

**CROCODILE
SPECIALIST
GROUP
NEWSLETTER**

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COVER PHOTOGRAPH: Approximately 2.5 m long female Mugger crocodile (*Crocodylus palustris*) entering a 4 m long burrow in Riko Kash Rearing Centre, Iran. Photograph: Asghar Mobaraki.

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Editorial

The passing of Don Ashley in June 2016 was reported in the last issue of the Newsletter – an obituary detailing the life of this long-standing and very active CSG member is on pages 4-5. We have also just learned that Dr. Mulji Modha, a leading East African authority on crocodiles, born in Kakira, Uganda, in 1939, passed away on 9 February 2016, in Winnipeg, Canada (<http://www.awaazmagazine.com/volume-13-issue-1/special-feature/item/779-dr-mulji-modha-1939-2016>).

A Crocodile Symposium organized by Dr. Mark Merchant and Professor Wu Xiaobing was held at the 8th World Congress of Herpetology (WCH8; Hangzhou, China, 15-21 August 2016). Prior to WCH8, senior CSG members (Charlie Manolis, Mark Merchant, Paolo Martelli) and members of the CSG Future Leaders Working Group (Matthew Shirley, Marisa Tellez, Pablo Siroski, Alexander Meurer) undertook a study tour of Chinese alligator (*Alligator sinensis*) reintroduction sites and private and government breeding facilities, in Anhui and Zhejiang Provinces. They also held discussions with Chinese authorities on progress with the reintroduction program, and made some recommendations for future activities and collaboration with the CSG (see pages 10-11).

I attended the IUCN World Congress (Hawaii, USA, 1-10 September 2016), along with some 10,000 other individuals, linked in various ways to the IUCN, SSC and other commissions. The Sustainable Use and Livelihoods

Specialist Group was very active, and had organised a series of side events in which both Hank Jenkins and I participated. I gave a formal presentation, entitled “Traceability in Wildlife Trade Chains - Be Careful What You Wish For”. The central point of the talk was that despite various technologies now being available for tracking the origins of various products through various supply chains (often linked to food and human health), investment in traceability in wildlife trade chains ultimately needs to be commensurate with the risks of illegal trade. The universal tagging system adopted by CITES (2000) for crocodylians skins, after a great deal of assistance and consultation from CSG members within and outside industry, has proven remarkably successful for 24 years. Not foolproof, but an effective tool for regulating international trade and for tracking crocodylian skins back to their domestic source, if needed. We could of course develop new and innovative systems, but why do it if the current system is working well? That we have the technology to write our name and address on a grain of rice, does not mean we should do so on every grain of rice in trade. Traceability was also on the agenda of CITES CoP17 (see below). SULI ran a number of “knowledge café” sessions to which we contributed. Two we contributed to were: “Integrating Traditional Knowledge into Species Conservation Status Assessments” and “Conservation, Animal Welfare and Animal Rights: Tensions & Synergies”. Sustainable use still does seem to be in the shadows behind the curtains within the main agendas of IUCN members, but one very solid outcome of the meeting was a commitment to finding a better route through which the voice of indigenous communities could be heard at IUCN meetings.

The CSG was the most represented IUCN Species Specialist Group at the 17th Conference of the Parties to CITES (CoP17; Johannesburg, South Africa, 24 September-4 October 2016), with at least 29 CSG members in attendance, in various capacities (including country delegations). Various members of the Steering Committee were present (Charlie Manolis, Hank Jenkins, Tom Dacey, Christine Lippai, Yoichi Takehara, Asghar Mobaraki, Oswald Braken Tisen, John Caldwell, Steve Broad) and the CSG Future Leaders Working Group (Matthew Shirley, Sally Isberg, Sergio Balaguera-Reina, Adrian Sugiarto, Ranier Manalo). Amendment proposals by Mexico (*Crocodylus moreletii*), Colombia (*C. acutus*) and Malaysia (*C. porosus*) were all approved by consensus, whilst Madagascar’s proposal (*C. niloticus*) was withdrawn, but Nile crocodiles were excluded from the proposed ban on all CITES-listed species from Madagascar (see below). An issue in which the CSG took a particular interest was traceability, and a decision was made to establish a Standing Committee Working Group to advance the issue. The opportunity was taken for many CSG members to meet the new Chair of SSC, Dr. Jon Paul Rodriguez, from Venezuela. A more detailed report on CoP17 is on pages 7-10).

At the 67th meeting of the CITES Standing Committee (SC67; 23 September 2016), Madagascar was facing a total trade suspension on all CITES-listed species, subject to reporting on illegal trade in rosewood. The SC decided to give Madagascar until 31 December 2016 to comply with

Obituary

J. Don Ashley (1948-2016)



reporting obligations, but more importantly, SC67 agreed to exclude *C. niloticus* from any potential trade suspension that may be imposed on trade in all CITES-listed species in early 2017. With respect to trade in captive-bred and ranches *Caiman crocodilus fuscus*, SC67 noted Colombia's report, and its commitment to further reporting at SC69 (late 2017) on overcoming difficulties with illegal ranching and wild harvest of *C. c. fuscus* (see pages 7-8 for more details). This matter was also raised by the EU, when supporting Colombia's downlisting proposal for the *C. acutus* population in Cispatá Bay.

Well known CSG member from Cuba, Roberto "Toby" Ramos-Targarona, retired from Empresa Forestal Integral "Ciénaga de Zapata", in September 2016 after celebrating 42 years of working with crocodiles in the Zapata Swamp. He is one of the "old-hands" in the crocodile world, and I remember sending him a large bundle of crocodile research papers in the 1970s. We wish Toby all the best in his retirement.

At the last CSG working meeting (Skukuza, May 2016), it was reported that a trans-shipping port was being proposed for the Goat Islands in southern Jamaica, and conservation concerns were not being addressed by either the authorities nor the developer. The Jamaican Government has decided not to allow the port to be built at this environmentally sensitive site in the Portland Bight Protected Area. This is good news for Jamaican crocodiles (*C. acutus*) and for other unique species of fauna and flora.

The first World Tomistoma Day was celebrated on 5 August 2016. This was coordinated by Colin Stevenson, Bekky Muscher Hodges, Aubrey Shwedick and Lauren Augustine, under the direction of CSG-Tomistoma Task Force Chair Bruce Shwedick. Congratulations to all involved (see pages 6-7).

Ashley Percy organised the first European Croc Networking Meeting at Crocodiles of the World (Brize Norton, Oxfordshire, UK, 14-16 October 2016). A brief report on this meeting is on pages 17-18.

A conference on Crocodylian Genetics, Morphology and Molecular Sciences is scheduled to be held at the Lake Charles Holiday Inn and Suites, Lake Charles, Louisiana, USA, 8-11 August 2017. A website is being constructed, and should be available shortly.

The 25th CSG Working Meeting will be held in Santa Fe, Argentina, in May 2018. Details will be posted as soon as they become available.

Donations have begun to arrive in response to the annual letters of request sent out in June 2016, and I am personally very grateful to all who have made a contribution, past and present. The support of CSG donors, big and small, is critical to the CSG's ability to operate effectively and sustain itself.

Professor Grahame Webb, *CSG Chair*.

CSG Vice Chairman for the Industry Thematic Group, James Donald Ashley, from Sopchoppy, Florida, USA, passed away on 26 June 2016. He was 68 years of age, and lost his battle with an aggressive cancer. Don was a long-term and highly valued CSG member. He was an ardent wildlife conservationist, and one of the first to articulate the "marsh to market" concept.

Don was born on 15 April 1948 in Orlando, Florida, USA. He was a dedicated family man and is survived by his wife Pamela, sons Brett (Juliet) and Kevin (Aimee) and daughter Jennifer Browning (Bert). He counted his 10 grandchildren as a true blessing. He is also survived by his three brothers - Ronnie, Tommy and Johnny.

Don's love of nature began when he worked for Ross Allen at the Silver Springs attraction in central Florida doing alligator and rattlesnake shows. He attended the University of Florida and went to work for the Florida Game and Fresh Water Fish Commission (GFC) in the early 1970s. Don's interest in wildlife conservation quickly turned to law enforcement, and he became a state wildlife officer. Always on the cutting edge of issues, Don recognized a need in Florida for more rigorous inspections of the hundreds of exhibits, zoos and other captive fish and wildlife enterprises in the state. He developed a wildlife inspection team, made up of law enforcement officers with biological degrees to meet this need. Don's acumen for recognizing needs, developing new programs, and working with agencies and legislators to accomplish those goals was recognized by the GFC and he was quickly promoted up the chain of command until attaining the rank of Major and Assistant Director of Law Enforcement. After moving to Tallahassee, the state capitol, he met his future wife Pamela, who was working a summer job in the radio room while attending Florida State University.

In 1977, the Florida population of the American alligator (*Alligator mississippiensis*) was reclassified from endangered

to threatened on the US Endangered Species Act, and the sale and interstate commerce of farm-raised alligator skins was reinstated. The three permitted alligator farmers in the state sought out Don's services to help them sell skins and open up international trade in alligator skins. At that time, the American alligator was listed on CITES Appendix I, and skins could not be exported to other countries. Don resigned from the GFC and began his alligator industry career as the executive officer for the Florida Alligator Farmers Association.

About the same time Don formed an industry group, the Southeastern Alligator Association, to represent commercial alligator interests in the USA. Don worked with the US Fish and Wildlife Service, the State of Louisiana, and the State of Florida, to submit a proposal to CITES CoP2 (1979) to reclassify alligators from Appendix I to Appendix II. The proposal was successful, despite resistance from some conservation groups concerned about restarting the international trade in alligator skins.

The alligator skin industry in the USA had been shut down for 9 years during the 1970s, and many of the traders, tanneries and manufacturers had been dissolved or had moved to different products. In 1979, it became difficult to sell skins for fair prices due to a dysfunctional distribution chain. The GFC relied on the sale of skins to reimburse nuisance alligator trappers for their services. However, the severely constrained distribution chain limited sales options and prices, creating a management problem in Florida. During the 1980s Ashley Associates represented Louisiana and Florida, as well as various industry groups in efforts to improve the value of alligator products. At the time, many CSG members were concerned about opening up markets again for crocodilian skins and that it would cause a "stimulation of illegal trade".

Don believed, as did alligator program managers in Louisiana and Florida, that providing a steady supply of sustainably harvested crocodilian skins into international markets would "divert trade from illegal to legal sources". This set up the ensuing debate through the 1980s of stimulation of trade versus diversion of trade. By the end of the 1980s, the CSG had itself become a strong supporter of sustainable use, and almost all skins in international trade were legally harvested and traded, thus supporting the diversion of trade premise.

Alligator farming in Florida had been completely closed cycle during the 1970s. In 1981, Don helped develop a research project, supported by the Florida Alligator Farmers Association, the Florida Cooperative Fish and Wildlife Research Unit, and the GFC to develop an alligator ranching program in Florida. This project formed the basis of the Florida alligator ranching program, which went operational in 1988.

Prior to the mid-1980s, the volume of trade in crocodilians was loosely tracked by TRAFFIC and sporadic reports to the CSG from producer countries. Trade volume by species and country of origin were highly debated issues during CITES meetings, usually based on fragmented data. In 1985 Don set up a project, in collaboration with the UNEP-World

Conservation Monitoring Centre, called the International Alligator Crocodile Trade Study (IACTS), to use CITES trade data to more closely monitor trade in crocodilian skins in exporting and importing countries. The IACTS reports have proved invaluable in terms of quantifying changes in international trade in crocodilian skins, for industry, management and research groups, especially the CSG.

Don was a major driving force behind the CITES universal tagging system introduced for crocodilian skins in the late 1980s. At that time, all American alligator skins had to be tagged with tags approved by the US Fish and Wildlife Service before they were exported. This confirmed that they were legal during international commerce. However, legally traded skins from some countries were not required to be tagged and once alligator skins reached their destination, the tags could be removed. It took nearly a decade but CITES finally adopted universal tagging as a resolution at CoP15 in 2000.

Don was appointed to the CSG as a "Corresponding", or non-voting, member of the group in 1989, then became a member and Deputy Vice Chair of the Industry group in 1995. Don proceeded to work with industry (farmers, traders, tanners, manufacturers, etc.) to become more involved in crocodilian conservation issues, with particular emphasis on sustainable use. Don was elevated to Vice Chair of Industry in 2005 and continued to be a tireless proponent for sustainable use and conservation of crocodilians until his death.

Don had a talent for developing effective slogans. One that he developed and is being widely used by the CSG is to ensure that trade is "legal, sustainable, and verifiable". He also created the "Marsh to Market" initiative in Louisiana, supporting economic incentives for rural trappers to wisely use natural resources. He promoted the idea of conservation, community, and commerce in this arena and worked with numerous agencies and groups within the southeastern USA and around the world through the CSG and IUCN to promote sustained use of crocodilians. He tirelessly worked to remove negative airport displays which discouraged use of leather products, and was instrumental in enacting legislation to allow importation of crocodilian hides into the state of California. He often assisted with hosting international delegations for educational session on various aspects of crocodilian management programs.

Don was also active in natural resource conservation at the local level. In the past he served on the Florida Wildlife Federation's Board of Directors and served on the Board of Trustees for the FSU Coastal and Marine Lab. Upon making Franklin County his home in the late 1980s he served on the Riverkeepers Board of Directors as well as the original Franklin County Habitat for Humanity.

The CSG and crocodilian conservation world will miss Don, both as a colleague and a friend.

Allan Woodward, *CSG Regional co-Chair for North America*,
(allan.woodward@myfwc.com).

CSG Student Research Assistance Scheme

The Fritz Huchzermeyer Veterinary Research Student Research Assistance Scheme (FHVS-SRAS; www.iucncsg.org/pages/Veterinary-Science-Grants-English.html) provided funding to one student in October 2016, bringing the total grant approvals for the year to 4.

1. Arvin Jet Marcaida (Philippines): Endoparasitic helminths in *Crocodylus mindorensis* and *Crocodylus porosus* from crocodile farms in the Philippines.

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

World Tomistoma Day

The 5th of August 2016 marked the first World Tomistoma Day [WTD; see CSG Newsletter 34(4): 7]. The aim was simply to raise awareness for Tomistoma (*Tomistoma schlegelii*) - perhaps the least-known of the world's crocodilians. We agree with the oft-used quote of Baba Dioum about people only conserving what they understand, and it is up to us to help people know and understand the value of Tomistoma and its fragile habitats throughout Malaysia and Indonesia.

WTD was coordinated by Colin Stevenson, Bekky Muscher-Hodges, Aubrey Shwedick and Lauren Augustine, under the direction of CSG-Tomistoma Task Force Chair Bruce Shwedick. Around the world, zoos housing this species offered support by hosting events that celebrated Tomistoma, and successfully put the species onto the radar of visitors who had previously never heard of it.

It is one thing to aim to 'educate' zoo visitors about a crocodilian of which most have never heard, quite another to make this a reality. We have been heartened by the efforts of the zoos to get behind this event, and to do so in ways that made sure visitors had fun whilst learning about Tomistoma - whether it was via a feeding demonstration, activities for children, or entertaining talks. Education needs to entertain.

Events were organised across Europe, USA and Asia. As many institutions as possible invited special guests to give talks and presentations, and some highlights were:

- San Antonio Zoo went all out with feeding demonstrations, activities for children, talks, posters, and specially-produced bracelets and Tomistoma-inspired cookies, as well as tables with artefacts and photographs. The San Antonio Chapter of the American Association of Zookeepers kindly provided the fantastic Tomistoma bracelets.
- Smithsonian's National Zoo, Washington DC: the CSG-TTF Chair was the special guest speaker at this event. The day also featured crocodilian capture demonstrations with Kevin Torregrosa, life-size Tomistoma cut-outs so visitors could get an idea of the size of the species, educational activities, and a table that was manned by crocodilian biologists including Bruce Shwedick, Kevin Torregrosa, and Paul Weldon. One fantastic idea here was a 'dig in a Tomistoma nest', where children could dig around a 'nest' and locate Easter eggs filled with prizes.
- Virginia Aquarium: a long-time supporter of the CSG-TTF, the aquarium featured wildlife biologist and conservationist Joe Wasilewski, Tomistoma feeding demonstrations, and a table manned by Chip Harshaw and Mark Swingle to talk about conservation and explain artefacts and information with zoo visitors. A particularly interesting activity was allowing visitors to 'be' a Tomistoma, hunting for fish in fragmented habitat - it gave them an insight into the perils of living in an area degraded by palm oil plantations. Virginia Aquarium also raised over \$US500 on the day for the CSG-TTF.
- St. Augustine Alligator Farm: a table set out artefacts and childrens' handouts, photographic opportunities (with a young Mugger crocodile) with proceeds going to crocodilian conservation, and the Tomistoma enclosure was decked out with fun facts for visitors to learn more about the species.
- Croc Encounters, Tampa: the facility invited guests to learn about Tomistoma via informational posters and presentations, and also encouraged donations to the cause (raising over \$US200 on the day that has been sent to CSG-



TTF). Anyone donating to the CSG-TTF were also able to feed some small crocodylians (under supervision, of course).

- Singapore Zoo: special feedings sessions were hosted, along with keeper talks and promotion via Social Media.
- Crocodiles of the World, UK: special talks were given by Tomistoma expert Agata Staniewicz, activities were provided for visiting children, donations were received via a purpose-built donation station, and perhaps the only Tomistoma cake ever was created by zoo chef Ben!
- Chester Zoo, UK: feeding demonstrations were arranged for the day, along with various educational activities and talks.
- Krokodýlí Zoo, Protovín: CSG-TTF supporter Mira Prochazka created an excellent educational video on Tomistoma that was distributed to other CSG-TTF members for presentation at other zoos. Along with this, the zoo had a special ceremony remembering Ralf Sommerlad (our late colleague whose birth date is the date for WTD), special guided zoo tours, museum, and a photograph gallery of Tomistoma and Lake Mesangat (Kalimantan, Indonesia).
- Dvur Kralove Zoo, Czech Republic: talks by Pavel Moucha in front of the zoo's Tomistoma exhibit, children's activities and Tomistoma feeding sessions were all supported by local radio stations.
- Fuengirola Zoo, Spain: Jesus Recuero, the newest member of the CSG-TTF, is the European studbook keeper for the species, and the zoo arranged several activities in support of World Tomistoma Day.
- Dresden Zoo, Germany: the zoo held special keeper presentations, along with artefacts and children's activities and face-painting.

The consensus from all zoos that took part was that WTD was a success on its first time out, creating a precedent that will be followed up and expanded in 2017. As usual, we learned lessons in preparation times, and are much better-placed to plan next year's activities.

The CSG-TTF wish to thank all the zoos and their staff and special guests who spent time, effort and their own funds on organising and participating in activities for the event. We also wish to invite other zoos to get involved in next year's event. For more information and for images and information on WTD, visit www.crocdag.org.

Colin Stevenson (coleosuchus@hotmail.com), Bekky Muscher-Hodges (muscherhodges@sazoo.org), Aubrey Shwedick (ashwedick@gmail.com) and Lauren Augustine (AugustineL@si.edu).

CITES

The 67th meeting of the CITES Standing Committee (SC67) took place on 23 September, prior to the 17th Meeting of the Parties to CITES (CoP17) on 24 September-5 October 2016, and the 68th SC meeting (SC68) on 5 October 2016, in Johannesburg, South Africa.

A total of 29 CSG members participated at these meetings, as members of Party delegations (Oswald Braken Tisen, Engkamat Lading, Ranier Manolo, Adrian Sugiarto, Heng Sovannara, Asghar Mobaraki, Giovanni Ulloa, Clara Sierra Diez, Yoshio Kaneko, Urbain Belemsobgo, Maheshwar Dhakal, Ratna Kusuma Sari, Jose Alberto Lemus), as visitors, observers or on the IUCN delegation. This included members of the CSG Executive Committee (Grahame Webb, Charlie Manolis, Christine Lippai, Tom Dacey), CSG Steering Committee (Hank Jenkins, Yoichi Takehara, John Caldwell, Steve Broad), CSG Future Leaders Working Group (Matthew Shirley, Sergio Balaguera-Reina, Sally Isberg) and general members (Sukaneo Iida, Gerry Swann, Stefan van As, Buddy Baker, Adriana Rivera).

CITES Standing Committee (SC67) (23 September 2016)

Two agenda items at the 67th meeting of the CITES Standing Committee (SC67) were of specific interest to the CSG.

1. Madagascar

At the 66th meeting of the CITES Standing Committee (SC66; January 2016), concerns were raised on the lack of progress made by Madagascar on the implementation of CITES for species of ebonies (*Diospyros* spp.), rosewoods and palisanders (*Dalbergia* spp.). At SC67 the CITES Secretariat (SC67 Doc. 19.1) recommended that the Parties suspend trade in all specimens of CITES-listed species, including *Crocodylus niloticus*, from Madagascar until various actions had been taken by Madagascar.

During the debate at SC67, the IUCN was asked by the Malagasy delegation to provide comments on its crocodile program. The CSG Chair provided a brief intervention, noting that Madagascar had already endured a 4-year trade suspension (2010-2014) on *C. niloticus*, and that it had since worked with the CSG to restructure its management program. A further trade suspension due to non-compliance with other CITES-listed species would be detrimental to the advances made to date. The USA suggested to SC that *C. niloticus* be excluded in the event that a trade suspension on CITES-listed species was recommended by SC67.

Finally, SC67 gave Madagascar until 31 December 2016 to comply with recommendations with respect to trade in *Diospyros* spp. and *Dalbergia* spp. The SC will then consider Madagascar's progress by postal vote, and take further action should it be considered warranted (ie a recommendation to the Parties to suspend commercial trade in all CITES-listed species, except *C. niloticus*, from Madagascar). The CSG welcomes the decision of SC67 to exclude *C. niloticus* from any trade suspension associated with trade in timber.

