and a higher proportion of fatal cases of victims were children (<10 years). We recommended essential baseline surveys and suggested public education about crocodile awareness and risks.

Eme, J., Cooper, C.J., Alvo, A., Vasquez, J., Muhtaseb, S., Rayman, S., Schmoyer, T. and Elsey, R.M. (2018). Scaling of major organs in hatchling female American alligators (*Alligator mississippiensis*). Journal of Experimental Zoology A, Ecology and Integrated Physiology (doi: 10.1002/jez.2236).

Abstract: Allometric equations represent relationships between morphological/physiological traits and body mass $Y = aM^b$, where Y is the trait, a is elevation, b is the exponent describing the shape of the line, and M is body mass. We measured visceral organ masses in hatchling alligators (*Alligator mississippiensis*) from five clutches from approximately 45 to 500 g wet body mass. The interaction between initial egg mass and clutch identity was significant for initial hatchling mass, but only egg mass, not clutch, had a significant effect on initial snout-vent and head length. Kidney and liver mass showed biphasic scaling with body mass, as determined by "breakpoint" analyses, with the breakpoint at 120 g wet body mass. Kidney and liver wet mass showed slopes $b > 1.0$ as animals increased approximately 45-120 g, with significantly lower b approximately 0.8-0.9 for alligators 120-500 g. Within kidney and liver mass, below and above the breakpoint, organ mass slopes tended to be similar across clutches. Lung and heart wet mass did not show biphasic scaling, with b approximately 0.8-0.9. Within lung and heart mass, clutches had statistically identical slopes. Combined clutch data for wet mass showed distinct regressions with $b > 1.4$ for approximately 45-120 g alligators' kidney and liver mass, compared with approximately 120-500 g alligators' kidney, liver, lung, and heart mass $b < 1.0$. Alligators show rapid kidney and liver growth following hatching, with higher rates than lung or heart tissue. Clutch, egg mass, and hatchling size influence organ size, and each factor should be accounted for in future studies exploring reptile morphology and physiology to assess environmental versus clutch contributions.

Voogdt, C.G., Merchant, M.E., Wagenaar, J.A. and van Putten, J.P. (2018). Evolutionary regression and species-specific codon usage of TLR15. Frontiers in Immunology (doi: 10.3389/fimmu.2018.02626).

Abstract: Toll-like receptors (TLRs) form an ancient family of innate immune receptors that detect microbial structures and activate the host immune response. Most subfamilies of TLRs (including TLR3, TLR5 and TLR7) are highly conserved among vertebrate species. In contrast, TLR15, a member of the TLR1 subfamily, appears to be unique to birds and reptiles. We investigated the functional evolution of TLR15. Phylogenetic and synteny analyses revealed putative TLR15 orthologs in bird species, several reptilian species and also in a shark species, pointing to an unprecedented date of origin of TLR15 as well as large scale reciprocal loss of this TLR in most other vertebrates. Cloning and functional analysis of TLR15 of the green anole lizard (*Anolis carolinensis*), saltwater

crocodile (*Crocodylus porosus*), American alligator (*Alligator mississippiensis*) and chicken (*Gallus gallus*) showed for all species TLR15 specific protease-induced activation of NF-κB, despite highly variable TLR15 protein expression levels. The variable TLR15 expression was consistent in both human and reptilian cells and could be attributed to species-specific differences in TLR15 codon usage. The species-specific codon bias was not or barely noted for more evolutionarily conserved TLRs (eg TLR3). Overall, our results indicate that TLR15 originates before the divergence of chondrichthyes fish and tetrapods and that TLR15 of both avian and reptilian species has a conserved function as protease activated receptor. The species-specific codon usage and large scale loss of TLR15 in most vertebrates suggest evolutionary regression of this ancient TLR.

Brocklehurst, R.J., Schachner, E.R. and Sellers, W.I. (2018). Vertebral morphometrics and lung structure in non-avian dinosaurs. Royal Society Open Science 5: 180983.

Abstract: The lung-air sac system of modern birds is unique among vertebrates. However, debate surrounds whether an avian-style lung is restricted to birds or first appeared in their dinosaurian ancestors, as common osteological correlates for the respiratory system offer limited information on the lungs themselves. Here, we shed light on these issues by using axial morphology as a direct osteological correlate of lung structure, and quantifying vertebral shape using geometric morphometrics in birds, crocodilians and a wide range of dinosaurian taxa. Although fully avian lungs were a rather late innovation, we quantitatively show that non-avian dinosaurs and basal dinosauriforms possessed bird-like costovertebral joints and a furrowed thoracic ceiling. This would have immobilized the lung's dorsal surface, a structural prerequisite for a thinned blood-gas barrier and increased gas exchange potential. This could have permitted high levels of aerobic and metabolic activity in dinosaurs, even in the hypoxic conditions of the Mesozoic, contributing to their successful radiation.

Platt, S.G., Elsey, R.M., Rainwater, T.R. and Fredenberg, M. (2018). A critical analysis of a historic size record for the American alligator. Southeastern Naturalist Notes 17(4): N60-N63.

Abstract: We critically evaluated a published historic account purported to be a new size record for *A. mississippiensis* (American alligator). According to a newspaper article published in 1885, this large alligator was killed in Natchitoches, LA, and reportedly measured 823 cm (27 ft) in length and weighed 355.3 kg (783.5 lb). We compared the reported values for total length (TL) and body mass (BM) with those predicted by a growth model describing the allometric relationship between these 2 variables. According to this model, an American alligator with a TL of 823 cm would have a BM of 2534 kg; alternatively, an American alligator weighing 355.3 kg would measure only 432 cm in length. Given these morphometric discrepancies, we are unable to accept this record. The largest credible size record for an American alligator remains an individual measuring 450 cm in length and weighing 458 kg, harvested in Wilcox County, AL, in 2014.

Atigre, R.H. (2018). Crocodiles of river Krishna: impact on agriculture, economy, and the sociology of human population in Sangli, Maharashtra, India. Journal of Threatened Taxa 10(11): 12571-12576.

Abstract: Krishna is one of the main rivers of the Deccan Plateau. It begins its course in the Western Ghats. A large human population relies on the river Krishna for agricultural irrigation, watering livestock (cattle), fishing and other activities. The presence of and attacks by the Mugger crocodile *Crocodylus palustris* on humans and livestock are reported in the Krishna resulted in the formulation of the present research. Data collection comprised on-site observations and field interviews using a structured questionnaire. Attacks were found to occur mostly during winter and summer seasons. During winter, crocodiles bask in the sunlight on river banks and attack in self-defense. The summer season corresponds with their breeding period and attacks occur as the crocodiles protect their nests.

Chen, X., Wei, Q., Wang, J., Peng, F., Li, E., Zhou, Y. and Zhang, S. (2018). Cytochemical patterns of the peripheral blood cells in Chinese alligator (*Alligator sinensis*). Tissue and Cell (https://doi.org/10.1016/j.tice.2018.10.004).

Abstract: The Chinese alligator (*Alligator sinensis*) is an endemic rare crocodilian species in China. In this study, we investigated the cytochemical patterns of peripheral blood cells in Chinese alligators for the first time by a range of cytochemical staining techniques including periodic acid-Schiff (PAS), sudan black B (SBB), peroxidase (POX), alkaline phosphatase (AKP), acid phosphatase (ACP), chloroacetic acid AS-D naphthol esterase (AS-D) and α-naphthol acetate esterase (α-NAE) staining. Erythrocytes were positive for PAS, and negative for all the other staining; heterophils were strongly positive for SBB, POX, ACP, AKP, AS-D and α-NAE, while weakly positive for PAS staining; eosinophils were strongly positive for PAS, POX, AKP, ACP and AS-D, and weakly positive for SBB and α-NAE staining; basophils were strongly positive for PAS, positive for POX, ACP, AKP and α-NAE, and weakly positive for AS-D, while negative for SBB staining; monocytes were weakly positive for PAS, ACP, AKP and α-NAE, while negative for SBB, POX and AS-D staining; lymphocytes were weakly positive for PAS and α-NAE, negative for all the other staining; thrombocytes were weakly positive for PAS, and negative for all the other staining. Our results add up knowledge about Chinese alligator blood cells.

Galligan, T.M., Hale, M.D., McCoy, J.A., Bermudez, D.S., Guillette L.J. Jr. and Parrott, B.B. (2018). Assessing impacts of precocious steroid exposure on thyroid physiology and gene expression patterns in the American alligator (*Alligator mississippiensis*). General and Comparative Endocrinology (doi: 10.1016/j.ygcen.2018.11.002).

