CROCODILE SPECIALIST GROUP NEWSLETTER

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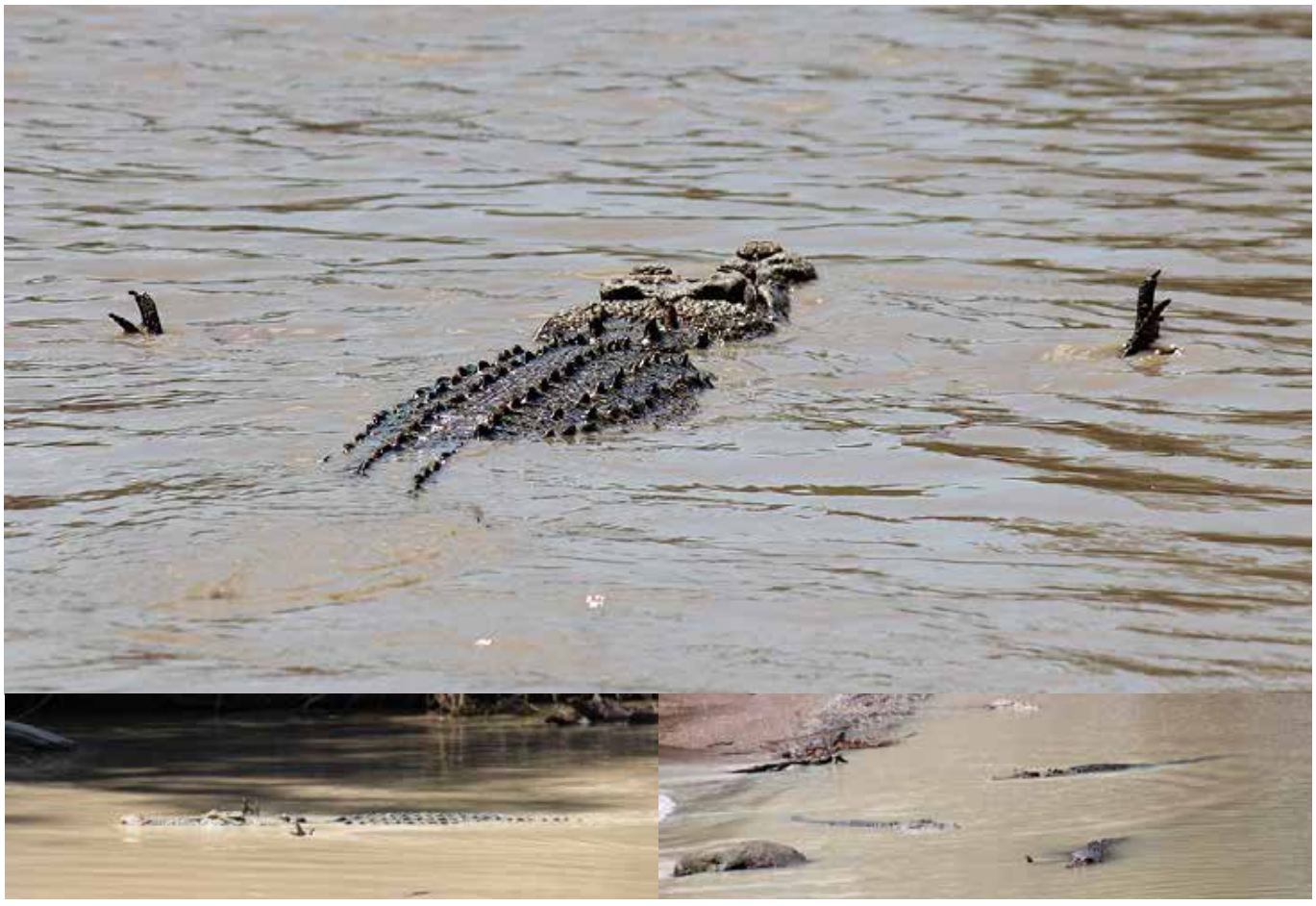

IUCN • Species Survival Commission

CROCODILE

SPECIALIST

GROUP

NEWSLETTER

VOLUME 34 Number 3
JULY 2015 - SEPTEMBER 2015

IUCN - Species Survival Commission

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COVER PHOTOGRAPH: Saltwater crocodiles (*Crocodylus porosus*) using "floating fishing" behaviour at Cahill's Crossing, Northern Territory, Australia (see page 27 for article). Photographs: Claire Peberdy.

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The CSG Newsletter provides information on the conservation, status, news and current events concerning crocodilians, and on the activities of the CSG. The Newsletter is distributed to CSG members and to other interested individuals and organizations. All Newsletter recipients are asked to contribute news and other materials.

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Editorial

The recent passing of Professor Harry Messel (CSG Chairman, 1900-2004) and Dr. Louis J. Guillette Jr. was very sad news indeed. An obituary to Harry Messel appears at pages 4-6, and an obituary for Lou Guillette will be included in the next issue of the newsletter. Both were champions in the world of crocodilian conservation and biology.

Perran Ross (CSG Red List Authority), Tom Dacey (Executive Officer) and I attended the 3rd IUCN Species Survival Commission Leaders meeting in Abu Dhabi, UAE (14-18 September 2015). The Chairs of most SSC Specialist Groups were present, with a large contingent of staff from the IUCN Species Program. These meetings, kindly funded by the UAE, provide an invaluable opportunity for the CSG to interact with other Specialist Groups, to get to know each other better, and to better understand how this array of voluntary groups function. It exposes various areas in which collaboration is possible, with IUCN Commissions, Programs, Regional Offices, Members and Partners. SSC members are at the coal face of conservation, each helping the IUCN achieve its mission with different species groups and various overarching themes. Detailed outcomes from the meeting will be reported in the next newsletter. We congratulate the following CSG members who received awards at the meeting: Dr. Jeff Lang and Alejandro Larriera (Species Survival Commission Chair's Citation of Excellence) and Elham Abtin (Harry Messel Award for Conservation Leadership).

The CSG was represented at the 28th meeting of the CITES Animal's Committee (Tel Aviv, Israel, 30 August-3 September 2015) by Hank Jenkins (CSG Vice Chair, CITES) and Dr. Matthew Shirley (Chair, Future Leadership Working Group; Chair, West and Central Africa). A major issue of interest to the CSG was an agenda item developed by an NGO (RESP) and submitted by Mexico and Italy, about traceability of reptile skins (https://cites.org/sites/default/files/eng/com/ac/28/E-AC28-14-02-02Rev.pdf). The issue arose with regard to snake skin trade, where there is no agreed universal tagging system (such as exists with crocodilians), and was proposing a largely photographic mechanism for identifying skins, that in the opinion of many would not be pracxtical for ensuring fashion companies could trace their supply chains to the point of capture. However, the agenda item shifted the focus from snakes to "all reptiles", which would include crocodilians, where the current universal tagging system is generally considered admirable. The AC recommended restricting the application of traceability systems to snake skins (in keeping with the AC's mandate). Furthermore, any tracking and trace systems should mirror the universal tagging system for crocodilian skins and be mandatory only up to the skinning/tannery stage of processing. Any tracking system beyond this stage should be voluntary (see https://cites.org/sites/default/files/eng/com/ac/28/ExSum/E-AC28-ExSum-02.pdf). Research into tracking and traceability systems is of course encouraged, but an overriding consideration needs to be implementation practicalities and costs.

Another major issue at AC28 was the Implementation of the Convention relating to captive-bred and ranched specimens (Decision 16.65) (AC28 Doc.13.1-Report from the Secretariat and AC28 Doc 13.2-Report of the Intersessional Working Group). These reports addressed issues such as overharvesting of wild populations, illegal trade, and misuse of source codes. The AC established a working group on Agenda items 13.1 and 13.2 to further review the reports, prepare recommendations, and report back to the Standing Committee in accordance with Decision 16.65.

Proposals for consideration at CoP17 included a draft proposal to remove the zero quota for trade in wild specimens of the Mexican population of Morelet's crocodile (*Crocodylus moreletii*) for commercial purposes (https://cites.org/sites/default/files/eng/com/ac/28/E-AC28-22-02.pdf) and a proposal for the transfer from Appendix I to Appendix II of *Crocodylus porosus* in Malaysia (https://cites.org/sites/default/files/eng/com/ac/28/E-AC28-22-03.pdf).

It is understood from discussions with the Colombian delegation at the AC meeting that Colombia is considering a downlisting proposal for *Crocodylus acutus* at CoP17. It was agreed that the best strategy forward was a proposal restricted to the Cispata Bay population, in accordance with the ranching criteria (Resolution Conf. 11.16), as opposed to a general down-listing under Resolution Conf. 9.24 as was attempted at CoP16 (2013). A ranching proposal would need to be submitted by the end of October 2015. Ongoing concerns about Colombia continuing to trade in ranched and wild harvested *Caiman crocodilus fuscus* skins, using captive-bred source codes, were discussed once again. Colombia has evidently closed 17% of registered farms that did not have the stocks required to match the CITES Export Permits with which they were being provided.

The 3rd West and Central Africa Regional CSG Meeting will be held on 8-10 December 2015. The theme of the meeting is "Crocodile Management Issues Across a Complex Landscape". Details on the meeting can be obtained from organisors at CSG2014.WACA@gmail.com.

Professor Grahame Webb, *CSG Chairman*.

Obituary

Professor Harry Messel (1922-2015)

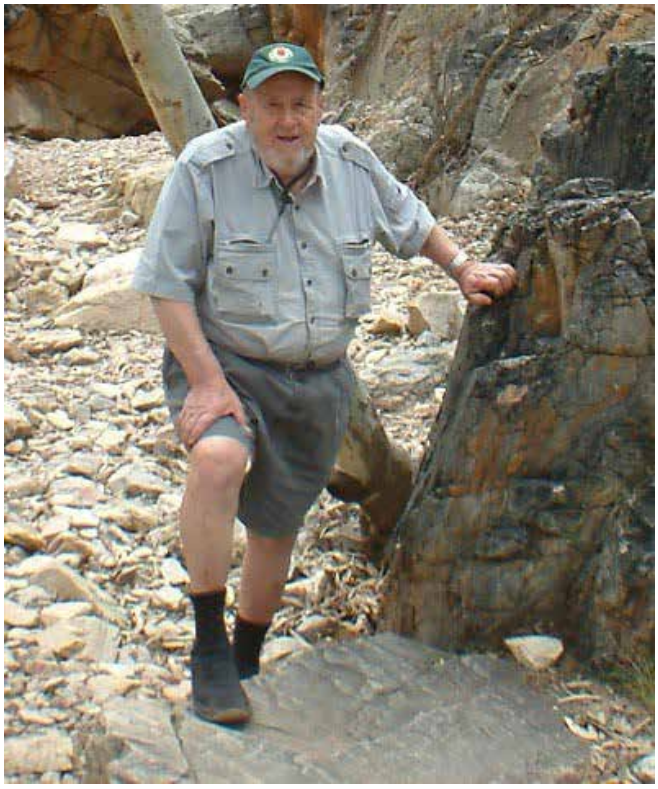


Figure 1. Professor Harry Messel in the Simpson Desert, 2012. Photograph: Pearce Dougherty.

On 8 July 2015 the world heard the news that Professor Harry Messel had died. He had evidently accepted his failing heart, with the same boldness and sense of "don't fight battles you cannot win" that was one of his many hallmarks. To many people, in different disciplines, in different countries, old and young, Harry was larger than life. He was a razor-sharp strategist who challenged life on his terms, beating the odds to reach 93 years of age. Everyone who knew Harry has remarkable personal stories about him, which are part of the legacy and legends he leaves for those who knew him.

Harry was a physicist, who rose to prominence in CITES, IUCN, SSC and the Crocodile Specialist Group, when he turned his attention to wildlife conservation in the late 1960s and early 1970s. By 50 years of age, scientists tend to have completed their best work, but Harry was not the average person - in his own brazen way, he would tell you that if you asked him! But his achievements prior to becoming involved with conservation were even more extraordinary.

Harry came from humble beginnings. The son of Ukrainian immigrants to Canada, he was born on 2 March 1922 at Levine Siding in Manitoba, and raised in Rivers, Manitoba, Canada. Hunting, trapping and fishing as a child assisted the family, and kindled a life-long interest in the outdoors. He attended Queens University in Ontario, served as a Canadian paratrooper towards the end of World War II, won fellowships to study mathematics and physics at the University of St. Andrews (Scotland) and the Dublin Institute for Advanced Studies (Ireland), took up a lectureship in mathematics at Adelaide University, Australia (1951-52), and at 29 years of age was appointed Professor of Physics and Head of the School of Physics at the prestigious University of Sydney. As the youngest professorial position ever appointed, he hit the ground running in a way few academics have even been able to do.

His personal goals for rebuilding and expanding the School of Physics became intimately entwined with a broader vision - that science within Australia, at all levels from school education to academic research performance, needed to be boosted for the ultimate good of Australian society. He recognised that the business and political sectors were not engaged with science, despite having the wealth and power needed to effect change, so he set about changing that. He accepted the "pursuit of excellence" as a personal banner, and found it a simple message to which all people could relate and aspire.

Within a decade, some of the most powerful business interests in Australia were contributing to his Science Foundation for Physics. He started the innovative International Science Schools for High School Students, which still brings the best and brightest of school children from around the world to interact with the world's leading scientists. He built the first computer in Australia, Silliac, and started a series of new thematic departments (Astrophysics, Astronomy, Atomic Energy, Plasma Physics, Cosmic Radiation, Computing, Theoretical Physics), all chaired by internationally renown scientists. He pursued these goals with unbelievable energy, travelling abroad often, and securing overseas funds along the way. He developed new science text books for schools, used by most Australian children and teachers for over a decade. He raised over $100 million dollars for science in the 1960s and 1970s, from unconventional sources. There was no precedent within Australian academic circles. He demonstrated astute business acumen and political expertise. He was the senior advisor to Lionel Murphy, the Attorney General within the somewhat revolutionary Whitlam Government that came to power in Australia in December 1972. His interest in crocodiles had already started, and one of that government's first actions, directly due to Harry's influence, was to ban the export from Australia of all crocodile skins.

I started work for Harry Messel in 1973 as a fresh PhD in zoology, with a keen interest in reptile research - an odd position within a School of Physics. But Harry had started an Environmental Physics Department, to develop efficient tracking devices for wildlife, and had chosen Saltwater crocodiles (*Crocodylus porosus*) as the vehicle upon which to test them. This was a project under the "physics" umbrella, with the outdoor elements he enjoyed personally. I got to study Saltwater crocodiles in the wilds of northern Australia… and it was within this context that I was able to study a much more complex multivariate problem … Harry Messel.

Harry was a tenacious, self-disciplined, workaholic,

who managed his time and most things for which he was responsible, with robotic precision. He set high standards for himself and was often disappointed that few others had that Messel drive. He had an insatiable appetite for information on world events, inside and outside of science, gleaned from the international media and his network of acquaintances. He was a rapid reader, with an ability to distill the key points of any document he read. He was an avid filer of information, and bound files like a lawyer, with cloth ribbon holding the paperwork together, and he could get to key pieces of information - new or old - within minutes.

The volume of information he dealt with made him worldly and adept at predicting future directions. With the "big picture" in focus, his attention to some fine details often seemed incongruous – but it was his way. He had a boomingly loud voice, and tended to test new ideas in a challenging way, by cutting straight to the chase, in strong, colourful and definitive language. It frightened the timid and those not prepared to risk his displeasure, but in reality he enjoyed being challenged. He was also quick to adapt his opinions if the result of an apparent heated and argumentative exchange revealed something new. Although perhaps not in vogue today, Harry was what used to be considered a "man's man" - he liked to drink (but rarely too much - occasionally), smoke (those distinctive cigars), hunt, fish and play cards, especially poker, where his use of bluff and power gave unique insights into the man. He liked to gamble on all manner of chance events, especially when fishing, and had a keen sense of humour, which he retained to the end. He guarded his personal life judiciously, and his tough exterior often seemed at odds with the quiet, gentle and caring way he interacted with his wife and three daughters. His private business interests, in which he was bold, innovative and successful, were something he rarely if ever mentioned.

When circumstances required it, Harry was one of the most persuasive individuals I have ever met. When antagonists challenged him, and he sensed a benefit, he could combine logic and charm with enormous skill to win them over. Sometimes he was hurt by criticism, and it stimulated a burst of spirited denial - but not often. He avoided head-on conflicts when he could: "there's no fight if you don't get into the boxing ring" was his explanation. Mostly, Harry seemed to speak his mind openly and frankly, without any sense of political correctness or cultural sensitivity. He seemed uncaring about whether people agreed or disagreed with him - but really, he was usually setting the bar at a higher level for his audience.

When it came to younger people, aspiring to greater things, or those lacking the confidence to take risk-laden steps before them, Harry could be quite a remarkable mentor. Many people in senior and challenging positions today can quote words of encouragement from Harry Messel as significant steps in their personal careers.

As I see it, it was the integration of all these skills and idiosyncrasies, combined with a truly agile and sharp mind, and a determination to succeed, that made Harry a unique character. But cross Harry in any significant way, and he could become a formidable opponent. Harry and I had some truly monumental conflicts, but once our hatchets were buried, we regained our friendship, respected each other, and communicated, often on a daily basis, for decades.

Harry's real bridge into the IUCN and SSC came with his realisation that Saltwater crocodiles in northern Australia were so depleted by the early 1970s, after decades of hunting, that whether or not the wild populations could recover was in doubt. Through the Crocodile Specialist Group, then headed by Professor Wayne King, he learned that most commercially valuable crocodilian species throughout the world were facing the same predicament. He supported the listing of all crocodilian species on the Appendices of CITES when it came into force in 1975, and like Wayne King, became a strong protectionist and champion for crocodile conservation.

His own program on Saltwater crocodiles in northern Australia gradually swung from advancing radio-telemetry to surveying the recovering crocodile populations across the whole north coast of Australia. As a consequence, management of crocodiles today is based on a very sound historical record of how the recovery took place. Added to this, under the umbrella of Harry's program a cadre of researchers were helped, encouraged and supported by Harry to research all aspects of crocodilian biology and crocodile biopolitics. The crocodile conservation and management programs in place across northern Australia today owe a great deal to Harry Messel.

Support from the IUCN, SSC and the CITES Secretariat were all part of the international interest Harry was stimulating in his own program and for crocodilian conservation in general, and he worked closely with all three organisations. Within the SSC he became Chair of the Crocodile Specialist Group (1990-2004), and a valued member of the SSC Steering Committee over the same time period. By the early 1990s Harry had accepted that sustainable use of wild crocodilian populations that had recovered (or were recovering) was critical to creating incentives for their long-term conservation. He also accepted that industry interests and expertise were critical elements of conservation, and welcomed industry experts into the Crocodile Specialist Group. He became a champion of the role sustainable use could play in conservation, and became actively involved in assisting countries to improve their management, and in helping get their proposals to trade approved by the Parties to CITES. This set the Crocodile Specialist Group on the same pathway it remains on today - supporting total protection or sustainable use, whichever has the best conservation advantage.

Through much of this period, Harry Messel had remained Head of the School of Physics, with a considerable administrative burden. He retired in 1987 after 35 years at the helm. But it did not last long. Between 1992 and 1997, Harry accepted the position of Chancellor and CEO of Bond University in Queensland. This unique private university had run into serious economic problems, and once again Harry Messel, at 70 years of age, worked tirelessly to restructure and

reorganise it, ensuring the sustainability of a fine institution. I remember his wife "Pipi", who survives him, and is as gracious as Harry often appeared not to be, telling me with concern that she had never seen him work so hard.

His retirement from the Crocodile Specialist Group in 2004 saw a decline in his active participation in crocodilian conservation matters, but he remained active, travelled often, and seemed to enjoy life immensely. He had mellowed - but just a little. His last trip to crocodile country in the Northern Territory was in 2008, and his last outback camping adventure into the Simpson Desert was in 2012 - at 90 years of age! If there is a single legacy from Harry Messel that stands out, it is his personal conviction that "The Pursuit of Excellence" is a laudable goal in life - not just in science and conservation.

Professor Grahame Webb, CSG Chairman *[modified slightly version to that provided to to the Species Survival Commission of the IUCN]*.

