CROCODILE SPECIALIST GROUP NEWSLETTER

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IUCN • Species Survival Commission

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COVER PHOTOGRAPH: "Offering 7" in El Templo Mayor Museum, Mexico City, Mexico, containing an American crocodile (*Crocodylus acutus*) skull and other objects related to the marine setting to honor the god Tláloc. See pages 8-10 for detailed article by Fabio Germán Cupul-Magaña.

EDITORIAL POLICY: All news on crocodilian conservation, research, management, captive propagation, trade, laws and regulations is welcome. Photographs and other graphic materials are particularly welcome. Information is usually published, as submitted, over the author's name and mailing address. The editors also extract material from correspondence or other sources and these items are attributed to the source. If inaccuracies do appear, please call them to the attention of the editors so that corrections can be published in later issues. The opinions expressed herein are those of the individuals identified and are not the opinions of CSG, the SSC or the IUCN unless so indicated.

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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

A grant of $US12,410 from CSG-TTF funds, all raised by TTF members, was provided to the People Resources and Conservation Foundation (PRCF) to undertake Phase I of a project titled "Focused Conservation of *Tomistoma schlegelii* in the Landscape of Danau Sentarum National Park, West Kalimantan, Indonesia". The project involves population surveys, development and initiation of a participatory conservation action plan, and sourcing of additional funding for Phase II. The completion date for Phase I is June 2014.

CSG members in the USA were deeply involved in the "2012 Christmas CrocFest", a fundraiser for crocodilian conservation, which took place on 8 December 2012 at Shawn and Jen Heflick's facility in Palm Bay, Florida. It raised a record $US15,000 for Orinoco crocodile conservation. The funds will be directed to Associacion Chelonia, to assist their activities with *C. intermedius* in Colombia (see pages 17-18).

"Summer CrocFest 2013" took place on 29 June 2013 at Reptile World Serpentarium in St. Cloud, Florida, USA. This event raised $US11,000, which will be directed towards a festival to be held in Jamaica to raise public awareness and support for Jamaican crocodiles (*Crocodylus acutus*) (see pages 18-19). The biennial CrocFests are proving to be very successful, and all CSG members and others involved are to be congratulated on their efforts.

In August I wrote to the Colombian CITES Management Authority congratulating them on a series of positive management actions, in which the CSG has had involvement, particularly through Deputy Chairman Alejandro Larriera. I also discussed CITES-published export quotas for Colombian *Caiman crocodilus fuscus* skins longer than 125 cm, which are produced through legal farming, despite exceeding the normal size limits for export. Checks and balances for larger caimans are important to ensure avenues allowing the flanks of larger wild adults continue to be excluded from legal trade.

The website of the 23rd Working Meeting of the Crocodile Specialist Group, (26-30 May 2014), to be held on the McNeese State University campus in Lake Charles, Louisiana, USA, is now up and running (www.CSG2014louisiana.com). Potential participants can view travel information, register for the meeting, make reservations in the low-priced university apartments (limited rooms available), register for field trips (limited availability), and view excursions offered.

In addition, information is available concerning a special scientific session, to be held during the meeting, on the broad topic of crocodilian reproduction. Presentations on the topic of crocodilian reproduction, both poster and oral, will be eligible for publication in a special issue of the peer-reviewed South American Journal of Herpetology (SAJH). The organizers of the 2014 CSG meeting and the editorial staff of SAJH have agreed to publish selected papers from the meeting in a special issue dedicated to crocodilian reproduction. Details of this project can be found at the meeting website listed above. For more details about this special journal issue, please contact Mark Merchant (CSG2014@mcneese.com) or Carlos Piña (cidcarlos@infoaire.com.ar).

The Proceedings of the 22nd CSG Working Meeting held in Sri Lanka (May 2013) are currently with the printer, and should be available soon. Anslem De Silva is to be congratulated for his considerable efforts leading to the timely production of these Proceedings.

The 8th training course on research techniques on caimans will be held between 24 October and 7 November 2013, at Mamiraua Reserve, Brazil, under the auspices of the Institute for Sustainable Development of Mamiraua. Further information can be obtained by contacting jacares@mamiraua.org.br.

The maintenance and ongoing development of the CSG website will be now be carried out by Colin Stevenson, with oversight by the CSG Executive Officer Tom Dacey. Colin will also take over maintenance of the CSG's Facebook page, which currently features 193 CSG "Members of the Month", who answered the recent questionnaire and request for details of their current and previous activities.

The first sections of the Crocodilian Capacity Building Manual are expected to be posted on the CSG website by the end of September 2013. We thank all of those members who devoted time and effort to contribute to this important CSG initiative. The manual is by no means complete, and we will be seeking assistance for outstanding sections in due course.