2. Colombia

The CITES Management Authority of Colombia reported on "Implementation of the Convention relating to captive-bred and ranched specimens - trade in *Caiman crocodilus*

fuscus skins from Colombia: (SC67 Doc. 16), dealing specifically with:

- a. Regulations and tracking mechanisms for monitoring the export of *C. crocodilus*.
- b. Status of the populations and prospects for establishing a ranching program at pilot sites;
- c. Export quota based on a non-detriment finding for ranching specimens at the pilot sites;
- d. Establishment and implementation of a marking system for ranching specimens;
- e. Clarification of whether national legislation currently prohibits the export of skins above a specified size; and,
- f. If such a prohibition does exist, clarification on whether there are legal measures in place authorizing the confiscation of skins obtained illegally, or, if not, adoption of measures for seizing skins of a size higher than the established limit.

The report was noted by SC67, and Colombia undertook to report further progress at SC69 (tentatively scheduled for December 2017).

17th Conference of the Parties (CoP17) (24 September-4 October 2016)

A number of items relating to crocodylians were dealt with at CoP17, including:

Traceability

Documents 45 (Traceability; Switzerland) and 46 (Pilot testing of a global traceability information system for reptile skins; Mexico): Japan, supported by TRAFFIC, noted that each supply chain had its own unique characteristics and believed it was important to strike a balance between providing a minimum standard of universal guidance and giving Parties the flexibility to deal with specific circumstances. Indonesia asked that it be clarified that they had not yet participated in the pilot projects referred to in Annex 2 of Doc. 46, indicating that it was still in the process of developing a memorandum of understanding with national stakeholders. The EU stressed the importance of assessing the costs to each stakeholder of implementing any systems under test, and of keeping the Animals Committee and Standing Committee informed of progress. GS1 offered to lend its expertise in the area of labelling and traceability.

Following debate, Brazil, Mexico, Switzerland and the Secretariat were assigned as a drafting group to produce a revised proposal for consideration by Committee 2. A revised Draft Decision on Traceability (CoP17 Com. II. 29; see below) was subsequently submitted for consideration, and one minor amendment was made before it was adopted [inclusion of “existing systems and” at 17.DD a) ii)].

“17.AA The Standing Committee shall establish a working group on traceability, which will work in collaboration with the Secretariat to:

- a) recommend a working definition of ‘traceability’ to assist Parties in work related to the implementation of traceability systems;
- b) encourage Parties that are developing traceability systems to ensure they are complementary, mutually supportive and standardized, as appropriate, and that they are adapted to the unique conditions relating to trade in CITES-listed species;
- c) provide general guidance on a mechanism to coordinate and oversee the development of traceability systems using lessons learned from the development of the global CITES permits and certificates system, global information and traceability systems, and other relevant initiatives;
- d) subject to the availability of external resources, and as appropriate, develop and make use of umbrella guidelines, and recommend standards, to develop traceability systems for different species that are mutually supportive and that generate standardized data;
- e) subject to the availability of external resources, analyse examples that describe CITES supply chains, including but not limited to those using Unified Modelling Language, and identify points throughout the supply chain where specimens should be located, verified, and its application defined, bearing in mind a wide range of production systems and life forms;
- f) take into account the work on e-permitting to ensure links between CITES permits and certificates and traceability identifiers;
- g) collaborate with United Nations and other relevant organizations that have experience in the development and use of traceability standards and systems; and,
- h) draft a resolution on traceability, as deemed necessary, to be submitted to the Standing Committee, taking into account any relevant conclusions and recommendations of the report resulting from Decision 17.CC, as appropriate, for consideration at the 18th meeting of the Conference of the Parties.”

The Parties are invited to:

“17.BB Parties are invited to:

- a) support the working group in its work on traceability;
- b) inform the working group on the development of projects and on new information related to traceability in response to the Notification issued by the Secretariat under Decision 17.CC;
- c) adhere, as appropriate, to international standards and norms related to traceability systems in the development of these systems;
- d) use data generated from traceability systems, as appropriate, in activities related to non-detriment findings and monitoring programmes; and
- e) collaborate in the provision of capacity-building programmes that promote South-South and North-South cooperation in the development of traceability systems.”

The Secretariat is directed to:

“17.CC The Secretariat shall issue a Notification, requesting Parties to provide information on the development of projects related to traceability.

17.DD Subject to the availability of external funding, the Secretariat shall:

- a) develop a portal on the CITES website on traceability, to make available:
 - i) recommendations by the working group on a definition of ‘traceability’, general traceability guidelines, and other relevant information;
 - ii) information on new and ongoing projects on traceability, including existing systems and lessons learned;
 - iii) information on global organizations working on traceability standards and systems; and
 - iv) relevant documents, research papers and guidelines on traceability; and,
- b) in collaboration with the Standing Committee working group established under Decision 17.AA and UN/CEFACT, commission a report by a global organization or expert with experience in the development of standards related to traceability, to:
 - i) describe a possible governance model (or models) for use in CITES traceability systems;
 - ii) describe the CITES supply chain using Unified Modelling Language or a similar tool;
 - iii) identify and recommend appropriate information exchange protocols and standards for use in CITES traceability systems;
 - iv) describe a generic CITES traceability standard for use as a common model; and
 - v) report to the Standing Committee on the conclusions of the report.”

Amendment Proposals

Four amendment proposals were considered at CoP17.

1. *Crocodylus acutus* (Colombia): The proposal to transfer the Cispatá Bay population of *C. acutus* from Appendix I to Appendix II was accepted by consensus.
2. *Crocodylus moreletii* (Mexico): The proposal to remove the zero quota on wild specimens of *C. moreletii* was accepted by consensus. Mexico is proposing to develop a ranching program with rural community involvement.
3. *Crocodylus niloticus* (Madagascar): Following consultation with Parties at CoP17, including the European Union (EU), Madagascar amended the annotation on its proposal to provide clarity and to address some of the concerns raised. Following presentation of its proposal, including the new annotation, Madagascar sought the establishment of a drafting group to refine the annotation.

The drafting group, comprising Egypt, EU, USA, CSG, Wildlife Management International and the CITES Secretariat, discussed the annotation, but were unable to reach consensus, mainly due to EU concerns about the “future implementation” of Madagascar’s management program. It appeared that the EU’s concerns did not lie with the annotation, but with future implementation of the program. When the proposal was reintroduced into Committee 1, the EU and USA voiced their concerns about future implementation, and Madagascar withdrew its proposal.

4. *Crocodylus porosus* (Malaysia): Indonesia voiced concerns about the wild harvest in the proposal to transfer *C. porosus* from Appendix I to Appendix II, citing concerns of potential illegal trade in wild crocodiles across the border with Sarawak. Korea initially opposed the proposal, but in the interests of reaching consensus, later supported the proposal. It was accepted by consensus.

Hunting Trophies

CoP17 Docs 39.1 (European Union) and 39.2 (South Africa) were combined as CoP17 Doc. 68, which led to Resolution Conf. 13.7 (Rev. CoP16) *Control of trade in personal and household effects* being modified such that hunting trophies will no longer be exempt from CITES permitting requirements, unless Parties have bilateral written agreements in place.

CITES and Livelihoods

CoP16 (2013) adopted Resolution Conf. 16.61 on CITES and Livelihoods, recognising that the implementation of CITES is better achieved with the engagement of rural communities, especially those which are traditionally dependent on CITES-listed species for their livelihoods.

The Standing Committee in consultation with the Secretariat, prepared CoP17 Doc. 16, reporting on the SC Working Group on this issue.

Rural Communities Committee

Recognising the important role that rural communities play in conservation, Namibia, Tanzania, Zambia and Zimbabwe proposed the establishment of a Rural Communities Committee of the Conference of the Parties (CoP17 Doc. 13; <https://cites.org/sites/default/files/E-CoP17-13.pdf>).

CITES Standing Committee (SC68) (4 October 2016)

SC68 elected Ms. Carolina Caceres (Canada) as the new SC Chair. She had served as Chair of Animals Committee over the last 3 years since CoP16.

SC68 was directed by CoP17 to establish a number of working groups. The Chair sought interest from SC members in heading the different intersessional working groups, so that some preparatory work could begin before SC69 (tentatively set for December 2017), but did not wish to fill the working

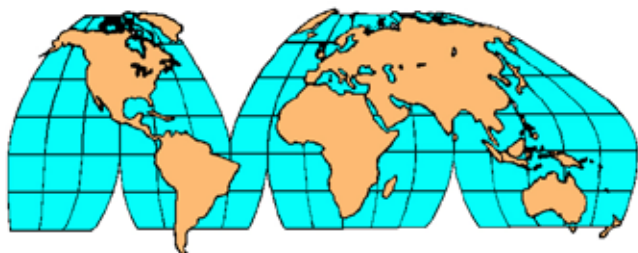
groups as many Parties were not present at SC68. The Working Group on Traceability will be co-chaired by Switzerland and Mexico.

Crocodile Farm Visit

On one of the free days, a group of CSG members was invited by Stefan van As to visit his farm (Le Croc - Crocodile Breeding Farm and Tannery), around 2 hours from Johannesburg. We are very grateful to Stefan for his hospitality, for the opportunity to see his marvellous facilities, and to meet with him and some of his key staff.

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

Regional Reports



East and Southeast Asia

China

At the 1st East-Southeast Asia CSG Regional Meeting in Cambodia (May 2015), Dr. Mark Merchant was approached by Prof. Wu Xiaobing (Anhui Normal University, China) to co-chair a crocodylian symposium at the 8th World Congress of Herpetology (WCH8; Hangzhou, China, 15-20 August 2016). Participation at WCH8 was an opportunity for CSG to visit breeding facilities and reintroduction sites for the Chinese alligator (*Alligator sinensis*) in Anhui and Zhejiang Provinces, and obtain an update on progress with the Chinese Alligator Action Plan (launched in 2002). A visit was also considered an opportunity to introduce some members of the CSG Future Leaders Working Group (CSG-FLWG) to China and the Chinese alligator program.

The CSG team comprised senior members (Charlie Manolis, Mark Merchant, Paolo Martelli) and CSG-FLWG members (Matthew Shirley, Marisa Tellez, Pablo Siroski, Alexander Meurer). Only Charlie Manolis had ever visited Anhui and Zhejiang Provinces (2001, 2005) and had first-hand experience with the Chinese alligator program and the key institutions and personnel involved.

Prof. Wu and some of his staff and postgraduate students accompanied the CSG team in both Anhui and Zhejiang Provinces, and Prof. Fang Shengguo and two of his postgraduate students from Zhejiang University joined the team in Zhejiang Province. Dr. Jiang Hongxing [State Forestry Administration (SFA), Beijing] joined the team in Wuhu. The following sites were visited prior to WCH8:

- Anhui Normal University (Wuhu, Anhui Province), where

the team was introduced to students and researchers working with Chinese alligators.

- Dajiang Alligator Farm (Wuhu, Anhui Province): currently holds around 5000 alligators, and is one of two privately-owned alligator farms (the other, Tangshan Alligator Farm, is in Nanjing, and reportedly holds 2000 alligators).
- Gaojinmiao Forestry Farm (Anhui Province), the main site for reintroduction of alligators in Anhui Province. Sixteen artificial breeding pens, holding around 455 adult alligators, have been constructed, and these stock are available for future reintroduction into restored wetlands.

Since 2006, 50 ponds (30 ha total water area) have been constructed within GFF. Planning has involved considerable scientific input to ensure wetlands have the highest probability of sustaining released alligators. Another 30 ponds are to be constructed in GFF in the near future.

Since 2006 there have been 11 releases (usually in May-June), involving a total of 93 animals (sex ratio of 1M:2F). The latest release was 18 alligators in May 2016. Some released alligators were tracked in 2006 and 2012 using radio-telemetry, and movement between ponds is known to occur. The first successful nesting was recorded in 2008, and since then 8 nests have been identified. Thick vegetation makes locating nests difficult, and the full extent of nesting to date is unknown.

The latest spotlight survey, carried out in 2015, confirmed alligators were distributed among 28 of the 50 ponds, and recruitment (ie hatchlings were sighted). Survivorship of released alligators is thought to be >85%, but no specific recapture or re-sight efforts have been carried out to verify this.

- Anhui Research Centre for Chinese Alligator Reproduction (Xuancheng, Anhui Province), the largest alligator facility in China, has served as the administrative centre for alligator management in Anhui Province since 1979. The captive alligator population has increased from around 10,000 individuals in 2006 to around 15,000 in 2016. ARCCAR relies on tourism as the main source of income, and receives around 100,000 visitors per year.
- Changxing Chinese Alligator Nature Reserve (Changxing, Zhejiang Province). Alligators are considered to be extinct in Zhejiang Province, and no suitable reintroduction sites have been identified. CCANR comprises the original breeding and rearing centre (10.5 ha; 5000 alligators) that was established in 1979, and a wetland area (22.9 ha; 500 adult alligators) that was constructed in 2007-2012. Alligators in the wetland are not fed, but sustain themselves within the restored habitat. Nesting was first recorded in 2014. Tourism is an integral part of the facility, and it receives around 80,000 visitors per year.

The team discussed options through which the CSG could

assist China with the Chinese alligator program, including:

- a. Support and help organize training workshops in crocodylian survey, capture and other techniques (eg stomach flushing, sampling for genetic and isotope analysis) for university, forestry and farm personnel.
- b. Workshop on crocodylian health assessment.
- c. The CSG-FLWG offered to assist Chinese students by reviewing draft manuscripts prior to submission to journals, to ensure that English expression does not become a negative factor in the review process.
- d. Participation at international meetings.
- e. Communication with researchers outside China could assist Chinese researchers to understand and explore new avenues of research, etc.
- f. The reintroduction program could be a little “bolder” with regard to the numbers of alligators being released. Reintroductions to date have generally involved low numbers of alligators being released at any one time, which may be appropriate in areas where habitat is limited or being restored over time, but other areas with considerable habitat have been identified (eg Wuchang Lake, Long Gan Lake), and there is an opportunity to potentially increase the wild population substantially over a much shorter timeframe. With the captive population now comprising some 28,000 alligators, the availability of animals for release is not a limiting factor. Experience from other release sites (eg Dongtan Wetland Park, Hongxing Reservoir, GFF) indicate that released alligators can become established and successfully breed in the wild.
- g. ARCCAR and CCANR provide forums for public education, but a more formal public education campaign could be implemented, with specific goals to change public perceptions and strengthen community involvement. The CSG’s Public Education and Community Participation group may be able to assist Chinese authorities with efforts to improve public education and increase community participation in the conservation of the remaining wild population in ANNRCA, but also in those areas where alligators have been reintroduced.
- h. ARCCAR and CCANR hold over 70% of the alligators held in captivity, and both are supported financially through tourism. The maintenance of large numbers of alligators in captivity requires ongoing financial support, and was one of the reasons why ARCCAR was registered as a CITES captive breeding operation in 1993, and CCANR in 2002, to provide options for producing income to support their conservation activities. Although neither facility has pursued the export of live animals (pets) or other products, the option is nonetheless still available.

The number of captive alligators in China has increased

significantly in recent years, with some 28,000 alligators currently held, mainly in government facilities (20,000) and privately-owned farms (7000). However, the status of the only natural wild population in the Anhui National Nature Reserve for Chinese Alligator (ANNRCA) has not improved over the last 5 years, and is currently estimated to comprise a population of 120-150 individuals.

The availability and quality of existing habitat appears to be a major constraint to establishing “new” wild populations through the reintroduction program. Although monitoring suggests a relatively high rate of survival of released animals, successful nesting, and some recruitment, no attempts have been made to capture any of the released alligators or recruits in order to: assess growth rates, body condition and diet; confirm survivorship; and, quantify the proportion of alligators in the population that are sighted during surveys. It is recommended that serious consideration be given to quantifying these additional indices of the reintroduced population (and habitat) that are critical to assessing the success of the reintroduction program.

The CSG acknowledges the significant progress made with the Chinese alligator reintroduction program, but urge authorities to “fast-track” the inclusion of other potential release sites into the program. Authorities are also urged to consider larger numbers of alligators for release at sites with substantial habitat, especially in view of the status of the wild alligator population in ANNRCA.

The visit was an important learning experience for CSG-FLWG members, and is expected to lead to long-term working relationships with Chinese students and researchers. Participation at WCH8 also provided the team with an opportunity to present their work in an international forum, and to meet with other researchers and managers working with reptiles and amphibians around the world.

The full report (CSG Visit to China, August 2016) is available on the CSG website (<http://www.iucncsg.org/pages/Publications.html>).

Charlie Manolis, *CSG Deputy Chair* (cmanolis@wmi.com.au).

REPRODUCTION IN A REINTRODUCED POPULATION OF CHINESE ALLIGATORS. The Chinese alligator (*Alligator sinensis*) is considered the most critically endangered crocodylian in the world (Xing 2010). Fewer than 150 Chinese alligators survive in the wild, and these occur in small populations at widely scattered sites; the largest population at any particular site numbers no more than 20 individuals and contains <10 adults (Thorbjarnarson and Wang 1999; Thorbjarnarson *et al.* 2002; Thorbjarnarson and Wang 2010). In contrast to the tenuous conservation status of wild populations, *ex-situ* propagation has proven remarkably successful and thousands of alligators (>14,000 in 2015; Lu Shunqing, unpubl. data) are now maintained at two Government-operated conservation-breeding centers

in China (Thorbjarnarson and Wang 2010; Platt 2012). An action plan prepared in 2001 by Chinese and international scientists strongly recommended that new wild populations be established by releasing captive-bred *A. sinensis* into suitable, but unoccupied habitat (Jiang *et al.* 2006). To this end, a trial release of 6 adult Chinese alligators (2M:4F) was conducted at Dongtan Wetland Park (DWP) on Chongming Island in June 2007 (Thorbjarnarson and Wang 2010; Platt 2012; Lu *et al.* 2014). DWP is a popular outdoor recreation area located on the outskirts of Shanghai encompassing 860 ha of restored freshwater marsh (described in greater detail by Lu *et al.* 2014). Thorbjarnarson and Wang (2010) considered DWP the most important site for alligator conservation in China.

Two of the released alligators (1M:1F) drowned in submerged crab nets shortly after being liberated, and another adult female succumbed to unknown causes in late 2009. Follow-up surveys conducted during 2014-15 found at least 9 alligators (three adults, two sub-adults, and four large juveniles) inhabiting DWP (Lu *et al.* 2014). Two cohorts of smaller alligators were present in DWP, the result of nesting that occurred in 2008 and again in 2012 (Lu *et al.* 2014). A third nesting event occurred in July 2014, although these eggs failed to hatch due to unfavorable incubation conditions resulting from unseasonably low air temperatures and heavy rainfall (Platt *et al.* unpubl. data). Here we report the release of an additional group of adult alligators at DWP during 2015-16, and describe nesting activity among the reintroduced population.

Second Chinese alligator reintroduction (2015)

Six adult Chinese alligators (2M:4F) aged 5-7-years-old were obtained by DWP from breeding centers in China and released into an acclimation pen in mid-June 2015. The acclimation pen encompasses 24,000 m² of marsh and open water surrounded by a heavy gauge wire fence (Fig. 1). The base of the fence is buried ca. 0.5 m belowground to prevent alligators from digging out. A large island (5000 m²) centrally located in the pen provides nesting habitat and burrowing substrate for the alligators. The initial plan called for the alligators to be confined for 1-2 years before being released. Pre-release confinement (ie “soft-release”)

is designed to accustom animals to the release area thereby easing their transition into the wild, dampen post-release dispersal, and foster the formation of stable territories (Knox and Monks 2014). Supplemental food was not provided to the confined alligators, which subsisted on naturally-occurring prey available within the pen. A VHF radio transmitter was attached to the tail (between the double caudal scutes) of each alligator to facilitate pre- and post-release monitoring. However, transmitters had detached from all alligators by October 2015. The alligators apparently over-wintered (2015-16) in burrows excavated on the island and began self-liberating from the pen shortly after emerging from dormancy in April 2016. By July 2016, only two alligators, including one nesting female (see below) remained confined within the pen.



Figure 1. Heavy gauge wire fencing surrounding acclimation pen at Dongtan Wetland Park where six captive-bred Chinese alligators were released in 2015. Island in background provides burrowing substrate and nesting habitat for alligators. This photograph was taken in early April 2015. The island has since become overgrown with rank vegetation that offers excellent concealment for nesting alligators. Photograph: Steven G. Platt.

Reproduction among reintroduced alligators

We conducted fieldwork in DWP from 15-20 July 2016 (Platt *et al.* 2016), a period coinciding with the initiation of

Table 1. Geographic coordinates, physical location, and description of Chinese alligator nests found at Dongtan Wetland Park in July 2016. NR= Not recorded.

Nest	Latitude (N)	Longitude (E)	Location/description/notes
1	31°31.191'	121°56.727'	Canal bank near research lab; mound constructed of grass (85 cm wide × 30 cm high) and positioned 1.5 m from water; female aggressively defended nest.
2	31°30.843'	121°56.992'	Bank of slough in wading bird colony; mound constructed of grass (80 cm wide × 40 cm high) and positioned 2.0 m from water; female not encountered at nest.
3	NR	NR	Island in acclimation pen; mound constructed of <i>Phragmites</i> and <i>Solidago</i> (50 cm wide × 28 cm high), and positioned 5.0 m from water; female aggressively defended nest.

alligator nesting (Thorbjarnarson and Wang 2010). To locate alligator nests, we searched potential habitat (eg islands, former nesting sites, elevated areas in open marsh, and canal banks) on foot. At each nest we noted the composition of the mound in relation to the surrounding vegetation, measured the external dimensions of the mound (height and width to nearest 1.0 cm), and estimated its distance to water (from center of nest mound). Geographic coordinates (WGS 1984 Datum) of the nest were determined with a hand-held Garmin 76 GPS unit. We then carefully opened the mound, removed the eggs, measured the length and width of each with a dial calipers (to the nearest 0.1 mm), and determined mass with Pesola scales (± 0.5 g). Egg viability and approximate embryo age were determined by the presence and extent of opaque banding (Ferguson 1985). Eggs were then replaced in the nest cavity, taking care to maintain the original upright orientation, and covered with moistened nesting material.