CSG Student Research Assistance Scheme

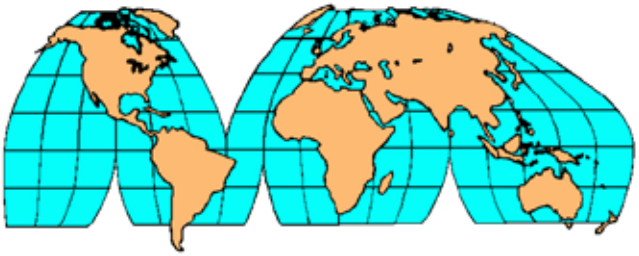
The CSG Student Research Assistance Scheme (SRAS; http://www.iucncsg.org/pages/General-Information.html) provided funding to two students in the July-September 2015 quarter.

1. Abel Ricardo Pineda Avendaño (Colombia): Population ecology of *Crocodylus acutus* and *Caiman crocodilus fuscus* in Urra Reservoir, Cordoba, Colombia.

2. Andre Yves (Brazil): Population structure of Broad-snouted caiman in Rio Doce State Park, Brazil.

Tom Dacey, *CSG Executive Officer, <csg@wmi.com.au>*.

Regional Reports



Latin America and the Caribbean

Brazil

CONSERVATION STATUS OF THE DWARF CAIMAN *PALEOSUCHUS PALPEBROSUS* IN THE REGION OF THE ARAGUAIA-TOCANTINS BASIN, BRAZIL. The Dwarf caiman (*Paleosuchus palpebrosus*) occurs in 10 South American countries (Medem 1981), including Brazil, where the species is widely distributed except in the southern part of the country (Magnusson 1989). In the latest conservation assessment by the Crocodile Specialist Group, Magnusson and Campos (2010) reported threats to *P. palpebrosus* populations and their habitats. Campos *et al*. (2013) recommended the establishment of permanent aquatic reserves for the protection of the species in Brazil.

Based on IUCN criteria for endangered species, *P. palpebrosus* falls within the category of "Low Concern," mainly due to its large area of distribution. However, *P. palpebrosus* is a highly secretive species that lives in environments such as springs and headwaters of fast-running rivers, wetlands, flooded forest and swampy plains between hills (Medem 1981; Magnusson 1989; Campos *et al*. 1995), which are environments under strong anthropogenic pressure. Until about 20 years ago, very little was known about the species, except for the pioneering work of Medem (1981) in Colombia and Magnusson (1989, 1992) in the Brazilian Amazon. This lack of information had been pointed out as a problem for the conservation of the species (Thorbjarnason 1992).

Efforts have focused on increasing the body of scientific knowledge about the species, not only in the region of the Pantanal wetland but also in those of Guapore-Mamore-Madeira and the Central Amazon (Campos *et al*. 1995; Campos and Sanaiotti 2006; Botero-Arias 2009; Campos *et al*. 2010, 2011, 2015; Campos and Magnusson 2013). Nevertheless, their unique environments continue to be under threat, their habitats being modified and/or destroyed by human activities such as urbanization, road construction, hydroelectric plants, deforestation, pollution, mining, and subsistence and accidental hunting (Campos and Mourão 2006). Muniz (2012) warned that the fragmentation of *P. palpebrosus* populations in the Pantanal and the Amazon, resulting from habitat destruction, directly affects the species' genetic variability.

The Cerrado biome is considered one of the world's hotspots that is under serious threat of disappearing, and the last remaining 20% of this biome is under direct threat of expansion of agribusiness involving soybeans, cereals and other cash crops (Myers *et al*. 2000). Few studies of the Dwarf caiman have been carried out in the Cerrado biome (Vilhaça 2004; Carvalho Jr and Batista 2013). We investigated the threats to the conservation of Dwarf caiman along river banks, swampy plains between hills, and small tributaries of the rivers and secondary tributaries of the Araguaia-Tocantins Basin which flow through the Cerrado.

In October 2014 we traveled almost 5000 km to the aquatic environments of the Dwarf caiman in the Araguaia-Tocantins Basin (14°54'S, 51°5'W), central Brazil, to document the conservation status of their environments. This area is one of the regions studied by Fábio Muniz during the course of his doctorate at INPA/UFAM, with Tomas Hrbek and Izeni Farias as mentors, and Zilca Campos as co-supervisor. During this field trip, we carried out surveys in the evenings to identify the presence of the species in the Garças, Mortes, Araguaia and Tocantins Rivers and their smaller tributaries.

During this survey, we found that most of the Cerrado vegetation has been replaced with cotton or soybean plantations, depending on the time of year, which stretch all the

Figure 1. (left) Pastures in permanent preservation area in the Garças River; (centre) Housing in permanent preservation area in the Garças River; (right) Beaches formed due to deforestation of the Araguaia River.

way down to the banks of small streams, in the riparian forests in the rivers. The typical plain formations of the Cerrado, which are important areas of springs and swamps, have been completely destroyed and transformed into watering holes for cattle, with rarely a swampy plain left intact. The gallery forests of the Araguaia, Garças, and Mortes Rivers have been cut down to make way for pastureland for cattle and human settlements (Fig. 1). The destruction of gallery forests has caused the erosion of soil, which is carried down to riverbeds, forming beaches that the locals use for leisure and recreation (Fig. 1). We found no Dwarf caiman along these stretches of river altered by anthropic activities and by intense traffic of people and boats, and the species was limited to stretches of river with preserved gallery forests.

Crocodilians are being hunted in this region, and we found a dead Black caiman (*Melanosuchus niger*) and a dead Spectacled caiman (*Caiman crocodilus*) at the Araguaia River (11º43'S, 50º43'W). The situation observed on the Tocantins River and its tributary streams was similar to that of the Araguaia River. However, the most striking change is the construction of dams for the formation of reservoirs for the region's hydroelectric plants (Fig. 2). The permanent flooding of areas of gallery forests due to river damming has brought the nesting areas of caimans close to roads and cities, making these previously protected and remote areas easily accessible along the roads.

Figure 2. Permanent Preservation Areas flooded by hydroelectric dam on the Tocantins River.

The threats are similar to those found in the surroundings of the Pantanal (Campos and Mourão 2006), but with the aggravating factor that the process of human occupation in the Araguaia-Tocantins Basin is continuous, intense and growing. In Brazil, this central region of the Dwarf caiman distribution is considered an agricultural region and much of the native vegetation has already been transformed into monoculture, and its aquatic environments have been fragmented. The roads are duplicated and asphalted in order to link cities and transport the crops produced in the region. Today there is also a railway for transporting crops from the region for export through Brazil's ports. Brazil's new Forest Code (Law No.12651/2012) for the region establishes the protection of 20% of a rural properties, and the restoration of permanent preservation area (PPA) in 30-m wide protective strips along up to 10 m wide. However, small streams and wetlands are not protected. The Dwarf caiman still appears to persist in preserved and uninhabited stretches of rivers, but these stretches are dwindling in the region of the Araguaia-Tocantins Basin, and if nothing is done, the area of distribution of this species may be restricted solely to the region's Conservation Units.

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South Asia and Iran

India

CROCODILE SURVEYS IN CORBETT NATIONAL PARK 2015. Surveys in areas in Corbett National Park (CNP) of the Corbett Tiger Reserve (CTR) were conducted in March 2015 as a part of the on-going Crocodilian and Freshwater Turtle Research and Conservation Project being implemented by Subir Mario Chowfin and Dr. Alison Leslie. Surveys in CNP include the use of trail cameras, shoreline surveys by boat, and stationary counts from vantage points (see Fig. 1).

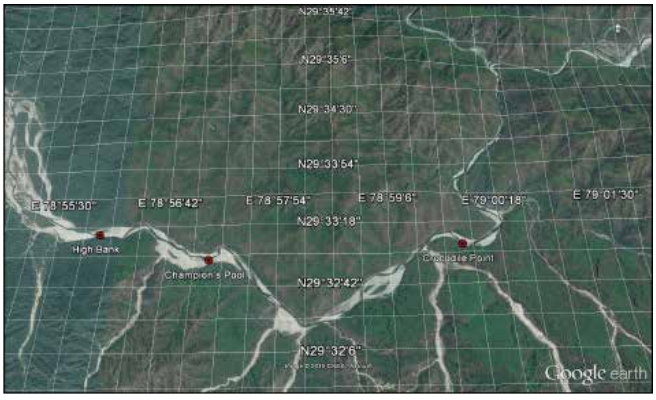

Figure 1. Vantage point locations on the Ramganga River in Corbett National Park, Corbett Tiger Reserve.

The surprise of the season was the recording of 17 adult Gharial (inclusive of 2 adult males) on the Ramganga River between Gairal and Ghetia Rao, based on vantage point observations at High Bank and Champion's Pool. Previous surveys of this stretch of the Ramganga River recorded 3 adults (inclusive

of an adult male) in 2008, and 5 adults (inclusive of an adult male) in 2013. The 2015 finding throws new light on numbers of this critically endangered crocodile in CNP. The crocodile population in CNP, in areas where Gharial and Mugger are sympatric, is estimated to be ~145 individuals [90 Gharial (62%) and 55 Mugger (38%)].

The project is being undertaken in collaboration with the Uttarakhand Forest Department and CTR. Valuable support has been provided by Columbus Zoo, CZS CBOT Endangered Species Fund, PPG Conservation and Sustainability Fund, as well as an Asia Seed Grant from Cleveland Metroparks Zoo. The supporting NGO is The Gadoli and Manda Khal Wildlife Conservation Trust and The University of Stellenbosch, South Africa, is the associated academic institution.

Subir Chowfin *(Gadoli and Manda Khal Wildlife Conservation Trust)* and Alison Leslie *(University of Stellenbosch)*.

SALTWATER CROCODILE PROJECT IN BHITARKANIKA OF ODISHA, INDIA: A SUCCESS. With initiation of the Government of India/FAO/UNDP Project "Crocodile Breeding and Management" a Crocodile Conservation Project was launched in 1975 in different states of the country. The Gharial (*Gavialis gangeticus*) and Saltwater crocodile (*Crocodylus porosus*) conservation program was first implemented in Odisha in early 1975. Subsequently, the Mugger (*Crocodylus palustris*) program was initiated, since Odisha has the unique distinction of having all three species of crocodilians.

Conservation and Research Centres were established by the Forest Department, Government of Odisha, at Tikarpada (Satkoshia Gorge Sanctuary), Dangmal (Bhitarkanika Wildlife Sanctuary/National Park) and Ramatirtha (Similipal Wildlife Sanctuary) for Gharial, Saltwater crocodile and Muggers, respectively. The main objective of the program was to quickly increase the populations using "grow and release" techniques. During the last 39 years the 'rear and rehabilitation' of crocodiles at various centres has been carried out successfully.

Studies have also been carried out to determine the appropriate method of population assessment, egg collection, egg incubation, hatching and husbandry of young crocodiles and various aspects of behavioural biology of the three species and their habitat features.

The *C. porosus* program is more of a success than the other two projects in the state. At a national level it is on the top as far as "rear and release" as well as building up of the depleted wild population is concerned. The population in the Bhitarkanika River system has gradually been built up over the last 40 years. The annual census conducted in the river systems of BWS/NP in January 2015 indicated that there were 1665 *C. porosus*, including more than 200 adults, and the population is still increasing. Density has increased from 0.87/km (1976) to 12/km (2015).

The annual census results indicate:

1. Successful implementation of the Saltwater Crocodile 'rear and rehabilitation' program in BWS/NP since 1975.

2. There has been a marginal increase (1.26%) in the crocodile population since the January 2014 census.

3. Successful nesting of wild and released crocodiles (about 70 nests were located in different parts of the sanctuary during the 2014 nesting season - more than 13 times as many as were recorded in the mid-1970s).

4. Kanika Range holds 75.3% of the current population.

5. Bhitarkanika has 10 crocodiles 16-18' in length, 6 at 18-20' and 3 at about 20'.

6. The areas (main Bhitarkanika River from Khola to Pathasala, Thanapati, Mahinsamada, Suhajore and Baunsagada Creeks, Kalibhanjadia, etc.) which have the higher concentration of crocodiles have the following characteristics:
   (a) Good mangrove cover/fringing mangrove vegetation;
   (b) A network of creeks and creeklets;
   (c) Plenty of fish as food;
   (d) Stretches of undisturbed mud banks as favoured basking/resting spots;
   (e) Less human disturbance (no illegal fishing activities);
   (f) Hypo-saline condition of water in the river and creeks; and,
   (g) Depth of water (2 m at the lowest tide in the major creeks/creeklets).

At present, Bhitarkanika holds the largest wild *C. porosus* population within the species' distribution in India, and about 80% of the total Indian population represented in the Bhitarkanika River systems of Odisha State.

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Europe

Germany

INDUCED NATURAL BREEDING OF THE PHILIPPINE CROCODILE (*CROCODYLUS MINDORENSIS*) AT THE COLOGNE ZOO. Since the first breeding of the Philippine crocodile in Europe, at Cologne Zoo in Germany (Ziegler *et al*. 2013), further breeding successes in Europe occurred in the Czech Republic (Protivin Crocodile Zoo), the UK (ZSL London Zoo) and Denmark (Krokodille Zoo). Due to these recent breeding successes and the inclusion of Protivin Crocodile Zoo into the European Studbook (ESB) the number of Philippine crocodiles within the ESB has increased from 15 sub-adults to 53 individuals, of which 29 are juveniles (Ziegler and Rauhaus 2015).

In February 2015, the two adult Philippine crocodiles at Cologne Zoo again showed interest in each other and were brought together for mating. Mating activities continued up to April 2015. Due to continued target training with the Philippine crocodiles at Cologne Zoo (Rauhaus and Ploetz 2014), individuals could easily be separated and thus mating activities controlled. By doing so we could invite the media on 19 February to show courtship and mating behaviours (approaching, tactile stimulation, bubbling and finally copulation) (see also Schneider *et al*. 2014).

Increased nesting activities of the female were observed during April, and egg deposition finally took place on 17 April 2015. Eleven eggs were laid, of which two were malformed and one destroyed. Of the remaining 8 eggs, 4 were left in the nest in the exhibit and 4 were transferred to two incubators, where two were incubated at "high" temperatures (31.5-31.9°C) and two at low temperatures (29.0-30.2°C). The eggs left in the nest did not show any signs of development, and the two eggs incubated at high temperatures hatched on 6 July 2015, after 80 days of incubation.

In contrast to Ziegler *et al*. (2013) we did not hear hatchling calls first, but found one hatchling penetrating the eggshell with its snout. We then played hatchling calls recorded from our first breeding success in July 2013 to encourage the hatchlings to answer, and after about 15 minutes the "pipped" hatchling and the unhatched animal started calling.

To facilitate both the mother and the hatchlings to live out natural social behavior we decided to transfer the eggs into the nest to induce natural hatching and to document mother-offspring interactions. We locked the female by using the target into a separable part of the enclosure, and placed the two hatching eggs together with the two eggs incubated at low temperatures inside the nest in the exhibit. We decided to place all the eggs from the incubators at the same time into the nest because we did not want to disturb the female a second time with another egg transfer.

When the slide gate was opened, the female entered the part of the enclosure with the nest, but initially remained for some time in the water in front of the nest. We replayed the hatchling calls from above the nest to stimulate the two hatchlings, which subsequently answered, and the female approached the nest. She approached the eggs and tactually scanned them with her snout; afterwards she started with the mouth transfer. The first hatchling, which had meanwhile emerged entirely out of the egg, escaped her first attempts to pick it up and she first carried the empty eggshell into the water, where she carefully opened it by breaking the shell with her teeth. This happened both above the water surface and under the water (here with closed eyes). Then she again approached the hatched animal, which remained on the top of the nest. The hatchling then started calling again and actively turned its head towards her mouth, so that the female could pick it up and carry it into the water after some failed attempts.

After a while she approached the second egg, took it into her mouth and carried it into the water, where she opened it the same way she had done with the first eggshell. By gently crushing the eggshell between her teeth under the water surface the juvenile swam out of her mouth towards the land part and rested there. So as not to disturb the mother and offspring interactions we in fact had blocked the enclosure from visitors from the beginning. As the Philippine crocodile couple held at Cologne Zoo is kept separated except for the mating season, the male had neither access to female nor to the nesting enclosure. In the latter enclosure we could record nest guarding behavior of the female including attacks towards the zoo staff standing at the visitor's side of the public enclosure which observed the events in the nest enclosure. During the next days mother and offspring interactions were peaceful and the mother stayed in immediate vicinity of the young.

As the two remaining eggs, which had been incubated at lower temperatures did not hatch during the following 7 days we decided to control the nest another time on 13 July 2015. We locked the female into the other enclosure and took the two eggs out of the nest. At that time the eggs we noticed that they were deeper into the nest relative to how we had buried them, so the mother must have covered them with further substrate. One of the eggs showed a rupture, but the hatchling obviously was not able to cut the eggshell membrane. This may be due to the changed climatic conditions, once being taken out of the incubator. We assisted by opening one side of the eggs before placing them back into the nest, on the 87th day after egg deposition.

Both hatchlings were in a relatively weak condition and did not call. After having let the female inside the nesting enclosure, we had replayed hatchling calls to attract the female towards the eggs in the nest. The female immediately began with the same behavior as was we had observed before. When the female had opened the eggshell of the third hatchling in the water, the emerging hatchling remained under water. With the mother locked away in the other enclosure we retrieved the hatchling by using a long dip net from above the enclosure, and positioned the hatchling on land. We then let the mother into the enclosure, but she ignored the moribund hatchling and finally stepped on it (and killed it) as she approached the other (fourth) hatchling inside the nest.

This dead hatchling had a total length of 24.3 cm, snout-vent length of 11.9 cm and weighed 53 g. The fourth hatchling was in better condition, having emerged from the egg and begin calling when the mother approached. After some hours it was moved by the mother towards the water, but it fell into the water before mouth transport could be accomplished.

From the following day on, all three hatchlings remained for most of the time close together on a flat land area in the enclosure, where the female occasionally approached them and continued with nest guarding behavior. One week after the third hatching event we opened the sliding gate between the female and nesting enclosures. From that point the mother increasingly moved from the young and the nesting enclosure during daytime for basking. The young remained hidden for most of the daytime. Feeding of the hatchlings during daytime could not be observed before 24 July, but we assume that they

Figure 1. (left) mouth transport; (centre) female crushing egg in the water of nesting enclosure with emerging young; (right) female guarding hatchlings. Photographs: Thomas Ziegler.

fed on offered crickets and earthworms during the night. The mother and offspring interactions were observed by our team by the hour and we currently are evaluating the data which will be presented in detail elsewhere.

This event represents the first successfully induced natural breeding of the Philippine crocodile in Europe. Based on this we could gather important and in part unknown data about the breeding and social behavior of this species, but also important information on how to keep the species in captivity. For example, the willingness of the mother to participate in the target training even with the freshly hatched young around her and thus the possibility to gently separate the female from the nest without interfering the breeding behavior provides important knowledge on handling the species in captivity during breeding. With our current knowledge it would have been no problem to leave the two eggs which had been incubated at lower temperatures inside the incubator and only inserting them into the nest later.

Now, with these many breeding successes in Europe in a relatively short period of time and after having had the chance to enable natural breeding in captivity, the main focus for the management of the Philippine crocodile conservation breeding will be the dispersal of the abundant offspring to other interested institutions and to build up suitable pairs in the future. As the parents of the European offspring have all been genetically screened as pure *C. mindorensis* (Hauswaldt *et al*. 2013; Ziegler *et al*. submitted), the offspring can also be considered as a valuable resource for future restocking projects in the Philippines.

This recent breeding success is dedicated to our dear friend Ralf Sommerlad, who passed away in June 2015, and who supported us so invaluably with building up of Philippine crocodile conservation breeding and target training at Cologne Zoo.

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East and Southeast Asia

Lao PDR

REDISCOVERY OF THE SIAMESE CROCODILE (*CROCODYLUS SIAMENSIS*) IN KHAMMOUANE PROVINCE, CENTRAL LAO PDR. The Siamese crocodile (*Crocodylus siamensis*) historically occurred over much of mainland Southeast Asia as well as parts of Indonesia. Its current distribution is greatly diminished and fragmented. Extant populations are in Cambodia, Indonesia, Lao PDR and Thailand; wild populations in Vietnam are possibly extirpated (Bezuijen *et al*. 2012). The Siamese Crocodile is listed on Appendix I of CITES, and is listed on the IUCN Red List

(2015) as Critically Endangered with decreasing population trends.