Abstract: The thyroid gland is sensitive to steroid hormone signaling, and many thyroid disrupting contaminants also disrupt steroid hormone homeostasis, presenting the possibility that thyroid disruption may occur through altered steroid hormone signaling. To examine this possibility, we studied short-term and persistent impacts of embryonic sex steroid exposure on American alligator thyroid physiology. Alligators from a lake contaminated with endocrine disrupting contaminants (Lake Apopka, FL, USA) have been shown to display characteristics of thyroid and steroid hormone disruption. Previous studies suggest these alterations arise during development and raise the possibility that exposure to maternally deposited contaminants might underlie persistent organizational changes in both thyroid and reproductive function. Thus, this population provides a system to investigate OCP-mediated organizational thyroid disruption in an environmentally-relevant context. We assess the developmental expression of genetic pathways involved in thyroid hormone biosynthesis and find that expression of these genes increases prior to hatching. Further, we show that nuclear steroid hormone receptors are also expressed during this period, indicating the developing thyroid is potentially responsive to steroid hormone signaling. We then explore functional roles of steroid signaling during development on subsequent thyroid function in juvenile alligators. We exposed alligator eggs collected from both Lake Apopka and a reference site to 17β-estradiol and a non-aromatizable androgen during embryonic development, and investigate effects of exposure on hatchling morphometrics and thyroidal gene expression profiles at 5 months of age. Steroid hormone treatment did not impact the timing of hatching or hatchling size. Furthermore, treatment with steroid hormones did not result in detectable impacts on thyroid transcriptional programs, suggesting that precocious or excess estrogen and androgen exposure does not influence immediate or long-term thyroidal physiology.

Mayakkannan, T., Kannan, T.A., Ramesh, G. and Venkatesan, S. (2018). Osteometrical study of sacrum and coccygeal vertebrae in a Marsh crocodile (*Crocodylus palustris*). International Journal of Current Microbiology and Applied Sciences 7(10): 1087-1094.

Abstract: The Marsh crocodile (*Crocodylus palustris*) was one of the three crocodilians species found in India. The present study designed to document the osteometrical details of sacral and coccygeal vertebrae of Marsh crocodile. The bones were prepared from a carcass brought for post-mortem examination. The sacrum and coccygeal vertebrae were 2 and 26 in number respectively. Both the vertebrae were concave on the anterior side and convex on the posterior side of the centrum (Procoelous type). The two sacral vertebrae were separate and typical consisting of a centrum, neural arch and other processes. The expansive ribs of sacral vertebrae formed a robust structure which connects the vertebral column to the pelvic girdle. Among 26 Coccygeal, first 16 were typical and the remaining were atypical vertebrae. Prominent chevron bones were observed up to 11th coccygeal vertebrae attaching to the postero-ventral edges of the centrum. Though the sample size was insufficient, the results of this study provided basic details of sacral and coccygeal vertebrae and helps in understanding the role of axial column in crocodilian locomotion which was functionally different from mammals, even during analogous gaits.

Hoffman, D.K., Heckert, A.B. and Zanno, L.E. (2018). Disparate growth strategies within Aetosauria: Novel histologic data from the aetosaur *Coahomasuchus chathamensis*. The Anatomical Record (https://doi.org/10.1002/ar.24019).

Abstract: Aetosaurs comprise a clade of quadrupedal, armored, omnivores to herbivores that lived across much of the supercontinent of Pangea during the Late Triassic. Their relative abundance in many units, and the rarity of other Triassic herbivores, points to them as key components of Late Triassic ecosystems. Debate persists about whether they were growing more or less slowly when compared to extant crocodylians, and bone histology is sparsely sampled within the group. We undertook a histological examination of *Coahomasuchus chathamensis* in order to address its ontogenetic trajectory and characterize its histology. We sampled a paramedian osteoderm from the holotype specimen, as well as five osteoderms (two paramedian, one lateral, and two of uncertain position) and two incomplete limb bones (radius and fibula), from referred specimens discovered at the type locality. Using these we estimated specimen ages with lines of arrested growth (LAGs) to determine that the study individuals reached from two to seven years old. All of the sampled elements contained woven-fibered bone with extensive vasculature within the internal cortex. In some specimens, more poorly vascularized, parallel-fibered bone is evident externally. The holotype of *C. chathamensis* represents a juvenile individual, and raises the possibility that the holotype of *C. kahleorum* is a juvenile as well, complicating aetosaur systematics and diversity. When compared to aetosaurs of similar size, it is clear that *C. chathamensis* was growing comparatively rapidly, about three times the rate of similarly sized specimens of *Aetosauroides scagliai* from Argentina. This discovery reveals the presence of disparate growth strategies within Aetosauria.

Tankrathok, A., Punpad, A., Kongchaiyapoom, M., Sosiangdi, S., Jangpromma, N., Daduang, S. and Klaynongsruang, S. (2018). Identification of the first *Crocodylus siamensis* cathelicidin gene and RN15 peptide derived from cathelin domain exhibit antibacterial activity. Biotechnology and Applied Biochemistry (https://doi.org/10.1002/bab.1709).

Abstract: Cathelicidins are effector molecules of vertebrate immunity that play vital roles against microbial invasion. They are widely identified in the mammal, but few have been reported in Crocodilians with considered as powerful immune system species. In the present study, we identified and characterized a novel cathelicidin from the blood of Siamese crocodile, *Crocodylus siamensis*. A cDNA sequence (501 base pair (bp)) encodes a predicted 166-residue prepropeptide of *C. siamensis* cathelicidin (Cs-CATH), which comprised of a 21-residue signal peptide, a 109-residue cathelin domain, and a 36-residue mature cathelicidin peptide. The multiple sequence alignment and phylogenetic analysis demonstrated that Cs-CATH shared a high degree of similarity with other crocodylian cathelicidins. Joint consideration of elastase cleavage site, physicochemical properties and predicted secondary structure demonstrated RN15 peptide represents a candidate antimicrobial peptide derived from Cs-CATH. The synthetic RN15 peptide possesses antimicrobial activity against Gram-positive and Gram-negative bacteria. Scanning electron microscopy (SEM) illustrated RN15 peptide induced bacteria cells exhibited morphological change. Besides, RN15 peptide performs low hemolytic activity against human erythrocytes and low cytotoxic activity against normal human dermal fibroblasts (NHDF). This is the first cathelicidin identified from *C. siamensis* and highlighted that its derived peptide from cathelin domain promising potent novel peptide antibiotics templates.

Hernandez-Rangel, S.M., Martinez, J.G., Farias, I.P. and Hrbek, T. (2018). A genomic toolbox for population assignment and monitoring of a conservation dependent Amazonian crocodylian (*Melanosuchus niger*: Alligatoridae: Crocodylia). Pan-American Journal of Aquatic Sciences 13(2): 179-187.

Abstract: We developed a set of 78 SNP markers using ddRADseq, to assign individuals of the black caiman to one of four geographic areas in the Central Amazon. With a simple genotyping protocol, it is possible to assign individuals an area of origin at $p<0.05$. The protocol thusprovides a useful tool for monitoring the geographic origin of individuals and commercialized subproducts.

Garcia Marsà, J., Ferratges Kwekel, F.A., Albalat, D. and Ossó, A. (2018). El cocodril de cala Fonda. Sobre les restes d'un cocodril (Crocodylia: Tomistominae) del Miocè marí de Tarragona. 8: 23-32.

Abstract: On the remains of a crocodile (Crocodylia: Tomistominae) from the Miocene marine of Tarragona. Two crocodile teeth from the Serravallian (Middle Miocene, Camp basin) outcrops of Cala Fonda (Tarragona, Catalonia) are herein described. Finding crocodile remains, mainly teeth, is relatively commonplace even if they are not abundant, in the Miocene marine outcrops of the Camp Basin, as well as in those of the southern of the neighbouring Vallès-Penedès Basin. Nevertheless, no formal description of them has been done hitherto. Only two isolated teeth are herein reported and thus their systematic placement is restricted to subfamily rank, being placed within Tomistominae (Crocodylia). Geological study of the outcrop enables us to better understand the paleoenvironmental context where the fossil remains were recovered and enhances our understanding of the paleobiogeography of those reptiles, thus confirming their pan-Mediterranean distribution.

Rainwater, T.R., Dewhirst, D. Pope, C.P., Murphy, T.M., Platt, S.G., Elsey, R.M. and Wilkinson, P.M. (2018). Bald eagle predation by an American alligator. Journal of Raptor Research 52: 516-518.