Professor Grahame Webb, CSG Chairman

CSG Student Research Assistance Scheme Update

The CSG Student Research Assistance Scheme (SRAS; http://www.iucncsg.org/pages/General-Information.html) provided funding to four students in the July-September quarter (see below). One further application is currently under review.

1. Myfannwyn Gibson (South Africa): Habitat availability and water quality effects on the prevalence of *Crocodylus niloticus* in Limpopo Province.

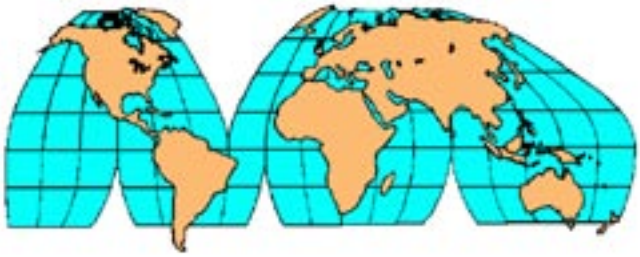
2. Franklin Cuapio Chavarria (Mexico): Microclimate of *Crocodylus acutus* nests and its effect on incubation, sex ratio, survival and physical characteristics of hatchlings.

3. Shiva Raj Thanet (Nepal): Habitat preference of Gharial (*Gavialis gangeticus*) and conservation measures in the Narayani River of Chitwan National Park, Nepal.

4. Maria Latorre (Argentina): Immune system as an indicator of toxicity of pesticides in *Caiman latiostris*.

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

Regional Reports



South Asia and Iran

India

NOTE ON DISPERSAL PATTERN OF RE-INTRODUCED GHARIAL IN THE GANGA RIVER, UTTAR PRADESH. Between 29 January 2009 and 12 February 2009, 131 Gharial (*Gavialis gangeticus*) were released into Ganga River at Hastinapur WildLife Sanctuary in Uttar Pradesh. These Gharial were 2.0-3.8-year-old juveniles and sub-adults from the Gharial Rehabilitation Centre, Kukrail at Lucknow, and were from the 2005-2006 batch. In the first phase 60 Gharial (18M:42F; 1.20-1.68 m TL, 7-12 kg BWt) were released, and in the second phase 71 Gharial (19M:52F; 1.20-1.80 m TL, 7-16 kg BWt) were released. Intensive post-release monitoring has been ongoing and data on habitat preference and dispersal has been collected for one year covering three seasons (winter, summer, monsoon).

On 26 September 2009, I (SKY) received a call from Etawah, informing me that a sub-adult Gharial has been rescued at Kandesi Minor, and that it has been released into the Chambal River at Udi Bridge. The individual was a marked (scute-clipped) specimen, indicating that it was captive reared. Instantly I decided to travel to Etawah from Maqdoompur Field Station in Hastinapur Wildlife Sanctuary where earlier in the year Gharial had been released. In Etawah, Mr. Rajeev Chauhan (SCoN) showed photographs to confirm the specimen (No. 6353). I was also happy to learn that the animal had survived and grown to a length of 1.98 m from its release size of 1.32 m. The Gharial had moved around 600 km, from Maqdoompur, through the Ganga Canal, to Etwah, a stretch known to have anthropogenic disturbances.

On 2 October 2009, during the post-monsoon monitoring of the released Gharial, I observed a sub-adult Gharial near Valawali Village, which is around 130 km upstream of the release site (Fig. 1). The closest distance I could approach this individual was about 50 m. Using an Image Stabilizer (10 x 30) the animal was estimated to be 1.80-1.90 m in length, had been scute-clipped, and the tag was missing.

The studies conducted on Gharial ecology and information based on anecdotal accounts, particularly on dispersal patterns, suggest that during the monsoon, juveniles and sub-adults disperse for predictably longer distances while adult dispersal is always very local and seems to be merely to maintain a home range. Biswas (1970) recorded that Gharial tend to move downriver from the Kosi in Bihar to the Ganges during the monsoon, while Rao (1933) reported Gharial in the Indus River going upstream with the rising water during the monsoon and downstream when the water levels receded in the fall and winter. Adult Gharial in Girwa River at Katerniaghat WildLife Sanctuary in Uttar Pradesh have been observed to disperse locally (8-10 km) every year and orient themselves upstream at the floodwater period during monsoon (Whitaker and Basu 1981).

Figure 1. Schematic showing movement of Gharial.

The observations recorded here on the dispersal of released Gharial suggest an unusual opportunistic behavior of Gharial movement during monsoon in both upstream and downstream directions, so far unreported from the Ganges and hence worthy of placing on record.