In Laos, *C. siamensis* is classified "at Risk", the highest nationally threat ranking (Bezuijen *et al*. 2006). The species was abundant in some parts of Laos until at least the early 1900s. Small breeding populations still persist, but a severe decline in range and abundance has occurred over the past century and now the species is rare or locally extinct at many sites (Bezuijen *et al*. 2013). Bezuijen *et al*. (2013) recorded the species at 13 sites in 6 river systems, with at least 36 individuals (1-11 per site) documented (Fig. 1). At all sites, crocodile densities and recruitment rates were extremely low. Thus, remnant *C. siamensis* populations in Laos are of global importance. However, Bezuijen *et al*. (2006) stated that most wetlands in Laos remain unsurveyed for crocodiles and it seems likely that other *C. siamensis* localities will be documented.

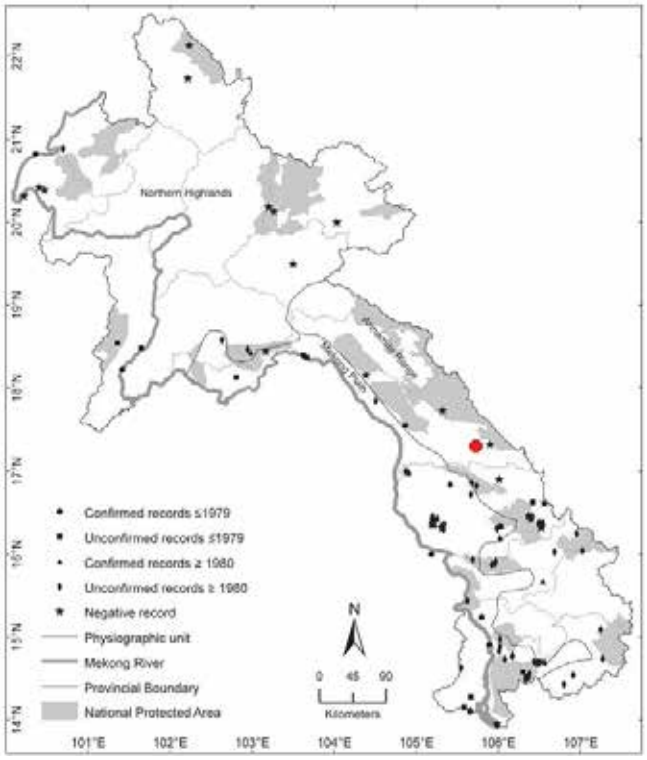

Figure 1. Distribution of *C. siamensis* in Laos (from Bezuijen *et al*. 2013); our new record is marked by the red dot.

During recent herpetological field research in central Laos we became aware of a *C. siamensis* population in Khammouane Province. Bezuijen *et al*. (2013) reported three negative records from Hin Nam No and Nakay-Nam Theun National Protected Areas and two unconfirmed records from the Nam Hin Boun River system (tributaries in Phou Hin Boun National Protected Area, previously "Khammouan Limestone National Protected Area") in Khammouane: one record from 1960-1979, and one in 1980-1999 (Bezuijen *et al*. 2006) - no further record could be made in Khammouane for the past 16 years. Because our evidence of *C. siamensis* in Khammouane is connected with the Xebangfai River system, it thus represents an reported and overlooked population, and at the same time the rediscovery of this species from this province.

Our record was made 3-4 km from Ban Soc, Bualapha District, Khammouane Province, near Hin Nam No National Protected Area, at ca. 160-170 m asl. A crocodile of ca. 3.5 m was seen by us in a lake system (Khun Khe Lake; Fig. 2), which is subdivided into two lakes in the dry season - the larger lake is about 100 m from the smaller lake. The surface area of the smaller lake is about 1800 m^2 and with 1.8 m maximum water depth, and the surface area of the larger lake is about 3000 m^2. Another pond exists about 800 m away, and has a surface area of ca. 200 m^2. Lake shores consist of shallow to steep base bars intermixed with steep rock walls. Large parts of the shore are covered by vegetation (shrubs, bamboos, trees). Fish, potential prey for crocodiles, were abundant in the lake, as were frogs, snakes, softshell turtles and otters.

Figure 2. Isolated large lake of Khun Khe Lake System, where crocodile was sighetd in June 2015. Photograph: Thomas Ziegler.

Figure 3. Large crocodile sighted in isolated large lake (see Fig. 2) of Khun Khe Lake System in June 2015. Photograph: Thomas Ziegler.

The crocodile was observed by us in the isolated small lake in March 2015 and in the isolated large lake in June 2015. Head crests and snout ridges were characteristic of *C. siamensis*. At the same time as the sighting of the large crocodile in March 2015, local villagers discovered another, smaller crocodile of about 2.5 m length in the separated large lake. With our current knowledge, the population covers at least two individuals, with unknown sex ratio.

Interviews with local people revealed that another individual with an injured tail was shot in the 1980s. In former times, the population must have been substantially larger. Crocodiles from that lake system were caught during the Indochinese Conflict, to supplement diet and income. An 80-year-old informant told us that crocodiles were abundant at the site during his childhood, but juveniles have not been sighted there for a long time. This supports our morphological determination, that the reported crocodiles are remnants of a natural *C. siamensis* population.

Concerning human-wildlife conflict, we saw buffalos and dogs in the surroundings of the lake, which also is used by local fishermen. Local villagers reported one non-fatal crocodile attack on a fisherman in former times. As mentioned, crocodiles were caught or shot in the area, with the last case being reported from the 1980s. We also recorded fire and forest burning as well as pollution in the immediate vicinity of the lakes. Also, Bezuijen *et al*. (2013) stated that crocodiles are under threat from a range of anthropogenic processes, mainly habitat loss and opportunistic collection. Because all documented breeding sites and most confirmed national records in Laos are in rural lands outside the national protected area system, conservation efforts require community-based approaches (Bezuijen *et al*. 2013). The latter authors also suggested that conservation approaches should first focus on protecting documented populations and their habitats.

Also the newly discovered population is currently not protected. It is located nearby a watershed protected area and is ca. 10 km distant from the border of Hin Nam No National Protected Area. Discussions with the forest resource management section led to plans to establish a provincial protected area under the management of the provincial natural resources and environment department in a first step, but which has to be decided by the Provincial Government first.

We also collected faecal samples for subsequent genetic screening to support the discovery of a natural population and to definitely exclude that the sighted crocodiles are escaped animals or hybrids. However, on the basis of the interviews with local villagers this is unlikely, but also because the closest Siamese crocodiles are about 400 km away in Vientiane Province. In Vientiane, the Ban Kuen Zoo houses the only known captive collection of *C. siamensis* in Laos (Phothitay *et al*. 2005; Thorbjarnarson 2003) - around 1000 individuals, most of which are suspected to be hybrids (Bezuijen *et al*. 2006, 2012). Thus, the absence of other crocodile institutions in Laos reduces the risk of hybridization of wild crocodiles with escaped hybrids (Bezuijen *et al*. 2006).

Besides the aforementioned, still outstanding genetical analysis, further research of the newly discovered population is desirable, in particular to document the actual population size, but also to record the surrounding fauna and flora. Results of first surveys conducted by our team revealed the existence of further so far not reported wildlife in the region, which will be dealt with in a separate article. Also educational advertising is required to reduce human-wildlife conflicts. In case that the newly discovered crocodile population in fact only consists of two animals, which may be of the same sex, a further step could be a population restocking with genetically wild *C. siamensis* of local provenance. This could be done by the release of breeding males into the site if only females are present, or vice versa (see also Bezuijen *et al*. 2013). In that case, genetically tested zoo stock could potentially be used for future restocking efforts.

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Science

Recent Publications

McCoy, J.A., Parrott, B.B., Rainwater, T.R., Wilkinson, P.M. and Guillette, L.J. Jr. (2015). Incubation history prior to the canonical thermosensitive period determines sex in the American alligator.

Reproduction 150: 279-287.

Abstract: Despite the widespread occurrence of environmental sex determination (ESD) among vertebrates, our knowledge of the temporal dynamics by which environmental factors act on this process remains limited. In many reptiles, incubation temperature determines sex during a discrete developmental window just prior to and coincident with the differentiation of the gonads. Yet, there is substantial variation in sex ratios among different clutches of eggs incubated at identical temperatures during this period. Here, we test the hypothesis that temperatures experienced prior to the reported thermosensitive period for alligators (*Alligator mississippiensis*) can impact how the sex determination system responds to thermal cues later in development. Temperature shift experiments on eggs collected from the field within 24 h of oviposition were employed to decouple various maternal influences from thermal effects, and results demonstrate a previously undefined window of thermosensitivity occurring by stage 15 of embryonic development, six stages earlier than previously reported. We also examine the intrasexual expression of several male- and female-biased genes and show that while male-biased genes display no intrasexual differences, ovarian CYP19A1 (aromatase) transcript abundance differs by approximately twofold depending on thermal exposures experienced at early stages of embryonic development. These findings expand our understanding of the ESD in the alligator and provide the rationale for reevaluation of the temporal dynamics of sex determination in other crocodilians.

Makanya, A.N. (ed.). (2015). The Vertebrate Blood-Gas Barrier in Health and Disease. Structure, Development and Remodeling. Springer International Publishing: Switzerland.

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Abstract: Despite the availability of deep-sequencing techniques, genomic and transcriptomic data remain unevenly distributed across phylogenetic groups. For example, reptiles are poorly represented in sequence databases, hindering functional evolutionary and developmental studies in these lineages substantially more diverse than mammals. In addition, different studies use different assembly and annotation protocols, inhibiting meaningful comparisons. Here, we present the "Reptilian Transcriptomes Database 2.0," which provides extensive annotation of transcriptomes and genomes from species covering the major reptilian lineages. To this end, we sequenced normalized complementary DNA libraries of multiple adult tissues and various embryonic stages of the leopard gecko and the corn snake and gathered published reptilian sequence data sets from representatives of the four extant orders of reptiles: Squamata (snakes and lizards), the tuatara, crocodiles, and turtles. The LANE runner 2.0 software was implemented to annotate all assemblies within a single integrated pipeline. We show that this approach increases the annotation completeness of the assembled transcriptomes/genomes. We then built large concatenated protein alignments of single-copy genes and inferred phylogenetic trees that support the positions of turtles and the tuatara as sister groups of Archosauria and Squamata, respectively. The Reptilian Transcriptomes Database 2.0 resource will be updated to include selected new data sets as they become available, thus making it a reference for differential expression studies, comparative genomics and transcriptomics, linkage mapping, molecular ecology, and phylogenomic analyses involving reptiles. The database is available at www.reptilian-transcriptomes.org and can be enquired using a wwwblast server installed at the University of Geneva.

Lance, V. (2015). Twenty-five years on: Introduction to the Symposium on Integrative Biology of Crocodilia. Integr. Comp. Biol. (doi: 10.1093/icb/icv076).

Farmer, C.G. (2015). Similarity of crocodilian and avian lungs indicates unidirectional flow is ancestral for Archosaurs. Integr. Comp. Biol. (doi: 10.1093/icb/icv078).

Abstract: Patterns of airflow and pulmonary anatomy were studied in the American alligator (*Alligator mississippiensis*), the black caiman (*Melanosuchus niger*), the spectacled caiman (*Caiman crocodilus*), the dwarf crocodile (*Osteolaemus tetraspis*), the saltwater crocodile (*Crocodylus porosus*), the Nile crocodile (*Crocodylus niloticus*), and Morelet's crocodile (*Crocodylus moreletii*). In addition, anatomy was studied in the Orinoco crocodile (*Crocodylus intermedius*). Airflow was measured using heated thermistor flow meters and visualized by endoscopy during insufflation of aerosolized propolene glycol and glycerol. Computed tomography and gross dissection were used to visualize the anatomy. In all species studied a bird-like pattern of unidirectional flow was present, in which air flowed caudad in the cervical ventral bronchus and its branches during both lung inflation and deflation and craniad in dorsobronchi and their branches. Tubular pathways connected the secondary bronchi to each other and allowed air to flow from the dorsobronchi into the ventrobronchi. No evidence for anatomical valves was found, suggesting that aerodynamic valves cause the unidirectional flow. In vivo data from the American alligator showed that unidirectional flow is present during periods of breath-holding (apnea) and is powered by the beating heart, suggesting that this pattern of flow harnesses the heart as a pump for air. Unidirectional flow may also facilitate washout of stale gases from the lung, reducing the cost of breathing, respiratory evaporative water loss, heat loss through the heat of vaporization, and facilitating crypsis. The similarity in structure and function of the bird lung with pulmonary anatomy of this broad range of crocodilian species indicates that a similar morphology and pattern of unidirectional flow were present in the lungs of the common ancestor of crocodilians and birds. These data suggest a paradigm shift is needed in our understanding of the evolution of this character. Although conventional wisdom is that unidirectional flow is important for the high activity and basal metabolic rates for which birds are renowned, the widespread occurrence of this pattern of flow in crocodilians indicates otherwise. Furthermore, these results show that air sacs are not requisite for unidirectional flow, and therefore raise questions about the function of avian air sacs.

Platt, S.G., Charruau, P. and Rainwater, T.R. (2014). Scavenging of crocodile eggs by vultures (*Cathartes aura* and *Coragyps atratus*) in Quintana Roo, Mexico. Bulletin of the Texas Ornithological Society 47(1-2): 37-40.

Abstract: Few published observations exist regarding scavenging or predation of crocodilian eggs and neonates by vultures. Here we report on black (*Coragyps atratus*) and turkey (*Cathartes aura*) vultures scavenging eggs, eggshell membranes, and dead neonates from an American crocodile (*Crocodylus acutus*) nest in Quintana Roo, Mexico. Our observations are noteworthy for several reasons. First, they complement previous accounts of vultures scavenging crocodilian eggs and neonates, and provide additional details on this under-reported behavior. Second, our findings are yet another example of how vultures can adjust foraging behaviors to best exploit available carrion resources. Finally, this study further highlights the utility of automated wildlife cameras for investigating poorly known

aspects of vulture biology.

Kofron, C.P. and Farris, P.A. (2015). Infrasound production by a yacare caiman *Caiman yacare* in the Pantanal, Brazil. Herpetology Notes 8: 385-387.

Abstract: We observed infrasound production with a water dance by a yacare caiman, which we recorded as a series of 16 high-resolution photographs. We subsequently used image enhancement tools to identify and differentiate the projected water drops from the background in each photograph. The water was projected approximately 75 cm upward into the air. The water dance that we observed was likely an evolved functional component of the roaring display rather than a physical artifact of sound production in water.

Dacke, C.G., Elsey, R.M., Trosclair, III, P.L., Sugiyama, T., Nevarez, J.G. and Schweitzer, M.H. (2015). Alligator osteoderms as a source of labile calcium for eggshell formation. Journal of Zoology (doi: 10.1111/jzo.12272).

Abstract: The calcium (Ca) demand on alligators in active reproduction is significant, yet the source of this additional Ca is unclear. Three possible sources for Ca mobilization are endolymphatic deposits, as in anurans and some lizards; short-lived skeletal medullary bone or analogous deposits, as in birds; or some other source such as the osteoderm layer of the integument or simply mobilization of structural bone. Here, we investigate possible extra-skeletal sources for labile Ca in the reproducing alligator, including endolymphatic Ca deposits, by analogy with anuran amphibian and some reptiles and integumentary osteodermal (scale) Ca deposits. We conducted X-ray image analyses of skulls for the presence of significant endolymphatic Ca deposits. We also examined dermal bone of scutes (osteoderm, scales) from the dorsal integument using both X-ray and histological analyses. Tissues from reproducing females containing mature but unovulated follicles were compared with those from specimens that had nested (laid eggs) or contained eggs within the oviduct at advanced stages of calcification. A small number of immature specimens and an adult male were also compared. No clear differences were observed in endolymphatic deposits between pre- and post-ovulatory specimens. Scute (osteoderm) X-ray density was significantly greater in females with ripe ovarian follicles compared with those that had recently laid (nested) or contained heavily calcified eggs within their oviducts. The latter groups also showed histological evidence of scute resorption compared with the former, suggesting that the scutes play a role in Ca storage during egglay.

Rhind, D., Ricketts, A., Calvert, G. and Lyons, K. (2015). *Crocodylus porosus* (Estuarine Crocodile). Fishing behavior. Herpetological Review 46(2): 248-249.

Campos, Z. (2015). Size of caimans killed by humans at a hydroelectric dam in the Madeira River, Brazilian Amazon. Herpetozoa 28(1/2): 101-104.

Clarac, F., Souter, T., Cornette, R., Cubo, J. and De Buffrénil, V. (2015). A quantitative assessment of bone area increase due to ornamentation in the Crocodylia. J. Morphol. (doi: 10.1002/jmor.20408).

Abstract: Bone ornamentation, in the form of highly repetitive motives created by pits and ridges, is a frequent feature on vertebrate skull roofs and osteoderms. The functional significance of this character remains a matter of controversy and speculation. The many diverging hypotheses proposed to explain it all share a common logical prerequisite: bone ornamentation should increase significantly the surface area of the bones that bear it. In order to test this assumption in the Crocodylia, we developed a method for quantifying the gain in area due to ornamentation using a three-dimensional-surface scanner. On crocodylian osteoderms, the gain in area can be up to 40%, and on the cranial table, it ranges between 10 and 32% in adult specimens (in both cases, it shows substantial differences between the adults of the various species included in the sample). Area gain on the snout is lesser (0-20% in adults), and more variable between species. In general, bone ornamentation is less pronounced, and results in fewer area gains in juvenile specimens. The main morphometric results yielded by this study are discussed in reference to the few comparative data available hitherto, and to the functional interpretations proposed by previous authors.

Wu, X.-C. and Brinkman, D.B. (2015). A new crocodylian (Eusuchia) from the uppermost Cretaceous of Alberta, Canada. Canadian Journal of Earth Sciences 52(8): 590-607.

Abstract: *Albertosuchus knudsenii* gen. et sp. nov. is described on the basis of an incomplete skeleton from the lower part (uppermost Cretaceous) of the Scollard Formation, southern Alberta, Canada. It is probably a crocodyloid, the only Canadian representative of the group and also the sole crocodylian known during the latest Cretaceous in Canada. Within the Crocodyloidea, *A. knudsenii* is one of the most basal forms and shares a sister-group relationship with the European genus *Arenysuchus*. However, it needs to be emphasized that because of its incompleteness, phylogenetic relationships proposed here for *A. knudsenii* may change when better-preserved specimens are found. *Albertosuchus knudsenii* differs from other crocodyloids in having no premaxilla-maxillary notch, a very short mandibular symphysis with the involvement of the splenial, and an extremely deep hypapophysis on the last cervical and anterior dorsal vertebrae. The discovery of *A. knudsenii* may expand the geographical range of the Crocodyloidea into Canada during the Cretaceous. Crocodylians in the lower part of the Scollard Formation are of low diversity compared with that of the corresponding Hell Creek Formation of Montana and Lance Formation of Wyoming, both farther to the south in the USA.

William B., J., Rao, G.D., Bharathidasan, M., Thirumurugan, R., Simon, S., Jayaprakash, R. and George, R.S. (2015). Ablation of sulcus spermaticus for birth control surgery in Mugger crocodiles (*Crocodylus palustris*). International Journal of Current Research and Review 7(14): 57-60.

Abstract: Mugger crocodiles breed twice in a year under captivity resulting in over population; requiring birth control measures. As the testis and vas deferens are intra-abdominal, the efficacy of surgical ablation of sulcus spermaticus that transport the sperm during copulation, on the dorsal surface of the phallus was assessed. Twelve male crocodiles weighing between 140 to 230 kg were immobilized and anaesthetized with a combination of xylazine-ketamine at the dose rate of 1.5 and 20 mg/kg body weight respectively. Under aseptic precautions the phallus was retracted through cloacal slit as the animal was positioned on dorsal recumbency. The mucous membrane guarding the groove and floor were resected to ablate the sulcus spermaticus and the mucous membrane on either side was sutured. After 6 to 8 months randomly 6 crocodiles were immobilized and the phallus was examined, which revealed no signs of regeneration of the groove. The study revealed that ablation of sulcus spermaticus could be followed as a birth control surgery in

male Mugger crocodiles without affecting the welfare and breeding behavior.

Blanco, A., Fortuny, J., Vicente, A., Luján, À.H., García-Marçà, J.A. and Sellés, A.G. (2015). A new species of *Allodaposuchus* (Eusuchia, Crocodylia) from the Maastrichtian (Late Cretaceous) of Spain: phylogenetic and paleobiological implications. PeerJ 3:e1171.