Abstract: Full-grown, healthy Bald Eagles (*Haliaeetus leucocephalus*) are rarely susceptible to natural predators. Thus, predation of these large raptors is relatively uncommon. Here, we report the predation of a recently-fledged Bald Eagle by an adult American alligator (*Alligator mississippiensis*) in coastal South Carolina, USA. The few previous reports of raptors in the diet of alligators are based on the discovery of bird remains or leg bands in alligator stomach contents, both of which could be the result of secondary ingestion or scavenging. To our knowledge, this report is the first documented case of predation of a Bald Eagle by an alligator or predation of a raptor by any crocodilian based on direct

observation of the predation event.

Butka, E.G. and Freedberg, S. (2018). Population structure leads to male-biased population sex ratios under environmental sex determination. Evolution (https://doi.org/10.1111/evo.13653).

Abstract: Spatial structure has been shown to favor female-biased sex allocation, but current theory fails to explain male biases seen in many taxa, particularly those with environmental sex determination (ESD). We present a theory and accompanying individual-based simulation model that demonstrates how population structure leads to male-biased population sex ratios under ESD. Our simulations agree with earlier work showing that the high productivity of female-producing habitats creates a net influx of sex-determining alleles into male-producing habitats, causing larger sex ratio biases and lower productivity in male-producing environments (Harts *et al*. 2014). In contrast to previous findings, we show that male-biasing habitats disproportionately impact the global sex ratio, resulting in stable male-biased population sex ratios under ESD. The failure to detect a male bias in earlier work can be attributed to small subpopulation sizes leading to local mate competition, a condition unlikely to be met in most ESD systems. Simulations revealed that consistent male biases are expected over a wide range of population structures, environmental conditions, and genetic architectures of sex determination, with male excesses as large as 30 percent under some conditions. Given the ubiquity of genetic structure in natural populations, we predict that modest, enduring male biased allocation should be common in ESD species, a pattern consistent with reviews of ESD sex ratios.

Mateus, O., Puértolas-Pascual, E. and Callapez, P.M. (2018). A new eusuchian crocodylomorph from the Cenomanian (Late Cretaceous) of Portugal reveals novel implications on the origin of Crocodylia. Zoological Journal of the Linnean Society (https://doi.org/10.1093/zoolinnean/zly064).

Abstract: The fossil record of Eusuchia extends back to the Early Cretaceous (Barremian), with the English species *Hylaeochampsa vectiana* being the oldest known representative of the clade so far. However, the eusuchian record from the Barremian to the Santonian is scarce and fragmentary worldwide. Here we described a new eusuchian crocodylomorph based on a partial skull and lower jaw from the Early Upper Cenomanian of the Tentugal Formation, in the Baixo Mondego region, west-central Portugal. The specimen exhibits a series of characters not seen in other taxa, allowing its assignment to a new genus and species named *Portugalosuchus azenhae* gen. et sp. nov. The results of a cladistic analysis place this specimen within Crocodylia, as the sister taxon to all other non-gavialoid crocodylians. Therefore, this Portuguese specimen represents the only well-documented and valid eusuchian species in the Cenomanian in Europe, and may be the oldest representative of Crocodylia known so far, helping to fill a gap in the fossil record of Eusuchia from the Barremian to the Campanian. In addition, the discovery of this new taxon sheds light on the radiation of Eusuchia and the origin of Crocodylia, which probably took place in Europe.

Young, B.A. and Bierman, H.S. (2018). On the median pharyngeal valve of the American alligator (*Alligator mississippiensis*). Journal of Morphology (https://doi.org/10.1002/jmor.20914).

Abstract: The middle ear cavities of crocodilians have complex connections with the pharyngeal lumen, including lateral and median components which both open into a single chamber located on the dorsal midline of the pharynx. This chamber and the surrounding soft-tissue is herein termed the median pharyngeal valve. In the American alligator (*Alligator mississippiensis*) this valve opens, for a duration of 0.3 s, approximately every 120 s; the patency of the median pharyngeal valve was not influenced by either auditory stimuli or by submersing the alligator underwater. The median pharyngeal valve has an outer capsule of dense connective tissue and fibrocartilage and an inner "plug" of loose connective tissue. These opposing surfaces are lined by respiratory epithelium and separated by a cavity that is continuous with the middle ear cavities and the pharyngeal lumen (through a central opening in the capsule termed the pore). The inner plug of the median pharyngeal valve is contacted by skeletal muscles positioned to serve as both elevators/retractors (which would open the valve) and elevators/protractors (which, in conjunction with gravity, would close the valve). Unlike other vertebrate valve systems, the median pharyngeal valve appears to function as a deformable ball check valve.

Theansungnoen, T., Tastub, P., Jangpromma, N., Yaraksa, N., Temsiripong, T. and Klaynongsruang, S. (2018). Antimicrobial Efficacy of a combination of crocodile (*Crocodylus siamensis*) leukocyte extract and hen egg lysozyme. Chiang Mai J. Sci. 45(2): 797-810.

Abstract: The combination of two or more natural antimicrobial substances is extensively used in clinical therapy. In this context, lysozymes represent an interesting group of naturally antimicrobial proteins, since they were found to display synergistic activity in combination with other antimicrobial substances. Furthermore, studies employing *Crocodylus siamensis* leukocyte extract (cLE) recently revealed the potent antimicrobial properties. However, potential synergistic interactions of cLE with other antimicrobials have not been reported to date. In this work, we were thus interested to investigate the synergy of cLE with hen egg lysozyme (hEL) in more detail. Employing a checkerboard technique, the combination of cLE and hEL *in vitro* showed partial synergy against foodborne *V. cholerae* (clinical isolation) with the fractional inhibitory concentration index (ΣFIC) value of 0.75. At the same concentration, a strong synergistic efficacy of the hEL-cLE combination was observed using time-kill assay. SEM images also suggest that the killing mechanism of the combination involves bacterial cell wall lysis and membrane damages. Additionally, in-vivo toxicity test of the combination in mice was performed. The results show that the hEL-cLE combination at 5 × ΣFIC neither induced significant modulation of most biological parameter levels in mice serum, nor affected the histopathological features of mice livers and kidneys. These observations provide clear evidence that the combination of hEL and cLE is essentially non-toxic and represents a promising target for development in clinical therapy from bacterial infection.

Watanabe, A., Gignac, P.M., Balanoff, A.M., Green, T.L., Kley, N.J. and Norell, M.A. (2018). Are endocasts good proxies for brain size and shape in archosaurs throughout ontogeny? Journal of Anatomy (doi: 10.1111/joa.12918).

Abstract: Cranial endocasts, or the internal molds of the braincase, are a crucial correlate for investigating the neuroanatomy of extinct vertebrates and tracking brain evolution through deep time. Nevertheless, the validity of such studies pivots on the reliability of endocasts as a proxy for brain morphology. Here, we employ microcomputed tomography imaging, including diffusible iodine-based contrast-enhanced CT, and a threedimensional geometric morphometric framework to examine both size and shape differences between brains and endocasts of two exemplar archosaur taxa – the American alligator (*Alligator mississippiensis*) and the domestic chicken (*Gallus gallus*). With ontogenetic sampling, we quantitatively evaluate how endocasts differ from brains and whether this deviation changes during development. We find strong size and shape correlations between brains and endocasts, divergent ontogenetic trends in the brain-to-endocast correspondence between alligators and chickens, and a comparable magnitude between brain–endocast shape differences and intraspecific neuroanatomical variation. The results have important implications for paleoneurological studies in archosaurs. Notably, we demonstrate that the pattern of endocranial shape variation closely reflects brain shape variation. Therefore, analyses of endocranial morphology

are unlikely to generate spurious conclusions about large-scale trends in brain size and shape. To mitigate any artifacts, however, paleoneurological studies should consider the lower brain–endocast correspondence in the hindbrain relative to the forebrain; higher size and shape correspondences in chickens than alligators throughout postnatal ontogeny; artificially 'pedomorphic' shape of endocasts relative to their corresponding brains; and potential biases in both size and shape data due to the lack of control for ontogenetic stages in endocranial sampling.

Finger Jr., J.W., Kelley, M.D., Elsey, R.M. and Mendonça, M.T. (2018). Visual obstruction has no effect on post capture corticosterone levels of juvenile American alligators (*Alligator mississippiensis*). Journal of Herpetology 52(4): 398-401.