We found three alligator nests in DWP during July 2016; two were constructed by females reintroduced in 2015 and another by a female released in 2007 (Table 1). One nest was constructed on an island in the acclimation pen, while the other two were built on slightly elevated substrates in the marsh. One of the latter nests was positioned within a few metres of a well-used footpath traversed by hundreds of park visitors, suggesting a high tolerance of human disturbance by the attending female. Another nest along a shallow canal in a wading bird colony was located a short distance away from a nesting site used in 2008. Because alligators often exhibit a high degree of nest site fidelity (Elsey *et al.* 2008), we consider it likely this nest was built by a female from the original (2007) reintroduction. Nest mounds were composed of vegetation occurring at the site (*Phragmites*, *Solidago* and *Panicum*) together with small amounts of soil, and constructed 1.5 to 5.0 m from water. Nest defense behavior by the attending female was observed at two of the three nests (Fig. 2; Table 1).



Figure 2. Female Chinese alligator aggressively defending partially completed nest mound on island in acclimation pen (16 July 2016). A clutch of 32 eggs was deposited in the nest <12 hours after this photograph was taken. Photograph: Steven G. Platt.

Together the three nests contained 84 eggs; this total included

83 intact eggs and one empty eggshell (Fig. 3). Eggs were deposited between 15 and 18 July and clutch size ranged from 25 to 32 (Table 2). We measured the linear dimensions of 83 intact eggs; mean (± 1 SD) length and width were 58.9 ± 4.4 mm (range= 51.7 to 67.2 mm) and 34.5 ± 1.7 mm (range = 31.8 to 39.6 mm), respectively. Mean egg mass was 45.8 ± 7.6 g (range = 36 to 60 g; n= 83) and clutch mass ranged from 956 to 1556 g (Table 2). Sixty-eight of the 84 (80.9%) eggs were viable, although one extremely thin-shelled egg appeared unlikely to hatch. The proportion of non-viable eggs in each clutch ranged from 3.7 to 40.0% (Table 2). The largest number of non-viable eggs (10) occurring within a single nest were found at the bottom of the clutch where the nesting media was sodden and cool. The low temperature probably precluded embryonic development of these eggs.

Table 2. Estimated date of laying and clutch attributes from three Chinese alligator nests found at Dongtan Wetland Park during July 2016. Nest number corresponds to Table 1. Mean egg mass (EM) and mean clutch mass (CM) are shown with standard deviation. Asterisk denotes clutch containing a broken egg not included in count of non-viable eggs.

Nest	Est. Lay Date	Clutch Size	Non-viable Eggs (%)	Mean EM (g)	Mean CM (g)
1	16-17 July	25	10 (40.0)	38.2 ± 1.0	956
2	18 July	27	1 (3.7)	55.9 ± 2.4	1556
3	15-16 July	32*	4 (12.5)	42.9 ± 1.9	1330



Figure 3. A clutch of 25 recently deposited Chinese alligator eggs. Nest materials consist largely of grass (*Phragmites* and *Panicum*). Photograph: Qijing He.

Given an incubation period of approximately 55 days (Thorbjarnarson and Wang 2010), neonates were expected to emerge from eggs in early to mid-September 2016. However, flooding resulting from heavy rainfall (200-300 mm) associated with the Super-typhoon Meranti on 15-16 September submerged two nests causing the loss of both

clutches. Crocodylian eggs are intolerant of flooding and submergence for more than 12 hours results in embryonic death (Joanen *et al.* 1977). Clutch mortality due to tropical storms is not unexpected as the alligator nesting season coincides with the annual peak in typhoon activity. Indeed, nest losses to tropical disturbances are commonplace among American alligator (*A. mississippiensis*) populations inhabiting coastal marshes of the United States (Fleming *et al.* 1976; Platt *et al.* 1995; Elsey *et al.* 2006). In contrast to the two marsh nests, the nest constructed on an island in the acclimation pen escaped flooding and the clutch hatched successfully; one of us (JW) observed three hatchlings in dense aquatic vegetation near the nest site on 25 and 27 September 2016 (Fig. 4). Assuming most of the 25 viable eggs in the clutch hatched, and given estimated survival rates of 10-12% (Ouchley 2013; Lu *et al.* 2014), 2-3 of these hatchlings can be expected to reach sexual maturity and enter the breeding population in 7-8 years.



Figure 4. Hatchling Chinese alligator photographed on 27 September 2016 near a nest that escaped flooding in the wake of Super-typhoon Meranti. Photograph: Feng Yu (East China Normal University).

In addition to our observations in 2016, park staff reported that a female alligator inhabiting Pine Island Lake nested during the summer of 2015. The nest was constructed adjacent to a burrow complex on Pine Island, and in close proximity to nesting sites used in 2012 and 2014. Park staff observed hatchlings in Pine Island Lake during September and October 2015, but not in 2016. We made multiple observations of an adult alligator during diurnal and nocturnal surveys of Pine Island Lake in July 2016, but likewise encountered no juveniles (Platt *et al.* 2016). Hatchlings may have succumbed to record low temperatures during the winter of 2015-16 (eg Brandt and Mazzotti 1990).

In conclusion, for reintroduction to be successful, released animals must ultimately grow, survive, and reproduce (Alberts 2007; Roe *et al.* 2015). Our studies (Lu *et al.* 2014; this study) and those of others (Wang *et al.* 2011) demonstrate that captive-bred Chinese alligators can successfully reproduce when returned to the wild. Furthermore, the progeny of reintroduced alligators are capable of surviving to reproductive age (Lu *et al.* 2014). Taken together, these findings indicate that reintroduction is a feasible management tool for restoring wild populations of Chinese alligators. Despite the successful reintroduction of 6 additional adult

alligators in 2015-16, the current population in DWP nonetheless consists of no more than 20 alligators (Lu *et al.* 2014) and as such, remains vulnerable to the extinction risks inherent in any small population (Gilpin and Soulé 1986). We therefore recommend the continued release of groups of captive-bred adult alligators in the coming years based on the demonstrably successful protocols (eg confinement in acclimation pen, self-release after 12 months) used in 2015-16.

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Latin America and the Caribbean

Paraguay

CAIMANS AND THE PILCOMAYO RIVER: REPORT ON THE STATUS OF A HYDROLOGICAL AND MEDIA PHENOMENON IN PARAGUAY. In mid-June 2016 a video, supposedly filmed in a place called Laguna Escalante in the Paraguayan Chaco, began to circulate on social media networks in Paraguay (eg Servin 2016; Sidder 2016). It showed an adult *Caiman yacare* stuck in the mud of a waterbody that was obviously drying out, and the cameraman's voice appeared very concerned about the welfare of the animals, and he was exclaiming that there were "many animals dying". As a result of the video footage considerable interest was expressed by the public and the media about the drought situation in that region, which is fed by the Pilcomayo River.

The Pilcomayo River originates in the Bolivian Andes, and the lower reaches run through the hot, semiarid lowlands known as the Chaco Plain. This stretch of the river relies on an annual pulse of water from its upper reaches during the rainy season (January to March), and at that time sediment is also deposited onto the Chaco Plain, causing natural siltation of the river channel downstream. To maintain the flow of water to cattle farms, an artificial channel was constructed from the upstream portion of the Pilcomayo River, at the point of siltation, resulting in maintenance of a "wetland

ecosystem” in this semi-arid region, that would otherwise have disappeared naturally.

Drought periods, due to reduced flow of water from the Pilcomayo River headwaters, have occurred in the past (eg in 2001 and 2008), and occurred again in 2016. But the situation in 2016 appears to have been exacerbated by the lack of maintenance by the Ministry of Public Works (MOPC) through the Joint Commission of the Pilcomayo River (COMIP) of the Paraguayan channel, the main channel for diverting the waters of the Pilcomayo River to Paraguayan territory.

Interestingly, early public attention was not focused on the status of the channel, but on the fauna, and especially the caimans, that were widely believed to be dying en masse - in the thousands. This “belief” was exacerbated by the circulation of fake photographs showing drought and mortalities supposedly from this region (which following more thorough examination, appeared to be from other countries and even other continents). Nonetheless, all this generated strong criticism of the Paraguayan Ministry of Environment (SEAM) for its apparent apathy in saving the caimans, and organized groups decided to take action to relocate the animals, even though they lacked the technical knowledge to do so. Some groups took advantage of the situation, and under the guise of activism, went to the drought-stricken areas to poach. So far SEAM and the National Police have seized more than 200 kg of bushmeat in the region, mostly from caimans.

It has been difficult to quantify caiman mortality precisely, as the affected area is extensive, and some areas mentioned in the social media have been arid for the last 15-20 years. Some localities visited by Government authorities and technical personnel have not had many dead caimans, but on the other hand videos taken by non-government organisations/groups show one particular lagoon with many dead and dying animals.

Throughout this process SEAM opened channels of communication and coordinated meetings with various stakeholders, which has led to a gradual easing of the “media frenzy”. The Environment Secretariat closely follows the work of the MOPC as a result of this situation, and the Minister of this portfolio was questioned by Parliament. SEAM is authorizing and coordinating the creation of artificial ponds to be filled with water from wells dug by service providers of the MOPC (so far there are 6 active wells out of 12 planned) for livestock and wild fauna, recognizing that as we alter the ecosystem through the provision of water, we should manage it responsibly.

SEAM has also held technical meetings with representatives of activist organizations to ensure that they are provided with up-to-date factual information. Rather than forbid the relocation of wild animals (as indicated by legislation), SEAM has indicated specific locations for the purposes of experimental rescues and relocations with certain specimens, under regulated conditions, and supervised by SEAM. Thus it has been possible to work with these groups jointly as strategic

allies to mitigate the effects of the drought on wildlife.

This situation clearly demonstrates the importance of working with various stakeholders and organizations, as well as training, information management and communication strategies in resource management and conservation.

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Sidder, A. (2016). Wildlife dying en masse as South American River runs dry. National Geographic, 22 July 2016 (<http://news.nationalgeographic.com/2016/07/pilcomayo-river-paraguay-caiman-capybara-fish-drought-death-water/>).

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Venezuela

FIRST REPORT OF CAPTIVE BREEDING OF ORINOCO CROCODILES IN A VENEZUELAN ZOO. On 3 June 2016 two Orinoco crocodiles (*Crocodylus intermedius*) were hatched in the zoo within Generalísimo Francisco de Miranda Park (Parque del Este), Caracas. Although *C. intermedius* has bred in captivity in private and Government farms as part of the conservation program for the species that involves restocking of the wild population, this is the first report of breeding in a Venezuelan zoo.

Previous nesting by the pair of crocodiles at the zoo has only produced infertile eggs, until now. On 2 March, 27 eggs were transferred to a simple incubator located in El Terrario Parque del Este, and after 91 days two hatchlings hatched. Staff at the zoo, especially Aura Quintero and her team, Nelly España, Juvenal Cardenas and Luis Merlo, are to be congratulated for their efforts, from the time of nesting and throughout the incubation period.

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South Asia and Iran

Iran

SECOND FATAL MUGGER CROCODILE ATTACK REPORTED IN IRAN. The conflict between humans and wildlife species is one of the major conservation issues in the world. In many countries, the successful conservation and recovery of crocodylian populations may lead to increased frequency of human-crocodile conflict (HCC), which then leads to negative public opinion on crocodylians (CSG 2016).

This may also occur when the interaction is with livestock, and where livelihoods are affected. Despite the relatively small population of Mugger crocodiles (*Crocodylus palustris*) that exists in Iran, HCC presents a potential management “problem” for the country.

In Iran, the numerous villages with natural and artificial ponds inside or close to dams result in close contact between local people and crocodiles. Moreover, in some areas, most of the villages and human settlements are adjacent to or very close to rivers and natural water bodies. Ponds are visited many times during the day by the local people, especially women and children, for daily usage and swimming. With such close contact with crocodiles, the most important factor preventing harm to crocodiles is the cultural and religious beliefs of the communities and their respect for crocodiles. In Baluchistan Province, due to water shortage, crocodiles are respected as a water-living creature, meaning that the existence of crocodiles points to the availability of water.

Despite the proximity and close contact with crocodiles, HCC is very rare - crocodiles rarely attack people, including children swimming in ponds. One of the most serious attacks was during the prolonged drought season in 2000, where a young boy swimming with his friends in a very small pond was drowned by an adult crocodile. Attacks on children by juvenile crocodiles have at times been reported to researchers carrying out fieldwork, and could be around 2-3 per year.

On 10 June 2016 a 10-year-old boy was fatally attacked by an adult Mugger in Keshari Pond, inside Gandou protected area. This is the second fatal attack reported in the country, and it resulted in many complaints by the local people. The boy was drowned, suggesting that the attack may not have been for feeding. At this time of year Mugger nests are hatching, and maternal care or hatchling defense, may have been a contributing factor. The lack of rain and water shortage seems to be another reason contributing to crocodiles being more aggressive.

Keshari Pond is part of the larger Azadi Pond, located beside Keshari village, which is up a hill and about 200 m above the pond. During a visit to the area two weeks after the attack, we spotlight surveyed the pond and counted 9 crocodiles, 7 of which were adult sizes. All crocodiles remained in the pond after the attack, but it was not clear whether the responsible crocodile was a male or female. Seems that, lack of water and food resources to be more reasons for crocodiles to be aggressive. No hatchlings were detected in the pond, but generally the crocodiles were sensitive to being approached. The village people are dependent on the ponds for their daily water.

A contributing factor is that livestock is taken by crocodiles, thereby causing economic loss for local communities. Local people are poor, and these economic losses impact on their livelihoods. The number of these incidents is considerable, and particularly serious when large crocodiles occur in small ponds with small amounts of food, causing the crocodile to become a nuisance. In places where food resources are very

particularly scarce, crocodiles are known to enter villages and settlements to find food and hunt chickens or other animals.

More and more requests to capture and relocate “problem” crocodiles are now being received by authorities, and in most cases crocodiles are moved to remote areas such as Pishin Dam. Although there is a mechanism through the Department of Environment offices to compensate local people for losses of livestock, regrettably compensation at times is not provided in sufficient time or amount. Plans are underway to expand the compensation program and to provide more support for local people. Consideration is being given by DOE to facilitating “insurance” policies as a means of compensating local people for losses.

There is no exploitation of crocodiles and local people do not harm them, and often prevent others from harming crocodiles. This unique feature provides potential for conservation measures (Mobaraki 2014). Hiring of local people by the DOE as staff and to assist in monitoring activities are another measure used to engage local people with conservation and management, and to increase their awareness about crocodiles.

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CSG (Crocodile Specialist Group) (2016). Human-Crocodile Conflict. <http://www.iucncsg.org/pages/Human%252dCrocodile-Conflict.html>.

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Europe

INAUGRAL EUROPEAN CROC NETWORKING MEETING. At the recent CSG working meeting in Skukuza, South Africa (May 2016), we realized that there were many isolated researchers in Europe that lacked a network of crocodile specialists. With this in mind, we decided that a more casual, networking meeting was necessary. In June 2016 we began the process of organizing a networking meeting with the intention of linking active, established researchers based in Europe with those interested in pursuing work with crocodiles.

Crocodiles of the World in Brize Norton, UK, hosted the event on 14-16 October 2016), placing participants in the middle

of a crocodile zoo. We had 54 participants representing 10 countries attend. Eleven speakers from research, zoos, trade and industry gave talks about who they were, how they got there, and what they are doing now. This included Skyping with Marisa Tellez and the Crocodile Research Coalition in Belize as part of the opportunities section (with much follow-up interest from participants of the meeting).

Participants were given a list of volunteer opportunities from around the world where they could expand their crocodile knowledge and skill set. We wanted to let students know that there were avenues to pursue their interest in crocodilians - even from Europe. The highlight was the speed dating session, where participants rotated in groups of three. This had positive reviews from students and experts as it ensured that each person spoke to at least 30 other people. Participants had the rest of the afternoon at "CrocFest UK" to discuss and interact with people they had met throughout the day.

We are happy to say it was a huge success! Connections were made, contacts exchanged, and an annual meeting started. Planning for next year has already begun!

We are still accepting information on volunteer and internship opportunities and compiling a list for next year's meeting, releasing information throughout the year as well. This is a great way to access potential volunteers, so please do not hesitate to contact me (ashley.pearcy@gmail.com) if you have an organization that is willing to take on volunteers or interns.



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Science



Recent Publications

Benedict, S. and Shilton, C.M. (2016). *Providencia rettgeri* septicaemia in farmed crocodiles. *Microbiology Australia* (doi: 10.1071/MA16039).

Abstract: Bacterial septicaemia is a major cause of morbidity and mortality in farmed saltwater crocodiles (*Crocodylus porosus*) in the Northern Territory. *Providencia rettgeri* is the most common aetiological agent. Efficacy of antibiotic treatment is dubious and there are high levels of resistance to antibiotics commonly used by farms, underlining the need for exploration of new approaches to managing the disease.

Sinton, T.J. and Byard, R.W. (2016). Pathological features of fatal crocodile attacks in northern Australia, 2005-2014. *Journal of Forensic Sciences* (doi: 10.1111/1556-4029.13171).

Abstract: Eleven deaths from crocodile attacks in the Northern Territory, Australia were reviewed. The male:female ratio was 8:3; age range-10-62 years, average 29.4 years. Four children were included (1 boy and 3 girls, aged 10, 11, and two at 12 years), and there were 7 aboriginal victims (64%). The attacks were witnessed in 8 cases with the victims swimming in fresh water N= 5, standing on a river bank N= 1, fishing in fresh water N= 1, or diving in the sea N= 1. At autopsy, several distinct patterns of injury were observed ranging from complete traumatic disruption of the body with only incomplete remains for examination (N= 5), to crushing of the head with fractures of the skull (N= 4), crushing of the chest with fractures of the ribs and sternum (N= 2), and avulsion of limbs (N= 4). In one case, there was decapitation. Autopsy evaluations were complicated by decomposition and loss of body parts.

Walker, E.M. (2016). The Historical Ecology of Queensland's Australian Saltwater Crocodile (*Crocodylus porosus*). Honors Thesis, Colby College, Waterville, Maine, USA. (Paper 815. <http://digitalcommons.colby.edu/honorsthesis/815>).

Abstract: Human wildlife conflict is a critical aspect of many societies, as it often plays a large role in government decisions. The iconic saltwater Australian crocodile (*Crocodylus porosus*) is one example of a species that has become the subject of human-wildlife conflict in Queensland, Australia. Decades of intensive hunting in Queensland, beginning at the time of the Second World War, drastically depleted crocodile populations, leading to a federal embargo on crocodile exports in 1972 and their protection in Queensland in 1974. Since protection, populations appear to be recovering with increasing densities in the north and increased sightings along the southernmost edge of their observed range. However, research has indicated that population recovery is slower than in the adjacent Northern Territory, although the drivers of this slow recovery and southern sightings remain unknown. Two potential drivers include range expansion due to climate change or re-colonization of areas from which they were previously extirpated. This study uses a variety of spatial and temporal density analyses in relation to human population size to examine the abundance and range status of crocodiles in Australia. It compares the distribution of sightings, nests and attacks over pre-exploitation (1871-1944), heavy exploitation (1945-1971) and post-exploitation (1972-2015) time periods to assess three related hypotheses: First, crocodile populations are expanding outside of known historical ranges. Second, crocodile populations have recovered to historical baseline abundances in areas that abut regions of high human population density. Third, crocodile attack rates have increased over time relative to human population size. While crocodile ranges do not appear to be expanding, they do heavily overlap with the highest anthropogenically altered areas. Furthermore, although crocodile abundance is difficult to characterize, attack rates have remained relatively low since the pre-exploitation period. These findings suggest that coastal development and crocodile removal plans may be driving crocodiles outside of natural habitat ranges and that the

recent southern sightings likely represent the re-colonization of crocodiles in former southern ranges. This study aims to provide management with historical information of crocodiles in relation to current trends to aid in successful management that allows crocodile populations to recover, while maintaining low instances of human-crocodile conflict.

Zender, A.J., Li, E.O., Suárez, A.F., Hoyos, S.L., Silva, S.W., Arroyo H.G. and Barrios-Arpi, M. (2016). Liver blood chemistry profile of the American crocodile (*Crocodylus acutus*) raised in captivity. *Revista de Investigaciones Veterinarias del Perú* 27(1): 24-30

Abstract: The liver blood chemical profile of the American crocodile (*Crocodylus acutus*) raised in captivity in the northern region of Peru was determined. Sixty crocodiles were sampled from a population of 255 animals belonging to the Zoológico del Centro de Acuicultura La Tuna Carranza, part of the National Fisheries Development Fund (FONDEPES) located in the region of Tumbes, Peru. The animals were classified as young (n= 24), subadults (n= 27) and adults (n= 9). A blood sample (6 ml) was taken from each animal by puncturing the post-occipital venous sinus while animals were under physical restraint. Serum was separated by centrifugation and concentration of each enzyme was measured by spectrophotometry. Variables studied were alanine aminotransferase (ALT), aspartate amino transferase (AST), alkaline phosphatase (ALP), total bilirubin, direct bilirubin, indirect bilirubin, total protein and albumin. Statistical difference (p<0.05) was found between age groups in ALT, FA, direct bilirubin, and total protein. All values with the exception of albumin showed high biological differences with those reported by the International Species Information System.