Abstract: The Late Cretaceous is a keystone period to understand the origin and early radiation of Crocodylia, the group containing all extant lineages of crocodilians. Among the taxa described from the latest Cretaceous of Europe, the genus *Allodaposuchus* is one of the most common but also one of the most controversial. However, because of its fragmentary record, several issues regarding its phylogenetic emplacement and its ecology remain unsolved or unknown. The discovery of a single specimen attributed to *Allodaposuchus*, represented by both cranial and postcranial remains, from the Casa Fabà site (Tremp Basin, NE Spain) in the lower red unit of the Tremp Fm. (early Maastrichtian, Late Cretaceous) offers a unique opportunity to deepen in the phylogenetic relationships of the group and its ecological features. The specimen is described in detail, and CT scan of the skull is performed in order to study the endocranial morphology as well as paratympanic sinuses configuration. In addition, myological and phylogenetic analyses are also carried out on the specimen for to shed light in ecological and phylogenetic issues, respectively. The specimen described herein represents a new species, *Allodaposuchus hulki* sp. nov., closely related to the Romanian *A. precedens*. The CT scan of the skull revealed an unexpected paratympanic sinuses configuration. *Allosaposuchus hulki* exhibits an "anterodorsal tympanic sinus" not observed in any other extant or extinct crocodilian. The caudal tympanic recesses are extremely enlarged, and the expanded quadratic sinus seems to be connected to the middle-ear channel. Phylogenetic analyses confirm the emplacement of the informal taxonomic group 'Allodaposuchia' at the base of Crocodylia, being considered the sister group of Borealosuchus and Planocraniidae. Although this is a preliminary hypothesis, the unique paratympanic configuration displayed by *A. hulki* suggests that it could possess a high-specialized auditory system. Further, the large cranial cavities could help to reduce the weight of the cranium. Concerning the postcranial skeleton, *Allodaposuchus hulki* shows massive and robust vertebrae and forelimb bones, suggesting it could have a bulky body. The myological study performed on the anterior limb elements supports this interpretation. In addition, several bone and muscular features seem to point at a semi-erected position of the forelimbs during terrestrial locomotion. Taking all above results into consideration, it seems plausible to suggest *A. hulki* could conduct large incursions out of the water and have a semi-terrestrial lifestyle.

Brunell, A.M., Rainwater, T.R., Sievering, M. and Platt, S.G. (2015). A new record for the maximum length of the American alligator. Southeastern Naturalist 14(3): N38-N43.

Abstract: An unusually large *Alligator mississippiensis* (American Alligator) was harvested in Alabama in 2014. We report on the animal's length and mass, and document the techniques used to obtain those measurements. We compare our measurements to other extreme lengths and weights reported for the species. We show that the size of the American Alligator is consistent with known allometric relationships of head length, total length, snout-vent length, tail girth, and weight. The specimen's straight-line total length of 450.0 cm (14 ft 9.25 in) makes it the longest officially measured American Alligator for Alabama and arguably the longest credible record for the species. We recommend using standardized techniques, particularly the straight-line total-length measurement, for documenting record-length or near-record-length American Alligators.

Abramyan, J. and Richman, J.M. (2015). Recent insights into the morphological diversity in the amniote primary and secondary palates. Developmental Dynamics (doi: 10.1002/dvdy.24338).

Abstract: The assembly of the upper jaw is a pivotal moment in the embryonic development of amniotes. The upper jaw forms from the fusion of the maxillary, medial nasal, and lateral nasal prominences, resulting in an intact upper lip/beak and nasal cavities; together called the primary palate. Due to the risk of craniofacial clefting, this process requires a balance of proper facial prominence shape and positioning, whilst still accommodating the vast phenotypic diversity of adult amniotes. As such, variation in craniofacial ontogeny is not tolerated beyond certain bounds. We have placed primary palatogenesis of amniotes into two categories, depending on whether the nasal and oral cavities remain connected throughout ontogeny or not. The transient separation of these two structures occurs in mammals and crocodilians, while remaining connected in birds, turtles and squamates. In the latter group, the craniofacial prominences fuse around a persistent choanal groove that connects the two cavities. Subsequently, select lineages within both categories develop a secondary palate that either completely or partially separates oral and nasal cavities in adults. Here we review the shared, early developmental events, and highlight the points at which development diverges in both primary and secondary palate formation

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Okamoto, K.W., Langerhans, R.B., Rashid, R. and Amarasekare, P. (2015). Microevolutionary patterns in the common caiman predict macroevolutionary trends across extant crocodilians. Biological Journal of the Linnean Society (doi: 10.1111/bij.12641).

Abstract: Both extinct and extant crocodilians have repeatedly diversified in skull shape along a continuum, from narrow-snouted to broad-snouted phenotypes. These patterns occur with striking regularity, although it is currently unknown whether these trends also apply to microevolutionary divergence during population differentiation or the early stages of speciation. Assessing patterns of intraspecific variation within a single taxon can potentially provide insight into the processes of macroevolutionary differentiation. For example, high levels of intraspecific variation along a narrow-broad axis would be consistent with the view that cranial shapes can show predictable patterns of differentiation on relatively short timescales, and potentially scale up to explain broader macroevolutionary patterns. In the present study, we use geometric morphometric methods to characterize intraspecific cranial shape variation among groups within a single, widely distributed clade, *Caiman crocodilus*. We show that *C. crocodilus* skulls vary along a narrow/broad-snouted continuum, with different subspecies strongly clustered at distinct ends of the continuum. We quantitatively compare these microevolutionary trends with patterns of diversity at macroevolutionary scales (among all extant crocodilians). We find that morphological differences among the subspecies of *C. crocodilus* parallel the patterns of morphological differentiation across extant crocodilians, with the primary axes of morphological diversity being highly correlated across the two scales. We find intraspecific cranial shape variation within *C. crocodilus* to span variation characterized by more than half of living species. We show the main axis of intraspecific phenotypic variation to align with the principal direction of macroevolutionary diversification in crocodilian cranial shape, suggesting that mechanisms of microevolutionary divergence within species may also explain broader patterns of diversification at

higher taxonomic levels.

Hill, R.V., Roberts, E.M., Tapanila, L., Bouare, M.L., Sissoko, F. and O'Leary, M.A. (2015). Multispecies shark feeding in the Trans-Saharan Seaway: Evidence from late Cretaceous Dyrosaurid (Crocodyliformes) fossils from northeastern Mali. PALAIOS 30(7):589-596.

Abstract: Feeding traces help to characterize trophic interactions of ancient ecosystems. In rare cases, they may also provide information that is not otherwise represented by body fossils in a particular paleoenvironment. Here, we describe a diverse suite of surficial bone modifications preserved on dyrosaurid crocodyliform bones. These new fossils come from extensive Upper Cretaceous (Maastrichtian) bone and coprolite-dominated phosphate conglomerates from deposits of the Trans-Saharan Seaway in northern Mali. Five specimens have bite traces indicative of feeding by at least two species of neoselachian sharks. Features of some traces suggest they were not made in a fatal attack, but after the dyrosaurids had died, and therefore represent instances of scavenging. Other traces may be attributed to predation or early scavenging. In addition to the shark bite traces, one specimen bears minute, crescent-shaped traces that we tentatively attribute to invertebrate activity. Importantly, the traces described here document the presence of species for which body fossils have not yet been discovered.

Fukuda, Y., Tingley, R., Crase, B., Webb, G. and Saalfeld, K. (2015). Long-term monitoring reveals declines in an endemic predator following invasion by an exotic prey species. Animal Conservation (doi: 10.1111/acv.12218).

Abstract: Invasive predators can cause population declines in native prey species, but empirical evidence linking declines of native predators to invasive prey is relatively rare. Here, we document declines in an Australian freshwater crocodile *Crocodylus johnstoni* population following invasion of a toxic prey species, the cane toad *Rhinella marina*. Thirty-five years of standardized spotlight surveys of four segments of a large river in northern Australia revealed that the density of freshwater crocodiles decreased following toad invasion and continued to decline thereafter. Overall, intermediate-sized freshwater crocodiles (0.6-1.2 m) were most severely impacted. Densities of saltwater crocodiles *Crocodylus porosus* increased over time and were generally less affected by toad arrival, although toad impacts were inconsistent across survey sections and size classes. Across the entire river, total freshwater crocodile densities declined by 69.5% between 1997 and 2013. Assessments of the status of this species within other large river systems in northern Australia, where baseline data are available from before the toads arrived, should be prioritized. Our findings highlight the importance of long-term monitoring programmes for quantifying the impacts of novel and unforeseen threats.

Schmidt, V. (2015). Fungal infections in reptiles - an emerging problem. Journal of Exotic Pet Medicine (doi:10.1053/j.jepm.2015.06.014).

Abstract: Dermatomycoses as well as disseminated systemic mycoses are caused by emerging obligate pathogenic fungi of the families Onygenaceae and Clavicipitaceae in captive as well as in free-living reptiles. Isolation and differentiation of fungal agents and evaluation of their pathogenicity in diseased reptiles using histopathological examination is necessary to determine the pathogenicity of a fungal isolate in the disease process. Fungi formerly known as *Chrysosporium* anamorph of *Nannizziopsis vriesii* have recently been reassigned to the family Onygenaceae, order Onygenales (Eurotiomycetidae, Eurotiomycetes, Ascomycota) based on phylogenetic studies. To date, 9 different reptile pathogenic species are known from this family, grouped in three phylogenetic lineages. The most relevant are *Nannizziopsis guarroi* affecting inland bearded dragons (*Pogona viticeps*) and green iguanas (*Iguana iguana*), as well as *Ophidiomyces ophiodiicola* in free-living snakes, which cause deep fungal dermatitis. Treatment with voriconazole is possible in bearded dragons and girdled lizards (*Cordylus giganteus*). Other obligate pathogenic fungi belong to the family Clavicipitaceae, which cause granulomatous glossitis, pharyngitis, and dermatitis, as well as disseminated visceral mycosis, in various lizards, tortoises, turtles and crocodilians. No reports exist about successful treatments against fungal pathogens in the family Clavicipitaceae. Also, voriconoazole should be used carefully in chameleons, as it does not seem to be well tolerated in these species.

Campos, Z., Mourão, G., Coutinho, M., Magnusson, W.E. and Soriano, B.M.A. (2015). Spatial and temporal variation in reproduction of a generalist crocodilian, *Caiman crocodilus yacare*, in a seasonally flooded wetland. PLoS ONE 10(6): e0129368

Abstract: We monitored the number of caiman (*Caiman crocodilus yacare*) nests in two ranches in the Brazilian Pantanal that cover an area of about 50,000 ha for 28 years (1987-2014). The number of nests was related to combinations of rainfall, water level, and number of days with temperature below 20°C, depending on the area. Most of the variation in number of nests could not be predicted by the environmental variables, but could be represented mathematically by a sine wave. We were not able to identify any external driver and suspect that the regular fluctuations may have resulted from an intrinsic population process. Presently, ranches are used as management units under the legislation for ranching Pantanal caimans. However, although some breeding females were recaptured in the area after periods of up to 21 years, most were not recaptured near nests or in general surveys of the area, suggesting that females are not strongly philopatric and that ranches do not represent isolated demographic units.

Moreno-Azanza, M., Canudo, J.I. and Gasca, J.M. (2015). Enigmatic Early Cretaceous ootaxa from Western Europe with signals of extrinsic eggshell degradation. Cretaceous Research 56 (Sep-Dec): 617-627.

Abstract: Crocodiloid eggshell is considered to be one of the most conservative among amniotes. This contrasts with the high body diversity observed within the crocodylomorph lineage, which extebds from the Triassic to the present. This incongruence raises a fundamental question in palaeology: is the crocodylomorph eggshell structure that conservative, or are there variations in this structure that have been misidentified in the fossil record or remain undiscovered to taphonomic biases? In this paper we re-examine eggshells from the Barremian of northern Spain that were previously assigned to chelonians. We erect a new oogenus and oospecies, *Mycomorphoolithus kohringi*, characterized by thin eggshells with mushroom-shaped or inverted cone shell units with blocky extinction with smooth or slightly undulating outer surface, covered by a highly variable number of pores of irregular size and shape. These variations in the pore opening pattern are here interpreted as evidence of degradation of the eggshell during embryo development, a process that has only been described in modern alligatorids. After discarding its chelonian and dinosaurian affinities, we identify them as related to Krokolithidae, but with enough differences to justify exclusion from this oofamily. In addition, eggshells from the Berriasian of England previously reported as dinosaurian-

spherulitic eggshells, are here assigned to undetermined oospecies of Mycomorphoolithus. Thus, the record of *Mycomorphoolithus* extends throughout most of the Lower Cretaceous. This long-surviving oogenus may represent eggshells of the non-eusuchian crocodylomorphs that are abundant in the microfossil sites where *Mycomorphoolithus* eggshells are found.

Murray, C.M., Easter, M., Padilla, S., Garrigós, D.B., Stone, J.A., Bolaños-Montero, J., Sasa, M. and Guyer, C. (2015). Cohort-dependent sex ratio biases in the American crocodiles (*Crocodylus acutus*) of the Tempisque Basin. Copeia 103(3): 541-545.

Abstract: A male-biased sex ratio of 3:1 has been reported for a population of American crocodiles (*Crocodylus acutus*) in the Tempisque River Basin, Guanacaste, Costa Rica. If confirmed, this would constitute one of the largest male-biased sex ratios reported for any population of a member of the genus *Crocodylus*. Here, we examine the aforementioned population of *C. acutus* and report on sex ratios of hatchling, juvenile, and adult age classes within a sample of 474 crocodiles captured in the Tempisque Basin between May 2012 and June 2014. Hatchling sex ratio is exceptionally male biased (3.5:1), an imbalance that is maintained in juveniles but is reduced in adults (1.5:1). Mark-recapture data document that juvenile males disperse from the study site, potentially to avoid competition, a process that reduces male bias in the adult age class. An increased role of males in human-crocodile conflict may be a result of juvenile males dispersing to human-inhabited areas.

Zucoloto, R.B. and Porto, C.R. (2015). Isolation of 25 new molecular microsatellite markers from *Alligator mississippiensis* (Alligatoridae, Alligatorinae) EST sequences using in Silico Approach. International Journal of Applied Science and Technology 5(2): 41-44.

Abstract: Microsatellite markers have been applied to conservation genetic studies of crocodilians since the second half of 1990s. The identification of highly transferable markers would be very important to crocodilian genetic studies. Here is described the identification of 25 new microsatellite markers from *Alligator mississippiensis* (Daudin, 1802) EST sequences and discussed their expected efficiency for the amplification of DNA of other crocodilian species.

Kluczkovski Jr., A., Kluczkovski, A.M., Moroni, F.T., Markendorf, F. and Inhamuns, A.J. (2015). Carcass yield and proximate composition of black caiman (*Melanosuchus niger*) meat. International Journal of Fisheries and Aquaculture 7(4): 47-53.

Abstract: The Amazon region is recognized as source of fish for the food industry. The interest in new products made from exotic animal meat has increased. The present study was carried out to evaluate carcass and meat characteristics of Amazon caiman. Samples (n= 184) of *Melanosuchus niger* were collected from a protected area in the Amazonas State (Brazil). The meat was analyzed for proximate composition: Moisture content 78.17%, protein 19.23%, lipids 1.09% and ash 0.73%. The yield of the carcasses and cuts were evaluated, and the average yield of carcass was 57.02%. The tail cuts had the highest yield. The results obtained can be useful for new Amazon basin products as well as for product labeling.

Zhao, J.H., Wang, S.S., Tu, G.J., Zhou, Y.K. and Wu, X.B.. (2015). Morphological and molecular characterization of *Ortleppascaris sinensis* sp. nov. (Nematoda: Ascaridoidea) from the Chinese alligator *Alligator sinensis*. J. Helminthol. 17:1-9.

Abstract: A new nematode species, *Ortleppascaris sinensis* sp. nov. (Ascaridoidea), is described from specimens found in the stomach and intestine of the Chinese alligator *Alligator sinensis* Fauvel, 1879 (Crocodilian: Alligatoridae) in the National Nature Reserve of Chinese Alligator (Chinese Crocodile Lake) in Anhui Province, China. This is the first description of *O. sinensis* sp. nov. in both China and this crocodile host, increasing its distribution in South Asia as well as expanding the number of helminths known to infect this crocodile. The detailed description of *O. sinensis* sp. nov., based on light and scanning electron microscopic examination, provides new taxonomic data for this species, and we also report sequences of the internal transcribed spacers (ITS), small subunit DNA segments (18S) and the cytochrome oxidase I (COI) gene.

Sorensen, C.A.E. (2015). Trophy Hunting in the U.S. Media: A Macro- and Micro-Level Frame Analysis. MSc thesis, Central European University, Budapest, Hungary.

Mobaraki, A. (2015). Sustainable Management and Conservation of the Mugger Crocodile (*Crocodylus palustris*) in Iran. MSc thesis, International University of Andalusia, Baeza, Spain.

Abstract: Small populations of Mugger crocodiles, with an estimate of more than 500 individuals, are distributed in the southeastern part of Iran, namely, the Sistan and Baluchestan province. The area is known as the western most global range of the species. The main characteristic of the population is that it has been divided into several sub-populations which are scattered. As a management option, the main areas of crocodile habitats have been designated as "protected areas" and "International wetland sites". The local name for the species in Iran is 'Gandou". The crocodiles occupy vast ranges of natural and artificial water bodies as their habitats. Crocodiles use any available resources as food like fish, birds, dogs and villager's livestock. However, they are mainly dependent on fish. The nesting season for the crocodiles in Iran has been reported to be in May and, consequently, the eggs hatch in July. Hatchlings have mean total length and weight of 30.47 cm and 84.29 g respectively. One of the most specific and important behaviors of the Mugger is burrowing which is mostly used as refuge, even by the hatchlings. Evidence indicating of nesting in the burrows is not found in the literature. Migration or movement between habitats is another considerable behavior of Muggers, which provides potential threat for the crocodiles that have to cross roads resulting in death by automobiles. Fortunately, as a unique situation in the world, there is no hunting of crocodiles in Iran and local people based on their cultural beliefs respect crocodiles and refrain from harming the species, although they have very close contact with crocodiles. Drought and flooding remain as the main natural threats for the crocodiles. Mugger crocodiles are listed in Appendix I of CITES, which prohibits commercial trade in that species.

Weinreich, S.J. (2015)Thinking with crocodiles: an iconic animal at the intersection of early-modern religion and natural philosophy. Early Science and Medicine 20(3): 209-240.

Abstract: This paper seeks to explore how culturally and religiously significant animals could shape discourses in which they were deployed, taking the crocodile as its case study. Beginning with the textual and visual traditions linking the crocodile with Africa and the Middle East, I read 16th- and 17th-century travel narratives categorizing American reptiles as "crocodiles" rather than "alligators," as attempts to mitigate the disruptive strangeness of the Americas. The second section draws on Ann Blair's study of "Mosaic Philosophy" to examine scholarly debates over the

taxonomic identity of the biblical Leviathan. I argue that the language and analytical tools of natural philosophy progressively permeated religious discourse. Finally, a survey of more than 25 extant examples of the premodern practice of displaying crocodiles in churches, as well as other crocodilian elements in Christian iconography, provides an explanation for the ubiquity of crocodiles in Wunderkammern, as natural philosophy appropriated ecclesial visual vocabularies.

Yang, Z., Wang, C., Wang, T., Bai, J., Zhao, Y., Liu, X., Ma, Q., Wu, X., Guo, Y., Zhao, Y. and Ren, L. (2015). Analysis of the reptile CD1 genes: evolutionary implications. Immunogenetics (doi: 10.1007/s00251-015-0837-2).

Abstract: CD1, as the third family of antigen-presenting molecules, is previously only found in mammals and chickens, which suggests that the chicken and mammalian CD1 shared a common ancestral gene emerging at least 310 million years ago. Here, we describe CD1 genes in the green anole lizard and Crocodylia, demonstrating that CD1 is ubiquitous in mammals, birds, and reptiles. Although the reptilian CD1 protein structures are predicted to be similar to human CD1d and chicken CD1.1, CD1 isotypes are not found to be orthologous between mammals, birds, and reptiles according to phylogenetic analyses, suggesting an independent diversification of CD1 isotypes during the speciation of mammals, birds, and reptiles. In the green anole lizard, although the single CD1 locus and MHC I gene are located on the same chromosome, there is an approximately 10-Mb-long sequence in between, and interestingly, several genes flanking the CD1 locus belong to the MHC paralogous region on human chromosome 19. The CD1 genes in Crocodylia are located in two loci, respectively linked to the MHC region and MHC paralogous region (corresponding to the MHC paralogous region on chromosome 19). These results provide new insights for studying the origin and evolution of CD1.