Abstract: Anecdotal observations suggest that visual obstruction after capture will calm crocodilians, leading many to hypothesize that eye covering reduces physiological stress. However, this has yet to be tested empirically. To investigate this, we randomly divided 20 juvenile American Alligators (Alligator mississippiensis) into two treatments (visual obstruction [VO] and no obstruction [NO]) and took blood samples immediately after capture (baseline) and 30 min after treatment to determine the effects of visual obstruction on alligator corticosterone (CORT) levels. We found that baseline and post treatment CORT levels were similar between both NO-treated and VO-treated alligators; however, CORT levels were significantly elevated 30 min after capture relative to baseline in both NO and VO alligators. Our results indicate that visual obstruction does not prevent or reduce handling stress after capture in crocodilians and that any observed behavioral alterations are independent of changes in CORT levels.

Milián-García, Y., Russello, M.A., Castellanos-Labarcena, J., Cichon, M., Kumar, V., Espinosa, G., Rossi, N., Mazzotti, F., Hekkala, E., Amato, G. and Janke, A. (2018). Genetic evidence supports a distinct lineage of American crocodile (*Crocodylus acutus*) in the Greater Antilles. PeerJ 6: e5836.

Abstract: Four species of true crocodile (genus *Crocodylus*) have been described from the Americas. Three of these crocodile species exhibit non-overlapping distributions - *Crocodylus intermedius* in South America, *C. moreletii* along the Caribbean coast of Mesoamerica, and *C. rhombifer* confined to Cuba. The fourth, *C. acutus*, is narrowly sympatric with each of the other three species. In this study, we sampled 113 crocodiles across *Crocodylus* populations in Cuba, as well as exemplar populations in Belize and Florida (USA), and sequenced three regions of the mitochondrial genome (D-loop, cytochrome b, cytochrome oxidase I; 3,626 base pair long dataset) that overlapped with published data previously collected from Colombia, Jamaica, and the Cayman Islands. Phylogenetic analyses of these data revealed two, paraphyletic lineages of *C. acutus*. One lineage, found in the continental Americas, is the sister taxon to *C. intermedius*, while the Greater Antillean lineage is most closely related to *C. rhombifer*. In addition to the paraphyly of the two *C. acutus* lineages, we recovered a 5.4% estimate of Tamura-Nei genetic divergence between the Antillean and continental clades. The reconstructed paraphyly, distinct phylogenetic affinities and high genetic divergence between Antillean and continental *C. acutus* populations are consistent with interspecific differentiation within the genus and suggest that the current taxon recognized as *C. acutus* is more likely a complex of cryptic species warranting a reassessment of current taxonomy. Moreover, the inclusion, for the first time, of samples from the western population of the American crocodile in Cuba revealed evidence for continental mtDNA haplotypes in the Antilles, suggesting this area may constitute a transition zone between distinct lineages of *C. acutus*. Further study using nuclear character data is warranted to more fully characterize this cryptic diversity, resolve taxonomic uncertainty, and inform conservation planning in this system.

De Klerk, H.M., Kearns, M. and Redwood, M. (2018). Controversial fashion, ethical concerns and environmentally significant behaviour: The case of the leather industry. International Journal of Retail & Distribution Management (https://doi.org/10.1108/IJRDM-05-2017-0106).

Abstract: Purpose - The purpose of this paper to report on the role of luxury value perceptions and ethical concerns in consumers' environmentally significant behaviour and purchase intent for genuine leather products. Design/methodology/approach - Non-probability sampling was done and 429 South African males and females, aged 26 years and older and who fell in a household income bracket that allowed them to purchase genuine leather products, completed a structured questionnaire during September 2016. Findings - The study determined that South African consumers' strong functional and individual luxury value perceptions drive their above-average purchase intent for genuine leather products. Strong individual value perceptions correlated negatively with their purchase intent. Respondents' expressed strong ethical concerns but almost never participate in environmentally significant behaviour. Research limitations/implications - Findings have implications for the leather industry and retailers and brands who would like to enter the South African luxury leather market. Due to the sampling method, findings can, however, not been generalised to the total population. Practical implications - The leather industry and leather brands should market themselves with the message that the highest pro-environmental and ethical standards have been maintained and that their products should therefore fulfil important individual and functional value perceptions. Originality/value - This study was the first of its kind about the multi-cultural South African leather market's luxury value perceptions, ethical concerns and environmentally significant behaviour.

Brignon, A. (2018). Rediscovery of Georges Cuvier's "crocodile de Sheppey" (*Crocodilus delucii* Gray, 1831) and signification of the "monitor de Sheppey" (London Clay, Ypresian). Annales de Paléontologie 104(4): 329-335.

Abstract: Unpublished drawings made by Georges Cuvier in 1809, while visiting the collection of the Deluc family in Geneva, reveal the vertebrae of the crocodilian and the so-called "monitor lizard" or serpent of Sheppey that Cuvier briefly described in 1824 in the new edition of his Recherches sur les ossemens fossiles (Research on Fossil Bones). The crocodilian cervical vertebra, holotype of *Crocodilus delucii* Gray, 1831, was identified at the Natural History Museum in Geneva, where much of the Deluc collection is preserved. This specimen of historical interest does not make it possible to change the status of the species, which is considered as a *nomen dubium*, in view of the paucity of the diagnostic elements offered by an isolated vertebra. As for the second vertebra, first identified by Cuvier as that of a "monitor lizard", and then as that of a snake, it appears to belong to the marine snake *Palaeophis toliapicus* Owen, 1841. This paper confirms that Cuvier is the first to have reported in a published work the presence of crocodilians and squamates in the London Clay Formation (Ypresian).

Shirley, M.G. and Elsey, R.M. (2018). Alligator production: breeding, egg collection, incubation, and hatching. SRAC Publication - Southern Regional Aquaculture Center 2018 No.0231 pp.6 pp. ref.6.

Abstract: In this publication the authors describes how alligator farmers collect, incubate, and hatch eggs to produce hatchlings. Also included are topics highlighting the history of captive breeding in Louisiana and Florida in the 1970s and 1980s, the concept of alligator ranching, and guidelines on the breeding, nesting, egg laying and collection, incubation and hatching of alligator eggs. Emphasis was also given on mosquito control to reduce the risk of West Nile Virus.

Biggs, M.A., Manfredi, K.R. and Georgi, J.A. (2018). Effects of tail prosthesis mass and length on the kinematics and activity of an American alligator. The FASEB Journal (Abstract Number:643.1).

Abstract: The tail has many functions for an American Alligator (*Alligator mississippiensis*). Previous research demonstrates that adding a prosthetic tail to a tailless alligator improves locomotor performance and restores posture. We experimented on the effects of prosthesis parameters on the kinematics and behavior of an American Alligator whose tail has been reduced to the proximal seven vertebrae. We tested three different prostheses to determine the effects of tail mass and length on behavior and restoration of proper locomotion and pelvic and spinal alignment. Prostheses effects were compared to a control alligator with a tail, and the previous results with a prosthesis. All three prostheses were solid silicone rubber, modeled from digital scans of an actual alligator tail. The first prosthesis tested was of a mass and length designed to restore center of mass to a normal position. This matched the expected 28% of the body mass that makes up the tail in alligators. In the second prosthesis, mass was the same as the first, but prosthesis length was increased 34%. For the third, length was the same as the first, but prosthesis mass was increased 34%. Behavioral data were collected over four different four-week periods, period one with no tail, and each successive period for tails one, two and three. The alligators' number of occurrences for 7 different behaviors were recorded using motion activated video cameras. Statistical behavioral differences between the alligator with the prosthesis and a normal control were noted within these categories: walking and getting into and out of the pond. Statistical differences between the periods for each tail were noted within these categories: tail whipping in period 1 was significantly different than period 4, swimming in period one compared to all other periods, and getting into and out of the pond in period 1 was significantly different than period 2. Locomotion was tested in a biomechanics lab using reflective markers and motion capture cameras. Stride parameters including stride length, stride duration, and duty factor were used to compare kinematic profiles between the control subject and the test subject. Marker position representing important skeletal landmarks were used to measure postural effects. Preliminary results from tail one show a relationship that most closely represents the high walk of the control alligator. Excessive length has a smaller effect on stride parameters. However, due to tail 3 having higher frictional braking forces relating to the higher mass, locomotion was more difficult for the subject and not enough locomotion data were captured to run statistical tests. The results suggest that mass is the more important factor for function than length. This raises questions about why tail length in alligators is fixed, and how abilities such as turning maneuverability with a shorter tail or better swimming with a longer tail may cause a certain tail length to be evolutionarily beneficial.