Acknowledgements

The observations were made during the Gharial Re-introduction Study. We are indebted to the Ministry of Environment & Forests (MoEF) and the Uttar Pradesh Forest Department for granting permission to conduct this study. We thank Mr. Ravi Singh (SG & CEO) WWF-India, Dr. Parikshit Gautam (Director) and Dr. Sandeep Behera (Senior Coordinator) Freshwater & Wetlands Programme, WWF-India, for their support. We express our gratitude to Dr. Asghar Nawab (Senior Project Officer) Freshwater & Wetlands Programme, WWF-India, for his valuable comments on the manuscript. We thank Mr. Viveksheel Sagar (Project Officer) Dolphin Conservation Programme, NARORA and our field staff for their help in data collection and field surveys.

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GHARIAL "BABY" BOOM IN CORBETT. In a path-breaking discovery, surveys this year of the Gharial population in Corbett Tiger Reserve (CTR) have revealed that Gharials have breed naturally and nesting has been very successful. Subir Mario Chowfin, in partnership with Dr. Alison Leslie and in collaboration with CTR authorities, is studying the population and nesting trends of Gharial and other crocodilian species in CTR.

During the 2013 nesting season a minimum of 13 Gharial clutches were recorded in the Boksar area of CTR alone. The surveys detected a record "baby boom" of Gharial in Boksar, with 350-400 hatchlings observed. The nesting season was estimated to have begun in mid-March, and hatching estimated as taking place towards the end of June. This is the first time that such successful hatching and in such large numbers have been observed in CTR throwing new light on the study of the species there.

Gharials are known to prefer free-flowing river systems, however the population in CTR appears to be utilizing reservoir conditions and is probably the only Gharial population living in a lake-like environment. It should be noted that surveys carried out in 1974, before the Ramganga River was dammed, predicted that the species would not survive in the altered habitats (ie from river to lake).

CTR is home to the third largest population of Gharial in the world, contributing around 20% of the global population of 200-250 adults. Further studies on the effects of the Kalagarh Reservoir on Gharial nesting areas in the CTR will be undertaken in detail as part of the ongoing multi-year research work.

Figure 1. Gharial hatchlings in Corbett Tiger Reserve.

Subir Chowfin, *c/o The Gadoli and Manda Khal Wildlife Conservation Trust, P.O. Box. 27, Pauri, District Pauri Garhwal, Uttarakhand 246001, India.*

UPDATE ON GHARIAL MORTALITIES IN NATIONAL CHAMBAL SANCTUARY, LATE 2012-EARLY 2013. At least 15 Gharials (*Gavialis gangeticus*) died in two seemingly separate episodes in late 2012-early 2013 in the National Chambal Sanctuary (NCS; Fig. 1).

Figure 1. Map of the affected zones in 2007-08 (based on Huchzermeyer *et al*. 2008; Whitaker *et al*. 2008; WWF 2008) and late 2012-early 2013 Gharial mortality events in the Chambal River, flowing through the NCS.

Four dead individuals were found over 31 days (2 October-1 November 2012), followed by 11 deaths over 49 days (14 January-3 March 2013) (see Table 1). The affected animals were recovered from a 90-km section of river (Fig. 2), and ranged between 0.71 and 4.65 m total length, and included juveniles, sub-adults and adults of both sexes. However, the identification of sex may be doubtful in some cases, particularly with juveniles.

Figure 2. Locations and dates of Gharial mortalities during late 2012-early 2013 in the Chambal River, flowing through the NCS.

While the mortalities in 2012 appear unrelated, the 11 mortalities in early 2013 seem to be a set of related events given their temporal (49 days) and spatial (80 km) proximity. This is only a speculative suggestion, since we do not have the necessary evidence to support this hypothesis at this stage. Water samples tested negative for chemical contamination (Vincent Rahim, pers. comm.) and there were no similar reports of other associated aquatic fauna being affected.

Post-mortem examinations attribute liver cirrhosis, lung congestion, cardiac arrest, septicaemia caused by enteritis, parasitic gastritis and hepatitis, and liver dysfunction as reasons for the death of different individuals, but it is not clear if these were gross observations or validated findings. Impairment of the liver was recorded in 5 instances (Nos. 1, 5, 7, 9, 12 in Table 1), and this may well have been the case. But it is important to note that in the 2007-08 Gharial mortality event, "the thin fibrous capsule of the liver, which is a normal feature of crocodilian anatomy, initially was misinterpreted as cirrhosis" and "post-mortem change likely was misinterpreted as inflammation in at least some cases" (Huchzermeyer *et al*. 2008a). Similarly, "gross finding of enteritis could not be substantiated". Parasitic gastritis was implicated in one instance (No. 7 in Table 1) and here too, it must be noted that gastric (stomach) ulcers associated with nematodes and pulmonary parasites (pentastomes) were a common finding in the 2007-08 Gharial mortality event and were interpreted as background or incidental findings, and that "these parasites are common in crocodilians and generally are not associated with significant host injury" (Huchzermeyer *et al*. 2008a). More worrying, the causative factors remain unknown.