Charruau, P. and González-Muñoz, R. (2015). Epibiont sea anemones inhabiting the American crocodile *Crocodylus acutus*. Marine Biodiversity (doi: 10.1007/s12526-015-0337-5).

Kvasilova, A., Jensen, B., Christoffels, V. and Sedmera, D. (2015). Development of the ventricular conduction system of the crocodilian heart. The FASEB Journal 29(1): Supplement 557.6.

Abstract: Unlike other cold-blooded vertebrates, crocodilians have a fully septated heart, similar to birds and mammals. It is not known whether they have a ventricular conduction system (VCS) as well. We studied a group of 8 embryos of the Siamese and Mugger Crocodile between 3 and 84 days of incubation, and serial early embryo sections with HNK-1/Hematoxylin staining of the Nile Crocodile. We employed optical mapping, ultrasound biomicroscopy, histo- and immunohistochemistry, in situ hybridization and 3D reconstruction. At the pre-septation stage (12 days of incubation), the ventricular activation pattern progressed in a left-to-right sweep, similar to that observed at early stages of avian and mammalian cardiogenesis. At two post-septation stages investigated (45 and 84 days) , epicardial activation patterns showed dual apical breakthroughs on either side of the interventricular septum. Immunohistochemistry using smooth muscle actin (SMA), sarcomeric actin, periostin and HNK-1 antibodies showed that myocardial SMA staining was present even after septation, while it disappears in comparable chick or mouse hearts. HNK-1 staining was prominent in the interventricular septum, similar to the situation in the chick and rat where it is considered a marker of the developing ventricular conduction system. In situ hybridization for Cx40 (VCS marker) showed a uniform expression in the entire trabeculated myocardium. We conclude that this is an evidence of evolutionary correlation between ventricular septation and presence specialized VCS in vertebrates.

Vasava, A., Patel, D., Vyas, R., Mistry, V. and Patel, M. (2015). Crocs of Charotar. Status, Distribution and Conservation of Mugger Crocodiles in Charotar, Gujarat, India. Voluntary Nature Conservancy: Vallabh Vidyanagar, India.

Abstract: Proper status of the Mugger (*Crocodylus palustris*) population in Charotar region was not known until recently. Except the study conducted by Vyas (2013), there wasn't any comprehensive study on the population of Muggers in charotar region. Upadhyay and Sahu (2013) provided Mugger numbers from very few localities. However both these studies indicated that there exists significant population of Muggers in charotar region. With numerous freshwater wetlands, Charotar harbours excellent habitats for the Muggers. Muggers have existed in this region for a long, but with no proper historical records available, it is difficult to ascertain the earlier status of the Muggers in the region. The Muggers of Charotar region survive in the man-made communal water bodies within the rural agricultural dominated region, establishing an ideal example of man-animal co-existence. Humans and Mugger crocodiles have been steadily increasing over the past years around these wetlands, which has resulted in different types of human-crocodile interactions in this region, varying from peaceful coexistence to conflict. Conserving Muggers in these human dominated landscapes require a firm understanding of people's relationship with this species. This Mugger population is under severe anthropogenic pressures and the conflict in the form of Muggers being found in human habitation and creating panic amongst the local residents is increasing with time. Considering that these wetlands still provide suitable habitat for Muggers, there was an urgent need for a systematic assessment of populations and the drivers affecting the populations. A study was carried out from June 2013 to January 2015 to find out the recent status of Muggers in the charotar region. The objectives of the project were (1) to understand the status and distribution of Muggers; (2) to identify the priority conservation areas; (3) to understand people's perception and attitude towards Muggers; and (4) to understand Mugger-human interaction. Mugger population assessments, interview surveys and other project related activities were carried out from May 2013 to January 2015. Information on Mugger occurrence, status and distribution were collected using both direct and indirect. Direct methods involved direct sightings through field survey whereas indirect methods included looking for Mugger signs (den/burrow, fecal matter) and interview surveys. Both day count survey and night spotlight survey were employed to assess the status and distribution of Muggers. Interviews with local residents were conducted to understand villagers' perceptions of, and attitudes towards Muggers, and to assess the human-Mugger interactions. A semi-structured survey instruction was prepared in the form of an interview-based questionnaire. Major Mugger habitats identifi ed were surveyed for collecting information on denning and nesting of Muggers. Burrow measurements such as height, width, depth, distance from water level and height above water level were recorded. 67 potential localities were surveyed to enumerate the distribution and population status of Muggers in Charotar region. Of these total villages surveyed, 36 belong to Kheda district and 32 villages belong to Anand district. We located Muggers at 27 of these villages, 10 of which were not previously known to be occupied by this species. Information about occurrence of Muggers was reported from another 16 villages, based on indirect evidences and local people's interviews. However, animals could not be sighted in these villages. It seems that these villages do not have a permanent breeding population but are used temporarily by roaming Muggers, especially during monsoons. Population surveys

yielded 183 records of Muggers. Of the total Muggers observed among all sites, 71% of the observations occurred in 6 localities; Deva, Vaso, Heranj, Marala-Naghrama, Traj and Malataj. Deva alone contributed about 29% (N=53) to the total population. Various sized Muggers were noted by direct sighting during the day count, which included 89 (54.60%) adults (>2 m), 60 sub-adults (1 to 2 m) and only 13 juveniles (<1 m) (ratio of juvenile to sub-adult to adult= 1:5:7). The Juvenile: Sub-Adult: Adult (J: SA: A) ratio was strongly adult biased. Both adults and sub-adults represented 92.08% (N= 150) of the sighted Muggers. Juvenile were represented in only 7.97% of the sightings. Thirteen villages having significant Mugger population were monitored for seasonal variation. Higher number of individuals were sighted in winter (mean= 87.25±11.29 SE), with maximum number of Muggers recorded in January 2014 (N= 116), whereas lower number of Muggers were sighted during monsoon (mean = 42.43± 2.37 SE) with lowest numbers recorded in the months of June 2014 (N= 36) and October 2014 (N= 37). Mugger nests were constructed starting from the dry season through the wet season with the earliest on around mid April. Egg-laying seems to take place at the height of the dry season till the onset of the wet season, from end of April to end of June. Hatching was observed commencing at the start of the wet season in the month of June and were observed till August. A total of 52 dens/burrows were recorded at 5 villages of which 31 were found to be actively used by Muggers. There was significant difference in the burrow height ($F_{6,22}$= 3.1225, $p<0.05$), distance from water-($F_{6,30}$= 31.293, $p<0.05$) and height above water level $F_{6,30}$= 22.514, $p<0.05$) between the sites. Whereas there was no significant difference in depth ($F_{6,28}$= 2.2022, $p>0.05$) and width ($F_{6,22}$= 1.068, $p>0.05$) of the burrows amongst the various sites. Of the total 52 burrows observed, 29 (55.77%) were in open areas without any canopy cover, whereas 15 (28.84%) of them were in open areas with little canopy cover and 8 of them were under the canopy of trees. We found an overall positive attitude toward the presence of Muggers in the area. However, local residents indicated a low level of knowledge concerning Muggers and their management. 44.75% of the total respondent reported that the Mugger population has increased over the last 10 years. 11.61% reported that the population has remained stable, whereas only 3.6% of the respondent reported a decrease in Mugger numbers over these years. Charotar holds a significant and health population of Muggers and can provide long-term survival to the species. The people have high positive attitudes towards Muggers. Currently the Mugger populations in Charotar region seems to be doing fine, however certain threats have been identified from present and earlier surveys. These problems need attentions from forest authorities, as this may pose danger to the Muggers and their habitat. The direct human infl uences such as poaching of Muggers for their skin and collection of eggs for food or medicinal purpose are not reported. It is fortunate enough for Muggers, that when most of the wild creatures are becoming victim of humans, it is somewhat safe from human's evil intentions. Certain threats such as inappropriate methods of fishing, habitat encroachment, food provisioning, road kills, flooding of burrows, negative portrayal of Mugger in media and drying up of wetlands in summer were identified. Recommendations developed from this study included: increasing the awareness of Muggers through targeted education, facilitating of stakeholder involvement, developing of proactive Mugger monitoring management strategies, and exploring different cost-effective conflict mitigation strategies.

Le Floch-Prigent, P., Verdeille, S. and Gillot, J.-B. (2015). Seriated CT-scan of a naturalized crocodile in the frontal plane. The FASEB Journal 29(1): Supplement 543.6 (doi: 10.1096/fj.1530-6860).

Abstract: A 98 cm long, naturalized crocodile had been CT-scanned all along his length when laid on the radiological table. The apparatus was a 128 detector rows 's, Siemens somatom edge CT-scan. Near one thousand (1000) frontal cross-sections were obtained. They revealed the removal of all the skeleton inside the skin except the head where the osseous data could be detailed. The remnant body was filled with a common material thus the shape of the neck, trunk, tail and of the four limbs could be appreciated. Thirteen (13) external views had been reconstructed from the cross-sections and were of good morphological value. The CT-scan has proved to be an unvaluable method in every gross-morphological anatomical study.

Martin, J.E., Vincent, P. and Falconnet, J. (2015). The taxonomic content of *Machimosaurus* (Crocodylomorpha, Thalattosuchia). Comptes Rendus. Palevol. (doi:10.1016/j.crpv.2015.03.006).

Abstract*: Machimosaurus* is a large teleosaurid thalattosuchian, a marine crocodylomorph historically recovered from Upper Jurassic strata of Europe. Several fragmentary remains are assignable to this genus but only four complete skulls have been reported, two of which are currently unavailable for study. A recent revision of the material assigned to *Machimosaurus* recognizes four valid species in this genus. Following a critical review of the diagnostic features of the various species, we confirm that the genus *Machimosaurus* is monospecific with *Machimosaurus hugii* as the sole and unique representative.

Tracy, C.R., McWhorter, T.J., Gienger, C.M., Starck, J.M., Medley, P., Manolis, S.C., Webb, G.J.W. and Christian, K.A. (2015). Alligators and crocodiles have high paracellular absorption of nutrients, but differ in digestive morphology and physiology. Integrative and Comparative Biology (doi: 10.1093/icb/icv060).

Abstract: Much of what is known about crocodilian nutrition and growth has come from animals propagated in captivity, but captive animals from the families Crocodilidae and Alligatoridae respond differently to similar diets. Since there are few comparative studies of crocodilian digestive physiology to help explain these differences, we investigated young *Alligator mississippiensis* and *Crocodylus porosus* in terms of (1) gross and microscopic morphology of the intestine, (2) activity of the membrane-bound digestive enzymes aminopeptidase-N, maltase, and sucrase, and (3) nutrient absorption by carrier-mediated and paracellular pathways. We also measured gut morphology of animals over a larger range of body sizes. The two species showed different allometry of length and mass of the gut, with *A. mississippiensis* having a steeper increase in intestinal mass with body size, and *C. porosus* having a steeper increase in intestinal length with body size. Both species showed similar patterns of magnification of the intestinal surface area, with decreasing magnification from the proximal to distal ends of the intestine. Although *A. mississippiensis* had significantly greater surface-area magnification overall, a compensating significant difference in gut length between species meant that total surface area of the intestine was not significantly different from that of *C. porosus*. The species differed in enzyme activities, with *A. mississippiensis* having significantly greater ability to digest carbohydrates relative to protein than did *C. porosus*. These differences in enzyme activity may help explain the differences in performance between the crocodilian families when on artificial diets. Both *A. mississippiensis* and *C. porosus* showed high absorption of 3-O methyl d-glucose (absorbed via both carrier-mediated and paracellular transport), as expected. Both species also showed surprisingly high levels of l-glucose-uptake (absorbed paracellularly), with fractional absorptions as high as those previously seen only in small birds and bats. Analyses of absorption rates suggested a relatively high proportional contribution of paracellular (ie non-mediated) uptake to total uptake of nutrients in both species. Because we measured juveniles, and most paracellular studies to date have been on adults,

it is unclear whether high paracellular absorption is generally high within crocodilians or whether these high values are specific to juveniles.

Valeris, C., Perera-Romero, L., Jasatao, R., Asatali, M. and Castellanos, H. (2014). First record of *Paleosuchus trigonatus* (Crocodylia: Alligatoridae) nesting in Venezuela. Bol. Acad. C. Fís., Mat. y Nat. 74(2): 9-14.

Abstract: Overall, the ecology of species of genus *Paleosuchus* is poorly known, even more things related to reproductive events. To date, few records exist on this subject in the scientific literature and reference to nests of this group to Colombia, Brazil, Ecuador and Peru, but not for Venezuela. In this sense, a nest of *Paleosuchus trigonatus* from the middle Erebato River, Upper Caura, Venezuela, which is the first record of its kind for the country is described. The nest was found on 15 May 2013, on the banks of a tributary of Washadi Creek, tributary of the Erebato River, in a unflooded area. It had been partially predated by *Tupinambis* sp. Thirteen (13) eggs were counted, eight (8) of which were intact. The micro-habitat where the nest was located was characterized and measured and weighed the eggs. The biomass of eggs varied between 82 and 91.5 grams. The nest was built at the base of a tree on a mound of active termites, to 150 cm of water body. These features are consistent with those reported for nests of this species in countries in the Amazon basin. The general condition of the eggs and the presence of the band suggests that it was built during the first days of May, at the beginning of the rainy season. Is priority the characterization of a larger number of *P. trigonatus* nests' to identify the reproductive habitat in the basin, information necessary for the conservation and management of this species in the region.

Amarasinghe, T.A.A., Madawala, M.B., Karunarathna, D.M.S.S., Manolis, S.C., de Silva, A. and Sommerlad, R. (2015). Human-crocodile conflict and conservation implications of saltwater crocodiles *Crocodylus porosus* (Reptilia: Crocodylia: Crocodylidae) in Sri Lanka. Journal of Threatened Taxa 7(5): 7111-7130.

Abstract: Human-wildlife conflict occurs when human requirements encroach on those of wildlife populations, with potential costs to both humans and wild animals. As top predators in most inland waters, crocodilians are involved in human-wildlife conflicts in many countries. Here we present findings of a 5-year survey on human-crocodile conflict on the island of Sri Lanka and relate the results to improving management practices. We aimed to quantify and understand the causes of human-crocodile conflict in Sri Lanka, and propose solutions to mitigate it. Visual encounter surveys were carried out to estimate the population size of Saltwater Crocodiles. We recorded 778 sightings of Saltwater Crocodiles at 262 of 400 locations surveyed, and estimate the total population to comprise more than 2000 non-hatchlings and to have increased at an average rate of 5% p.a. since 1978. We propose four crocodile vigilance zones within the wet zone and one crocodile vigilance zone within the dry zone of the country. Specific threats to Saltwater Crocodiles identified in crocodile vigilance zones were: habitat destruction and loss; illegal killing and harvesting (17 killings out of fear, ~200 incidents of killing for meat and skins, ~800 eggs annually for consumption); unplanned translocations; and, interaction with urbanization (10 incidents of crocodiles being run over by trains/vehicles and electrocution). Additionally, 33 cases of crocodile attacks on humans were recorded [8 fatal, 25 non-fatal (minor to grievous injuries)] and more than 50 incidents of attacks on farm and pet animals.

Keenan, S.W. and Elsey, R.M. (2015). The Good, the Bad, and the Unknown: Microbial symbioses of the American alligator. Integr. Comp. Biol. (doi: 10.1093/icb/icv006).

Abstract: Vertebrates coexist with microorganisms in diverse symbiotic associations that range from beneficial to detrimental to the host. Most research has aimed at deciphering the nature of the composite microbial assemblage's genome, or microbiome, from the gastrointestinal (GI) tract and skin of mammals (ie humans). In mammals, the GI tract's microbiome aids digestion, enhances uptake of nutrients, and prevents the establishment of pathogenic microorganisms. However, because the GI tract microbiome of the American alligator (*Alligator mississippiensis*) is distinct from that of all other vertebrates studied to date, being comprised of Fusobacteria in the lower GI tract with lesser abundances of Firmicutes, Proteobacteria, and Bacteroidetes, the function of these assemblages is largely unknown. This review provides a synthesis of our current understanding of the composition of alligators' microbiomes, highlights the potential role of microbiome members in alligators' health (the good), and presents a brief summary of microorganisms detrimental to alligators' health (the bad) including *Salmonella* spp. and others. Microbial assemblages of the GI tract have co-evolved with their vertebrate host over geologic time, which means that evolutionary hypotheses can be tested using information about the microbiome. For reptiles and amphibians, the number of taxa studied at present is limited, thereby restricting evolutionary insights. Nevertheless, we present a compilation of our current understanding of reptiles' and amphibians' microbiomes, and highlight future avenues of research (the unknown). As in humans, composition of microbiome assemblages provides a promising tool for assessing hosts' health or disease. By further exploring present-day associations between symbiotic microorganisms in the microbiomes of reptiles and amphibians, we can better identify good (beneficial) and bad (detrimental) microorganisms, and unravel the evolutionary history of the acquisition of microbiomes by these poorly-studied vertebrates.

Helbo, S., Bundgaard, A.G. and Fago, A. (2015). Myoglobin oxygenation and autoxidation in three reptilian species. Comp. Biochem. Physiol. A Mol. Integr. Physiol. (doi: 10.1016/j.cbpa.2015.04.009).

Abstract: Differences between species in the oxygen (O_2) affinity (P50) of myoglobin (Mb) may serve to fine tune O_2 supply to cardiac and skeletal muscle in ectotherms. In support of this view, it has been shown that fish Mb O_2 affinities differ between species when measured at the same temperature, but are in fact similar when adjusted for *in vivo* muscle temperatures, most likely to maintain intracellular O_2 delivery in species adapted to different environments. It is unknown whether similar adaptations exist in the O_2 affinity of Mb from reptiles, despite this group of ectothermic vertebrates displaying great variation in the tolerance to both temperature and hypoxia. In this study, we have purified Mb from muscle tissues of three reptilian species (turtle, tortoise and alligator) with different lifestyles. We have measured O_2 binding characteristics and autoxidation rates of the three Mbs and measured the effects of temperature, lactate and blocking of reactive thiols on the O_2 affinity of turtle Mb. Our data show that, at a constant temperature, reptilian Mbs have similar O_2 affinities that are lower than those of mammalian Mbs, which may optimize intracellular O_2 transport at lower body temperatures. Reptilian Mbs have lower autoxidation rates than both mammalian and fish Mbs, which may be beneficial during oxidative stress. Furthermore, the O_2 affinity of turtle Mb is without allosteric control and independent of either lactate or thiol covalent modification. This study reveals some common adaptive patterns in the temperature-dependent regulation of Mb oxygenation

in vertebrates.

Cunningham, S.W. (2015). Spatial and genetic analyses of Africa's sacred crocodile: *Crocodylus suchus*. ETD Collection for Fordham University. Paper AAI1584730. (http://fordham.bepress.com/dissertations/AAI1584730).

Abstract: Chapter 1: Conservation and management of widespread species can be improved with proper understanding of patterns of genetic differentiation within the species of concern. Through the identification of appropriate units of management, effective conservation measures can be created to preserve the genetic diversity of a species into the foreseeable future. Here, we use a combination of mtDNA barcoding and nuclear genetic markers to assess levels of population sub-structuring in the newly rediscovered, cryptic species, *Crocodylus suchus*. Bayesian cluster analyses of 9 microsatellites suggest that marked levels of differentiation are present within the species. In keeping with patterns found on other African crocodiles, observed patterns of divergence are a generally associated with major aquatic landscape features. Regional clustering results suggest patterns of differentiation between West and Central African *C. suchus* populations comparable to those described in other African crocodilians. Further research, including additional sampling in the Congo basin, would clarify putative management units in this species. Chapter 2: The niche of an organism is defined by fundamental attributes of the species' natural history including its behavioral, physiological, and reproductive ecologies. These characteristics arise in response to both phylogenetic inertia and contemporary selective forces. Among closely related taxa, it is predicted that niche conservatism should result in poorly differentiated niche space. However, among more distantly related species, the converse should be true. We tested the idea that despite broad historic sympatry, the newly re-discovered crocodile (*Crocodylus suchus*), exists in a divergent niche space than the congeneric Nile crocodile (*C. niloticus*) that is more closely related to non- African members of *Crocodylus*. Our environmental niche models for both species indicate that significantly different bioclimatic factors influence each species' model and that the niche of *C. suchus* is much more constrained than that of *C. niloticus*. The niche divergence observed among these taxa and their previously unrecognized phylogenetic distance support theories of niche evolution. In addition, published field observations of both species support our model's predictions and suggest that *C. suchus* is much more vulnerable to local extirpation than *C. niloticus*. We argue that niche differences between the two species provide additional support and urgency for the recognition of *C. suchus* as proposed by Hekkala & Shirley *et al*. (2011).