Furst, N., Gatson, B., Swift, S., Heard, D. and Wellehan, J. (2018). The influence of intramuscular epinephrine on cardiovascular flow patterns in American alligators (*Alligator mississippiensis*) during recovery from isoflurane anesthesia. Veterinary Anaesthesia and Analgesia 45(6): 885.e4-885.e5.

Abstract: Introduction: The mechanism by which epinephrine hastens anesthetic recovery in alligators is unknown. Echocardiography was used to observe alterations in cardiovascular flow patterns following epinephrine administration in isoflurane-anesthetized alligators. Methods: Using a crossover design, 10 alligators (5.7 ± 1.4 kg) were anesthetized with isoflurane in oxygen for 90 minutes. Upon discontinuing isoflurane, alligators were randomly administered either epinephrine (0.1 mg kg^{-1}) or equal volume saline into the triceps muscle. A blinded observer recorded the following times during recovery: return of spontaneous ventilation, return of palpebral reflex, return of withdrawal reflex, reaction to stimulation, spontaneous movement, and extubation that occurred after return of spontaneous ventilation and movement. Echocardiography was performed before anesthetic induction, immediately before discontinuing isoflurane, and following treatment administration. Cardiovascular flow patterns across the Foramen of Panizza, pulmonary outflow tract, and left aortic outflow tract were observed using color flow and spectral Doppler. Following normality evaluation, recovery parameters were analyzed using paired two-tailed t-tests; $p<0.05$ was considered significant. Results: Following epinephrine administration, biphasic flow across the pulmonary artery observed throughout systole prior to treatment was replaced by a single flow wave with a peak in mid-systole. Saline administration caused no change in flow profiles across the pulmonary artery. All recovery parameters occurred significantly faster following intramuscular epinephrine. Conclusion: Biphasic flow across the pulmonary valve during isoflurane anesthesia likely represents closure of the cog wheel valve mid-systole limiting pulmonary outflow. Continuous flow across the pulmonary valve following epinephrine administration suggests reduced pulmonary-to-systemic shunting, allowing faster recovery from isoflurane anesthesia in this species.

Clarac, F. and Quilhac, A. (2018). The crocodylian skull and osteoderms: A functional exaptation to ectothermy? Zoology (https://doi.org/10.1016/j.zool.2018.12.001).

Abstract: The crocodylians are ectothermic semi-aquatic vertebrates which are assessed to have evolved from endothermic terrestrial forms during the Mesozoic. Such a physiological transition should have involved modifications in their cardio-vascular system allowing to increase the heat transfers with the surrounding environment by growing a peripheral vascularization which would be mainly located in the dermal skeleton: the dermatocranium and the osteoderms. In order to assess the implication of these anatomical regions in thermal exchanges, we have recorded the temperature above a set of representative skin areas in order to draw comparisions between the skull, the osteoderms, and the rest of the body parts which present either none or residual dermal ossification. We computed the data after the specimens were successively laid in different stereotyped environmental conditions which involved significant variations in the environmental temperature. Our results show that the osteoderms collect the external heat during the basking periods as they become significantly warmer than the surrounding skin; they further release the heat into the core of the organism as they turn out to be colder than the surrounding skin after a significant cooling period. In disregard of the environmental temperature variations, the skull table (which encloses the braincase) remains warmer than the rest of the cranial regions and shows less temperature variations than the osteoderms; a result which has lead us to think that the braincase temperature is monitored and controlled by a thermoregulatory system. Therefore, as hypothesized by previous others regarding the skull of the crocodylians and of other ectothermic vertebrates such as the squamates, we assume that the crocodylian skull possesses shunting blood pathways which tend to maintain both the braincase and the main sensory organs at the nearest to the optimal physiological temperature depending on the external temperature variations. Concerning the skin vascularization, the study of an albino *Alligator mississippiensis* specimen permitted to observe the repartition of the superficial blood vessels by transparency through the skin. We thus testify that the skin which covers either the skull or the osteoderms is more vascularized than the skin which does not present any subjacent dermal ossification. We consequenly deduce that the significant contrast in the thermal behavior between the dermal skeleton and the rest of the body is indeed correlated with a difference in the relative degree of skin vascularization. This last assessment confirms that the development of the dermal skeleton should have played a functional role in the crocodylian transition from endothermy to ectothermy through the set-up of a peripheral vessel network.

Brandt, LA. (2018). Baseline data on alligator nesting in Arthur R. Marshall Loxahatchee National Wildlife Refuge to inform future monitoring. Journal of Fish and Wildlife Management (doi:10.3996/092017-JFWM-078).

Abstract: Monitoring key ecological attributes helps land managers understand the current state of the resource and decide if management action is necessary. Baseline data on spatial and temporal variability of attributes to be monitored is important for development of successful monitoring programs. In this study, I collected data from 2000-2004 on American alligator *Alligator mississippiensis* nesting in the Arthur R. Marshall Loxahatchee National Wildlife Refuge to determine feasibility of conducting alligator nest surveys and collect baseline data on alligator nesting status and variability. Nest data were used to provide examples of potential monitoring strategies for tracking trends over time or understanding the effects of different hydrologic conditions on alligator nesting. Conducting ground surveys with airboats in Arthur R. Marshall Loxahatchee National Wildlife Refuge proved to be an effective method of finding alligator nests. Number of nests per 1.6 km x 1.6 km (256 ha) plot ranged from 1 to 12, and by year 17 from 28 to 53. Overall, average number of nests per hour ranged from 1.8 ± 0.26 (SE) in 2000 to a low of 0.84 ± 0.08 in 2004. Using data from this study for the six plots sampled each year, and assuming no change in variability, power analysis shows that 10 years of sampling would allow for detection of an annual 10% change in number of nests per hour, with power and level of certainty set equal at 90% (beta and alpha both 0.10). Additionally, 15 years of data would allow for a detection of a 5% change per year. Thirty-seven plots per area would be necessary to assess a 40% difference in number of alligator nests per hour in areas with different hydrologic conditions with power and level of certainty at 90%. These data and analyses, along with examples of monitoring strategies, can be used to guide development of more specific monitoring protocols that address restoration objectives and management actions throughout the Florida Everglades.

Somaweera, R., Brien, M.L.,Platt, S.G., Manolis, C. and Webber, B.L. (2018). Direct and indirect interactions with vegetation shape crocodylian ecology at multiple scales. Freshwater Biology (doi: 10.1111/fwb.132).

Abstract: As one of the world's largest predators of freshwater environments, crocodylians play an important role in shaping their community. In turn, many aspects of crocodylian life histories are influenced and have been shaped by characteristics of their environment, especially vegetation. However, our understanding of just how vegetation impacts crocodylian life histories remains limited, particularly in regard to indirect interactions. Such interactions can be critical for understanding population dynamics and, therefore, for informing conservation management decisions. We reviewed contemporary understanding of these plant–crocodylian interactions in peer-reviewed journals and the grey literature, synthesising life historyshaping dynamics against aspects of their ecology. We then conceptualised how global environmental change, including climate change, species invasions and land use change, may threaten these critical dependencies, and how future conservation plans need to account for these pressures. We identified five primary aspects of crocodylian ecology - habitat selection, nesting ecology, communication, physiology, and feeding ecology- that are probably shaped by vegetation interactions at different spatial scales. These interactions include direct and indirect impacts, with both positive and negative outcomes from a crocodylian perspective. Anthropogenic impacts on environments via global environmental change drivers is causing unprecedented change to vegetation dynamics. What is often overlooked is how these changes impact large aquatic predators such as crocodylians. Our synthesis shows that while many impacts can be identified, their magnitude and mechanism are not well understood, making management driven mitigation challenging. We recommend that future studies prioritise quantifying how vegetation communities shape the suitability of crocodylian nest sites, and how to best detect the fingerprint of impacts caused by invasive alien plants on demographic change in crocodylians over longer durations. An improved understanding of the impact of vegetation impacts on crocodylians is essential for building effective conceptual frameworks and management agendas for the conservation of these iconic reptiles.

Monticelli, P., Ronaldson, H.L., Hutchinson, J.R., Cuff, A.R., d'Ovidio, D. and Adami, C. (2018). Medetomidine-ketamine-sevoflurane anaesthesia in juvenile Nile crocodiles (*Crocodylus niloticus*) undergoing experimental surgery. Vet. Anaesth. Analg. (doi: 10.1016/j.vaa.2018.09.004).