Twyman, H., Valenzuela, N., Literman, R., Andersson, S. and Mundy, N.I. (2016). Seeing red to being red: conserved genetic mechanism for red cone oil droplets and co-option for red coloration in birds and turtles. *Proceedings of the Royal Society B* (<http://dx.doi.org/10.1098/rspb.2016.1208>).

Abstract: Avian ketocarotenoid pigments occur in both the red retinal oil droplets that contribute to colour vision and bright red coloration used in signalling. Turtles are the only other tetrapods with red retinal oil droplets, and some also display red carotenoid-based coloration. Recently, the CYP2J19 gene was strongly implicated in ketocarotenoid synthesis in birds. Here, we investigate CYP2J19 evolution in relation to colour vision and red coloration in reptiles using genomic and expression data. We show that turtles, but not crocodiles or lepidosaurs, possess a CYP2J19 orthologue, which arose via gene duplication before turtles and archosaurs split, and which is strongly and specifically expressed in the ketocarotenoid-containing retina and red integument. We infer that CYP2J19 initially functioned in colour vision in archosaurs and conclude that red ketocarotenoid-based coloration evolved independently in birds and turtles via gene regulatory changes of CYP2J19. Our results suggest that red oil droplets contributed to colour vision in dinosaurs and pterosaurs.

Finger, Jr., J.W., Hamilton, M.T., Metts, B.S., Glenn, T.C. and Tuberville, T.D. (2016). Chronic ingestion of coal fly-ash contaminated prey and its effects on health and immune parameters in juvenile American alligators (*Alligator mississippiensis*). *Archives of Environmental Contamination and Toxicology* (doi: 10.1007/s00244-016-0301-9).

Abstract: Coal-burning power plants supply approximately 37 % of the electricity in the United States. However, incomplete combustion

produces ash wastes enriched with toxic trace elements that have historically been disposed of in aquatic basins. Organisms inhabiting such habitats may accumulate these trace elements; however, studies investigating the effects on biota have been primarily restricted to shorter-lived, lower-trophic organisms. The American alligator (*Alligator mississippiensis*), a long-lived, top-trophic carnivore, has been observed inhabiting these basins, yet the health or immune effects of chronic exposure and possible accumulation remains unknown. In this study, we investigated how chronic dietary ingestion of prey contaminated with coal combustion wastes (CCWs) for 25 months, and subsequent accumulation of trace elements present in CCWs, affected juvenile alligator immune function and health. Alligators were assigned to one of four dietary-treatment groups including controls and those fed prey contaminated with CCWs for one, two, or three times a week. However, no effect of Dietary Treatment (p>0.05) was observed on any immune parameter or hematological or plasma analyte we tested. Our results suggest that neither exposure to nor accumulation of low doses of CCWs had a negative effect on certain aspects of the immune and hematological system. However, future studies are required to elucidate this further.

Tellez, M., Boucher, M. and Kohlman, K. (2016). Population status of the American Crocodile (*Crocodylus acutus*) in Caye Caulker, Belize. *Mesoamerican Herpetology* 3: 450-460.

Abstract: We assessed the population status of the American Crocodile (*Crocodylus acutus*) via nocturnal eyeshine and capture investigations in January, March, and April of 2016 in Caye Caulker, Belize. We encountered 55 crocodiles along a 22.15 km survey route. The majority of crocodiles occupied coastal mangrove habitat in the southern (more developed) and northern (less developed) regions of the island. The *C. acutus* population was composed of 36% juveniles, 40% subadults, 16% adults and 7% were identified as eyeshine only (encounter rate= 2.4 crocodiles/km). The population sex ratio was 1:1, and the cutaneous parasite *Paratrichosoma* was found on 92% of the captured crocodiles. Our data suggest a relatively stable and healthy population of *C. acutus* on Caye Caulker, but recent increases in pollution and human settlement could threaten the viability of this population.

Poletta, G.L., Simoniello, M.F. and Mudry, M.D. (2016). Biomarkers of oxidative damage and antioxidant defense capacity in *Caiman latirostris* blood. *Comparative Biochemistry and Physiology Part C* 179: 29-36.

Abstract: Several xenobiotics, and among them pesticides, can produce oxidative stress, providing a mechanistic basis for their observed toxicity. Chronic oxidative stress induces deleterious modifications to DNA, lipids and proteins that are used as effective biomarkers to study pollutant-mediated oxidative stress. No previous report existed on the application of oxidative damage and antioxidant defense biomarkers in *Caiman latirostris* blood, while few studies reported in other crocodylians were done in organs or muscles of dead animals. The aim of this study was to characterize a new set of oxidative stress biomarkers in *C. latirostris* blood, through the modification of conventional techniques: 1) damage to lipids by thiobarbituric acid reactive substances (TBARS), 2) damage to DNA by comet assay modified with the enzymes FPG and Endo III, and 3) antioxidant defenses: catalase, superoxide dismutase and glutathione; in order to apply them in future biomonitoring studies. We successfully adapted standard procedures for CAT, SOD, GSH and TBARS determination in *C. latirostris* blood. Calibration curves for FPG and Endo III showed that the three dilutions tested were appropriate to conduct the modified comet assay for the detection of oxidized bases in *C. latirostris* erythrocytes. One hour of incubation

allowed a complete repair of the damage generated. The incorporation of these biomarkers in biomonitoring studies of caiman populations exposed to xenobiotics is highly important considering that this species has recovered from a serious endangered state through the implementation of sustainable use programs in Argentina, and represents nowadays a relevant economic resource for many human communities.

Kluczkovski, A., Jr., De Francisco, A., Beirão, L., Kluczkovski, A. and Barbosa, H. (2016). Lipids of Amazon caimans: a source of fatty acids. *African Journal of Biotechnology* 15(29): 1559-1565.

Abstract: Some species of fish and other aquatic organism are important sources of protein and fatty acids that are beneficial to human health and can be industrially processed. The fatty acid profile of *Caiman crocodilus* and *Melanosuchus niger* (native to the Brazilian Amazon flooded forest) was determined in samples of a commercial cut (tail fillet) and fat (fat body and somatic fat) of these two species. There were no statistically significant differences in the total lipid content between them ($p \geq 0.05$) and both had higher levels of palmitic, stearic (saturated), and oleic (unsaturated) acids. However, omega 3 (ω -3) and omega 6 (ω -6) were not detected in the samples of the commercial cut; they were present only in the fats evaluated. Clinical studies are necessary to assess the influence of fatty acids from Amazon caimans on human diet and the feasibility of obtaining new products such as nutraceuticals.

Kozłowski, H.N., Lai, E.T., Havugimana, P.C., White, C., Emili, A., Sakac, D., Binnington, B., Neschadim, A., McCarthy, S.D. and Branch, D.R. (2016). Extracellular histones identified in crocodile blood inhibit *in vitro* HIV-1 infection. *AIDS*.

Abstract: It has been reported that crocodile blood contains potent antibacterial and antiviral properties. However its effects on HIV-1 infection remain unknown. We obtained blood from saltwater crocodiles to examine whether serum or plasma could inhibit HIV-1 infection. We purified plasma fractions then used liquid chromatography-mass spectrometry (LC-MS/MS) to identify the inhibitory protein factor(s). We then analyzed the ability of recombinant proteins to recapitulate HIV-1 inhibition and determine their mechanism of action. *Crocodylus porosus* plasma was tested for inhibition of Jurkat T-cell HIV-1 infection. Inhibitor(s) were purified by reverse-phase chromatography then identified by protein LC-MS/MS. Anti-HIV-1 activity of purified plasma or recombinant proteins was measured by p24 ELISA and luciferase readouts, and mechanism of action determined by measuring HIV-1 RNA, cDNA and transcription (using IG5 cells). Crocodile plasma contains potent inhibitors of HIV-1 infection that were identified as histones. Recombinant human histones H1 and H2A significantly reduced JR-FL infection (IC₅₀ of 0.79 μ M and 0.45 μ M, respectively) while H4 enhanced JR-FL luciferase activity. The inhibitory effects of crocodile plasma, recombinant H1 or recombinant H2A on HIV-1 infection was during or postviral transcription. Circulating histones in crocodile blood, possibly released by neutrophil extracellular traps (NETs), are significant inhibitors of HIV-1 infection *in vitro*. Extracellular recombinant histones have different effects on HIV-1 transcription and protein expression, and are downregulated in HIV-1 patients. Circulating histones may be a novel resistance factor during HIV-1 infection, and peptide versions should be explored as future HIV-1 therapeutics that modulate viral transcription.

Evans, L.J. (2016). Assessing the impacts of habitat fragmentation and subsequent anthropogenic expansion on the behavioural, nesting and population ecology of the estuarine crocodile, *Crocodylus*

porosus. PhD thesis, Cardiff University, Cardiff, UK.

Abstract: The project sought to examine the effects of habitat loss and fragmentation on the ecology and population genetics of the estuarine crocodile (*Crocodylus porosus*). Additionally, the role played by humans in this anthropogenically-altered landscape was examined. Through the utilisation of a host of technologies, some previously established, some completely novel in crocodilian research, a new insight into how the landscape is utilised by these cryptic predators was developed. This project represents a first detailed look at Sabah's crocodilian population, as well as being the first active crocodile research carried out in Sabah's longest river. Male crocodiles were found to adhere to one of two behavioural strategies, territorial and nomadic, mirroring findings of Campbell *et al.* (2013). Territory sizes were, however, found to be smaller than those described in Australia, this was attributed to increased prey availability and ecosystem productivity. Only two females were tagged and appeared to also display differences in behavioural strategy. However, due to the small sample size, further work is required to confirm this. Both males and females were found to avoid barriers and were unwilling to pass beyond the barrier, despite no physical obstruction. Nests were detectable aerially through the use of drones and medium-large scale surveys shown to be feasible. Nests were found to all display a number of similarities in terms of habitat characteristics, allowing for refined modelling of survey locations. This allows for a larger survey area to be completed given a limited number of flights, highlighting its cost effectiveness versus traditional methods of nest surveying. Genetic analysis suggested that there was no evidence of a genetic bottleneck following the population recovery that has occurred over the last 30 years. Geographically indistinct haplogroups were discovered, as well as limited levels of inbreeding. The project also indicated that the population studied had undergone a population expansion that seems to have coincided with the onset of the last ice age and is likely attributable to changes in climate.

Cureg, M.C., Bagunu, A.M., Van Weerd, M., Balbas, M.G., Soler, D. and Van Der Ploeg, J. (2016). A longitudinal evaluation of the Communication, Education and Public Awareness (CEPA) campaign for the Philippine crocodile *Crocodylus mindorensis* in northern Luzon, Philippines. *International Zoo Yearbook* (doi: 10.1111/izy.12112).

Abstract: The Philippine crocodile *Crocodylus mindorensis* is Critically Endangered and its range is restricted to a few localities in human-dominated landscapes. Therefore, the survival of this species in the wild depends strongly on the support of local people. Communication and education are prerequisites for successful *in situ* conservation. Over a 12-year period, the Mabuwaya Foundation distributed posters, calendars and comic books, organized theatre shows, gave school lectures, facilitated community meetings and established a crocodile rearing station/visitor centre to mobilize local support for the conservation of the Philippine crocodile in the northern Sierra Madre in Luzon. This paper documents changes in people's awareness of and attitudes towards the conservation of the Philippine crocodile, and changes in people's behaviour in 10 barangays (villages) in the municipality of San Mariano. Most people living in crocodile habitat now know that the Philippine crocodile is protected by law and support the conservation of the species in the wild. Hunting, the destruction of nests and the use of destructive fishing methods have all significantly declined in these areas. As a result of the integrated conservation program, the Philippine crocodile population is slowly recovering.

Stein, M., Hand, S.J. and Archer, M. (2016). A new crocodile

displaying extreme constriction of the mandible, from the late Oligocene of Riversleigh, Australia. *Journal of Vertebrate Paleontology* (doi: 10.1080/02724634.2016.1179041).

Abstract: A new fossil crocodile, *Ultrastenos willisi*, is described from a cranium and postcranial materials collected from the Riversleigh World Heritage Area, northwestern Queensland, Australia. The mandible displays pronounced anterior constriction, approaching that seen in the extant gharial, *Gavialis gangeticus*, and false gharial, *Tomistoma schlegelii*. As such, *U. willisi* potentially filled the ecomorphological niche associated with longirostry that has been previously unaccounted for in Riversleigh's Oligo-Miocene crocodile fauna. The pronounced constriction and features of the posterior cranium further distinguish *U. willisi* from all other known crocodiles, including the only reported Australian Oligo-Miocene longirostral crocodile, *Harpacochampsia camfieldensis*, from Bullock Creek in the Northern Territory. *Ultrastenos willisi* is recognized as a new genus and species assigned to subfamily Mekosuchinae on the basis of phylogenetic analysis.

Bouwman, H. and Cronje, C. (2016). An 11-digit identification system for individual Nile crocodiles using natural markings. *Koedoe*; 58(1): a1351 (doi: 10.4102/koedoe.v58i1.1351).

Abstract: Research and conservation of wild crocodiles and husbandry of captive crocodiles requires the reliable identification of individuals. We present a method using the individual colour markings on the first 10 single-crest scutes on the tails of Nile crocodiles (*Crocodylus niloticus*). The scutes are scored by number for colour, with a prefix for left or right providing a binary 11-digit identification number (identification numbers [IDs]; eg 12232232242 and 22333233232) per crocodile. A survey of 359 captive Nile crocodiles showed no duplication. However, 42% had asymmetrical scute markings requiring a binary approach. There does not seem to be a change in patterns with age, except that the number of missing scutes increased. A small trial showed that this method can be applied in the field, although more work is needed to determine observer bias and establish parameters for observability in the field. It is unlikely that both left and right IDs would be obtainable for each individual, but other distinctive markings such as scute shape and damage can be used to register the two IDs to one individual. Having two independent IDs for each crocodile provides the possibility of two independent population estimates for equal effort without having to link left and right IDs to individuals. Our proposed method would be useful in conservation, individual tracking and husbandry. Conservation implications: A non-invasive marking and recapture method for Nile crocodile is presented whereby the first 10 single-crest scutes are scored for colour, allowing conservation practitioners to count and monitor crocodile populations and individuals. This method provides two equal-effort estimations of population size, as left and right hand sides are scored independently.

Jangpromma, N., Preecharram, S., Srilert, T., Maijaroen, S., Mahakunakorn, P., Nualkaew, N., Daduang, S. and Klaynongsruang, S. (2016). *In vitro* and *in vivo* wound healing properties of plasma and serum from *Crocodylus siamensis* blood. *Journal of Microbiology and Biotechnology* (doi: 10.4014/jmb.1601.01054).

Abstract: The plasma and serum of *Crocodylus siamensis* have previously been reported to exhibit potent antimicrobial, antioxidant and anti-inflammatory activity. During wound healing, these biological properties play a crucial role for supporting the formation of new tissue around the injured skin in the recovery process. Thus, this study aimed to evaluate the wound healing properties of *C.*

siamensis plasma and serum. The collected data demonstrate that crocodile plasma and serum was able to activate *in vitro* proliferation and migration of HaCaT, a human keratinocyte cell line, which represents an essential phase in the wound healing process. With respect to investigating cell migration, a scratch wound experiment was performed which revealed the ability of plasma and serum to decrease the gap of wounds in a dose-dependent manner. Consistent with *in vitro* results, remarkably enhanced wound repair was also observed in a mouse excisional skin wound model after treatment with plasma or serum. The effects of *C. siamensis* plasma and serum on wound healing were further elucidated by treating wound infections by *Staphylococcus aureus* ATCC 25923 on mice skin coupled with a histological method. The results indicate that crocodile plasma and serum promote the prevention of wound infection and boost re-epithelialization necessary for the formation of new skin. Therefore, this work represents the first study to demonstrate the efficiency of *C. siamensis* plasma and serum with respect to their wound healing properties and strongly supports the utilization of *C. siamensis* plasma and serum as therapeutic products for injured skin treatment.

Chang, M.S., Gachal, G.S., Qadri, A.H. and Memon, K.H. (2016). Physico-chemical assessment of water quality and its effects on Marsh Crocodiles, *Crocodylus palustris* population in Haleji Lake Wildlife Sanctuary, Thatta, Sindh, Pakistan. *Sindh University Research Journal* 48(1)

Abstract: Present study was carried out in Haleji Lake Wildlife Sanctuary (24° 48' N, 60° 47' E) Thatta, Sindh, Pakistan from January to December 2009. Evaluation of physico-chemical quality of water such as: temperature (air and water), pH, electrical conductivity, total dissolved solids, turbidity, calcium, magnesium, bi-carbonate, chloride, sodium, potassium, sulphur, carbonate, biological oxygen demand and dissolved oxygen were compared with the recognized standards of world health organization and their impacts on Marsh Crocodiles. It was examined that the level of EC, Turb, Hard, K and HCO₃ was higher and Lake water suggest that the current population is threatened. While pH, TDS, Ca, Mg, Alkal, Cl, Na, SO₄, As, BOD and DO values were in tolerable range. We analyzed our data with mean ± SD (Standard Deviation). Marsh Crocodile is considered vulnerable and threatened in Pakistan due to hunting pressure, alteration of habitat and poor water quality in the last decades. The current studies witnessed that the quality of lake water was changing as a result of discharge of untreated wastes from industries. Due to poor water quality of Haleji Lake which may pose problems to crocodile population.

Loza-Rubio, E., Rojas-Anaya, E., López-Ramírez, R.D., Saiz, J.C. and Escribano-Romero, E. (2016). Prevalence of neutralizing antibodies against West Nile virus (WNV) in monkeys (*Ateles geoffroyi* and *Alouatta pigra*) and crocodiles (*Crocodylus acutus* and *C. acutus-C. moreletii* hybrids) in Mexico. *Epidemiology and Infection*.

Abstract: West Nile virus (WNV) is a mosquito-borne neurotropic viral pathogen maintained in an enzootic cycle between mosquitoes (vectors) and birds (natural hosts) with equids, humans, and other vertebrates acting as dead-end hosts. WNV activity in Mexico has been reported in several domestic and wild fauna and in humans, and the virus has been isolated from birds, mosquitoes, and humans. However, no serological studies have been conducted in monkeys, and only two in a limited number of crocodiles (*Crocodylus moreletii*). Here we present data on the prevalence of neutralizing antibodies against WNV in 53 healthy wild monkeys (49 *Ateles geoffroyi* and four *Alouatta pigra*), and 80 semi-captive healthy crocodiles (60

C. acutus and 20 *C. acutus*-*C. moreletii* hybrids) sampled during 2012. None of the monkey sera neutralized WNV, whereas 55% of the crocodile sera presented neutralizing antibodies against WNV. These results can contribute to the design of surveillance programs in Mexico.

Warner, J.K., Combrink, X., Myburgh, J.G. and Downs, C.T. (2016). Blood lead concentrations in free-ranging Nile crocodiles (*Crocodylus niloticus*) from South Africa. *Ecotoxicology* 25(5): 950-958.

Abstract: Generally crocodylians have received little attention with regard to the effects of lead toxicity despite their trophic status as apex, generalist predators that utilize both aquatic and terrestrial habitats, thereby exposing them to a potentially wide range of environmental contaminants. During July-October 2010 we collected whole blood from 34 sub-adult and adult free-ranging Nile crocodiles (*Crocodylus niloticus*) from three separate populations in northeastern South Africa in order to analyze their blood lead concentrations (BPb). Concentrations ranged from below detectability (<3 µg/dL, n= 8) to 960 µg/dL for an adult male at the Lake St Lucia Estuary. Blood lead concentrations averaged 8.15 µg/dL (SD= 7.47) for females and 98.10 µg/dL (SD= 217.42) for males. Eighteen individuals (53 %) had elevated BPbs (≥10 µg/dL). We assessed 12 general linear models using Akaike's Information Criterion (AIC) and found no significant statistical effects among the parameters of sex, crocodile size and population sampled. On average, crocodiles had higher BPbs at Lake St Lucia than at Ndumo Game Reserve or Kosi Bay, which we attribute to lead sinker ingestion during normal gastrolith acquisition. No clinical effects of lead toxicosis were observed in these crocodiles, even though the highest concentration (960 µg/dL) we report represents the most elevated BPb recorded to date for a free-ranging vertebrate. Although we suggest adult Nile crocodiles are likely tolerant of elevated Pb body burdens, experimental studies on other crocodylian species suggest the BPb levels reported here may have harmful or fatal effects to egg development and hatchling health. In light of recent Nile crocodile nesting declines in South Africa we urge further BPb monitoring and ecotoxicology research on reproductive females and embryos.

Sirsat, S.K.G., Sirsat, T.S., Price, E.R. and Dzialowski, E.M. (2016). Post-hatching development of mitochondrial function, organ mass and metabolic rate in two ectotherms, the American alligator (*Alligator mississippiensis*) and the common snapping turtle (*Chelydra serpentina*). *Biology Open* (2016) 0, 1-9 doi:10.1242/bio.017160.