Combrink , A.S. (2014). Spatial and Reproductive Ecology and Population Status of the Nile Crocodile (*Crocodylus niloticus*) in the Lake St Lucia Estuarine System, South Africa. PhD thesis, University of KwaZulu-Natal, Pietermaritzburg, South Africa.

Abstract: The Lake St Lucia estuarine system, Africa's largest and oldest protected estuary, also contains the largest Nile crocodile (*Crocodylus niloticus*) population in a single waterbody in South Africa. We investigated the species' spatial and reproductive ecology as well as population status in order to make management recommendations. During the first decade of the 21st Century, the St Lucia estuarine lake experienced a prolonged drought, streams ceased flowing and in 2006 more than 90% of the total water area evaporated. We conducted 10 aerial surveys from 2009-2013 and recorded the majority of crocodiles in the Narrows, a ~27 km low salinity channel south of the lake. Above average rainfall at the end of 2010 resulted in the refilling of the lake, and most crocodiles moved north to the lake. We estimated the sub-adult and adult population at 1005 ± 137 individuals. We investigated detailed movements and activity for 18 Nile crocodiles using GPS-satellite transmitters. The overall activity level was 41.0%, and it differed significantly throughout the day. There was a significant seasonal effect on activity, peaking during autumn (52.0%), while crocodiles were most inactive in winter (30.5 %). Crocodile size and mobility were positively correlated with mean daily movement (1244 m). Adults moved more at night, but sub-adults were significantly more mobile during the day. There was a considerable seasonal variation in mobility, with the longest movements during autumn and the shortest in winter. About 60% of total daily movements were <1 km per day, but for sub-adults this calculation was 96%. We recorded complex and varied home range patterns for 14 Nile Crocodiles, resulting from differences in size, sex, reproductive status and habitat. The median home range and core-use area of adults were significantly greater than sub-adults. Three size-related patterns of home range behaviour emerged for adult males; transient, (<3.0 m TL), topographically confined (3.5-4.0 m TL) and "territorial" (>4.0 m TL). Adult males revealed an inverse correlation between home range size and crocodile size, while the home range sizes of adult females were generally more homogeneous. All nesting females displayed an explosive increase in mobility and space-use subsequent to the nesting period, and all adults, except one female in the central lake, moved during winter in the drought period to large crocodile congregations south of the lake. Sub-adults occupied significantly smaller home ranges than adults, which were habitat specific with strict spatial partitioning. They remained in shallow vegetated areas adjacent to deep water, avoiding open deep water altogether. Nile crocodile nests have been monitored since 1982, with mean nest abundance = 76.19 ± 6.42, range: 29-141. The macro-level heterogeneity of nesting habitats reflects the spatio-temporal diversity of the Lake St Lucia system, and is possibly unique within a single Nile Crocodile population. Changes in nest abundance and distribution were seemingly related to increased human disturbance and habitat transformation in the northern and southern parts of the lake. Hydrological variability, especially during droughts, combined with the state of the estuary mouth (i.e. open or closed), affected prey abundance/availability contributing to large variation (6.9-56.4%) in nest effort from 1982 - 2013. All nests were located close to freshwater streams or seepage areas. We confirmed the re-use of the identical nest-site by a female, while other females oviposited in nest-sites occupied by different females during previous years. Despite variable nest effort, the St Lucia nesting population remains the largest recorded nesting population in South Africa, and least vulnerable to flooding. The mean home range of nesting Nile crocodile females (0.85 ha) was significantly smaller than non-nesting females (108.41 ha) during the nesting season. Activity levels and mean daily movements on the nest were 8.1 ± 2.5% and 213 ± 64 m, respectively, and increased to 47.9 ± 11.7% and 2176 ± 708 m during the post-nesting period. Overall levels of nest fidelity were 82.8 ± 11.7%, which increased to 87.3 ± 7.8% at night. The highest nest fidelity recorded during incubation was 99.7% over a 96-day period. We investigated nest predation, hatchling liberation and nest-guarding activities of nesting Nile crocodile females using remote camera traps. We captured 4305 photographs of 19 nest-guarding females over 4 years. Seven nests (36.8%) were raided by the egg predators Water monitors (*Varanus niloticus*) and Marsh mongooses (*Atilax paludinosus*), on average 12.1 days ± 6.2 subsequent to trap camera employment. All females settled back on the nest following the first predation event and on average, females returned to their nests three times ± 0.8 between nest raids before finally abandoning the nest. Nest raids continued on average 5.9 days ± 1.6 while on average 18.8 ± 4.0 raids per nest were recorded. Five females were captured by trap cameras liberating hatchlings. During the day females were almost never photographed on the nest, but during the late afternoon or early evening females moved onto the nest and continued to

stay there during the night. Females always defended their nests aggressively against non-human intruders. We investigated homing behaviour and specific movements using a GPS-satellite transmitter by translocating an adult female (2.7 m), with a known home range, ~50 km north (straight line distance) to the False Bay area of Lake St Lucia. Following release, the individual moved a total distance of 178.3 km over 136 days (mean daily movement = 1311 ± 207 m), compared with 60.4 km (mean daily movement = 444 ± 32 m) for the identical time period the previous year. Homing movement was not continuous, but characterised by periods of extensive and directed mobility followed by prolonged periods of inactivity associated with freshwater or low salinity habitats. The translocated crocodile displayed remarkable navigational abilities, even though this required negotiating complex habitat challenges including extensive areas of the lake that were either hypersaline or completely dry, resulting in frequent and extensive overland movements. On 14 September 2012, the individual returned to the same freshwater pool where it was captured 136 days previous. This is the first study to confirm homing behaviour for Nile crocodiles, and supports growing evidence that crocodilians and other ectothermic taxa possess complex navigational abilities. Our study revealed numerous novel insights into the ecology and behaviour of Nile crocodiles and some of the findings may be applicable to other crocodilian taxa. We hope the results will guide the management and conservation of this threatened species.

Eversole, C.B., Henke, S.E., Wester, D.B., Ballard, B.M. and Powell, R.L. (2015). Responses of American alligators (Alligator mississippiensis) to environmental conditions: Implications for population and ecosystem monitoring. Herpetologica 71(1): 37-45.

Abstract: Accurate monitoring of wildlife populations is critical for species management and conservation. If management practices are based on inaccurate data, managers might not be implementing management strategies appropriately, which can have severe ecological consequences. We used a generalized linear mixed-model analysis to predict and explain the relative abundance of American Alligators (*Alligator mississippiensis*) within inland freshwater wetlands. Models were developed for three alligator age classes: hatchlings (≤30.5 cm total length [TL]), subadults (30.6-182.9 cm TL), and adults (≥183 cm TL). Independent variables included environmental parameters that we measured during nighttime surveys. We conducted 135 nighttime alligator surveys, and recorded 7689 observations of alligators in three study lakes. We found that the relative abundance of alligators is variable among age classes and lakes. Final models for each age class differed when lakes were analyzed separately compared with when lakes were combined into one analysis; models differed across age classes as well. These results indicate that alligator occurrence and relative abundance is multifaceted and complex. Survey techniques should accurately quantify age- and population-specific data. Managers and scientists should target particular age classes during surveys on the basis of prevailing environmental conditions.

Pritz, M.B. (2015). Crocodilian forebrain: Evolution and development. Integrative and Comparative Biology (doi: 10.1093/icb/icv003).

Abstract: Organization and development of the forebrain in crocodilians are reviewed. In juvenile *Caiman crocodilus*, the following features were examined: identification and classification of dorsal thalamic nuclei and their respective connections with the telencephalon, presence of local circuit neurons in the dorsal thalamic nuclei, telencephalic projections to the dorsal thalamus, and organization of the thalamic reticular nucleus. These results document many similarities between crocodilians and other reptiles and birds. While crocodilians, as well as other sauropsids, demonstrate several features of neural circuitry in common with mammals, certain striking differences in organization of the forebrain are present. These differences are the result of evolution. To explore a basis for these differences, embryos of *Alligator misisippiensis* were examined to address the following. First, very early development of the brain in *Alligator* is similar to that of other amniotes. Second, the developmental program for individual vesicles of the brain differs between the secondary prosencephalon, diencephalon, midbrain, and hindbrain in *Alligator*. This is likely to be the case for other amniotes. Third, initial development of the diencephalon in *Alligator* is similar to that in other amniotes. In *Alligator*, alar and basal parts likely follow a different developmental scheme.

Brown, C.M. and Vavrek, M.J. (2015). Small sample sizes in the study of ontogenetic allometry; implications for palaeobiology. PeerJ. 3: e818.

Abstract: Quantitative morphometric analyses, particularly ontogenetic allometry, are common methods used in quantifying shape, and changes therein, in both extinct and extant organisms. Due to incompleteness and the potential for restricted sample sizes in the fossil record, palaeobiological analyses of allometry may encounter higher rates of error. Differences in sample size between fossil and extant studies and any resulting effects on allometric analyses have not been thoroughly investigated, and a logical lower threshold to sample size is not clear. Here we show that studies based on fossil datasets have smaller sample sizes than those based on extant taxa. A similar pattern between vertebrates and invertebrates indicates this is not a problem unique to either group, but common to both. We investigate the relationship between sample size, ontogenetic allometric relationship and statistical power using an empirical dataset of skull measurements of modern *Alligator mississippiensis*. Across a variety of subsampling techniques, used to simulate different taphonomic and/or sampling effects, smaller sample sizes gave less reliable and more variable results, often with the result that allometric relationships will go undetected due to Type II error (failure to reject the null hypothesis). This may result in a false impression of fewer instances of positive/negative allometric growth in fossils compared to living organisms. These limitations are not restricted to fossil data and are equally applicable to allometric analyses of rare extant taxa. No mathematically derived minimum sample size for ontogenetic allometric studies is found; rather results of isometry (but not necessarily allometry) should not be viewed with confidence at small sample sizes.

Kohno, S., Bernhard, M.C., Katsu, Y., Zhu, J., Bryan, T.A., Doheny, B.M., Iguchi, T. and Guillette, L.J. Jr. (2015). Estrogen Receptor 1 (ESR1; ERα), not ESR2 (ERβ), modulates estrogen-induced sex reversal in the American alligator, a species with temperature-dependent sex determination. Endocrinology 156(5): 1887-1899.

Abstract: All crocodilians and many turtles exhibit temperature-dependent sex determination where the temperature of the incubated egg, during a thermo-sensitive period (TSP), determines the sex of the offspring. Estrogens play a critical role in sex determination in crocodilians and turtles, as it likely does in most non-mammalian vertebrates. Indeed, administration of estrogens during the TSP induces male to female sex reversal at a male-producing temperature. However, it is not clear how estrogens override the influence of temperature during sex determination in these species. Most vertebrates have two forms of nuclear estrogen receptor, ESR1 (ERα) and ESR2 (ERβ). However, there is no direct evidence concerning

which ESR is involved in sex determination, since a specific agonist or antagonist for each ESR has not been tested in non-mammalian species. We identified specific pharmaceutical agonists for each ESR using an *in vitro* transactivation assay employing American alligator ESR1 and ESR2; these were PPT (4,4',4"-(4-propyl-[1H]-pyrazole-1,3,5-triyl)trisphenol) and WAY (7-bromo-2-(4-hydroxyphenyl)-1,3-benzoxazol-5-ol), respectively. Alligator eggs were exposed to PPT or WAY at a male-producing temperature just prior to the TSP and their sex was examined at the last stage of embryonic development. Estradiol-17β (E2) and PPT, but not WAY, induced sex-reversal at a male-producing temperature. PPT-exposed embryos exposed to the highest dose (5.0 μg/g egg weight) exhibited enlargement and advanced differentiation of the Müllerian duct. These results indicate that ESR1 is likely the principal estrogen receptor involved in sex reversal as well as embryonic Müllerian duct survival and growth in American alligators.

Campos, Z., Sanaiotti, T., Marques, V. and Magnusson, W.E. (2015). Geographic variation in clutch size and reproductive season of the Dwarf caiman, *Paleosuchus palpebrosus*, in Brazil. Journal of Herpetology 49(1): 95-98.

Abstract: We studied nesting of Cuvier's Dwarf Caiman, *Paleosuchus palpebrosus*, in flooded forest around the Amazon River, and streams draining into the Brazilian Pantanal. Nests were located by searching on foot. Eighty nests were located in the Amazonian sites between 2001 and 2010, and 35 nests were found in the Serra das Araras Ecological Station and streams draining Urucum Mountain on the periphery of the Pantanal between 2006 and 2011. Sizes of embryos indicated that nesting occurs in the Amazonian sites during the dry season and coincides with falling water levels. Although nesting coincides with the warmest and wettest months in the streams around the Pantanal, the streams are not subject to long-term floods. Clutch size varied from 8 to 21 eggs, was correlated with female size, and the mean clutch size did not differ between the Amazonian sites and those around the Pantanal.

Patathananone, S., Thammasirirak, S., Daduang, J., Gung Chung, J., Temsiripong, Y. and Daduang, S. (2015). Inhibition of HeLa cells metastasis by bioactive compounds in crocodile (*Crocodylus siamensis*) white blood cells extract. Environ. Toxicol. (doi: 10.1002/tox.22138).

Abstract: Matrix metalloproteinases (MMPs) play a key role in cancer progression, including cell invasion, metastasis, cell growth, apoptosis, angiogenesis, and cell adhesion. Thus, suppression of the MMPs activities is crucial for inhibiting cancer cells metastasis. Herein, bioactive agents from crocodile (*Crocodylus siamensis*) leukocyte extracts (WBCex) showed the anticancer activity with HeLa cells and inhibited the migration and invasion process by reducing gelatinases (MMP-2, MMP-9) activity and their protein levels. This mechanism is regulated via interfering Ras and p38 signal transduction. Moreover, disrupting VEGF and integrin-signaling cascade by bioactive agents are the predictable mechanisms that cause the decreasing of MMP-2 and MMP-9 activity. Hence, bioactive substances in WBCex may play the mode of action similar with MMPs inhibitor due to HeLa cell metastasis being suppressed *in vitro*.

Sariya, L., Kladmanee, K., Bhusri, B., Thaijongrak, P., Tonchiangsai, K., Chaichoun, K. and Ratanakorn, P. (2015). Molecular evidence for genetic distinctions between Chlamydiaceae detected in Siamese crocodiles (*Crocodylus siamensis*) and known Chlamydiaceae species. Japan Journal of Veterinary Research 63(1): 5-14.

Abstract: Chlamydiosis, caused by Chlamydiaceae, is a zoonotic disease found in humans and several species of animals, including reptiles and amphibians. Although chlamydiosis in saltwater crocodiles has been previously reported in South Africa and Papua New Guinea, the reported strains have not been identified or confirmed. Therefore, the main aim of this study was to sequence and characterize Chamydiaceae isolated from Siamese crocodiles. Results showed the 16S ribosomal (r) RNA and the 16S/23S rRNA gene of the crocodile isolates were closely related to the genus *Chlamydophila* with matched identity greater than 98%. The phylogenetic tree constructed from the 16S/23S rRNA gene showed the crocodile cluster diverges far from *Cp. caviae* with a 100% bootstrap value. The tree based on the ompA gene loci distinguished the crocodile strains into genotypes I, II, and III. The present study is the first report on *Chlamydophila* detected in Siamese crocodiles that is genetically distinct from the known species of Chlamydiaceae.

Michaela Černíková, M., Gál, R., Polášek, Z., Janíček, M., Pachlová, V. and Buňka, F. (2015). Comparison of the nutrient composition, biogenic amines and selected functional parameters of meat from different parts of Nile crocodile (*Crocodylus niloticus*). Journal of Food Analysis and Composition.

Abstract: The aim of the study was to compare nutritional parameters (contents of fat, protein and the individual amino acids), biogenic amines (histamine, tyramine, phenylethylamine, tryptamine, putrescine, cadaverine, spermidine and spermine) content, selected functional properties (colour and textural properties) and pH values of six parts of crocodile carcass (tail dorsal - TD, tail ventral - TV, neck - N, shoulder - S, leg - L and cheek - C). The individual parts of the crocodile carcass showed different values of nutritional parameters. TD and C had the highest values of Essential Amino Acid Index (104-126). Valine, threonine and leucine were determined as limiting amino acids in individual parts of the crocodile carcass. The content of biogenic amines was very low. These results will provide crocodile meat producers as well as consumers with new and useful information about the nutritional value of this meat and its relevance for nutrition.

Lázaro, W.L., de Oliveira, R.F., dos Santos-Filha, M., da Silva, C.J., Malm, O., Ignácio, A.R.A. and Díez, S. (2015). Non-lethal sampling for mercury evaluation in crocodilians. Chemosphere 138: 25-32.

Abstract: Mercury (Hg) is a ubiquitous environmental contaminant that poses potential threats to ecosystems due to its toxicity to humans and wildlife. The development of non-lethal sampling techniques is a critical step for evaluation of Hg in threatened species in tropical floodplain environments, where most of Hg found is the result of land use and gold mining activities, and more methylation sites are available. We evaluated the spatial and seasonal effectiveness of caudal scutes and claws to estimate Hg bioaccumulation in crocodilians (*Caiman yacare*), in the scarcely documented Pantanal. Hence, we investigated the potential for Hg bioaccumulation in top predators according to its proximity to mining sites, and in water bodies with different hydrological characteristics and connectivity with the main river during two phases of the flood pulse (dry and flood). The highest Hg concentrations were detected in caimans captured close to mining activities, in claws (2176 ng g^{-1} ww) and caudal scutes (388 ng g^{-1} ww). THg concentration in claws was related to the flood season and its mean concentration was thirteen fold higher than Hg concentration in scutes during whole year. Both tissues were found to be effective as non-lethal sampling techniques for measuring Hg bioaccumulation in reptiles over time. Nevertheless, claw tissue seems to have a more consistent result, since its constitutional chemical characteristics makes it a better

indicator of spatial patterns that influence on Hg exposure.

Finger, Jr., J.W., Thomson, P.C., Bagal, U.W., Moran, C., Glenn, T.C., Miles, L.G., Khatkar, M.S., Gongora, J., Adams, A.L., Benedict, S., Kieran, T.J. and Isberg, S.R. (2015). Extending Crocodile Genetic Tools. RIRDC Publication No. 15/051. RIRDC: Canberra.

Abstract: This project was developed to expand upon findings reported in RIRDC projects US-109A and US-139A, as well as the more recent publication of the saltwater crocodile genome (Green *et al*. 2014). The main objective of this project was to generate a large single nucleotide polymorphism (SNP) marker resource for later saturation of the genetic linkage map and fine mapping of quantitative trait loci (QTL). Another objective of this project was to learn more about basic crocodile biology, namely immune function and stress, and the underlying genetic function to evaluate their incorporation into CrocPLAN. This report describes the development of new phenotypic trait panels for farmed saltwater crocodiles. Among these is the major crocodilian stress hormone, corticosterone (CORT), which should be useful for the development of animal welfare standards and the eventual selection of individuals in the future.Immune assays, some of which have never been previously used in crocodilians, were employed in this project to assess immune function. These immune assays, which are relatively easy to perform and cheap, could be employed in any farming setting to assess immune function in the future. Levels of estradiol (ESTR) and testosterone (TEST) are also detailed in this report, for the first time in the saltwater crocodile.

Bierman, H.S. and Carr, C.E. (2015). Sound localization in the alligator. Hearing Research (doi:10.1016/j.heares.2015.05.009).

Abstract: In early tetrapods, it is assumed that the tympana were acoustically coupled through the pharynx and therefore inherently directional, acting as pressure difference receivers. The later closure of the middle ear cavity in turtles, archosaurs, and mammals is a derived condition, and would have changed the ear by decoupling the tympana. Isolation of the middle ears would then have led to selection for structural and neural strategies to compute sound source localization in both archosaurs and mammalian ancestors. In the archosaurs (birds and crocodilians) the presence of air spaces in the skull provided connections between the ears that have been exploited to improve directional hearing, while neural circuits mediating sound localization are well developed. In this review, we will focus primarily on directional hearing in crocodilians, where vocalization and sound localization are thought to be ecologically important, and indicate important issues still awaiting resolution.

Zhang, F., Messenger, K. and Wang, Y. (2015). Relationship between nest defence behaviours and reproductive benefits in Chinese alligators. Amphibia-Reptilia (doi: 10.1163/15685381-00002990).