Abstract: OBJECTIVE: To describe the anaesthetic, physiological and side effects of intramuscular (IM) medetomidine and ketamine, followed by inhalational anaesthesia with sevoflurane, in Nile crocodiles (*Crocodylus niloticus*). STUDY DESIGN: Observational trial. ANIMALS: Ten juvenile captive-bred Nile crocodiles undergoing surgical implantation of skeletal beads and muscular electrodes. METHODS: During preanaesthetic examination, the following variables were assessed: heart (HR) and respiratory (fR) rates, and response to palpebral, corneal and toe- and tail-pinch withdrawal reflexes. The crocodiles were injected IM with an initial combination of medetomidine and ketamine and re-evaluated at 5 minute intervals for 20 minutes, or until they appeared unresponsive. If that did not occur, the drugs were redosed according to a decision tree based on the observed effects. The righting, biting and palatal valve reflexes were assessed in the unresponsive crocodiles, and used to confirm anaesthetic induction. Anaesthesia was maintained with sevoflurane in oxygen. At the end of surgery, medetomidine was antagonized with IM atipamezole. RESULTS: The decision tree identified 0.3 mg kg^{-1} medetomidine and 15 mg kg^{-1} ketamine as a useful drug combination, which resulted in anaesthetic induction and surgical anaesthesia 16 ± 8 and 16 (25-20) minutes after injection, respectively. Compared to baseline, HR and fR significantly decreased after anaesthetic induction ($p<0.001$), but then remained stable throughout surgery. Intraoperatively, cloacal temperature [27 (26-30)°C] did not change over time ($p= 0.48$). The total dose of atipamezole was 2 (1-3) mg kg^{-1} and time to recovery was 36 (20-60) minutes. Perioperative complications were not observed. CONCLUSIONS: and clinical relevance Medetomidine and ketamine, injected IM and followed by sevoflurane anaesthesia, may be regarded as a useful anaesthetic technique for juvenile Nile crocodiles undergoing minimally invasive experimental surgery.

Prasad, K.K., Srinivasulu, C., Srinivasulu, A., Rao, G.R.K. and Shivaiah, C. (2018). Reassessment of status and spatial analysis of the distribution of *Crocodylus palustris* in Manjeera Wildlife Sanctuary, Telangana State, India. Herpetological Conservation and Biology 13(3): 569-575.

Abstract: We studied the population status of Marsh crocodiles (*Crocodylus palustris*) in Manjeera Wildlife Sanctuary (MWS), Telangana State, India, and analyzed their size classes, distribution, and conservation status. We conducted 64 night-time spotlight surveys between 2011 and 2017 to estimate the *C. palustris* population in the sanctuary. The density of sighted crocodiles, excluding juveniles in the night-time spotlight survey, varied from 5.50/km^2 to 5.91/km^2. The population of *C. palustris* has grown from 0.41 to 5.4 individuals/km^2 in the sanctuary. Spatial analysis showed the statistically significant locations of high and low values and we discuss threats to the conservation of *C. palustris* to improve management practices in Manjeera Wildlife Sanctuary.

Campos, Z., Muniz, F. and Magnusson, W.E. (2018). Where are the black caimans, *Melanosuchus niger* (Crocodylia: Alligatoridae), in the Xingu River basin, Brazil? Herpetology Notes 11: 1021-1024.

Morgan, G.S., Albury, N.A., Rímoli, R., Lehman, P., Rosenberger, A.L. and Cooke, S.B. (2018). The Cuban crocodile (*Crocodylus rhombifer*) from Late Quaternary underwater cave deposits in the Dominican Republic. American Museum Novitates 3916: 1-56.

Abstract: Late Quaternary fossils representing a locally extinct population of the Cuban crocodile (*Crocodylus rhombifer*) are reported from two underwater caves in the Dominican Republic.

A large fossil sample of *C. rhombifer*, from Oleg's Bat Cave near Bavaro in the southeastern Dominican Republic, consists of four nearly complete skulls, numerous isolated cranial elements and mandibles, and more than 100 postcranial bones representing most of the skeleton. These fossils were collected from a completely submerged portion of the cave at a depth of 11 m and about 100 m from the nearest entrance. A skull, mandibles, and two vertebrae of a Cuban crocodile were also found in a second cave called Ni-Rahu, northeast of Santo Domingo. We identify the fossil crocodile skulls from the Dominican Republic as *C. rhombifer* because they share the following characters with modern skulls of *C. rhombifer* from Cuba (as well as fossil skulls from Cuba, the Bahamas and Cayman Islands): short, broad, and deep rostrum; large orbits; convex nasals along the midline (midrostral boss); prominent swelling on the lacrimals anterior and medial to the orbits; low but obvious ridges extending anteriorly from the lacrimals to the nasals and posteriorly from the lacrimals to the prefrontals and frontals, outlining a distinct diamond- or rhomboid-shaped structure; strongly concave interorbital region and cranial roof; high, narrow ridges on the internal margins of the orbits, extending from the prefrontals to the frontals and posteriorly to the postorbitals; prominent ridges along the lateral margins of the cranial roof on the postorbitals and squamosals, terminating as noticeable protuberances on the posterolateral corners of the squamosals; premaxillary/maxillary suture on the palate essentially horizontal or transverse to the long axis of the skull at the level of the first maxillary tooth; 13 teeth in the maxilla. Certain aspects of the ecology and anatomy of living *C. rhombifer* in Cuba, and carbon isotope data from fossil crocodile bones from both the Dominican Republic and the Bahamas, indicate that the Cuban crocodile is a terrestrially adapted predator. The fossil deposits in Oleg's Bat Cave and other underwater caves in the Dominican Republic lack freshwater vertebrates, such as fish and turtles, but contain abundant samples of hystricognath rodents, small ground sloths, and other terrestrial vertebrates, including large land tortoises, that apparently were the primary prey of the crocodiles. Bats are abundant in the fossil deposits in Oleg's Bat Cave, and may have been an additional food source. Bone collagen from a tibia of *C. rhombifer* from Oleg's Bat Cave yielded an AMS radiocarbon date of 6460 ± 30 ryrBP (equivalent to 7320 to 7430 cal yrBP). The chronology for the local extinction of *C. rhombifer* in Hispaniola is currently unknown, except to document the presence of this species in the eastern Dominican Republic in the early Holocene. Radiocarbon dates and historical records confirm that Cuban crocodiles survived into the period of European colonization (post-1492) in the Bahamas and on Grand Cayman. The only species of crocodile currently found in Hispaniola, the American crocodile (*C. acutus*), occurs in coastal marine habitats and in two inland brackishwater lakes: Lago Enriquillo in the Dominican Republic and the nearby Etang Saumâtre in Haiti. *Crocodylus acutus* has no fossil record in Hispaniola or elsewhere in the West Indies, suggesting that this species may be a very recent (late Holocene) immigrant in the Antillean region. *Crocodylus rhombifer* has one of the most limited geographic ranges of any living crocodylian species, known only from freshwater swamps in south-central Cuba and the Isla de Juventud (Isla de Pinos) off the southwestern coast of Cuba. Locally extinct or extirpated populations of *C. rhombifer* from fossil deposits in the Dominican Republic, Grand Cayman and the Bahamas document a considerably wider distribution for this species during the Late Quaternary.

Effendi, I., Elizal, Rizal, Y., Wiyati, R. and Maryanti, S. (2018). Preliminary study on ecotourism potency of tropical forest and coastal area on PT Diamond Raya Timber concession area, Riau Province. IOP Conference Series: Earth and Environmental Science 216 012046.

Abstract: This preliminary studies aimed to examine potency the area to explore as ecotourism base tropical forest, coastal area, agrotourisme and cuotural tourism. Thestudy indicates that the concession has the potential to be an ecotourism area, which contributes to companies, governments and communities. Tourism objects include 1) tropical forest; Sumatran tiger conservation area, primate habitat area (gibbon, ungko, monkey), bird habitat (hornbill, punai, bayan, magpie, parrots), tropical forest biodiversity, tropical forest bee farming, tropical forest nursery area, traditional forest harvesting method etc. 2) coastal area; biodiversity of mangrove forest, biodiversity of coastal biota, wild crocodile viewing, tourism of fireflies, mangrove forest walk, planting mangrove activities, mangrove nursery, fishing etc. 3) The agroforestry and silvofishery programs of the company will contribute to the ecotourism program. Agroforestry objects include; viewing agrucutural area, planting, harvesting, cooking and eating some tropical fruit. Silvofishery objects are; viewing shrimp and fish pond area, harvesting, cooking and eating shrimp and some fishes. In addition, local culture can be part of the tourism object, among others; culinary tour, art and culture community presentation, and Malay kampong culture.