Abstract: The ontogeny of endothermy in birds is associated with disproportionate growth of thermogenic organs and increased mitochondrial oxidative capacity. However, no similar study has been made of the development of these traits in ectotherms. For comparison, we therefore investigated the metabolism, growth and muscle mitochondrial function in hatchlings of a turtle and a crocodylian, two ectotherms that never develop endothermy. Metabolic rate did not increase substantially in either species by 30 days post-hatching. Yolk-free body mass and heart mass did not change through 30 days in alligators and heart mass was a constant proportion of body mass, even after 1 year. Yolk-free body mass and liver mass grew 36% and 27%, respectively, in turtles during the first 30 days post-hatch. The mass-specific oxidative phosphorylation capacity of mitochondria, assessed using permeabilized muscle fibers, increased by a non-significant 47% in alligator thigh and a non-significant 50% in turtle thigh over 30 days, but did not increase in the heart. This developmental trajectory of mitochondrial function is slower and shallower than that previously observed in

ducks, which demonstrate a 90% increase in mass-specific oxidative phosphorylation capacity in thigh muscles over just a few days, a 60% increase in mass-specific oxidative phosphorylation capacity of the heart over a few days, and disproportionate growth of the heart and other organs. Our data thus support the hypothesis that these developmental changes in ducks represent mechanistic drivers for attaining endothermy.

Gignac, P. and O'Brien, H.D. (2016). Suchian feeding success at the interface of ontogeny and macroevolution. *Integrative and Comparative Biology* (doi:10.1093/icb/icw041).

Abstract: There have been a number of attempts to explain how crocodylian bite-force performance covaries with cranial form and diet. However, the mechanics and morphologies of crocodylian jaws have thus far remained incongruent with data on their performance and evolution. For example, it is largely assumed that the functional anatomy and performance of adults tightly fits the adult niche. At odds with this precept are groups with resource-dependent growth, whose juvenile stages undergo shifts in mass, morphology, and resource usage to overcome strong selection related to issues of small body size, as compared to adults. Crocodylians are an example of such a group. As living suchians, they also have a long and fossil-rich evolutionary history, characterized by analogous increases in body size, diversifications in rostrudental form, and shifts in diet. Here we use biomechanical and evolutionary modeling techniques to study the development and evolution of the suchian feeding apparatus and to formally assess the impact of potential ontogenetic-evolutionary parallels on clade dynamics. We show that patterns of ontogenetic and evolutionary bite-force changes exhibit inverted patterns of heterochrony, indicating that early ontogenetic trends are established as macroevolutionary patterns within Neosuchia, prior to the origin of Eusuchia. Although selection can act on any life-history stage, our findings suggest that selection on neonates and juveniles, in particular, can contribute to functionally important morphologies that aid individual and clade success without being strongly tied to their adult niche.

Moore, B.C., Spears, D., Mascari, T. and Kelly, D.A. (2016). Morphological characteristics regulating phallic glans engorgement in the American alligator. *Integrated and Comparative Biology* (doi: 10.1093/icb/icw012).

Abstract: The distal part of the crocodylian phallus consists of a bulbous glans containing well-developed vascular tissues that can inflate before or during sexual activity, enlarging and elaborating the glans into a complex, though still functionally undefined, copulatory structure. An enlarged glans putatively interacts with the female cloaca and may change the shape of her reproductive tract to facilitate insemination and increase the probability of fertilization. Here, we investigated the cellular-level properties of the glans and other inflatable phallic tissues associated with the sperm-conducting sulcus spermaticus in the American alligator (*Alligator mississippiensis*). Using histochemical staining, we visualized and defined collagen and elastin fiber densities and orientations in these tissues. Extracellular matrix architectures provided insights about phallic glans material properties and how they may affect tissue strength and flexibility during inflation and in response to copulatory forces. We also investigated the potential sources of fluids that induce inflation in alligator phalli. Combining serial sectioning and three-dimensional reconstruction, we identified a pair of supracrural plexus vascular bodies at the proximal end of the alligator phallus that extend distally adjacent to ventro-medial sulcus tissues. Together, our gross and histological examination of the American alligator phallic glans suggests that its tissues are

arranged in a manner that would allow vascular inflation to expand the glans to a specific and repeatable shape, and potentially release secretory products into the female reproductive tract. Both elements could play roles in postcopulatory sexual selection, by mechanically and/or chemically affecting female reproductive physiology.

Brennan, P.L.R (2016). Studying genital coevolution to understand intromittent organ morphology. *Integrative and Comparative Biology* (doi: 10.1093/icb/icw018).

Abstract: Male intromittent organs are exceedingly diverse, yet we know comparatively little about female genital diversity. However, the most direct mechanical interaction between males and females occurs during copulation, and therefore, genital coevolution is expected to be widespread. This means that diversification of male structures must influence diversity of female genital features and vice versa. As we expand our understanding of coevolutionary interactions between the sexes, we need to expand our knowledge of three basic areas: First, we need quantitative data, on morphological variation of female genitalia. Second, we need to study the mechanics of copulatory interactions, and third, we need to use this understanding to determine which features of genital morphology are under selection, and how their variable morphology and function may affect fitness. Though studying coevolution is certainly difficult, this knowledge is crucial to our understanding of diversity in morphology of the male intromittent organ.

Aráez, J.L.D., Delfino, M., Lujána, A.H., Fortuny, J., Bernardini, F. and Alba, D.M. (2016). New remains of *Diplocynodon* (Crocodylia: Diplocynodontidae) from the Early Miocene of the Iberian Peninsula. *Comptes Rendus Palevol* (doi:10.1016/j.crpv.2015.11.003).

Abstract: We describe crocodylian remains from the Early Miocene (MN4) site of Els Casots (Subirats, Vallès-Penedès Basin, NE of the Iberian Peninsula). Referral to *Diplocynodon* (Alligatoroidea: Diplocynodontidae) is justified by several cranial and postcranial features, including: (1) the subequal and confluent alveoli of the maxilla (fourth and fifth) and dentary (third and fourth); (2) the position of the foramen aëreum on the quadrate; (3) the small and ventrally reflected medial hemicondyle of the quadrate; (4) the distinct dorsoventral step on the frontal; and (5) the bipartite ventral osteoderms. Multiple morphological features are consistent with an attribution to *Diplocynodon ratelii*, previously known from the Early Miocene (MN2) of France, and discount an alternative attribution to other species of the genus, including *Diplocynodon ungeri* from the Middle Miocene (MN5) of Austria. The described material from Els Casots is smaller in size than the French material of *D. ratelii*, possibly reflecting an earlier ontogenetic stage. The described remains constitute the first report of *D. ratelii* and the youngest record of *Diplocynodon* in the Iberian Peninsula, where only *Diplocynodon muelleri* and *Diplocynodon tormis* have been previously reported. The presence of *Diplocynodon* further supports the lacustrine depositional environment previously inferred for Els Casots and also indicates a relatively high temperature.

Dzul-Caamal, R., Hernández-López, A., Gonzalez-Jáuregui, M., Padilla, S.E., Girón-Pérez, M.I. and Vega-López, A. (2016). Usefulness of oxidative stress biomarkers evaluated in the snout scraping, serum and Peripheral Blood Cells of *Crocodylus moreletii* from Southeast Campeche for assessment of the toxic impact of PAHs, metals and total phenols. *Comparative Biochemistry and Physiology, Part A*.

Abstract: In this study, we assessed the effects of inorganic and

organic pollutants [As, Cu, Fe, Mn, Pb, Zn, PAHs (11 compounds) and total phenols] from a panel of biomarkers [$O_2\bullet$, H_2O_2 , thiobarbituric acid reactive substances (TBARS), carbonyl proteins (RC=O), superoxide dismutase (SOD), catalase (CAT), glutathione peroxidase (GPx) and total cytochrome P450 activities] evaluated in the Snout Scraping (SS), Serum (S) and Peripheral Blood Cells (PBC) of the Morelet's crocodile (*Crocodylus moreletii*) inhabiting the reference locality (Lake Mocu) and polluted locality (Champton River) using Principal Component Analysis (PCA). In male crocodiles from the reference site, only H_2O_2 in PBC was related to levels of fluoranthene on the Keel of Caudal Scales (KCS), but, in females, no association was detected. In contrast, a sex-linked response was detected in specimens from the polluted locality. Levels of benzo[a]pyrene, benzo[a]anthracene, chrysene, pyrene, phenanthrene, acenaphthene, Zn, Cu, and Pb in KCS of the female crocodile were related to the oxidative stress biomarkers on PBC, including the total CYP450 activity and levels of $O_2\bullet$, H_2O_2 in serum. However, in male crocodiles, the oxidative stress in SS and in the serum (TBARS, RC=O, CAT, GPx), and SOD in PBC was related to As, Pb, Cu, Fe, and benzo[a]pyrene water concentrations and to the burdens of As, Fe, Mn, indeno[1,2,3 cd]pyrene in KCS. These results confirm the usefulness of minimal or non-invasive methods of evaluating the oxidative stress response for the environmental monitoring program on the wild Morelet's crocodile that is subject to special protection in Mexican guidelines.

Marques, T.S., Bassetti, L.A.B., Lara, N.R.F., Millan, C.H., Piña, C.I. and Verdade, L.M. (2016). Population structure of the broad-snouted caiman (*Caiman latirostris*) in natural and man-made water bodies associated with a silvicultural landscape. *Salamandra* 52(1): 1-10.

Abstract: The Broad-snouted caiman (*Caiman latirostris*) is a South American crocodylian with a wide geographical distribution. Water bodies originally occupied by the species have suffered extreme anthropogenic pressure; however, *C. latirostris* has a high adaptive capacity to colonize man-made habitats such as decanting ponds and artificial reservoirs for agriculture or livestock. In this context, the present study aimed at identifying the population structure of *C. latirostris* in a silvicultural landscape in southeastern Brazil. Fifty-two caimans of various classes were captured with baited traps and steel cable snares at night. The estimated population size was 51 individuals excluding class I individuals. The population density was estimated to be 2.6 individuals/ha with a linear density of 11.3 individuals/km. The intermediate values of linear density estimates herein are similar to other areas, suggesting that silvicultural landscapes can be relevant for *C. latirostris* conservation. Therefore, the role of silvicultural landscapes in crocodylian conservation should be taken into consideration for environmental certification processes related to forestry in the Neotropics.

Murray, C.M., Easter, M., Padilla, S., Marin, M.S. and Guyer, C. (2016). Regional warming and the thermal regimes of American crocodile nests in the Tempisque Basin, Costa Rica. *Journal of Thermal Biology* 60: 49-59.

Abstract: Spatial variation in global climate change makes population-specific responses to this enigmatic threat pertinent on a regional scale. Organisms with temperature-dependent sex determination (TSD) potentially possess a unique physiological susceptibility that threatens population viability if rapid environmental effects on sex ratios render populations non-viable. A heavily male-biased sex ratio for hatchling American crocodiles of the Tempisque Basin, Costa Rica requires assessment of how nest temperature affects sex determination at this site, how females

might compensate for these effects when creating nests, and how current patterns of climate change might alter future sex ratios and survival in hatchling cohorts. We demonstrate high within-nest variation in temperature but predict a female bias at hatching based on nest temperatures quantified here. Further, our data suggest that egg size and metabolic heating associated with this factor outweighs microhabitat parameters and depth in influencing nest thermal regimes. Finally, we document regional warming in the Tempisque Basin over the last 15 years and project that further heating over the next 15 years will not yield hatchling sex ratios as male biased as those currently found at this site. Thus, we find no support for nest temperature or climate change as likely explanations for male-biased American crocodile (*Crocodylus acutus*) sex ratios in the Tempisque Basin.

Anwised, P., Jangpromma, N., Temsiripong, T., Patramanon, R., Daduang, S., Jitrapakdee, S., Araki, T. and Klaynongsruan, S. (2016). Cloning, expression, and characterization of Siamese crocodile (*Crocodylus siamensis*) hemoglobin from *Escherichia coli* and *Pichia pastoris*. The Protein Journal (doi: 10.1007/s10930-016-9669-7).

Abstract: Recombinant *Crocodylus siamensis* hemoglobin (cHb) has been constructed and expressed using *Escherichia coli* as the expression system in conjunction with a trigger factor from the Cold-shock system as the fusion protein. While successful processing as soluble protein in *E. coli* was achieved, the net yields of active protein from downstream purification processes remained still unsatisfactory. In this study, cHb was constructed and expressed in the eukaryotic expression system *Pichia pastoris*. The results showed that cHb was excreted from *P. pastoris* as a soluble protein after 72 h at 25°C. The amino acid sequence of recombinant cHb was confirmed using LC-MS/MS. Indeed, the characteristic of Hb was investigated by external heme incorporation. The UV-Vis profile showed a specific pattern of the absorption at 415 nm, indicating the recombinant cHb was formed complex with heme, resulting in active oxyhemoglobin (OxyHb). This result suggests that the heme molecules were fully combined with heme binding site of the recombinant cHb, thus producing characteristic red color for the OxyHb at 540 and 580 nm. The results revealed that the recombinant cHb was prosperously produced in *P. pastoris* and exhibited a property as protein-ligand binding. Thus, our work described herein offers a great potential to be applied for further studies of heme-containing protein expression. It represents further pleasing option for protein production and purification on a large scale, which is important for determination and characterization of the authenticity features of cHb proteins.

De A. Marsola, J.C., Batezelli, A., Montefeltro, F.C., Grellet-Tinner, G. and Langer, M.C. (2016). Palaeoenvironmental characterization of a crocodylian nesting site from the Late Cretaceous of Brazil and the evolution of crocodyliform nesting strategies. Palaeogeography, Palaeoclimatology, Palaeoecology 457: 221-232.

Abstract: Despite the vast crocodyliform fossil record, little is known about the reproductive biology and nesting strategies of the extinct members of the group. Here we report a large accumulation of crocodylian fossil eggs from the type-locality of the baurusuchid *Pissarrachampsia sera*. Sedimentary facies and architectural elements of the site support a palaeoenvironmental model with a shallow lacustrine, playa-lake system interacting to ephemeral braided fluvial channels, with aeolian influence and development of sandy soils. The presence of pedogenic calcretes in the palaeosols indicates arid to semi-arid conditions. The crocodylian affinity of the eggs is supported by the thin eggshell which bears wedge-

shaped shell units with tabular microstructures. Furthermore, taphonomic data support an autochthonous assemblage of eggs and skeletal remains, hinting at a monotypical stratigraphic horizon and suggesting *P. sera* as the egg-laying taxon. The repeated pattern of four (eventually five) eggs per clutch at the site demonstrates that *P. sera* laid fewer eggs compared to modern crocodylians, indicating that k-selected reproductive strategy pattern is pervasive in the fossil record of Notosuchia. In the crocodyliform phylogenetic framework, the k-strategy and the “egg clutch sizes” optimization of Notosuchia is opposite to the strategy with larger clutches consistently occurring in modern Crocodylia and Neosuchia, the sister clade to Notosuchia. Yet, the lack of data on more early-branching taxa renders unclear which pattern is plesiomorphic for Crocodyliformes as a whole.

Drymala, S.M. and Zanno, L.E. (2016). Osteology of *Carnufex carolinensis* (Archosauria: Psuedosuchia) from the Pekin Formation of North Carolina and its implications for early crocodylomorph evolution. PLoS ONE 11(6): e0157528.

Abstract: Crocodylomorphs originated in the Late Triassic and were the only crocodile-line archosaurs to survive the end-Triassic extinction. Recent phylogenetic analyses suggest that the closest relatives of these generally gracile, small-bodied taxa were a group of robust, large-bodied predators known as rauisuchids implying a problematic morphological gap between early crocodylomorphs and their closest relatives. Here we provide a detailed osteological description of the recently named early diverging crocodylomorph *Carnufex carolinensis* from the Upper Triassic Pekin Formation of North Carolina and assess its phylogenetic position within the Paracrocodylomorpha. *Carnufex* displays a mosaic of crocodylomorph, rauisuchid, and dinosaurian characters, as well as highly laminar cranial elements and vertebrae, ornamented dermal skull bones, a large, subtriangular antorbital fenestra, and a reduced forelimb. A phylogenetic analysis utilizing a comprehensive dataset of early paracrocodylomorphs and including seven new characters and numerous modifications to characters culled from the literature recovers *C. carolinensis* as one of the most basal members of Crocodylomorpha, in a polytomy with two other large bodied taxa (CM 73372 and *Redondavenator*). The analysis also resulted in increased resolution within Crocodylomorpha and a monophyletic clade containing the holotype and two referred specimens of *Hesperosuchus* as well as *Dromicosuchus*. *Carnufex* occupies a key transition at the origin of Crocodylomorpha, indicating that the morphology typifying early crocodylomorphs appeared before the shift to small body size.

Poapolathep, S., Giorgi, M., Hantrakul, S., Klangkaew, N., Sanyathitiseree, P. and Poapolathep, A. (2016). Pharmacokinetics of marbofloxacin in freshwater crocodiles (*Crocodylus siamensis*) after intravenous and intramuscular administration. Journal of Pharmacology and Therapeutics (doi: 10.1111/jvp.12335).

Abstract: To evaluate the fate and disposition of marbofloxacin (MBF) in freshwater crocodiles (*Crocodylus siamensis*), MBF was administered either intravenously (i.v.) or intramuscularly (i.m.) at a dosage of 2.0 mg/kg body weight. The concentrations of MBF in plasma were measured using high-performance liquid chromatography equipped with a fluorescence detector. The concentrations of MBF in the plasma were measurable up to 144 h after i.v. and i.m. administration. After the first 45 min, the mean pharmacokinetic profiles produced by the two administration routes were almost identical. No statistically significant differences in the pharmacokinetic parameters between the groups were observed. The half-life was long (about 2.5 days), the volume of distribution was large (about 1.44 L/kg), λ_z was small (0.01 h⁻¹), and the clearance

was slow (22.6 mL/h/kg). The absolute i.m. bioavailability (F%) was 105.36%. The dose of MBF administered in this study seems to produce appropriate PK-PD parameters that predict antibacterial success for disease caused by susceptible bacteria. More studies are warranted to evaluate the likely residues after administration of multiple doses.

Andrew, R., Milner, C. and Lockley, G. (2016). Dinosaur swim track assemblages: characteristics, contexts, and ichnofacies implications. Chapter 10. Pp. 152-181 in *Dinosaur Tracks: The Next Steps*, ed. by P.L. Falkingham, D. Marty and A. Richter. Indiana University Press: Bloomington, Indiana, USA.

De Andrade, D.V., Bevier, C.R. and De Carvalho, J.E. (Eds.) (2016). *Amphibian and Reptile Adaptations to the Environment. Interplay between Physiology and Environment*. CRC Press: Boca Raton, Florida, USA.

Steel, L. and Buffetaut, E. (2016). Arthur Smith Woodward, Florentino Ameghino and the first Jurassic 'Sea Crocodile' from South America. *Geological Society, London, Special Publications* 430: 311-319.

Abstract: The Natural History Museum (NHMUK) fossil reptile collections contain a set of specimens sent to Arthur Smith Woodward in 1908 by the Argentinian palaeontologist, Florentino Ameghino. This collection includes a skull and other material of *Cricosaurus*, a metriorhynchid thalattosuchian (or 'sea crocodile'), a group of marine crocodylomorphs that existed from at least the Middle Jurassic to the Early Cretaceous. Handwritten labels in Spanish, probably by Ameghino, and notes in English signed by Smith Woodward are still with the specimens. Using Ameghino and Smith Woodward's correspondence to investigate the history of the specimens, we have determined that they came from the Vaca Muerta Formation of the Neuquén Basin in Patagonia, they were in the fossil collection of the Museo Nacional, Buenos Aires (MNBA) and that Ameghino loaned them to Smith Woodward for a study that was never published. Therefore, they will be returned to Museo Argentino de Ciencias Naturales 'Bernardino Rivadavia', Buenos Aires. These fossils, although not the most impressive, are probably the first metriorhynchid material collected in South America.

Whiting, E.T., Steadman, D.W. and Vliet, K.A. (2016). Cranial polymorphism and systematics of Miocene and living *Alligator* in North America. *Journal of Herpetology* 50(2): 306-315.

Abstract: We examined the osteology of Neogene *Alligator*, with a focus on fossils from the late Miocene (~8-7 million years ago [Ma]) Moss Acres Racetrack locality in Marion County, Florida, USA. These fossils have been referred previously to *Alligator* cf. *A. mefferdi* (early late Miocene, ~12-10 Ma, Nebraska), an extinct species that we and others have found to be lacking autapomorphic characters. Furthermore, numerous cranial polymorphisms, previously regarded as diagnostic autapomorphies or synapomorphies, exist in several species of *Alligator*, particularly in *Alligator prenasalis* (late Eocene-early Oligocene, ~36-33 Ma, South Dakota and possibly Nebraska), *Alligator olseni* (early Miocene, ~18-17 Ma, Florida), and the extant American alligator (*Alligator mississippiensis*; southeastern United States). Except for minute differences in two scapular characters, the fossil *Alligator* from Moss Acres Racetrack is virtually indistinguishable from the *A. mississippiensis* morphotype, suggesting its referral to that lineage rather than to an extinct species. Cladistic analysis upholds this notion, with *A.*

mississippiensis and the Moss Acres Racetrack *Alligator* being sister taxa in a unified clade isolated from *A. mefferdi*. This implies that the *A. mississippiensis* morphological lineage has existed in North America with very little change for the past 7-8 million years.

Pooley, S. (2016). The entangled relations of humans and Nile crocodiles in Africa, c.1840-1992. *Environment and History* 22: 421-454.