Abstract: The evolutionary theory in parental care predicts that parents may defend more vigorously of nests with higher survival and reproductive benefits. Based on this prediction, we proposed that the occurrence of nest defence behaviours in Chinese alligators might be connected to reproductive benefits (clutch size, fertility rate, and hatching rate). In this study, we examined the relationship between the occurrence of nest defence behaviours and (1) the variations in clutch size, fertility rate, and hatching rate of wild Chinese alligators, and (2) the variations in clutch size and fertility rate of captive Chinese alligators in a semi-natural facility. Results showed that for the wild Chinese alligators, the fertility and hatching rates with nest defence behaviours were higher than those without nest defence behaviours. The results also showed that for the captive Chinese alligators, the fertility rates with nest defence behaviours were higher than those without nest defence behaviours. These results suggested that nest defence behaviours in Chinese alligators might be relative to reproductive benefits, thus likely to further improve the probability of the species' reproductive success.

McCurry, M.R., Evans, A.R. and McHenry, C.R. (2015). The sensitivity of biological finite element models to the resolution of surface geometry: a case study of crocodilian crania. PeerJ 3:e988.

Abstract: The reliability of finite element analysis (FEA) in biomechanical investigations depends upon understanding the influence of model assumptions. In producing finite element models, surface mesh resolution is influenced by the resolution of input geometry, and influences the resolution of the ensuing solid mesh used for numerical analysis. Despite a large number of studies incorporating sensitivity studies of the effects of solid mesh resolution there has not yet been any investigation into the effect of surface mesh resolution upon results in a comparative context. Here we use a dataset of crocodile crania to examine the effects of surface resolution on FEA results in a comparative context. Seven high-resolution surface meshes were each down-sampled to varying degrees while keeping the resulting number of solid elements constant. These models were then subjected to bite and shake load cases using finite element analysis. The results show that incremental decreases in surface resolution can result in fluctuations in strain magnitudes, but that it is possible to obtain stable results using lower resolution surface in a comparative FEA study. As surface mesh resolution links input geometry with the resulting solid mesh, the implication of these results is that low resolution input geometry and solid meshes may provide valid results in a comparative context.

Rajkumar, H.S., Mustoe, G.E., Khaidem, K.S. and Soibam, I. (2015). Crocodylian tracks from Lower Oligocene Flysch deposits of the Barail Group, Manipur, India. Ichnos: An International Journal for Plant and Animal Traces 22(2): 122-131.

Abstract: A marine tidal delta siltstone from Gelmon locality in Northeast India preserved three crocodylian footprints and an elongate depression that appears to be a tail drag mark. Similar drag marks occur in nearby bedding surfaces. The discovery of crocodylian tracks from the basal part of Laisong Formation, Barail Group (Late Eocene-Early Oligocene age) of Manipur, India is noteworthy because of the age and the geographic location. Crocodylian tracks are rare in Cenozoic formations and they have not previously been reported from Asia. The footprints are herein named as a new ichnogenus and ichnospecies, *Indosuchipes manipurensis*.

Böhmer, C., Rauhut, O.W.M. and Wörheide, G. (2015). Correlation between *Hox* code and vertebral morphology in archosaurs. Proceedings of the Royal Society B 282(1810): 20150077.

Abstract: The relationship between developmental genes and phenotypic variation is of central interest in evolutionary biology. An excellent example is the role of *Hox* genes in the anteroposterior regionalization of the vertebral column in vertebrates. Archosaurs (crocodiles, dinosaurs including birds) are highly variable both in vertebral morphology and number. Nevertheless, functionally equivalent *Hox* genes are active in the axial skeleton during embryonic development, indicating that the morphological variation across taxa is likely owing to modifications in the pattern of Hox gene expression. By using geometric morphometrics, we demonstrate a correlation between vertebral *Hox* code and quantifiable vertebral

morphology in modern archosaurs, in which the boundaries between morphological subgroups of vertebrae can be linked to anterior Hox gene expression boundaries. Our findings reveal homologous units of cervical vertebrae in modern archosaurs, each with their specific *Hox* gene pattern, enabling us to trace these homologies in the extinct sauropodomorph dinosaurs, a group with highly variable vertebral counts. Based on the quantifiable vertebral morphology, this allows us to infer the underlying genetic mechanisms in vertebral evolution in fossils, which represents not only an important case study, but will lead to a better understanding of the origin of morphological disparity in recent archosaur vertebral columns.

Mallison, H., Pittman, M. and Schwarz, D. (2015). Using crocodilian tails as models for dinosaur tails. PeerJ PrePrints (https://dx.doi.org/10.7287/peerj.preprints.1339v1).

Abstract: The tails of extant crocodilians are anatomically the closest approximation of the tails of non-avian dinosaurs, and therefore a good starting point for any reconstruction of non-avian dinosaur tail muscles. However, we here demonstrate some methodological problems using crocodile tails, firstly regarding the general reconstruction of tail mobility from osteology, secondly for the reconstruction of tail musculature for the quantification of muscle forces, especially the m. caudofemoralis longus, and thirdly with respect to the anatomical differences between crocodilians and non-avian dinosaurs, especially in relation to the reconstruction of m. caudofemoralis brevis. Our results show that, given the current limited knowledge of crocodilian tails, volumetric reconstructions should be created on the basis of more gross morphological data than is usually used, and that biomechanical studies should include sensitivity analysis with greater parameter ranges than often applied.

Khan, M.Z., Latif, T.A., Ghalib, S.A., Khan, I.S., Hussain, B., Zehra, A., Siddiqui, S., Kanwal, R., Jabeen, T. and Tabbassum, F. (2015). Breeding and population status of Marsh crocodile (*Crocodylus palustris*) in Manghopir Shrine area, Karachi. Canadian Journal of Pure and Applied Sciences 9(2): 3399-3407.

Abstract: A study on breeding and population status of Marsh crocodile (*Crocodylus palustris*) in Manghopir Shrine area was undertaken during 2010-2013. There is a 61 m wide and 122 m long water pond adjacent to the shrine. This pond is home to 144 Marsh crocodiles - 98 adults, 28 subadults, 15 juveniles and 3 hatchlings. In this area, the Sheedi Community (native people of the area) is providing shelter to the species. The pond and its adjacent area are small for such a large population. They cannot perform their communal activities such as basking, breeding as the habitable area of the crocodiles is overpopulated. Though there is a large number of sexually mature crocodiles, a few nest, but due to intraspecific competition, animals cannot breed. Only five successful nesting events were observed during the study period. Additionally, there are no adequate husbandry measures taken for the protection of eggs and hatchlings. According to the Community, these Marsh crocodiles are gifts from their Saint, Sheikh Sakhi Sultan. Shortage of food and lack of requisite territory for biological activities are major threats to the Marsh crocodiles in the Manghopir Shrine Area.

Grap, N.J., Monzel, A.S., Kohl, T. and Bleckmann, H. (2015). *Crocodylus niloticus* (Crocodilia) is highly sensitive to water surface waves. Zoology (doi:10.1016/j.zool.2015.03.004).

Abstract: Crocodiles show oriented responses to water surface wave stimuli but up to now behavioral thresholds are missing. This study determines the behavioral thresholds of crocodilians to water surface waves. Nile crocodiles (*Crocodylus niloticus*) were conditioned to respond to single-frequency water surface wave stimuli (duration 1150 ms, frequency 15, 30, 40, 60 and 80 Hz), produced by blowing air onto the water surface. Our study shows that *C. niloticus* is highly sensitive to capillary water surface waves. Threshold values decreased with increasing frequency and ranged between 12.8 μm (15 Hz) and 0.5 μm (80 Hz) peak-to-peak wave amplitude. For the frequencies 15 Hz and 30 Hz the sensitivity of one spectacled caiman (*Caiman crocodilus*) to water surface waves was also tested. Threshold values were 12.8 μm (15 Hz) down to 1.76 μm (30 Hz), ie close to the threshold values of *C. niloticus*. The surface wave sensitivity of crocodiles is similar to the surface wave sensitivity of semi-aquatic insects and fishing spiders but does not match the sensitivity of surface-feeding fishes which is higher by one to two orders of magnitude.

Shafiei-Astani, B., Ong, A.H.K., Valdiani, A., Tan, S.G., Yien, C.S.Y., Ahmady, F., Alitheen, N.B., Ng, W.L. and Kuar, T. (2015). Molecular genetic variation and structure of Southeast Asian crocodile (*Tomistoma schlegelii*): Comparative potentials of SSRs versus ISSRs. Gene (doi:10.1016/j.gene.2015.06.053).

Abstract: *Tomistoma schlegelii*, also referred to as the "false gharial", is one of the most exclusive and least known of the world's fresh water crocodilians, limited to Southeast Asia. Indeed, lack of economic value for its skin has led to neglect the biodiversity of the species. The current study aimed to investigate the mentioned case using 40 simple sequence repeat (SSR) primer pairs and 45 inter-simple sequence repeat (ISSR) primers. DNA analysis of 17 *T. schlegelii* samples using the SSR and ISSR markers resulted in producing a total of 49 and 108 polymorphic bands, respectively. Furthermore, the SSR- and ISSR-based cluster analyses both generated two main clusters. However, the SSR based results were found to be more in line with the geographical distributions of the crocodile samples collected across the country as compared with the ISSR-based results. The observed heterozygosity (HO) and expected heterozygosity (HE) of the polymorphic SSRs ranged between 0.588-1 and 0.470-0.891, respectively. The present results suggest that the Malaysian *T. schlegelii* populations had originated from a core population of crocodiles. In cooperation with the SSR markers, the ISSRs showed high potential for studying the genetic variation of *T. schlegelii*, and these markers are suitable to be employed in conservation genetic programs of this endangered species. Both SSR- and ISSR-based STRUCTURE analyses suggested that all the individuals of *T. schlegelii* are genetically similar with each other.

Fernandez Blanco, M.V., Bona, P., Olivares, A.I. and Desojo, J.B. (2015). Ontogenetic variation in the skulls of Caiman: the case of *Caiman latirostris* and *Caiman yacare* (Alligatoridae, Caimaninae). Herpetological Journal 25: 65-73.

Abstract: Caiman is one of the five extant genera of alligatorid crocodylians. While several quantitative and qualitative studies exist on morphological variation in the genus, little is known about ontogenetic effects. Here, we quantify ontogenetic variation in morphology for *Caiman yacare* and *C. latirostris* in a phylogenetic context. A linear regression analysis on 12 skull measurements of *C. yacare* and *C. latirostris* against ameasure of size (the first axis of a PCA of all variables) showed high correlation coefficients (r^2= 0.89-0.99) and negative allometry. Eight allometric trajectories showed common slopes at different intercepts, reflecting a common ontogenetic pattern of morphological growth fixed early in ontogeny. The anterior width of the snout and the posterior width of the skull table are suitable to discriminate between the two species. The relationship between snout width and snout length is isometric in *C.*

latirostris while it is negatively allometric in *C. yacare*. These results confirm that the snout shape is a distinctive feature between species established early in ontogeny. The narrowing and lengthening of the snout in *C. yacare* during ontogeny results in adult forms widely represented in other extant taxa within the genus. The broader and shorter snout in *C. latirostris* is probably an autapomorphic feature of this species within Caimaninae.

Klein, H. and Lucas, S.G. (2015). Evolution of the semi-aquatic lifestyle in Archosaurs - evidence from the tetrapod footprint record. Geological Association of Canada, Miscellaneous Publication 01/2015; 9: 105-113.

Abstract: The semi-aquatic lifestyle in archosaurs is documented by skeletal remains of specialized ?proterosuchids, phytosaurians, poposauroids, crocodylomorphs and avemetatarsalians from the Late Permian-Early Triassic to the present. Correspondingly, tetrapod footprints of the ichnogenera *Apatopus* (phytosaurs), *Batrachopus* and *Crocodylopodus* (Crocodylomorpha), as well as those of modern crocodylians, preserve adaptive features that provide evidence of a semi-aquatic lifestyle and preceding terrestrial habitus. Ichnofossils and body fossils have similar stratigraphic ranges: *Apatopus*/semi-aquatic phytosaurs (Late Triassic); *Batrachopus*/terrestrial crocodylomorphs (Late Triassic-Early Jurassic); footprints/skeletons of semi-aquatic crocodylomorphs (Jurassic-Recent). The earliest phase of phytosaurian evolution, including a presumed terrestrial stage in the Early-Middle Triassic, is unknown. Morphologically and temporally, the chirotheriid ichnogenus *Synaptichnium* from the Early-Middle Triassic, matches hypothetical footprints of terrestrial phytosaurians. Features shared by *Synaptichnium* and the phytosaur ichnotaxon *Apatopus* are: 1) elongate pes imprints, digits increasing in length from I to IV, digit IV longest, 2) extended, antero-laterally directed digit V, 3) relatively large manus, digit III longest and 4) relative position/orientation of imprints. Differences are the compact metatarsal-phalangeal axis and thick phalangeal pads in *Synaptichnium* due to cursorial habits, whereas *Apatopus* has a crocodilian appearance. Furthermore, the scarcity of *Apatopus* vs. abundance of swim traces is considered to reflect an aquatic environment and poor preservation potential. The footprint record thus provides important evidence of the evolution of terrestrial to semi-aquatic lifestyles in more than one group of Mesozoic archosauromorphs.

Submitted Publications

SALTWATER CROCODILES FISHING FOR MULLET. Fishing behaviour in Saltwater crocodiles (*Crocodylus porosus*) has been recently reported by Britton and Britton (2013) and Rhind *et al*. (2015). On 31 August 2015 we had the opportunity to witness this behaviour first-hand.

At around 1230 h we observed 27 *C. porsosus* congregating on the upstream side of Cahill's Crossing on the East Alligator River in Kakadu National Park (Northern Territory, Australia). One individual was estimated to be 4.0-4.5 m in length, and the others were 2.5-3.5 m long.

About 20 of the 27 *C. porosus* were observed on the surface of the water with their forelimbs fully extended out from their body, with "palms" facing outward (see front cover; Fig. 1) - the "floating fishing" behaviour described by Britton and Britton (2013). This behaviour coincided with a large number of Mullet (*Liza ordensis*) which were evident on the surface of the water as a result of spring tides (high tide at the crossing was 7.7 m at 1228 h).

As the crocodiles floated with outstretched forelimbs, they would attempt to catch mullet that made contact with their forelimbs, with their jaws. A number of crocodiles were observed to be successful in catching, and eating, mullet using this fishing method (Fig. 1). One 2.5 m long crocodile was observed to catch a mullet at the crossing, but then swim about 100 m upstream to consume it - presumably away from the potential interference of other crocodiles.

Figure 1. Saltwater crocodile "fishing" for mullet (foreground) and eating mullet captured using this method (background). Photograph: Claire Peberdy.

The largest crocodile (4.0-4.5 m) was not observed to employ the fishing method. Information from local crocodile management rangers indicated that this adult male had only recently moved into this section of the East Alligator River. Interestingly, none of the 15-20 crocodiles (accurate count was not possible) sighted downstream side of the crossing were observed using this fishing method.

Literature Cited

Britton, A. and Britton, E. (2013). *Crocodylus porosus* (Saltwater Crocodile). Fishing behavior. Herpetological Review 44(2): 312.

Rhind, D., Ricketts, A., Calvert, G. and Lyons, K. (2015). *Crocodylus porosus* (Estuarine Crocodile). Fishing behavior. Herpetological Review 46(2): 248-249.

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OUR 2012 "GEOFFROY (1809)" ERROR CORRECTED, AND THE PRIME EXAMPLE OF THE EGYPTIAN NILE CROCODILE IS ALREADY ELECTED. In Ross *et al*. (2012) we were wrong about Étienne Geoffroy Saint-Hilaire's (EGSH) famous and illustrated essay "Description des Crocodiles d'Egypte" being published in 1809. To the contrary, we are today convinced by Sherborn (1897) and Tollitt (1986), and more importantly some details within the text itself, that this important work in which *Crocodilus marginatus*, *C. lacunosus* and *C. complanatus* became available was not published in 1809, but rather the picture of the two (*C. vulgaris*) crocodiles was published in 1826, and the text about the 5 species of sympatric Nile region crocodiles is dated as 1827 according to some authors, and 1829 according to others.

We do not yet understand the discrepancy between 1827 and 1829, but note that Tollitt (1986) explicitly agreed with and followed Sherborn (1897) about the publication date 1827 being decidedly appropriate for Crocodiles of Egypt, in contrast to the alleged year 1829 as was claimed by Étienne EGSH's son Isidore (Sherborn 1897; Tollitt 1986). Our most simplistic guess is that 1827 was the date of the really big (oversize) printing of the text, the same size as the 1826 book of plates. If so, then perhaps 1829 is the year of the

smaller sized printing of the text (half the size of paper as the plates), which has a different pagination. For example, the herpetology library at the Museum of Comparative Zoology (MCZ) at Harvard University has an oversize book of plates, and a more modest size book of text, and on the title page it says 1809 (M.DCCC.IX) and Arthur Loveridge annotated it to "[- 1829.]" in pencil.

On page 210 in the Harvard copy, EGSH wrote about some ancient Egyptian crocodiles and cited a catalog published in Paris in 1826. This fact falsifies the Ross *et al*. (2012) hypothesis, while at the same time it does not resolve the 1827 versus 1829 question. The same applies to the EGSH citation to information in "le Bulletin des sciences de la Société philomathique, année 1826" on page 235 in the MCZ Harvard copy. We apologize for overlooking the two 1826 dates printed in plain view by EGSH about the Crocodiles of Egypt, and also some more clues in the text that the year of publication being as early as 1809 was impossible.

In the MCZ's copy (dated 1829 by A. Loveridge), *Crocodilus marginatus* becomes available on p. 260, and *C. lacunosus* on p. 261, and *C. complanatus* on p. 263. Interestingly, in Loveridge (1957) the *Crocodylus niloticus* synonymy entry for "*Crocodilus marginatus* Geoffroy Saint-Hilaire, Crocodiles, in Descr. Egypte, p. 260; Nile River near Thebes, Egypt" was dated 1827, and *C. lacunosus* "p. 261: (mummy) Egypt" was also dated 1827, as was also *C. complanatus* as "p. 263: (mummy) Egypt". It appears as though 1827 and 1829 can have the same page numbers for these names. Corroborating this hypothesis, Boulenger's (1889) "*Crocodilus niloticus*" (sic) synonymy had "*Crocodilus marginatus*, Geoffr. Descr. Egypte, p. 260" and *C. lacunosus* as p. 261, and *C. complanatus* as p. 263, all with 1829 as the year of availability. Clearly Boulenger (1889) and Loveridge (1957) cite the same page numbers, but different years.

At least superficially confounding the "*Crocodilus vulgaris*" synonymy in Strauch (1866) has *C. marginatus* as page 565 in "Geoffroy St. Hilaire. Description de l'Egypte 2e édit. XXIV" meaning vol. 24 of the edition that was not the 1809 first edition of the book series that in its 2nd edition (but not in the 1st) included the EGSH essay about the Crocodiles of Egypt. Similarly, Strauch's (1866) *C. lacunosus* (p. 567) and *C. complanatus* (p. 570) also disagree with the above germane data in both Boulenger (1889) and Loveridge (1957).

Contrary to and directly and substantively contradicting Ross *et al*. (2012), the name *Crocodilus chamses* Bory is older than *C. marginatus*, *C. lacunosus* and *C. complanatus*. The count of crocodile species inhabiting Egypt and the Nile was one in 1768 (Laurenti), and one in 1788 (LaCépède) and one in 1807 (Cuvier) or also in 1807 a total of two (EGSH), and the same two sympatric Nile Crocodiles hypothesis (in this case *C. chamses* sympatric with *C. suchus*) was repeated in 1824 (Bory). Thus it was not until 1827 or 1829 that the count of species in Egypt jumped to five. There was also an 1826 hypothesis of two sympatric species in and along the Nile River in northern Sudan, namely *C. multiscutatus* distinguished from *C. vulgaris*, but EGSH (1827) did not mention this 1826 development. In this case, although the type-locality of *C. multiscutatus* was technically a short distance outside of Egypt, it still counts as a sixth allegedly biologically different kind of Nile River region Nile crocodile (*vulgaris* = *chamses*, *suchus*, *multiscutatus*, *marginatus*, *lacunosus*, *complanatus*). See Ross (2013) for some germane details and an evaluation of the *C. multiscutatus* hypothesis in 1826, which is correctly not a CITES regulated taxon.