De Silva, A., Probst, J.M., De Silva, P.D.D.S. and Karunarathna, S. (2018). An incident of a Mugger crocodile (*Crocodylus palustris*) devouring a pangolin (*Manus crassicaudata*). WILDLANKA 6(3): 147-150.

Abstract: Yala National Park is a hotpot for the mugger crocodile (*Crocodylus palustris*) as large numbers of it inhabit the park. The mugger feeds on a variety of animals such as fish, birds, reptiles, chelonians, amphibians, crabs and small to large mammals. We report here the first report of it feeding on a pangolin (*Manus crassicaudata*).

Corrêa Bergamasco, J.J., Magalhães Pereira, R., Rios Rodriguez, J.E. and Fernandes Cabral, B.T. (2018). Thoracic trauma by black caiman's bite in the Amazon region. The Journal of Cardiothoracic Trauma 3(1): 24-26.

Abstract: Alligator attacks are rare, being mostly by accidental causes, for lack of care in regions where the presence of these animals is confirmed or by provocation of them. There are few reports of accidents by these animals. The reported species hereafter is *Melanosuchus niger* from the Amazon rainforest. The patient aged 32 years, coming from the countryside of Amazonas, was admitted to the emergency room 3 days after the accident with black caiman's bite. Alligator attacks of the species *M. niger* are very severe, due to its size around 6 m of length and overwhelming strength, being capable to cause extensive and deep lacerations with its bite. Cases like this are not easy to conduct. Since the injury was on an atypical place, the severity of the symptoms was increased, leading to dyspnea and huge blood loss.

Hassan, R., Aziz, N.F.M., Adzhar, M.A.A.M., Gan, M.I.Z.A., Ahmad, R. and Ung, C.L.M. (2018). A taphonomic study of *Crocodylus porosus* (Crocodylidae) and *Tomistoma schlegelii* (Gavialidae) remains from Western Sarawak, Malaysian Borneo: Applications for public education. Trends in Undergraduate Research 1(1): a23-32.

Abstract: This study documented details of the dentitions, skulls and other skeletal remains of *Crocodylus porosus* and *Tomistoma schlegelii*, from western part of Sarawak, Malaysian Borneo. The remains of both reptiles were exhumed, followed by standard cleaning procedures and then detail morphological assessments were carried out accordingly. Both species show similar structure of vertebral columns, but *T. schlegelii* has the following unique structures: a long and narrower snout, D-shaped eye sockets, long and sharp pointed protruding quadratojugal bones, straight maxillae and dentary, a smooth surfaced skull, elongated triangular suborbital fenestrae, round shaped internal nares and visible supraoccipital from a dorsal view. *Crocodylus porosus* has heterodont dentition with bluntpointed and irregular size of teeth whereas *T. schlegelii* has almost homodont dentition with sharp and similar size teeth. This is the first collection of teeth, skulls and other skeletal remains of both species obtained from Sarawak, and the materials have been

used regularly to educate the public through science exhibitions, hoping they will spark the interests of young budding scientists to be involved in wildlife taphonomic studies in the future.

Sanachan, N. and Boonmee, K. (2018). The successful crocodile farming business in the central of northeastern region. Dhammathas Academic Journal 18(3).

Abstract: This study was aimed to study 1) the operation of croc. farming in the central of northeastern region 2) factors influenced the success of croc. farming in the central of northeastern region 3) present the operation patterns of the successful croc. farming in the central of northeastern region. The statistics used were percentage, mean, Standard Deviation, and Stepwise-Multiple Regression Correlation Coefficient. The results of the study were revealed: 1) all 4 operation aspects as enterpriser characteristics, management resources, business environments, and key success factors of the business were in low level significantly at .05 regardless the research hypothesis 2) key success factors of croc. farming business consisted of 10 out of total 67 factors and 3) the successful croc. farming business pattern in the central of northeastern region was 7S 2T 3P which comprised Sources of funds, Skills/Training, Sewage Collection, Save environment, Support License, Satisfied of Price, Social networks, Technology of Innovation, Technology of Quality, Place, and Policy of Tax.

Kumazawa, Y., Hattori, S. and Taga, Y. (2018). Semi-nondestructive certification of crocodilian leather by LC-MS detection of collagen marker peptides. Analytical Chemistry (doi: 10.1021/acs.analchem.8b05180).

Abstract: Leather produced from crocodile, alligator, and caiman skin is widely used in the fashion industry. Crocodilian leather is generally more expensive than mammalian leather, and the value greatly differs even between the crocodilian species. However, inappropriate labeling of the animal source on leather products sometimes arises from accidental or fraudulent substitution, which is difficult to unambiguously detect by existing methods. In the present study, animal source identification of crocodilian leather was carried out using type I collagen-derived marker peptides generated after dechroming, heat denaturation, and trypsin digestion. Definitive discrimination between the three crocodilian species and also a related species, lizard, was achieved based on the detection patterns of selected six marker peptides, determined by LC-MS. Furthermore, powdering of the leather samples enabled a reduction in the sample amount required and allowed the elimination of the dechroming step. Approximately 100 μg of powder was taken from commercial leather watch straps by filing, resulting in only slight damage to the undersides of the straps. The animal sources of the crocodilian products and also a crocodile-embossed calf product were successfully identified using a combination of the crocodilian marker peptides and previously established mammalian marker peptides. This semi-nondestructive species identification method is not only useful for certification of leather products but also for monitoring of international trade of leather and skin.

Uriona, T.J., Lyon, M. and Farmer, C.G. (2018). Lithophagy prolongs voluntary dives in American alligators (*Alligator mississippiensis*). Integrative Organismal Biology 1(1). (https://doi.org/10.1093/iob/oby008).

Abstract: Many vertebrates ingest stones, but the function of this behavior is not fully understood. We tested the hypothesis that lithophagy increases the duration of voluntary dives in juvenile American alligators (*Alligator mississippiensis*). After ingestion of granite stones equivalent to 2.5% of body weight, the average duration of dives increased by 88% and the maximum duration increased by 117%. These data are consistent with the hypothesis that gastroliths serve to increase specific gravity, and that the animals compensate by increasing lung volume, thereby diving with larger stores of pulmonary oxygen.

Pashchenko, D.I. (2018). A new interpretation of the crocodile forelimb morphological features as adaptation to parasagittal quadrupedal locomotion on the ground. Doklady Biological Sciences 483(1): 235-238.

Abstract: We describe the crocodile forelimb features that distinguish them from other reptiles. Reduction of the clavicle and a change in the coracoid shape seem to be another way of maintaining the efficient step length, while the antebrachium and manus transformations create peculiar oblique manus position on the ground to promote the forelimb parasagittalization.

Zhang, L., Chen, D., Yu, L., Wei, Y., Li, J. and Zhou, C. (2019). Genome-wide analysis of the ovodefensin gene family: Monophyletic origin, independent gene duplication and presence of different selection patterns. Infection, Genetics and Evolution 68: 265-272.

Abstract: Ovodefensins (OvoDs) represent a group of cysteine-rich host defense peptides that are abundant in the egg white. Recent studies have found that ovodefensins are specific to birds and reptiles. However, the entire repertoire and evolutionary relationships of this gene family have not been thoroughly elucidated to date. Following our cross-species and genome-wide computational study, a total of 94 ovodefensin genes with multiple novel cysteine sequence motifs were identified from 22 phylogenetically divergent species. Phylogenetic analysis suggests that a large number of OvoDs evolved by gene duplication after species divergence. Furthermore, the OvoD genes in each species trend to be clustered densely in a syntenic region flanked by the XKR6 and MTMR9 genes, indicating that they are of monophyletic origin and appear to have emerged via independent gene duplication events in snakes, turtles, crocodiles, birds and the green lizard. Furthermore, positive selection sites are located primarily in the mature peptide region of the turtle, lizard and snake OvoD genes. Moreover, the duplicate OvoDAs in birds seem to be maintained in almost identical sequences and functions by strong purifying selection. Genome-wide identification and analyses of the OvoD gene family may greatly improve our understanding of the potential evolutionary relationship scenario of the OvoD gene family. Continued sequence mining and functional studies of OvoDs will be helpful in shedding light on the relationships between OvoDs and other defensin-related gene families.