Abstract: The nature of European explorers' and hunters' perceptions of the wildlife they encountered during their travels, and how this shaped their responses to it, has been surprisingly little studied. This may in part be because of the wealth of primary material and the dearth of secondary sources. Animal studies has come of age in recent decades, with a focus on how humans have conceptualised and related to animals, but much of this new field concerns domesticated or captive animals and has tended towards philosophical, political and theoretical approaches. Yet there is much to be gained from a historical exploration of the abundant sources on Europeans' encounter with wildlife, notably during the height of colonial exploration and adventuring in Africa. This review focuses on the Nile crocodile (*Crocodylus niloticus* and *C. suchus*) in Africa. Crocodiles had a major impact on European travellers, elicited extreme reactions and reveal an irrational difference in attitudes to large mammalian predators, as opposed to reptilian. The oft-repeated statement that Nile crocodiles kill more humans and are more hated than any other predator (or even, all other predators) in Africa is still current. The expansion of human settlement and activities into the habitats of crocodiles and increasing demands on water supplies is resulting in escalating conflicts and some experts regard crocodiles as a 'growing threat to rural livelihoods and development'. If these important apex predators of the continent's waterways are to be conserved, then a good place to start seems to be with an exploration of the long history of interactions with them that have shaped expert and public perceptions of crocodile.

Price, E.R., Sirsat, T.S., Sirsat, S.K.G., Kang, G., Keereetaweep, J., Aziz, M., Chapman, K.D. and Dzialowski, E.M. (2016). Thermal acclimation in American alligators: effects of temperature regime on growth rate, mitochondrial function, and membrane composition. *Journal of Thermal Biology* (doi:10.1016/j.jtherbio.2016.06.016).

Abstract: We investigated the ability of juvenile American alligators (*Alligator mississippiensis*) to acclimate to temperature with respect to growth rate. We hypothesized that alligators would acclimate to cold temperature by increasing the metabolic capacity of skeletal muscles and the heart. Additionally, we hypothesized that lipid membranes in the thigh muscle and liver would respond to low temperature, either to maintain fluidity (via increased unsaturation) or to maintain enzyme reaction rates (via increased docosahexaenoic acid). Alligators were assigned to one of 3 temperature regimes beginning at 9 mo of age: constant warm (30°C), constant cold (20°C), and daily cycling for 12 h at each temperature. Growth rate over the following 7 mo was highest in the cycling group, which we suggest occurred via high digestive function or feeding activity during warm periods and energy-saving during cold periods. The warm group also grew faster than the cold group. Heart and liver masses were proportional to body mass, while kidney was proportionately larger in the cold group compared to the warm animals. Whole-animal metabolic rate was higher in the warm and cycling groups compared to the cold group - even when controlling for body mass - when assayed at 30°C, but not at 20°C. Mitochondrial oxidative phosphorylation capacity in permeabilized fibers of thigh muscle and heart did not differ among treatments. Membrane fatty acid composition of the brain was largely unaffected by temperature

treatment, but adjustments were made in the phospholipid headgroup composition that are consistent with homeoviscous adaptation. Thigh muscle cell membranes had elevated polyunsaturated fatty acids in the cold group relative to the cycling group, but this was not the case for thigh muscle mitochondrial membranes. Liver mitochondria from cold alligators had elevated docosahexaenoic acid, which might be important for maintenance of reaction rates of membrane-bound enzymes.

Blanco, A. and Brochu, C.A. (2016). Intra- and interspecific variability in allodaposuchid crocodylomorphs and the status of western European taxa. *Historical Biology: An International Journal of Paleobiology* (doi:10.1080/08912963.2016.1201081).

Abstract: The genus *Allodaposuchus* is an endemic eusuchian from the Late Cretaceous of Europe. This genus was erected in 1928 by Baron Franz Nopcsa based on *Allodaposuchus precedens* from the Maastrichtian of Romania. Fragmentary skulls recovered from France and Spain were later referred to *A. precedens*, but three new species of *Allodaposuchus* have since been described: *A. subjuniperus*, *A. palustris* and *A. hulki*. A set of remains from Velaux, France, was recently interpreted as an ontogenetic series of *A. precedens*, prompting the argument that other species referred to *Allodaposuchus* are synonyms of *A. precedens*. Here, we review intra- and interspecific variability among allodaposuchids. Diagnostic characters for different allodaposuchids are outside the ranges of variation for modern species. Ontogenetic (intraspecific) variation observed in the allodaposuchid from Velaux is not in conflict with the presence of at least four taxa in the European Archipelago during the Late Cretaceous.

Sideleau, B., Edyvane, K. and Britton, A. (2016). An analysis of recent saltwater crocodile (*Crocodylus porosus*) attacks in Timor-Leste and consequences for management and conservation. *Marine and Freshwater Research*.

Abstract: Saltwater crocodiles (*Crocodylus porosus*) are potentially dangerous to humans, yet they have major cultural value to many people in Timor-Leste. Recent increases in attack risk are influencing attitudes, threatening culls of remaining wild crocodile populations. To understand patterns that may assist mitigation, we compiled attack records for the period April 2007-April 2014 using the CrocBITE online database. Recorded attacks (n= 45) showed a high fatality rate (82.2%), the majority (77.8%) recorded since 2010. The highest proportion of attacks (46.7%) occurred in southern coast wetlands suited to crocodiles, areas representing major sources of food, livelihoods, and ecosystem services (i.e., fisheries, timber, coastal protection) for locals. Subsistence fishing posed the highest attack risk, particularly from September to February when food security is low. Attacks matched gender roles (most victims were males, the primary fishers) and demographic patterns (teenagers, the fastest growth group, comprised the highest proportion). Predicted increases in food insecurity, fishing activities, coastal impacts and rising human and crocodile populations pose worrying implications for human-crocodile conflict. We recommend essential baseline surveys enabling meaningful management decisions, and suggest that tailored management and educational awareness based on proven existing models could substantially mitigate attack risk while remaining compatible with traditional Timorese attitudes towards crocodiles.

Bhattacharai, S. (2016). Notes on Mugger Crocodile *Crocodylus palustris* (Lesson, 1831) hunting on *Axis axis* in Bardia National Park, Nepal. *HYLA: Herpetological Journal* 2015(2): 41-44.

Abstract: Mugger Crocodile *Crocodylus palustris* is a specialized voracious predator. Hunting strategy of the Mugger on the *Axis axis* deer and food storing for later use behavior of *Crocodylus palustris* is documented in Bardia National Park, Nepal. Understanding the diet of the Mugger is of great significance in Bardia National Park for its conservation and management.

Allan, N. (2016). Lacoste's crocodile has serious bite. *Journal of Intellectual Property Law & Practice* 11(3): 159-160.

Abstract: The General Court has rejected an appeal from the Fourth Board of Appeal of the Office for Harmonisation in the Internal Market (OHIM) and upheld Lacoste's opposition to the registration of a crocodile or caiman figure as a Community trade mark (CTM) for leather goods, clothing and footwear on the grounds of likelihood of confusion with Lacoste's well-known crocodile mark. The court accepted that the opposing signs had a low degree of visual similarity but found that, because of an average degree of conceptual similarity and the high level of acquired distinctiveness of Lacoste's crocodile, the general public was likely to believe that the goods bearing the respective signs came from the same undertaking. In particular, the court considered that the representation of the caiman applied for might be perceived as a variant on the representation of Lacoste's crocodile.

Campos, Z. and Magnusson, W.E. (2016). Density and biomass estimates by removal for an Amazonian crocodylian, *Paleosuchus palpebrosus*. *PLoS ONE* 11(5): e0156406.

Abstract: Direct counts of crocodylians are rarely feasible and it is difficult to meet the assumptions of mark-recapture methods for most species in most habitats. Catch-out experiments are also usually not logistically or morally justifiable because it would be necessary to destroy the habitat in order to be confident that most individuals had been captured. We took advantage of the draining and filling of a large area of flooded forest during the building of the Santo Antônio dam on the Madeira River to obtain accurate estimates of the density and biomass of *Paleosuchus palpebrosus*. The density, 28.4 non-hatchling individuals per km², is one of the highest reported for any crocodylian, except for species that are temporarily concentrated in small areas during dry-season drought. The biomass estimate of 63.15 kg*km⁻² is higher than that for most or even all mammalian carnivores in tropical forest. *P. palpebrosus* may be one of the World's most abundant crocodylians.

Barksdale, S. (2015). Novel Antimicrobial Peptides in Alligator and Crocodile. MSc thesis, George Mason University, Fairfax, Virginia, USA.

Abstract: Novel antibiotics are needed to fight the rising tide of drug resistance in pathogenic bacteria. One possible source is cationic antimicrobial peptides (CAMPs), small proteins produced by the innate immune system. CAMPs have a range of mechanisms including direct antibacterial action and immunomodulatory effects. Crocodylians are part of an ancient clade, the Archosaurs, and are more closely related to birds and dinosaurs than other living reptiles. Very little is known about the innate immune systems of crocodylians, but research has found that the serum of these species have antimicrobial activity beyond that of human serum. This activity is thought to be partly due to CAMPs, though only a handful of crocodylian CAMPs have been described. In this thesis, four novel CAMPs from members of the order Crocodylia are investigated. A hepcidin from *Crocodylus siamensis*, an iron-regulating peptide with 4 intramolecular disulfide bonds, is found to have weak

activity against *Pseudomonas aeruginosa*, *Escherichia coli*, and *Staphylococcus aureus*. Two fragments of an apolipoprotein found in the blood of *Alligator mississippiensis* were found to have strong activity against a range of Gram negative and Gram positive bacteria, including multi-drug resistant bacteria. These fragments were found to be alpha-helical and to depolarize the bacterial membrane. A cathelicidin from *A. mississippiensis* is strongly active against *P. aeruginosa* and multi-drug resistant *Acinetobacter baumannii* and permeabilizes the bacterial membrane. These analyses give us greater understanding of the crocodylian innate immune system. In addition, these CAMPs could be used as a basis for new antimicrobials.

Cunha, F.A.G. Barboza, R.S.L. and Rebêlo, G.H. (2016). Communal nesting of *Caiman crocodylus* (Linnaeus, 1758) (Crocodylia: Alligatoridae) in lower Amazon river floodplain, Brazil. *Herpetology Notes* 9: 141-144.

Katsu, Y., Kohno, S., Oka, K. and Baker, M.E. (2016). Evolution of corticosteroid specificity for human, chicken, alligator and frog glucocorticoid receptors. *Steroids* 113: 38-45.

Abstract: We investigated the evolution of the response of human, chicken, alligator and frog glucocorticoid receptors (GRs) to dexamethasone, cortisol, cortisone, corticosterone, 11-deoxycorticosterone, 11-deoxycortisol and aldosterone. We find significant differences among these vertebrates in the transcriptional activation of their full length GRs by these steroids, indicating that there were changes in the specificity of the GR for steroids during the evolution of terrestrial vertebrates. To begin to study the role of interactions between different domains on the GR in steroid sensitivity and specificity for terrestrial GRs, we investigated transcriptional activation of truncated GRs containing their hinge domain and ligand binding domain (LBD) fused to a GAL4 DNA binding domain (GAL4-DBD). Compared to corresponding full length GRs, transcriptional activation of GAL4-DBD-GR-hinge/LBD constructs required higher steroid concentrations and displayed altered steroid specificity, indicating that interactions between the hinge/LBD and other domains are important in glucocorticoid activation of these terrestrial GRs.

Balaguera-Reina, S.A., Venegas-Anaya, M., Sanchez, A., Arbelaez, I., Lessios, H.A. and Densmore, L.D. III (2016). Spatial ecology of the American crocodile in a tropical Pacific island in Central America. *PLoS One*.11(6): e0157152.

Abstract: Conservation of large predators has long been a challenge for biologists due to the limited information we have about their ecology, generally low numbers in the wild, large home ranges and the continuous expansion of human settlements. The American crocodile (*Crocodylus acutus*) is a typical apex predator, that has suffered from all of these characteristic problems, especially the latter one. Humans have had a major impact on the recovery of this species throughout its range, even though most of the countries it inhabits have banned hunting. The last decade has made it clear that in order to implement sound conservation and management programs, we must increase our understanding of crocodile spatial ecology. However, in only two countries where American crocodiles have telemetry studies even been published. Herein we have characterized the spatial ecology of *C. acutus* on Coiba Island, Panama, by radio-tracking (VHF transmitters) 24 individuals between 2010 and 2013, to determine movement patterns, home range, and habitat use. We have then compared our findings with those of previous studies to develop the most comprehensive assessment of American crocodile spatial ecology to date. Females showed a higher average movement

distance (AMD) than males; similarly, adults showed a higher AMD than sub-adults and juveniles. However, males exhibited larger home ranges than females, and concomitantly sub-adults had larger home ranges than juveniles, hatchlings, and adults. There was an obvious relationship between seasonal precipitation and AMD, with increased AMD in the dry and “low-wet” seasons, and reduced AMD during the “true” wet season. We found disaggregate distributions according to age groups throughout the 9 habitat types in the study area; adults and hatchlings inhabited fewer habitat types than juveniles and sub-adults. These sex- and age-group discrepancies in movement and habitat choice are likely due to the influences of reproductive biology and Coiba’s precipitation cycle. Juveniles also showed distinct movement patterns and home ranges; however, with sexual maturation and development, these behaviors became more characteristic of adults and sub-adults. Ours is one of a very small number of studies that will allow future management and conservation planning to be based on the comprehensive integration of the spatial ecology of a Neotropical crocodylian apex predator.

Ou, Y. and Ho, W.S. (2016). Crocodile blood extract induces the apoptosis of lung cancer cells through PTEN activity. *Oncology Reports* (<http://dx.doi.org/10.3892/or.2016.4914>).

Abstract: Current treatment strategies for lung cancer cause undesirable side-effects. Integrated medicine with a curative approach has become a common approach to the treatment strategy. Recent studies suggest that American alligator blood is effective in reducing colorectal cancer cell viability in vitro, but the mechanism remains unclear. In the present study, we aimed to study the anticancer activity of crocodile blood extracts on lung cancer cell line A549 and investigate the possible mechanisms involved. In vitro studies were utilized to investigate the effects on the cancer cells after incubation with the blood extracts. The active fraction that showed more efficacy in inhibiting cell growth was characterized in the supernatant (S2) from whole blood extracts. High performance liquid chromatography (HPLC) analysis revealed that S2 contained more polar moiety from whole blood. S2 induced DNA fragmentation. Cell cycle arrest in the G1/M phase was demonstrated and mitochondrial membrane permeability was disrupted. An increase in the generation of reactive oxygen species (ROS) and increased activities of caspase-3 and caspase-7 were detected. Furthermore, release of cytochrome c, upregulation of expression of Bax, p53, p21, Bid, cleaved forms of the caspase family and PARP along with downregulation of Bcl-2, PCNA, MDM2, caspase-8, wild types of caspase family proteins and PARP were recorded after treatment with S2 fractions. Moreover, the PI3K/AKT survival pathway was downregulated by S2 fractions in the lung cancer cell line.

González-Desales, G.A., Monroy-Vilchis, O., Zarco-González, M.M. and Charrau, P. (2016). Nesting ecology of the American crocodile in La Encrucijada Biosphere Reserve, Mexico. *Amphibia-Reptilia* (doi:10.1163/15685381-00003051).

Abstract: Nesting of the American crocodile (*Crocodylus acutus*) is affected by natural and anthropogenic processes. In Mexico, few studies exist on reproductive traits of wild populations. We assessed the key reproductive characteristics of *C. acutus* in the La Encrucijada biosphere reserve and the environmental and anthropogenic factors that influence them. From February to June 2014, we searched for nests in the reserve. Clutch incubation temperature was recorded by data loggers and climatic variables were obtained from La Encrucijada meteorological station. Additionally, outside the study area, net primary productivity was obtained for different sites in Mexico to relate it to clutch characteristics. We found 34 nests in 9 nesting areas. Egg laying occurred in March, and hatching

took place from mid-May to early June. Mean clutch and eggs characteristics are among the higher reported for *C. acutus*. Some egg attributes had a relationship with the net primary productivity. There was no relation between hatching success and external and internal characteristics of the nest. A high percentage of nests was poached (50%) mainly for egg consumption and fear of crocodiles, and the nests closer to the river, trees or human settlements are more likely to be poached.

González-Desales, G.A., Monroy-Vilchis, O., Charruau, P. and Zarco-González, M.M. (2016). Aspectos ecológicos de la anidación de *Caiman crocodilus chiapasius* (Bocourt, 1876) en la reserva de la biosfera La Encrucijada, México. *Animal Biodiversity and Conservation*, 39(2): 155-160.

Abstract: Studies on caiman, *Caiman crocodilus chiapasius*, in Mexico are scarce. The present study was conducted to evaluate the key characteristics regarding the reproductive ecology of caiman in Mexico. We conducted nest searches from April to September 2014. We observed that nests were built in June and that hatching occurred in September and October. The phase of the moon had an effect on nesting events. The height of the nest, the distance to the nearest tree, and the distance from the top of the nest to the first egg were related to hatching success and incubation temperature.

Murray, C.M., Easter, M., Merchant, M., Rheubert, J.L., Wilson, K.A., Cooper, A., Mendonca, M., Wibbels, T., Marin, M.S. and Guyer, C. (2016). Methyltestosterone alters sex determination in the American alligator (*Alligator mississippiensis*). *General and Comparative Endocrinology* 236: 63-69.

Young, M.T., Hastings, A.K., Allain, R. and Smith, T.J. (2016). Revision of the enigmatic crocodyliform *Elosuchus felixi* de Lapparent de Broin, 2002 from the Lower-Upper Cretaceous boundary of Niger: potential evidence for an early origin of the clade Dyrosauridae. *Zoological Journal of the Linnean Society* (doi: 10.1111/zoj.12452).

Abstract: The enigmatic crocodyliform '*Elosuchus*' *felixi* from the Echkar Formation (upper Albian to lower Cenomanian, Early-Late Cretaceous boundary) west of In Abangharit, Agadez District, Niger, is here re-described. Our assessment of the material shows that there are at least two taxa amongst the referred material: '*E.*' *felixi*, including the holotype (an incomplete lower jaw) and two larger incomplete lower jaws; and an incomplete premaxilla, which we refer to *Elosuchus* sp. All other referred material is herein considered Crocodyliformes indeterminate. Based on our study of '*E.*' *felixi* we refer it to a new genus, *Fortignathus*. A comparative study and updated phylogenetic analyses both suggest that *F. felixi* comb. nov. is a non-hyposaurine dyrosaurid or a dyrosaurid sister taxon. This is supported by four characteristics, including: inferred double festooned maxillae, a large gap between the D2 and D3 alveoli, gladius-shaped anterior dentary, and enlarged D4 alveoli that have a subrectangular cross section. The paucity of material means we refrain from referring *F. felixi* comb. nov. to Dyrosauridae. This species and suggestive material from the Cenomanian of Sudan allows us to formulate two hypotheses, however: (1) basal dyrosaurids were either freshwater or could live in both freshwater and saltwater ecosystems; and (2) Africa was their place of origin and dispersal.

Vieira, L.G., Santos, A.L.Q., Lima, F.C., De Mendonça, S.H.S., Menezes, L.T. and Sebben, A. (2016). Ontogeny of the appendicular

skeleton in *Melanosuchus niger* (Crocodylia: Alligatoridae). *Zoological Science* 33(4): 372-383.

Abstract: The objective of the present study was to analyze chondrogenesis and the ossification pattern of the limbs of *Melanosuchus niger* in order to contribute with possible discussions on homology and the fusion pattern of autopodial elements and phylogeny. In the Reserva Extrativista do Lago Cuniã, Rondônia, Brazil, 6 nests were marked and two eggs removed from each nest at 24-hour intervals until hatching. Embryos were cleared using KOH; bone tissue was stained with alizarin red S and cartilage with Alcian blue. Routine staining with HE was also performed. In the pectoral girdle, the scapula showed ossification centers before the coracoid process. In the pelvic girdle, the ilium and the ischium were condensed as a single cartilage, although ossification took place through two separate centers, forming distinct elements in the adult. The pubis developed from an independent cartilaginous center with free end, which reflects its function in breathing. In the initial stages, the stylopodium and the zeugopodium developed from the condensation of a Y-shaped cartilage in the limbs, and differentiation of the primary axis and digital arch were observed. The greatest changes were observed in the mesopodia. In their evolution, Crocodylia underwent a vast reduction in the number of autopodial elements as a consequence of fusions and ossification of some elements. This study shows that the chondrogenesis and ossification sequences are dissociated. Moreover, the differences between *M. niger* and other species show clear variation in the patterns for these events in Alligatoridae.

Gardner, B., Garner, L.A., Cobb, D.T. and Moorman, C.E. (2016). Factors affecting occupancy and abundance of American alligators at the northern extent of their range. *Journal of Herpetology*.

Abstract: Populations of American Alligators (*Alligator mississippiensis*) generally are considered more abundant at present than historically; however, little information exists to assess the population of alligators in North Carolina at the northern extent of the species' range. Investigation of the factors influencing the distribution and abundance of alligators in North Carolina could shed light on the species' response to rapid environmental change in the region. We conducted a two-phase study: 1) to assess the distribution of alligators in North Carolina using a site-occupancy design; and 2) to assess the patterns in abundance using a repeated sampling design for population estimation. Results showed that both occupancy and abundance decreased in more northern sites, in sites with higher salinity, and in sites that were generally more westward. Sites sampled later in June were more likely to be occupied than those sampled earlier in the month. Abundance also increased with greater shoreline vegetation complexity and varied between lakes, rivers, and estuaries. Compared with studies from 30 years prior, the population seems fairly stable in terms of abundance and distribution. Given the northern limits of the species and the negative association with salinity, continued monitoring is warranted to understand changes in distribution and abundance with respect to predicted rates of sea-level rise, salinization, and urbanization locally around coastal cities like Wilmington.

Brusatte, S.L., Muir, A., Young, M.T., Walsh, S., Steel, L. and Witmer, L.M. (2016). The braincase and neurosensory anatomy of an early Jurassic marine crocodylomorph: Implications for crocodylian sinus evolution and sensory transitions. *The Anatomical Record* (doi: 10.1002/ar.23462).