We are still very clearly of the opinion that *C. chamses* Bory de Saint-Vincent, 1824, is a purely vain and not necessary name for an already existing taxon, namely *C. vulgaris* Cuvier, 1807, and it was clearly wrong when (following the German 1974 model of 7 mesorostrine subspecies in Africa) CITES in Wermuth and Fuchs (1983) listed *Crocodylus niloticus chamses* as a valid taxon that does not occur in Egypt and the Nile. The same fault persists in the Fuchs (2006) book which was prominently recommended by the CSG about identifying crocodile skins. We reiterate that CITES should neither recognize nor regulate *C. n. chamses* Bory, 1824, because the 1974 model for African mesorostrines was structurally flawed. It is our opinion that *C. vulgaris* (which equals *C. niloticus*) and *C. chamses* have the same syntypes, and taking Duméril and Bibron's (1836) page 106 citation of "the specimen brought back from Egypt by EGSH, which this scholar and Georges Cuvier both took for the type of their Crocodile vulgaire" ("Nous citerons en exemple, l'individu rapporté d'Égypte par M. Geoffroy, celui que ce savant et M. Cuvier ont, l'un et l'autre, pris pour type de leur Crocodile vulgaire.") as a lectotype designation, we today assert that the specimen shown in figure 1 on plate 3 (it mistakenly says plate 4 on it) in Geoffroy-Saint-Hilaire (1807) is the lectotype of *C. vulgaris* Cuvier, 1807, and this accomplished, it then follows that this individual specimen (and its provenance) and its famous iconotype illustration (see our Fig. 1) is simultaneously and automatically the lectotype of *C. chamses* Bory. Concerning new vain names inheriting the older type(s), the ICZN (1999) Code says in Article 72.7 that when any new name (nomen novum) replaces an earlier and available name, "then the two names are objective synonyms; both of the nominal taxa they denote have the same name-bearing type".

However, we explicitly note and caution that the paralectotypes of *C. vulgaris* could possibly be interpreted by some people (including us) as including all of the syntypes of *C. suchus* EGSH, 1807, but in contrast the paralectotypes of *C. chamses* Bory, 1824, do not and could not include any of the specimens individually and explicitly identified in EGSH (1807) as being his own *C. suchus*, because *C. suchus* EGSH, 1807, was recognized as a valid and current species by Bory de Saint-Vincent (1824) in addition to *C. chamses* (= *C. vulgaris*, today's *C. niloticus*). This discrepancy is caused by Cuvier's lifelong refusal to recognize Geoffroy's *C. suchus* as real. Thus, Cuvier (1807, 1817, 1824) recognized one species of crocodile in the Nile (alone *C. vulgaris* = today's *niloticus*), while in contrast EGSH (1807, 1823) recognized two Nile Crocodile species

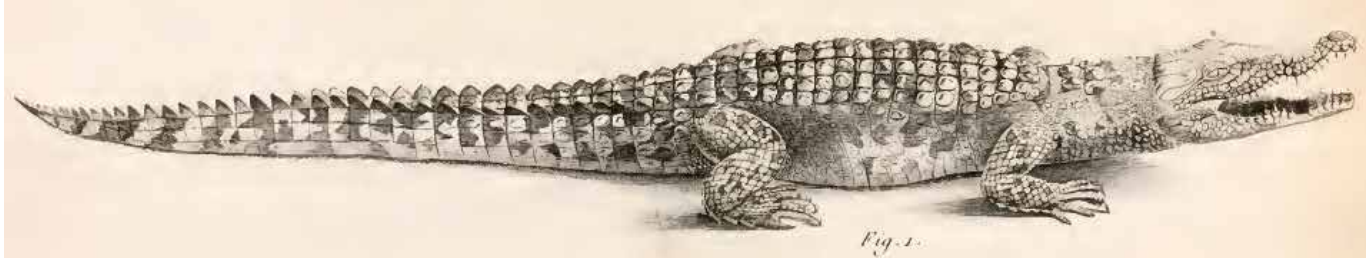

Figure 1. On page 86 in EGSH (1807) in the "Explication de la Planche III" (plate 3) it says "Fig. 1. Le crocodile vulgaire, dessiné d'après un grand individu que j'ai rapporté d'Égypte." The lectotype of *C. vulgaris*, and our choice (we nominate it) as theoretically, philosophically and historically the most parsimonious neotype for *C. niloticus*, is this whole animal depicted in latero-dorsal view across the bottom of Annales du Muséum d'Histoire Naturelle (Paris), volume 10 (original series), plate 3.

(*C. vulgaris* and *C. suchus*), and later Bory (1824) also recognized two Nile Crocodiles (*C. chamses* and *C. suchus*).

Because there is no Geoffroy (1809) paper about the Crocodiles of Egypt, it was not until later than 1824 that EGSH identified the specimen which served as the examined and reported individual of his EGSH (1807) *C. suchus* post-cranial details (such as coloration and scale counts) as being the Adanson's "Crocodile vert" (= "crocodile vert") stuffed individual in the museum in Paris numbered MNHN 7524 and discussed in Ross (2012) and illustrated (in whole animal dorsal view) in 2012 in figures 1 and 2, and there is an extra clear photo of a potentially taxonomically important part of it (a lateral view detail of the osteoderm distribution within the axilla to groin flank skin) in Ross (2013).

Part but not all of the Niger and Niger River localities associated with the species-group name *C. suchus* are from the EGSH (1807) distribution which included the place "Niger" but without any associated mention of Michel Adanson, and thus not clearly today's Senegal River. However, in "Description des crocodiles d'Égypte" by EGSH (1827, 1829) it is explained that the specimen that furnished the scale counts and coloration for the type description of *C. suchus* EGSH, 1807, was collected at "Niger" (today's Senegal River) by Michel Adanson. It is the example of Adanson's Green Crocodile that Kischlat and Ross (2013) were and still are very excited about, because there is sufficient indication in D'Alton and Burmeister (1854) to justify recognizing *Crocodylus viridis* (D'Alton and Burmeister, 1854) as an available name with this exact same specimen (MNHN 7524 in the collection of modern reptiles) as the holotype. In this case there is absolute certainty that the individual specimen MNHN 7524 is the "Crocodile vert du Niger" ("Krokodile vert du Niger") of Michel Adanson, and even though Adanson's not binominal (crocodile vert is French) book was first published in the year before 1758 (namely 1757), the ICZN (1999) Code in Article 72.4.4 and then Art. 12.2.1 allows the one physical (stuffed and 1.28 m long) specimen of Green Crocodile of the Senegal River collected by Michel Adanson to be the holotype of Adanson's Green Crocodile, le Crocodile vert, *C. viridis* D'Alton & Burmeister, 1854, today's *Crocodylus viridis* (or equally possibly *Crocodylus niloticus viridis*) by indication (reference to a previously published description even if published before 1758, or not consistently binominal, or both).

Concerning some germane confusing italics, from its context it is clear that "Adanson's Croc. viridis" was a latinization as *C. viridis* in 1854 and then abbreviated, while in contrast the abbreviation "Cr. vert d'Adanson" in Duméril (1858) meant "Crocodile vert d'Adanson" in the same format as his 1858 "Crocodile vulgaire, Cuv." (and "Cr. vulgaire, Dum. Bib.") which was also French.

Approaching the end, we note that on page 5 (*Tupinambis*) of the Leiden museum's 248 pp. book of "Reptiles d'Egypte" by Isidore Geoffroy-Saint-Hilaire, which does not include the essay about crocodiles, he has a footnote saying "Voir, pour ce regarde le Trionyx et le Crocodile, decrits par M. Geoffroy Saint-Hilaire, Membre de l'Institut, le tome II Histoire naturelle, première édition, et le tome XXIV seconde edition". This Leiden (Naturalis) book's first page of "Le tupinambis du Nil" is page 121 of the MCZ's complete volume 24 of the second edition dated misleadingly 1809 ("M.DCCC.IX") on it, which lacks this footnote. The 248 page book by Isidore Geoffroy-Saint-Hilaire is dated "M.DCCC.XXVII" (1827). The most parsimonious interpretation of the p. 5 footnote in the Isidore Geoffroy-Saint-Hilaire (1827) book of his own (not his father's) collected works about the reptiles and fishes of Egypt (extracted and repaginated from volume 24 of the second edition of "Description de l'Egypte") is that Etienne about the turtle *Trionyx* is in volume 2 of the 1809 edition, and Etienne about "le Crocodiles" (all five species in Egypt and the Nile, and some of them also in other big rivers in Africa) is in volume 24 of the 2nd edition which can not be 1829, because this footnote is in Isidore Geoffroy-Saint-Hilaire (1827). Note that this conclusion contradicts the Sherborn (1897) and Tollitt (1986) information that Isidore Geoffroy-Saint-Hilaire said in print that the essay titled "Description des crocodiles d'Egypte, par M. Geoffroy Saint Hilaire, Membre de l'Institut" was published in 1829. Indeed, the title of the Croc. d'Egypte essay is on page 526 of volume 24 of "Histoire naturelle: Zoologie. Impremerie de C.L.F. Panckoucke. M.D.CCC.XXIX" (1829). This other (off the internet) copy is clearly the Royal edition, because it says "Dediée au Roi" (as opposed to "Publié par les ordres de sa Majesté l'Empereur Napoléon le Grande" and "A Paris, de l'Imprimerie Impériale. M.DCCC.IX" on the Harvard 1829 copy). Note also that the internet 1829 dated Panckoucke Royal edition has *C. marginatus* on page 565, and *C. lacunosus* on p. 567, and *C. complanatus* on p. 570, in agreement with Strauch (1866) above.

The citation of page 167 for "*Crocodilus lacunosus*, Geoff. Crocod. d'Égypte" on p. 105 in Duméril & Bibron (1836) is presumably meant to be page 567, and similarly their (1836) citation of p. 165 for *C. marginatus* is presumably a lapsis for p. 565 (but we do not really know). There is no page number for *C. complanatus* in Duméril and Bibron (1836), and in the germane synonymy entries there is no year cited for either *C. lacunosus* or *C. marginatus* becoming available.

The Royal edition has "CROCODILES. PL. 2" at the top of every other page. We presume that the first appearance of this plate 2 picture was in 1826, but we do not actually know. The picture without any text by anyone might have been, hypothetically, in the 1809 book of plates, but if so then it should have been cited (discussed as the one above and the smaller one pictured below) within the normal text wording of the Royal edition's Crocodiles by EGSH chapter.

As exemplified by Sherborn (1897) and Tollitt (1986), much of what we think that we know about the earliest date of availability for the 3rd, 4th and 5th species of Nile crocodiles recognized by EGSH is circumstantial, and we relatedly believe that some information from Étienne's son Isidore and separately the date printed on the title page of the volume of text (and possibly the plates also) are not always entirely trustworthy.

Concerning Duméril and Bibron's (1836) page 106 lectotype designation for *C. vulgaris* Cuvier, 1807 (and today automatically also for *C. chamses* Bory de Saint-Vincent, 1824), we append 10 citations (including Erp. gén. itself) that include quotations that serve to corroborate and illuminate the 1836 designation of the specimen (and its provenance) depicted as figure 1 on plate 3 in volume 10 of Annales du Museum (Paris) as the lectotype.

1. Cuvier (1807) on page 65 said "*Crocodilus vulgaris* ... (Ann. mus. Paris. X, tab. 3)" (meaning figure 1 on plate 3), as opposed to the specimens illustrated in figures 5 and 12 on plate 1, and as opposed to fig. 7 on pl. 2, and also as opposed to the unillustrated Dr. Roussillon neonate in alcohol from Senegal, and further as opposed to other African mesorostrine crocodilian material known to him. The ICZN (1999) Code allows a published illustration (and its provenance) to serve as the name bearing standard for a taxon, but it is simultaneously understood and explicitly stated (Arts. 73.1.4 and 74.4) that as opposed to its picture (presumably published), it is actually the specimen (which can be found or lost) that actually owns the name.

2. Geoffroy-Saint-Hilaire (1807) on page 80 in his discussion of the American crocodile species, of which he had several examples, compared these *C. acutus* with (and found them to be different from and distinct from) a big example of the Nile River crocodile that he (EGSH) had brought to Paris from Egypt ("Je comparai

ces crocodiles à un grand individu du Nil que j'avois rapporté d'Égypte"). This *C. vulgaris* specimen is surely the "Ann. mus. Paris. X, tab. 3" individual that had already been cited with page priority by Cuvier (1807). It is the "grand individu que j'ai rapporté d'Égypte" (page 86, EGSH explaining figure 1 on plate 3 in 1807) that Duméril and Bibron (1836) selected and functionally designated as the prime individual example of the Nile crocodile for nomenclatural purposes.

3. Cuvier (1817) on page 20 said "Le Crocodile vulgaire, ou du Nil. (Lac. Crocodilus. L.) Geoffr. Ann. Mus. X, III, 1" (meaning figure 1 on plate 3 in volume 10), and in addition to Egypt and the Nile, he added that "Il paraît habiter toutes les rivières de la partie moyenne de l'Afrique" (and we observe and stress again that in 1817, as well as in 1807 and 1824, Georges Cuvier did not recognize *C. suchus*).

4. EGSH (1823) on page 82 mentioned "le *Crocodilus vulgaris*, soigneusement caractérisé d'après un individu que j'avais rapporté d'Égypte, tant par M. Cuvier que par moi-même. (Ann. du Mus., tom. X, p. 82.)", with p. 82 being the start of the EGSH original 1807 "crocodile vulgaire. *Crocodilus vulgaris*" pages 82-84 text and page 86 "Explication de la Planche III" including "Fig. 1. Le crocodile vulgaire, dessiné d'après un grand individu que j'ai rapporté d'Égypte."

5. Bory de Saint-Vincent (1824) on page 105 listed "Geoffr. Ann. Mus. T. X, p. 82, pl. 3 (mal à propos numérotée 4), fig. 1 (parfaite)" in his synonymy of "Le Chamsès, *Crocodilus Chamses*, N.; *Crocodile vulgaire*, Cuv.", and taxonomically significant concerning the original syntype series we reiterate that Bory (1824) on page 106 recognized "Le Suchos, *Crocodilus Suchus*, Geoffroy, ... pl. 3, fig. 2, 3 et 4 (le squelette de la tête d'après un individu momifié)" as a valid species, and this second Nile species included the whole stuffed animal labeled in Michel Adanson's handwriting as "Krokodile vert du Niger" (p. 207). We now firmly believe that Bory (1824) learned the identity of Geoffroy's (1807) post-cranial details animal from Cuvier (1807).

6. Cuvier (1824) merely repeated his 1807 germane statement (quoted above). In this case, because it was a proper (changed by the addition of *Crocodilus cataphractus* Cuvier, 1824) second (revised) edition of an earlier (unchanged in 1812 first edition) reprinting of an even earlier (1807) work, he could have changed his mind about recognizing *C. suchus*, but he did not. Note that what we call Cuvier (1824) is called Cuvier (1825) by many people. For example, "*Crocodylus cataphractus* Cuvier, 1825" (sic) was an Appendix 1 CITES animal in Wermuth and Fuchs (1983), and "*Crocodylus cataphractus cataphractus* Cuvier, 1825" (sic) is in Fuchs (2006) with a preface by Grahame Webb. In contrast, we follow Boulenger (1889) and Loveridge (1957) about citing *C. cataphractus* as becoming available in Cuvier (1824).

7. EGSH (1827) in the on-line Royal (Panckoucke) edition (with "Montbeliardi" stamped on the title page dated "M.D.CCC. XXIX"), on pages 559-560 including him speaking of "une seule espèce grande, indomptable et principalement célèbre comme appartenant au Nil. Celle-ci fut l'animal que, par ce motif, M. le baron Cuvier et moi nous appelâmes crocodilus vulgaris... Nous fimes choix, comme devant nous révéler les qualitiés de l'espèce, du sujet que j'ai rapporté en revenant d'Égypte, et qui avait été peint sur les lieux par mon honorable collaborateur M. Redouté jèune." It appears that the 1807 crocodile engraving (the *C. vulgaris* iconotype) was done by a son or younger brother of the "M.H.J. Redouté" (p. 563) who did the 1826 plate of two examples (the upper 1.90 m long, the lower smaller) of C. vulgaris. Note that although the scale counts and coloration details are prone to be confusing, the individual lectotype specimen that would be designated in 1836 has its total length and selected other measurements given on page 563 in EGSH (1827).

8. Duméril and Bibron (1836) on page 104 in their "Le Crocodile vulgaire. *Crocodilus vulgaris* Cuvier" section, and then in their "Variety A" of it on p. 105 cited "as an example, the specimen brought back from Egypt by M. Geoffroy, which this scholar and M. Cuvier both took for the type of their Crocodile vulgaire" (original French quoted above).

9. Duméril and Duméril (1851) on page 27 started their "Variété A" of "C. vulgaire. Vulgaris Cuv." with "Nil: M. Geoffroy Saint-Hilaire, type de Cr. vulgaris Cuv. (Ann. Mus. Hist. nat., t. X, p. 40, pl. 1, fig. 5 et 12, et pl. 2, fig. 7), et du Cr. vulgaire, Cr. vulgaris Geoffr. (Ann. Mus. Hist. nat. t. X, p. 67)". In this case page 67 is the starting page of EGSH (1807) which included plate 3 and its explication, and this same plate 3 (and obviously the figure 1 picture) also got cited by Cuvier (1807) as quoted above at our example #1. We observe that although the whole Nile crocodile (wild and very large) pictured in plate 3 was cited in Cuvier (1807, 1817, 1824) as the highest value syntype (most complete and reliable Egypt Nile provenance), the figure 1 animal across the bottom of plate 3 can be overlooked in some synonymy situations because it it is traditionally considered to be in a paper that is not Cuvier (1807). We disagree, and take Volume 10 (in the original series) as a whole in which two adjacent crocodile papers share one (#3) of three crocodile plates. As such, we independently agree with *C. vulgaris* being "pls. i-iii" and *C. suchus* being just "pl. iii" in volume 10 of "Ann. Mus. Hist. Nat. (Paris)" in Loveridge (1957).

10. Strauch (1866) on page 43 said that "Geoffroy St. Hilaire. Annales du Muséum X. p. 82. pl. III. f. 1" is biologically in the taxon "*Crocodilus vulgaris* Cuvier".

Based on information in EGSH (1827), we believe that the *C. vulgaris* lectotype specimen was 2.86 m long, but we do not know if that length was live, fresh dead, as a flat skin and head, or stuffed. Separately, we deduce from the same source that the larger (upper) of the two 1826 (plate 2, figure 1) *C. vulgaris* examples (not types in any way) was 1.9 m long, and the youngster below it was smaller than that. Thus the 1807 whole animal illustration in Geoffroy's (and Cuivier's) plate 3 (in Vol. 10 of Annales du Mus. Hist. nat., Paris, original series) is the only published figure of the lectotype. We suspect that the physical specimen is not currently locatable, but it was in Paris in 1807, and was probably stuffed (after being transported from Egypt as flat hornback skin with its head attached).

The designation of the Ann. mus. X, pl. 3, fig. 1 (our Fig. 1) animal as the unique, recognizable and individual lectotype provenance and specimen of *C. vulgaris* Cuvier, 1807, was (and still is) needed in the interests of biological clarity, because when the *C. suchus* lectotype skull (Thebes, Egypt, mummy) and the *C. suchus* paralectotype stuffed whole animal ("crocodile vert" from Adanson at the Senegal River region) are included in *C. vulgaris* (as they were by Cuvier, because he did not recognize *C. suchus* as real), the syntype series of *C. vulgaris* is hypothetically (and prominently in the DNA literature today) two CITES regulatable species-group taxa.

The ICZN (1999) Code at Recommendations 74A, 74B, 74D and 74E supports the lectotype selection of Ann. Mus. X, pl. 3, fig. 1 in preference to any of the other syntypes of C. vulgaris. Further, if and when someone petitions the ICZN to replace the two *Paleosuchus*

(= a mistake made in 1768, but with the very best of intentions) syntypes of *Crocodylus niloticus* Laurenti, 1768, with a neotype of *C. niloticus*, we very strongly recommend that the best choice (in agreement with Article 75, and defending stability and established usage) is Ann. Mus. X, pl. 3, fig. 1 from Cuvier (1807) and EGSH (1807).

The I-spelling *Crocodilus* Cuvier genus, and the Y-spelling *Crocodylus* Laurenti genus can become objective synonyms of each other if and when they are both based on the same individual Nile River in Egypt wild crocodile that was collected by EGSH and transported by himself to France and then stuffed by a taxidermist as a museum mount, and then published as an artist's picture (and specimen provenance) as figure 1 on plate 3 in vol. 10 of Annales du Musèum (Paris), and cited by both Cuvier (1807) and Geoffroy (1807) as *C. vulgaris*.

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