Pu, W., Guo, G., Yang, N., Li, Q., Yin, F., Wang, P., Zheng, J. and Zeng, J. (2019). Three species of *Aeromonas* (*A. dhakensis*, *A. hydrophila*, and *A. jandaei*) isolated from freshwater crocodiles (*Crocodylus siamensis*) with pneumonia and septicemia. Letters in Applied Microbiology (https://doi.org/10.1111/lam.13112).

Abstract: Hundreds of farmed Siamese crocodiles (*Crocodylus siamensis*) died during July 2016 at a farm in Wenchang, Hainan, China. In two necropsied crocodiles, we observed symptoms of dermatorrhagia, hepatomegaly and hepatic congestion. Pulmonitis was diagnosed by pulmonary congestion and pulmonary fibrinous exudate. Septicaemia was diagnosed by isolation of three *Aeromonas* species from blood and visceral tissues; *A. dhakensis*, *A. hydrophila*, and *A. jandaei* were identified by biochemical and molecular tests. We used a zebrafish model to determine the half-maximal lethal dose (LD_{50}), and *A. dhakensis* was found to be the most virulent species, with an LD_{50} of 8.91×10^5 CFU/ml. The results of a drug sensitivity test indicated that these species were sensitive to 11 antibiotics. This is the first report of *A. dhakensis*, *A. hydrophila* and *A. jandaei* being isolated from a mixed infection in Siamese crocodiles.

Whitaker, N. and Srinivasan, M. (2018). Preliminary observations on deep body temperatures in female Mugger crocodiles (*Crocodylus palustris* Lesson:1831) in a captive facility. International Journal of

Current Microbiology and Applied Science 7(12): 2835-2842.

Abstract: Crocodylians being poikilotherms, are of interest because of their massive sizes, and how they respond to situations where behavioural thermal selection varies. The purpose of this study was to examine Tb trends in *Crocodylus palustris*, with respect to post-feeding, the impact of enclosure maintenance, how visitor numbers affected Tb, and variability within and between animals. The three subject animals comprised a group of 31 crocodiles, held in a natural pond. Hobo TM loggers were used to record deep body temperatures, which were inserted surgically into the peritoneal cavity of ten females. Prior to this, all animals were measured, weighed, and codes recorded. Crocodiles maintained a very narrow regime in temperature chosen, and rainfall did not result in an increase in Tb; minor increases in Tb were observed post-feeding, a decrease in Tb was observed on the Park's day off. A major maintenance activity resulting in elevated Tbs for up to a week in all animals. Despite large deviations in female weight, Tb remained similar. Oscillation in Tb was similar, lower thresholds being at 0700 hrs, and peaking at 1700hrs.

Jiménez López, J. and Mulero-Pázmány, M. (2019). Drones for conservation in protected areas: Present and future. Drones (doi:10.3390/drones3010010).

Abstract: Park managers call for cost-effective and innovative solutions to handle a wide variety of environmental problems that threaten biodiversity in protected areas. Recently, drones have been called upon to revolutionize conservation and hold great potential to evolve and raise better-informed decisions to assist management. Despite great expectations, the benefits that drones could bring to foster effectiveness remain fundamentally unexplored. To address this gap, we performed a literature review about the use of drones in conservation. We selected a total of 256 studies, of which 99 were carried out in protected areas. We classified the studies in five distinct areas of applications: "wildlife monitoring and management"; "ecosystem monitoring"; "law enforcement"; "ecotourism"; and, "environmental management and disaster response". We also identified specific gaps and challenges that would allow for the expansion of critical research or monitoring. Our results support the evidence that drones hold merits to serve conservation actions and reinforce effective management, but multidisciplinary research must resolve the operational and analytical shortcomings that undermine the prospects for drones integration in protected areas.

Acosta, I.C.L., Martins, T.F., Nóbrega, Y.C., Mantovani, T.C., Silva-Soares, T., Santos, M.R.D., Tadokoro, C.E. and Labruna, M.B. (2019). First record of *Amblyomma rotundatum* Koch, 1844 (Acari: Ixodidae) parasitizing wild *Caiman latirostris* (Reptilia: Crocodylidae) in the Atlantic rainforest biome, Southeastern Brazil. Herpetology Notes 12: 9-11.

Deakin J.E. and Ezaz, T. (2019). Understanding the evolution of reptile chromosomes through applications of combined cytogenetics and genomics approaches. Cytogenetic and Genome Research (doi: 10.1159/000495974).

Abstract: Studies of reptile (nonavian reptiles) chromosomes began well over a century ago (1897) with the initial report on the description of sand lizard (*Lacerta agilis*) chromosomes. Since then, chromosome analysis in reptiles has contributed significantly to understanding chromosome evolution in vertebrates. Reptile karyotypes are also unique, as being the only vertebrate group where the majority of the species possess variable numbers of macro- and microchromosomes, which was first reported for iguanids and teiids in 1921. In addition, many reptiles have microchromosomes as sex chromosomes, highlighting their evolutionary significance, yet very little is known about their evolutionary origin and significance in shaping amniote genomes. Advances in genomic technologies in recent years have accelerated our capacity to understand how sequences are arranged within a genome. However, genomic and cytogenetic analyses have been combined for only 3 species to provide a deeper understanding of reptile chromosome evolution and sequence organization. In this review, we highlight how a combined approach of cytogenetic analysis and sequence analysis in reptiles can help us answer fundamental questions of chromosome evolution in reptiles, including evolution of microchromosomes and sex chromosomes.

Holthaus, K.B., Eckhart, L., Valle, L.D. and Alibardi, L. (2019). Review: Evolution and diversification of corneous beta-proteins, the characteristic epidermal proteins of reptiles and birds. Journal of Experimental Zoology Part B: Molecular and Developmental Evolution (https://doi.org/10.1002/jez.b.22840).

Abstract: In all amniotes specialized intermediate filament keratins (IF-keratins), in addition to keratin-associated and corneous proteins form the outermost cornified layer of the epidermis. Only in reptiles and birds (sauropsids) the epidermis of scales, claws, beaks, and feathers, largely comprises small proteins formerly indicated as "beta-keratins" but here identified as corneous beta-proteins (CBPs) to avoid confusion with true keratins. Genes coding for CBPs have evolved within the epidermal differentiation complex (EDC), a locus with no relationship with those of IF-keratins. CBP genes have the same exon–intron structure as EDC genes encoding other corneous proteins of sauropsids and mammals, but they are unique by encoding a peculiar internal amino acid sequence motif beta-sheet region that allows formation of CBP filaments in the epidermis and epidermal appendages of reptiles and birds. In contrast, skin appendages of mammals, like hairs, claws, horns and nails, contain keratin-associated proteins that, like IF-keratin genes, are encoded by genes in loci different from the EDC. Phylogenetic analysis shows that lepidosaurian (lizards and snakes) and nonlepidosaurian (crocodilians, birds, and turtles) CBPs form two separate clades that likely originated after the divergence of these groups of sauropsids in the Permian Period. Clade-specific CBPs evolved to make most of the corneous material of feathers in birds and of the shell in turtles. Based on the recent identification of the complete sets of CBPs in all major phylogenetic clades of sauropsids, this review provides a comprehensive overview of the molecular evolution of CBPs.

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van der Ploeg, J., Ratu, F., Viravira, J., Brien, M., Wood, C., Zama, M., Gomese, C. and Hurutarau, J. (2018). Human-Crocodile Conflict in Solomon Islands. MECDM & WorldFish: Honiara.

Saidykhan, S. (2018). "The Only Good Crocodile is a Dead One": Contradictions in Conservation Policies and Agricultural Activities in the Gambia, 1938 1965. MA thesis, Ohio University, USA.

Abstract: In 1938, the colonial office in Bathurst appointed a forestry management committee to design and implement an aggressive reforestation plan. The committee planted imported tree species and conserved [native] wild bamboo and rhun palm trees. It also created forest and wildlife parks in the colony of Gambia. During this time, the administration's Department of Agriculture initiated several projects: rice and other food grain cultivation for food sufficiency; peanut cultivation to develop a viable cash crop; and exploitation of forest timber products and huntable exotic game. The outcome of this contradiction was stringent conservation policies often with severe consequences for the African residents of the colony. This thesis offers new sources that demonstrate how agricultural activities and resource exploitation undermined conservation, and the colonial conservation policies neglected the local ways of forest and wildlife conservation in the Gambia. It hopes to contribute to the growing environmental scholarship of West Africa most of which neglect conservation. This is a study of forest and wildlife conservation in the Gambia, examining the colonial conservation policies, and how agricultural policies and activities, particularly the introduction of animal drawn-plow, mechanized rice farming, and exportation of wild animal species undermined conservation.

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