Abstract: Modern crocodylians are a morphologically conservative group, but extinct relatives (crocodylomorphs) experimented

with a wide range of diets, behaviors, and body sizes. Among the most unusual of these fossil groups is the thalattosuchians, an assemblage of marine-dwellers that transitioned from semiaquatic species (teleosaurids and kin) into purely open-ocean forms (metriorhynchids) during the Jurassic and Cretaceous Periods (ca 191-125 million years ago). Thalattosuchians can give insight into the origin of modern crocodylian morphologies and how anatomy and behavior change during a major evolutionary transition into a new habitat. Little is known, however, about their brains, sensory systems, cranial sinuses, and vasculature. We here describe the endocranial anatomy of a well-preserved specimen of the Jurassic semiaquatic teleosaurid *Steneosaurus* cf. *gracilirostris* using X-ray micro-CT. We find that this teleosaurid still had an ear well attuned to hear on land, but had developed large internal carotid and orbital arteries that likely supplied salt glands, previously thought to be present in only the fully pelagic metriorhynchids. There is no great gulf in endocranial anatomy between this teleosaurid and the metriorhynchids, and some of the features that later permitted metriorhynchids to invade the oceanic realm were apparently first developed in semiaquatic taxa. Compared to modern crocodylians, *Steneosaurus* cf. *gracilirostris* has a more limited set of pharyngotympanic sinuses, but it is unclear whether this relates to its aquatic habitat or represents the primitive condition of crocodylomorphs that was later elaborated.

Meunier, L.M.V. and Larsson, H.C.E. (2016). Revision and phylogenetic affinities of *Elosuchus* (Crocodyliformes). *Zoological Journal of the Linnean Society* (doi: 10.1111/zoj.12448).

Abstract: Elosuchidae is a clade of longirostrine Crocodyliformes currently confined to Barremian through Cenomanian deposits in north-west Africa and Great Britain. The clade is currently composed of *Elosuchus cherifiensis* (Lavocat 1955), *Elosuchus felixi* de Lapparent de Broin, 2002, *Sarcosuchus imperator* Broin & Taquet 1966, *Sarcosuchus hartii* Buffetaut & Taquet 1977, *Vectisuchus leptognathus* Buffetaut & Hutt 1980 and, by some authors, *Stolokrosuchus lapparenti* Larsson & Gado 2000. We redescribe *Elosuchus* from assigned and new material. This genus occurs in terrestrial Cenomanian deposits in Morocco and Algeria and known from multiple relatively complete skulls. The holotype is unknown but the assigned lectotype in the Muséum National d'Histoire Naturelle (Paris, France) is composed of a fragmentary ventral braincase. Referred paralectotype material housed in the same museum includes multiple fragmentary specimens and two nearly complete skulls. These and additional material in the Canadian Museum of Nature and Royal Ontario Museum were used to re-examine the genus. The original and new material show a number of autapomorphies among crocodyliforms: a unique contribution of the squamosal and jugal to the postorbital anterolateral process and a highly modified suborbital fenestra that displaces the antorbital cavity anteriorly and forms a bony wall separating the cavity from the orbit. Two diagnosable morphotypes are revealed, one from the Kem Kem beds, Morocco, and the other from Gara Samani, Algeria. We retain *Elosuchus cherifiensis* for the Kem Kem form and erect a new species *Elosuchus broinae* sp. nov. for the Algerian form. The revised diagnosis for *Elosuchus* questions the validity of *E. felixi*. *Elosuchus* is incorporated into a phylogenetic analysis that includes extensive revisions to character scores for relevant taxa. The resulting topologies recover *Elosuchus* sister to *Meridiosaurus vallisparidisi* Mones 1980, within a complex of 'Pholidosauridae' that includes elosuchids and dyrosaurids but excludes *Stolokrosuchus*. This phylogenetic revision is used to discuss the evolution of this clade and its contribution to crocodyliform diversity during the Cretaceous.

Barksdale, S.M., Hrifko, E.J., Myung-Chul Chung, E. and van

Hoek, M.L. (2016). Peptides from American alligator plasma are antimicrobial against multi-drug resistant bacterial pathogens including *Acinetobacter baumannii*. *BMC Microbiology* (doi: 10.1186/s12866-016-0799-z).

Abstract: Our group has developed a new process for isolating and identifying novel cationic antimicrobial peptides from small amounts of biological samples. Previously, we identified several active antimicrobial peptides from 100 µl of plasma from *Alligator mississippiensis*. These peptides were found to have in vitro antimicrobial activity against *Pseudomonas aeruginosa* and *Staphylococcus aureus*. In this work, we further characterize three of the novel peptides discovered using this process: Apo5, Apo6, and A1P.

Milián-García, Y., Jensen, E.L., Mena, S.R., Fleitas, E.P., Rodríguez, G.S., Manchena, L.G., López, G.E. and Russello, M.A. (2016). Genetic evidence for multiple paternity in the critically endangered Cuban crocodile (*Crocodylus rhombifer*). *Amphibia-Reptilia* (doi: 10.1163/15685381-00003056).

Abstract: Conservation strategies can be most effective when factors influencing the persistence of populations are well-understood, including aspects of reproductive biology such as mating system. Crocodylians have been traditionally associated with a polygynous mating system, with genetic studies revealing multiple paternity of clutches in several species. The endemic Cuban crocodile, *Crocodylus rhombifer*, is currently listed as Critically Endangered, and is one of the least understood crocodylian species in terms of its mating behavior. Here, we tested a hypothesis of multiple paternity in the Cuban crocodile by collecting genotypic data at 9 microsatellite loci for 102 hatchlings from 5 nests sampled at the Zapata Swamp captive breeding facility and analyzing them in relation to data previously collected for 137 putative parents. All 5 nests showed evidence of multiple paternity based on the numbers of alleles per locus, with sibship analyses reconstructing all nests as having 4 to 6 full-sib family groups. Accordingly, mean pairwise relatedness values per nest ranged from 0.21 to 0.39, largely intermediate between theoretical expected values for half-siblings (0.25) and full-siblings (0.50). It is not possible to differentiate whether the multiple paternity of a nest was due to multiple matings during the same breeding season, or a result of sperm storage. Our results reveal that the *C. rhombifer* mating system is likely best characterized as promiscuous and suggest that the standard practice of enforcing a 1:2 sex ratio at the captive breeding facility should be altered in order to better maintain a demographically and genetically healthy *ex situ* population.

Gredler, M.L. (2016). Developmental and evolutionary origins of the amniote phallus. *Integrative and Comparative Biology* (doi: 10.1093/icb/icw102).

Abstract: An intromittent phallus is used for sperm transfer in most amniote taxa; however, there is extensive variation in external genital morphology within and among the major amniote clades. Amniote phalluses vary in number (paired, single, or rudimentary), spermatid canal morphology (closed tube or open sulcus), and mode of transition between resting and tumescent states (inflation, rotation, eversion, or muscle relaxation). In a phylogenetic context, these varying adult anatomies preclude a clear interpretation for the evolutionary history of amniote external genitalia; as such, multiple hypotheses have been presented for the origin(s) of the amniote phallus. In combination with historic embryological studies, recent comparative developmental analyses have uncovered evidence that, despite extensive morphological variation in adult anatomy,

embryonic patterning of the external genitalia is similar among amniotes and begins with emergence of paired swellings adjacent to the cloaca. External genital development in mammals, squamates (lizards, snakes, and amphisbaenians), Rhynchocephalians (tuataras), turtles, crocodylians (alligators, crocodiles, and gharials), and birds proceeds by iterative sequences of budding and fusion events, initiated by emergence of paired swellings adjacent to the embryonic cloaca. Conservation of the embryonic origins, morphogenetic processes, and molecular genetic mechanisms involved in external genital development across Amniota supports derivation from the common ancestor of amniotes, and suggests that lineage-specific divergence of later patterning events underlies the variation observed in extant adult amniote phallus morphology.

Mazzotti, F.J., Cherkiss, M.S., Parry, M., Beauchamp, J., Rochford, M., Smith, B., Hart, K. and Brandt, L.A. (2016). Large reptiles and cold temperatures: Do extreme cold spells set distributional limits for tropical reptiles in Florida? *Ecosphere* 7(8): e01439.

Abstract: Distributional limits of many tropical species in Florida are ultimately determined by tolerance to low temperature. An unprecedented cold spell during 2-11 January 2010, in South Florida provided an opportunity to compare the responses of tropical American crocodiles with warm-temperate American alligators and to compare the responses of nonnative Burmese pythons with native warm-temperate snakes exposed to prolonged cold temperatures. After the January 2010 cold spell, a record number of American crocodiles (n= 151) and Burmese pythons (n= 36) were found dead. In contrast, no American alligators and no native snakes were found dead. American alligators and American crocodiles behaved differently during the cold spell. American alligators stopped basking and retreated to warmer water. American crocodiles apparently continued to bask during extreme cold temperatures resulting in lethal body temperatures. The mortality of Burmese pythons compared to the absence of mortality for native snakes suggests that the current population of Burmese pythons in the Everglades is less tolerant of cold temperatures than native snakes. Burmese pythons introduced from other parts of their native range may be more tolerant of cold temperatures. We documented the direct effects of cold temperatures on crocodiles and pythons; however, evidence of long-term effects of cold temperature on their populations within their established ranges remains lacking. Mortality of crocodiles and pythons outside of their current established range may be more important in setting distributional limits.

Zychowski, G.V. and Godard-Coding, C.A.J. (2016). Reptilian exposure to polycyclic aromatic hydrocarbons and associated effects. *Environmental Toxicology and Chemistry* (doi: 10.1002/etc.3602).

Abstract: Reptiles are an underrepresented taxon in ecotoxicological literature, and the means by which toxicants play a role in population declines are only partially understood. Among the contaminants of interest for reptiles are the polycyclic aromatic hydrocarbons (PAHs), a class of organic compounds that is already a concern for numerous other taxa. The objectives of this review are 1) to summarize the existing literature on reptilian exposure to PAHs and synthesize general conclusions, 2) to identify knowledge gaps within this niche of research, and 3) to suggest future directions for research. Results confirm a relative scarcity of information on reptilian exposure to PAHs, although research continues to grow, particularly after significant contamination events. Orders Testudines and Squamata are better represented than Crocodylia and Rhynchocephalia. For the taxonomic orders with relevant literature (all but Rhynchocephalia), some species are more frequently represented than others. Few

studies establish solid cause-effect relationships after reptilian exposure to PAHs, and many more studies are suggestive of effect or increased risk of effect. Despite the scarcity of information in this area, researchers have already employed a wide variety of approaches to address PAH-related questions for reptiles, including molecular techniques, modeling, and field surveys. As more research is completed, a thoughtful interpretation of available and emerging data is necessary to make the most effective use of this information.

Wang, Y.Y., Sullivan, C. and Liu, J. (2016). Taxonomic revision of *Eoalligator* (Crocodylia, Brevirostres) and the paleogeographic origins of the Chinese alligatoroids. *PeerJ* 4: e2356.

Abstract: The primarily Neotropical distribution of living alligatoroids raises questions as to when and how the ancestors of *Alligator sinensis* migrated to China. As phylogeny provides a necessary framework for historical biogeographic issues, determining the phylogenetic positions of the Chinese alligatoroids is a crucial step towards understanding global alligatoroid paleobiogeography. Besides the unnamed alligatoroids from the Eocene of Guangdong Province, three Chinese fossil taxa have been referred to Alligatoroidea: *Alligator lucius*, *Eoalligator chunyii* and *Eoalligator huiningensis*. However, none of these fossil taxa has been included in a phylogenetic analysis. The genus *Eoalligator* was established to accommodate *E. chunyii* from Guangdong Province. *E. huiningensis* from Anhui Province was later erected as a second species, despite no distinctive similarities with *E. chunyii*. By contrast, the putative crocodyline *Asiatosuchus nanlingensis* was established based on material from Guangdong Province, close to the *E. chunyii* specimens geographically and stratigraphically. Furthermore, specimens of *A. nanlingensis* and *E. chunyii* share four distinctive characters, but display no evident differences. As a result, the taxonomic relationships of these three species require restudy.

Daltry, J.C., Langelet, E., Solmu, G.C., van der Ploeg, J., van Weerd, M. and Whitaker, R. (2017). Successes and failures of crocodile harvesting strategies in the Asia Pacific region. Pp. 345-362 in *Tropical Conservation: Perspectives on Local and Global Priorities*, ed. by A.A. Aguirre and Raman Sukumar. Oxford University Press: New York.

Serrano-Gómez, S.S., Guevara-Chumacero, L.M., Barriga-Sosa, I.D.L.A., Ullóa-Arvizu, R., González-Guzmán, S. and Vázquez-Peláez, C.G. (2016). Low levels of genetic diversity in *Crocodylus acutus* in Oaxaca and Guerrero, Mexico, and molecular-morphological evidence of the presence of *C. moreletii*. *Biochemical Systematics and Ecology* 69(Dec): 51-59.

Abstract: The genetic variation in *C. acutus* from the Pacific coast of Mexico was investigated using mitochondrial DNA data. Overall, the localities sampled included three in the State of Guerrero and three in the State of Oaxaca, Mexico. We inferred phylogenetic and genealogical relationships, and genetic diversity was determined, using partial sequences of the mitochondrial control region. Additional published sequences from GenBank for *C. acutus* and *C. moreletii* were utilized. The results obtained from 73 crocodile sequences indicate the presence of 5 haplotypes grouped into two monophyletic lineages, one corresponding to *C. acutus* and the other to *C. moreletii*. The presence of *C. moreletii* in Chacahua (Oaxaca) was unexpected. The level of nucleotide diversity was nil and moderate in *C. acutus* and *C. moreletii* lineages, respectively, consistent with other publications concerning Crocodylia. Further studies of crocodiles in Chacahua (Oaxaca) are necessary to assess the possibility of hybridization.

Crossley II., D.A, Ling, R., Nelson, D., Gillium, T., Conner, J., Hapgood, J., Else, R. and Eme, J. (2016). Metabolic responses to chronic hypoxic incubation in embryonic American alligators (*Alligator mississippiensis*). *Comparative Biochemistry and Physiology Part A: Molecular & Integrative Physiology* (<http://dx.doi.org/10.1016/j.cbpa.2016.08.017>).

Abstract: Chronic hypoxic incubation is a common tool used to study developmental changes in reduced O₂ conditions, and it has been useful for identifying phenotypically plastic periods during ontogeny in laboratory settings. Reptilian embryos can be subjected to natural hypoxia due to nesting strategy, and recent studies have been important in establishing the phenotypic responses of several species to low developmental oxygen. In particular, the cardiovascular responses of American alligators (*Alligator mississippiensis*) to low developmental oxygen have been detailed, including a substantial cardiac enlargement that may support a higher mass specific metabolic rate. However, embryo mass-specific metabolic demands of hypoxic incubated alligator embryos have not been measured. In this study, alligator eggs were incubated in 10% O₂ (H) or 21% O₂ (N) environments for the entire course of embryonic development. Acute metabolic measures in 21% and 10% O₂ were taken for both H and N groups. We hypothesized that acute 10% O₂ exposure has no impact on metabolic rate of embryonic alligators, and that metabolic rate is unaffected by chronic hypoxic incubation when studied in embryos measured at 21% O₂. Our findings suggest phenotypic changes resulting from hypoxic incubation early in incubation, in particular relative cardiac enlargement, enable embryonic alligators to sustain metabolic rate during acute hypoxic exposure.

Brien, M.L., Webb, G.J., McGuinness, K.A. and Christian, K.A. (2016). Effect of housing density on growth, agonistic behaviour, and activity in hatchling saltwater crocodiles (*Crocodylus porosus*). *Applied Animal Behaviour Science* (<http://dx.doi.org/10.1016/j.applanim.2016.08.007>).

Abstract: The purpose of this study was to examine the effect of density on growth rate, agonistic behaviour, activity and use of space by hatchling *C. porosus* in captivity. Hatchling *C. porosus* were raised in identical enclosures (1.5 m²) at different densities (3.3, 6.7, 13.3 and 20.0 hatchlings/m²; or 0.30, 0.15, 0.08 and 0.05 m²/hatchling respectively). Hatchlings came from 5 different clutches, hatched on the same day, spread evenly between density treatments (2 replicates per treatment). Growth rate (grams per day) was assessed between 4 and 25 days of age, which is a reliable indicator of post-hatching growth trajectories for this species. Clutch and initial body mass (BM) had a strong influence on growth rate, with a lower growth rate among the largest hatchlings born. The highest mean growth rate in body mass occurred at 6.7/m² (6.12 ± 1.24 g/d) and was lowest at the highest density (20.0/m²: -2.33 ± 0.63 g/d). Behavioural observations taken every 10 min on day 19 (24 h period) confirmed that hatchlings remained relatively inactive and hidden under cover for most of the day, and were more active at night, with peaks at dusk and dawn. However, the level of hourly activity (mean movements per individual per hour) was highest at densities of 13.3/m² and 20.0/m², compared with densities of 3.3/m² and 6.7/m². Behavioural observations at 1700-0800 h over 3 days (days 17-19) revealed that the frequency of agonistic interactions (mean per animal per night) was highest at the lower densities (3.3/m²; 6.7/m²) and decreased with increased density (13.3/m²; 20.0/m²). The results suggest that as density increases above 6.7/m², growth rate in hatchling *C. porosus* during the first 3 weeks begins to decline as activity increases. However, at the lowest density (and group size: 5), 1 or 2 individuals become dominant and grow large at the expense of the remaining hatchlings. Based on these results, it appears that the high and low densities tested may have an adverse

effect on hatchling *C. porosus* growth rate and behaviour in captivity.

Fleury, V., Murukutla, A.V., Chevalier, N.R., Gallois, B., Capellazzi-Resta, M., Picquet, P. and Peaucelle, A. (2016). *Physical Review E* 94(2): 022426 (<http://dx.doi.org/10.1103/PhysRevE.94.022426>).

Abstract: We present a detailed study of the formation of the amniotic sac in the avian embryo, and a comparison with the crocodile amniotic sac. We show that the amniotic sac forms at a circular line of stiffness contrast, separating rings of cell domains. Cells align at this boundary, and this in turn orients and concentrates the tension forces. The tissue fold which forms the amniotic sac is locked exactly along this line due to the colocalization of the stiffness contrast and of the tensile force. In addition, the tensile force plays a regenerative role when the amniotic sac is cut. The fold forming the ventral side of the embryo displays the same characteristics. This work shows that amniote embryogenesis consists of a cascade of buckling events taking place at the boundaries between regions of differing mechanical properties. Hence, amniote embryogenesis relies on a simple and robust biomechanical scheme used repeatedly, and selected ancestrally.

Rivera, S.J., Pacheco, L.F., Achá, D., Molina, C.I., Miranda-Chumacero, G. (2016). Low total mercury in *Caiman yacare* (Alligatoridae) as compared to carnivorous, and non-carnivorous fish consumed by Amazonian indigenous communities. *Environmental Pollution* (<http://dx.doi.org/10.1016/j.envpol.2016.07.013>).

Abstract: Mercury contamination in the River Beni basin is an important health risk factor, primarily for indigenous communities that live along the river. Among them are the Tacana, living in their original territory with sustainable use of their natural resources, consuming fish, *Caiman yacare*, and other riverine resources as their main source of protein. To assess mercury exposure to Tacana people, total mercury (THg) was evaluated in the muscle of 7 commercial fish, and *C. yacare* (Yacare caiman) during 2007 and 2008. THg was extracted by acid digestion and concentrations were determined by atomic absorption spectrometry. Mean mercury concentrations in *C. yacare* were 0.21 ± 0.22 µg g⁻¹ Hg w.w. (wet weight), which is lower than expected given its high trophic level, and its long life-span. It is possible that mercury in *C. yacare* is accumulated in other organs, not included in this study; but it is also possible that physiological mechanisms are involved that help caimans get rid of ingested mercury, or simply that *C. yacare*'s diverse diet reduces THg accumulation. Carnivorous fishes (*Pygocentrus nattereri*, *Pseudoplatystoma tigrinum*, *Zungaro zungaro*, *Plagioscion squamosissimus* and *Leiarius marmoratus*) had the highest total mercury concentrations, ranging from 0.35 to 1.27 µg g⁻¹ Hg w.w. moreover, most were above the limit recommended by WHO (0.5 µg g⁻¹ Hg w.w.); except for *Leiarius marmoratus*, which presented a mean of 0.353 ± 0.322 µg g⁻¹ Hg w.w. The two non-carnivorous fish species (*Prochilodus nigricans* and *Piaractus brachypomus*) present mean concentrations of 0.099 ± 0.027 and 0.041 ± 0.019 µg g⁻¹ Hg w.w., respectively. Finally, recommendations on the consumption habits of Tacana communities are discussed.

Mayr, G. (2016). Avian feet, crocodylian food and the diversity of larger birds in the early Eocene of Messel. *Palaeobiodiversity and Palaeoenvironments* (doi:10.1007/s12549-016-0243-2).

Abstract: The lower Eocene lacustrine sediments of the Messel fossil site in Germany yielded a very rich and diversified avifauna. Most of the well-preserved skeletons stem from small-sized birds, whereas complete specimens of larger avian species are rare. There exist,

however, a number of isolated feet of larger birds, 8 of which are described in the present study. Except for one, all of these specimens exhibit broken leg bones with missing ends, which suggests that they represent feeding remains of predators or scavengers. Crocodylians, which are very abundant and diversified in the fossil record of Messel, are the most likely candidates, and the preservation of the Messel feet corresponds well with that of unambiguous crocodylian feeding remains from the late Oligocene of Europe. The 8 feet described in the present study belong to just as many different species, most of which are otherwise unknown in the fossil record of Messel. Except for one, all specimens probably are from terrestrial taxa. These fossils attest to a hidden diversity of medium-sized to large terrestrial birds in the Messel palaeoenvironment and a bias in the taphonomic composition of the bird community towards the remains of small to medium-sized avian species.

Barão-Nóbrega, J.A.L., Marioni, B., Dutra-Araújo, D., Botero-Arias, R., Nogueira, A.J.A., Magnusson, W.E. and Da Silveira, R. (2016). Nest attendance influences the diet of nesting female spectacled caiman (*Caiman crocodilus*) in Central Amazonia, Brazil. *Herpetological Journal* 26: 65-71.

Abstract: Although nesting ecology is well studied in crocodylians, there is little information on the diet and feeding habits of nesting females. During the annual dry season (November-December) of 2012, we studied the diet of female spectacled caiman (*Caiman crocodilus*) attending nests (n= 33) and far from nests (n= 16) in Piagaçu-Purus Sustainable Development Reserve (PPSDR), Central Amazonia, Brazil. The proportion of empty stomachs in nest-attending females was larger, and the occurrence of fresh food items was lower when compared to females not attending nests. Fish was the most frequent prey item for non-nesting females, while terrestrial invertebrates and snail operculae were the prey items most commonly recovered from stomachs of nesting females. Our study demonstrates that, despite enduring periods of food deprivation associated with nest attendance, nesting females of *C. crocodilus* still consume nearby available prey, possibly leaving their nest temporarily unattended.

Barão-Nóbrega, J.A.L., Puls, S., Acton, C. and Slater, K. (2016). *Crocodylus moreletii* (Morelet's Crocodile). Movement. *Herpetological Review* 47(2): 292.

Barão-Nóbrega, J.A.L., Villalobos, S.S., Cubitt, E., Garcia-Gil, F. and Slater, K. (2016). *Crocodylus moreletii* (Morelet's Crocodile). Diet and feeding behavior. *Herpetological Review* 47(2): 292-293.

Richard, J., Lucky, E. and Anthony, O. (2016). Efficacy of *Osteolaemus tetraspis* Pituitary Gland (APG) Hormone on induced spawning of *Clarias gariepinus*. *Journal of Fisheries and Livestock Production* 4(3): 1000177.

Abstract: The experiment was conducted to ascertain efficacy of *Osteolaemus tetraspis* Pituitary Gland (APG) hormone on induced spawning of fish. The research work was carried out between January and May 2008 at the Nigeria Institute of Oceanography and Marine Research (NIOMR) Sapele. Thirty-nine fish samples of *Clarias gariepinus* (36 females and 3 males) and three alligators were used. The means weight of the fish was 800 ± 20 g while that of the alligator was 5.0 ± 0.2 k g. Three replicate trials were done to observe spawning activities using three different doses, (0.5 ml, 1.0 ml and 2.0 ml) of acetone-dried APG. Ovulation was recorded after 11-13 hours post-injection. Eggs were obtained by stripping

and fertilized artificially with milt from the male *Clarias* and incubated in plastic bowls. Hatching occurred within 20-26 hours after fertilization at a water temperature of 25-26 degree centigrade. Fertilization and hatching percentages increased (p<0.05) with increase in hormone dosage. ANOVA of the means of hatching did not show any significant difference in the dosage used. The overall breeding performances of the APG hormone were found to be satisfactory. Experiment on standardization of the APG hormone is however recommended.

Wang, H., Zhang, S., Zhou, Y. and Wu, X. (2016). Immunohistochemical localization of somatostatin in the brain of Chinese alligator *Alligator sinensis*. *The Anatomical Record* (doi: 10.1002/ar.23474).

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

Haddad, V. Jr. (2016). Aquatic animals inducing mechanical injuries. Pp. 217-226 in *Aquatic Dermatology*, ed. by D. Bonamonte and G. Angelini. Springer International Publishing: Switzerland.

Abstract: Injuries and envenomation are caused by poisonous, venomous, and traumatogenic aquatic animals. In this chapter we discuss the main aquatic animals that can cause trauma in humans, which are included in the Phyla Cnidaria (corals), Echinodermata (sea urchins), Crustacea (crabs and mantis shrimp) and Chordata (fish and reptiles), emphasizing the clinical aspects of the wounds and the therapeutic measures used to control the manifestations.

Submitted Publications

Felix and Pocho: two *Crocodylus acutus* individuals which were "affable" with humans

More than in any of the diverse kinds of fishes and also more so than in all of the living and fossil amphibians and further more so than in any of the other orders of reptiles (all of whose brains are devoid of an enlarged frontal lobe), the living Crocodylia has its brain the most evolved and newly developed for the functions of thinking and

planning ahead, and for feeling empathy with another animal. Both of these kinds of abilities and thought processes are famously human specialties, and are directly associated with the frontal lobe. Thus, with its modern and innovative starting of a fully functional frontal lobe, the crocodilian brain is (in this one very special and important way) very much like our own, at least when compared with the “lower” vertebrates that lack the developed and active frontal lobe.

It would be misleading to suggest or attribute the psychological and emotional feelings of empathetic friendship directed from a crocodilian toward a human as being normally expected. However, it is simultaneously scientifically correct and insightful when I today claim that if any reptile might actually be frontal lobe intelligent enough to enjoy an empathetic individual friendship with a human, it is here explicitly predicted to be a crocodilian, and further to only happen rarely and in very peculiar and unusual circumstances. Further, it is argued below that this seemingly empathetic (crocodilian toward human) mentality probably occurs more recognizably and frequently in some special selected species.

There are anecdotes in Trutnau and Sommerlad (2006) about alligatorids, such as: the Graubaum’s tame *Alligator sinensis* in Germany; a man with some fairly large *Alligator mississippiensis* that he played and publicly showed-off with in Florida; a large *A. mississippiensis* that sunbathed and shared time in a private swimming pool with a man in Switzerland; some *Caiman crocodilus* that roamed inside a home in Germany; and, a 1.3 m long *C. crocodilus* in an apartment in Germany that climbed up onto a bed and slipped itself under the covers with a pair of humans one very cold night when the heating was not working (it ended up occupying the warm zone between the two people, with its head sticking out like theirs, but was thereafter banned from the bedroom).

Anecdotes about Crocodylidae included a man in Sumatra, Indonesia, who could lift up and hold a good-sized *Crocodylus porosus*, apparently with safety. However, there are the two famous stories about large captive salties in Australia that were tame until the time when, in each case, something went dangerously wrong. Similarly, one young *Mecistops cataphractus* in Germany which came for food when its name was called, and that habitually got its throat rubbed by its owner, eventually bit its human. Additionally, two unusual individual *C. acutus* are discussed below - pets with the names “Pocho” (in Spanish) and “Felix” (in English).

The friendly mesorostrine crocodile that can be trusted to not bite people is not a popular concept in our culture. It is possible that extreme longirostrines do not bite in self defense, and I have known *A. mississippiensis* in zoos that were so fat and overweight that they paid little attention to their cage cleaners, and I have seen some that could even be picked up and carried around for display to the public. However, neither Felix nor Pocho were obese, and the species (*C. acutus*) has the adult head shape and differentially toothed snout of a versatile and serious predator.

One time in Costa Rica, when Gilberto (“Tico Tarzan” or “Chito”) Shedden was feeling particularly and overwhelmingly depressed about something, his adult crocodile companion Pocho crawled out of the water and lay on the ground in front of him and appeared to listen sympathetically and intently to Gilberto’s words of woe, which could be a behaviour that approaches or achieves proper empathy, and it was in fact interpreted that way by Mr. Shedden, who was thoroughly familiar with his American crocodile’s normal repertoire of ways, and said that in this instance his reptile’s demeanor and presence was very very special, and it honestly appeared to Gilberto that Pocho the crocodilian knew that its human was sad, and the cold-blooded creature voluntarily responded in a supportive way, like saying “I join you and hear your grief” communicated through

body language.

The special friendship and bond between Gilberto Shedden and Pocho involved mutual respect, and I especially note the concept of clear and unambiguous vocal signals combined with similarly unambiguous and ritualized visual signals from the human (to the crocodile) about what was happening. Pocho’s story is absolute proof that a formerly wild crocodilian can adapt and become part of a human family and further be trusted in public performances with its special person. The anecdote about the special and individual instance of Pocho’s behaviour that was interpreted by Mr. Shedden as being empathetic is detailed at YouTube.com in a 45 minute documentary “The man who swims with crocodiles” (published 11 November 2013; narrated by Roger Horrocks of South Africa and highly recommended).

Other sources include Kimberly Barron (2011) with pictures, and anonymous (underwater) with pictures, and a very brief text 2011 item “World-famous crocodile ‘Pocho’ dies” in the CSG Newsletter 30(4): 10-11 (from listed internet sources). The crocodile’s owner’s name was spelled “Gilberto Sheedan” (sic) in the 2011 CSG Newsletter, and he was called “Gilberto Graham” (sic) in the Underwater Times item, but I follow Barron (2011) and Horrocks (2013) about Gilberto Shedden. There are apparently instances of the spelling “Poncho” for this Costa Rican crocodile Pocho.

I too have enjoyed a relationship of mutual trust and understanding with an American crocodile (in my case originally from Colombia through New York City in 1965, and living in captivity in Canada and the northeastern USA), but my pet *C. acutus* sadly died before it was as large as Pocho was when Gilberto Shedden rescued and medically treated his juvenile wild Costa Rican archosaur, nursing the 2 m long youngster back to health and saving its life. In some ways I was lucky that my companion Felix died and got buried along a roadside when I was foolishly traveling on a day in 1975 that was devastatingly hot on the roadways (from above, from the sides, and the big surprise was also radiating from below off the pavement), and I accidentally cooked my crocodile while driving in southwestern Louisiana, because when a pet crocodilian gets really large it then needs more than an occasional and relatively short stay in a bathtub. I was living in a camper van and moving from place to place frequently (including in frozen winter), while in comparison Gilberto Shedden in Costa Rica had a lake of suitable proportions on his property, and the warm local climate was what the wild crocodile was accustomed to.

Like Gilberto and Pocho, I communicated clearly to Felix about what was happening, at least when it was important. Every time that I intended to get my hands physically on, or for some reason significantly close to Felix, it was the ritual that I would first and repeatedly say “Fingers Felix” and show my hands, fingers outspread, both sides (turning them over so that there could be no confusion), indicating in a slow yet firm visual and vocal command that what was about to happen would be a case of human fingers, as opposed to crocodile food. I would then reach slowly and gently, and would sometimes be avoided, but never bitten, and not even a show of teeth or other threat of causing damage (but sometimes a fairly brief but loud and poignant vocalization of unhappy protest). In contrast the command at feeding time (no matter what the food actually was) was “Fish! Fish Felix!” said repeatedly and excitedly, and then the food was violently thrown down suddenly into the crocodile’s zone and sometimes got caught before it could make a splash in the shallow water. I believe that the Fingers versus Fish dichotomy was the only words that I employed, and thereby by keeping my vocabulary simple, we had no accidents.

Before I felt safe letting strangers and children touch and then hold

my crocodile, I had made it a frequent part of my handling routine with Felix that I would stick my finger(s) into the crocodile's eye(s), touch its ears, open its mouth with two hands, turn it over onto its back, and often I vigorously rubbed and poked and pulled on the reptile's skin all over including its arms and legs, fingers and toes, armpits and groin (but not actually entering the creature's cloacal opening), just to make sure that whatever the children might do, their actions would be considered to be within the realm of "normal" experiences that the crocodile had been conditioned to be accustomed to, and such "normal" handling by anyone would therefore be tolerated (hopefully). The strategy worked, and although it is almost a crocodilian reflex to bite when its handler's fingers get too close to its ears and eyes, Felix had been trained on purpose by me to expect such happenings as ordinary, and my intelligent crocodile voluntarily and consciously suppressed its normal (both captive and wild) urge to snap.

Gilberto Shedden conditioned Pocho to being accustomed to being handled, and they enjoyed a familiar routine when playing together in the water, and similar to me and Felix, the Costa Rican *C. acutus* learned that a certain amount of abuse is just part of the fun, and to accomplish this personal "growth" the crocodile then consciously or subconsciously suppressed its old and almost reflex behaviors and then substituted instead some new decisions and ideas about what is acceptable behavior that it (he or she) will newly allow a human to do to it. Felix would wiggle and squirm side-to-side in displeasure, or run or swim away, but I was never bitten in anger, but I was also realistic and practical about how, and about exactly what I dared to ask my cold-blooded companion to do. A good part of my success was due to habitually handling Felix, and frequently traveling and taking my crocodile with me in a small suitcase in summer, or in a cloth bag and inside my shirt in the cold of winter. Felix once took the long train trip from Cochrane to Moosonee (northern Ontario, Canada), on the edge of the arctic tundra, and back.

In Toronto, my American crocodile from Colombia was often loose on the floor of wherever I was living, and there were times when visitors would ask to hold the crocodile, and I would do the Fingers thing and catch Felix, who would sometimes twist and turn from the excitement of being pursued and pulled out from underneath something or whatever, and I would deem it unsafe to hand over my pet *C. acutus* to the visitor directly. Rather, what I would do is to put the reptile inside its carrying case and then take it for a walk around the block before returning to my own home with a crocodile who was now on its visiting behavior, and soon would be ready for being trusted to show appropriate restraint. It always worked for me with Felix, and similarly Chito Shedden and his Pocho had routines that Tico Tarzan purposefully built into their normal interactions (of an extraordinary nature, such as playing in the water together).

Both Felix and Pocho made the decision to not bite the hand that feeds them (a special person at first, and then generalized to all people), and although the sample is small, there is at least one species of living crocodilian that can, at all ages, enjoy a close friendship with people. For example, there was once a time when I was suddenly remarkably sad, and I told Felix about it (in English, and for my own benefit), and then surprisingly my crocodile did something that it had never done before, and also never did afterwards. This unique incident was on a warm summertime afternoon (Felix had no need for heat), when after my verbal tale of woe I was feeling dejected and lay down on a low bed, lying flat and supine on my back, when silently and deliberately Felix climbed up onto the bed and then climbed further up to rest on top of me, and then slid along my body and across my chest to finally and dramatically stop, now posed and remaining essentially chin to touching chin with me. It was enough to make me forget my worst feelings, being instead reminded that Felix needed me. A dog would be expected to do the same, but Felix

in Toronto, and separately Pocho in Costa Rica were proper true crocodiles.

When circumstances required it, I would take Felix inside my sleeping bag, beside me (with our noses together at the open end) to share my body heat through the cold of the night, and it showed forethought that, when appropriate, Felix would get properly positioned inside the cold empty sleeping bag before I decided to go to bed myself. This was while traveling in my many windowed camper van, so the sleeping bag would perhaps very slightly slow down the reptile's loss of accumulated daytime (moving around inside the van from sunny spot to another) daylight heat, but Felix was really waiting for and expecting me.

It is surprising that even one crocodilian could actually make friends with a human and visa versa. However, granted that it is possible (my own experience), it was no great surprise when two years ago I learned about Gilberto Shedden, and I smilingly noticed that his recently deceased crocodile was the same species as Felix. Similarly I find it easy to believe Paulino Ponce (1997) about Zamorita, the large (3.5 m) wild Mexican *C. acutus* that "was tolerated by local fishermen and habituated to humans". See Ponce (1997) for a good photo of the animal, and an anecdote about an even larger "imprinted" American crocodile also in Puerto Villarta.

Of all of the living Crocodylia, the American crocodile is the most dorsally naked and unarmoured, because numerous osteoderms within existing rows, and also numerous whole transverse rows of stiff bony plates have been deleted, and have instead been replaced by soft and flexible skin. Thus, *C. acutus* gains the ability to bend around and backwards to protect its relatively scaleless neck and body. However, simultaneously this mesorostrine *Crocodylus* species newly assumes and acquires the compensatory mental obligation of becoming clever and adaptable, and must evolve to be smart enough that individual *C. acutus* are able to learn from experiences and to think ahead, and each one (young or old, male or female) must be able to think for itself, because this species is missing so much of its defensive bony dorsal, dorsolateral and flank skin protection.

I think that the generalist shape of the head and snout in *C. acutus* is philosophically congruent with its species being a quick and independent learner, as opposed to at least some longirostrines and at least some brevirostrines, neither of which appear to me to independently think very much, and rather seem to individually behave pretty much the same as their age group throughout the whole population. Relatedly, the dorsal armor can be generalized as stiffer and heavier (more complete) on extreme longirostrine and extreme brevirostrine crocodilian taxa.

Compared to the several common pet store caymans that I had earlier owned as a child, it was my good luck that my first proper true crocodile was a species and individual with its dorsal armor so remarkably derived and vestigial that only one transverse row of nuchals remained (the post-occipitals were notably reduced also; Fig. 1), and thus the relatively undefended gap of various enlarged spaces of bare and flexible skin separating the head from the body armor was enormous by crocodilian standards. Many normally observable transverse cervical and thoracic rows of ossified scales were completely missing on Felix, but this remarkable absence was a natural phenomenon and was merely an extreme of wild variation, similar to the iconotype of *Crocodylus lewyanus* from the Magdalena of Colombia (the same as Felix, presumably), whose cervical and thoracic scalation was discussed in Ross (2014). It appears that at least some particularly naked-necked American crocodiles have lived in the Barranquilla region for a long recent time.

My experience was limited to a stunted and little-fed (just enough food to keep the creature healthy looking) crocodile that could for a long time be carried around in a large and softly bottomed and flexibly sided leather briefcase, or shoved inside my shirt. It is the well fed Pocho who has shown us that even when a youngster grows over the years to become very large, the reptile can stay and remain germanely trustworthy if (with a sample of the one adult Pocho) the species is the American crocodile, and I am sure that (in addition to the Ludwig Trutnau and Ralf Sommerlad synopsis above) there are other such stories about other crocodilians. For example, there apparently was some degree of friendly relationship reported by Ross (1997) about a man in the Caribbean and his local Jamaican crocodile (*C. acutus*) who was called Alice. Also during the 1990s, a Canadian newspaper reported that a family in Illinois, USA, had a crocodilian (presumably an American alligator) as a household pet for 42 years. Named Alice and said to be female, the reptile “took baths” with the children and on occasion “snuggled into bed” with an adult human (see in CSG Newsletter 13(3): 19 about “Toilet trained gator” in 1994). The common name for the American crocodile in Jamaica is “alligator”, and thus the alliterative “Alice the Alligator” or “Alice Alligator” explains the coincidence.

I remember fondly and clearly that there were several times in conversation when someone would say the word “fish” in a sentence, and then responsively crawling out from some hiding place would come Felix, just enough to get noticed, and to see what was happening. That crocodile was actively listening to the human activity, and there is no doubt that it knew and recognized that one (very important to Felix) word. However, we experimented and confirmed that Felix did not know f-i-s-h spelled out as letters. I gave “cats eyes” Felix a male name, and during the 10 years that we were together I employed the pronoun “he” for my archosaurian companion, but in truth I had no real information about my pet’s sex, until I postmortem finger probed the fresh carcass the Brazaitis way, and felt something that might well have been a penis.

Separately there could possibly be forethought and planning involved when in various species-group taxa (in various family group taxa) a local population performs a continuous side-by-side chain across a water flow, and thereby produces a net of waiting teeth that collectively traps and then swallows whole groups of obligatorily moving fish.

Also separately and relatedly is the planning and predictive thinking involved in some crocodilian trapping and ambush attacks employed on large terrestrial mammals. Two examples of frontal-lobe intelligence from Lawrence Earl (1954) are 1) “Dempster kept studying the river, anxious to learn from it. He noticed that the big game of the Zambezi, the crocodile and the hippo, held one another in high mutual respect. Rarely did he see the two in the same neighborhood. Once he did when a mother hippo and her baby became separated from the herd. As Dempster watched from shore through binoculars - his whole world centered on the river - five crocodiles swam silently in on the fat, taupe-colored mother hippo. When of a sudden she saw them, she lunged savagely at the nearest. The other crocodiles with perfect, harmonizing teamwork closed in to nip her from the rear. She turned, enraged, her great red maw agape, to chase them off. With these heckling tactics the crocodiles gradually drew the fuddled mother away from her baby. When they had drawn her far enough they left her swiftly to pounce on the young one. For a moment the surface of the river foamed with the savage fury of their attack. There were half a dozen shrill, bleating cries; then the crocodiles and the little hippo were gone” (p. 58) about Mr. Bryan Herbert Dempster of Natal, South Africa, either shortly before WW2 with his father, or more likely alone in 1947 and soon after; and 2) “Dempster had not observed the first large crocodile gliding in, almost invisible beneath the surface. Suddenly

he caught sight of its nostrils and eyes, like small pimples in the water, moving silently to the reedy drinking-place where the game came. Then it was ready. In one flashing movement the big reptile swiveled round on its front legs, crashed its terrible tail through the reeds. The blow landed with a pile-driver thud on the hindquarters of the drinking antelope, and the kudu was on his side in the water. Again the crocodile moved with blinding speed and Dempster saw two others join in swift attack from nowhere. Now the three saurians, working as a well-knit team, seized the bellowing kudu in their long, steely jaws and, arching their backs in unison, began to pull their victim into deep water. The crocodiles worked silently, deadly certain of every move” (p. 214), various relatively short distances above and below Victoria Falls.



Figure 1. This *C. acutus* with postoccipital scales reduced to a bilaterally symmetrical osteoderm count of approximately two was flown from Barranquilla, Colombia, to a Bronx, New York pet store, and was captive in North America 1965-1975, named Felix.

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