Detailed information was obtained for one juvenile Gharial (No. 12 in Table 1). Comparing the results of the biochemical analysis of this Gharial with the 'normal blood biochemical values for the species' (Huchzermeyer *et al*. 2008a,b), and the generic normal range for other crocodilians (Huchzermeyer 2003), we noted the following:

Table 1. Details of Gharial mortalities during late 2012-early 2013 in the Chambal River (National Chambal Sanctuary). Data for Nos. 1, 3, 5-7, 9 are from Sujoy Bannerjee (pers. comm.) and for Nos. 2, 4, 8, 10-13, 14b, 15 from Vincent Rahim (pers. comm.).

No.	Date	Location	Location Coordinates	TL	Sex	Findings
1.	2 Oct 12	Near Patharra	26°29'38.35"N, 79°12'07.85"E	3.70	F	Liver cirrhosis.
2.	18 Oct 12	Nr Gyanpura ghat	26°40'35.02"N, 78°59'08.03"E	2.10	F	Body putrefied.
3.	24 Oct 12	Nr Asewa/Shergarh	26°29'06.00"N, 79°16'16.71"E	0.71	M	Congestion of lungs.
4.	1 Nov 12	Near Dinnpura	26°47'24.09"N, 78°43'39.04"E	4.65	M	Congestion of respiratory and blood vascular system. Died of cardiac arrest.
5.	14 Jan 13	Near Patharra	26°29'38.35"N, 79°12'07.85"E	1.62	M	Liver damage.
6.	30 Jan 13	Near Bhareh	26°29'35.85"N, 79°15'31.20"E	1.53	M	Septicaemia caused by enteritis
7.	1 Feb 13	Near Nada (Sahson)	26°33'01.09"N, 79°05'01.07"E	2.50	M	Parasitic gastritis, hepatitis.
8.	2 Feb 13	Near Barechha	26°36'28.05"N, 79°00'51.06"E	1.30	F	Respiratory infection.
9.	7 Feb 13	Nr Pachhiangaon ka Pura	26°44'08.07"N, 78°50'28.04"E	2.50	F	Liver cirrhosis.
10.	9 Feb 13	Near Gyanpura ghat	26°40'35.02"N, 78°59'08.03"E	1.50	F	Putrefaction of viscera. Cause not diagnosed.
11.	9 Feb 13	Near Gyanpura ghat	26°40'35.02"N, 78°59'08.03"E	3.10	F	Putrefaction of viscera. Cause not diagnosed.
12.	12 Feb 13	Near Gyanpura ghat	26°40'35.02"N, 78°59'08.03"E	1.83	F	No external injuries. Died due to liver dysfunction.
13.	13 Feb 13	Near Kosar ki Marhaiyan	26°45'28.9"N, 78°46'38.3"E	3.10	F	Body putrefied.
14a.	18 Feb 13	Near Kachhuri	26°37'05.7"N, 79°00'33.2"E	1.78	F	Immobile, indisposed. See text.
14b.	1 Mar 13	Near Kachhuri	26°37'05.7"N, 79°00'33.2"E	-	-	Body putrefied. Same as 14a.
15.	3 Mar 13	Near Kanakpura	26°39'32.8"N, 79°00'13.0"E	3.20	F	Body putrefied.

1. Albumin levels (2.0 g/dl) were higher than normal Gharial values (1.44-1.68 g/dl), but within the generic normal range (1.4-2.3 g/dl).
2. SGOT (or AST) levels (190 U/L) were higher than two of the normal Gharial values (28.56 and 34.67 U/L) and the generic normal range (16.6-18 U/L). The abnormally high AST levels of the third normal value (413.17 U/L) may be suspect since the sample was hemolyzed.
3. SGPT (or ALT) levels (153 U/L) were higher than two of the normal Gharial values (22.38-23.78 U/L) and the generic normal range (13.1-20.2 U/L). The ALT levels of the third normal value (48.59 U/L) may be suspect since the sample was hemolyzed.
4. Creatinine levels (0.7 mg/dl) were higher than normal Gharial values (0.32-0.5 mg/dl), but within the generic normal range (0.21-1.65 mg/dl).
5. Total protein levels (4.0 g/dl) were lower than normal Gharial values (6.19-6.24 g/dl), but within the generic normal range (3.7-9.37 g/dl).
6. Urea levels (37.8 mg/dl) have no comparative normal Gharial values. However, if 'Urea' was an erratum for 'Uric acid', these levels were well above the normal Gharial values (4.02-5.09 mg/dl) and the generic normal range (3.03-8.17 mg/dl).

Nothing specific was noted with the blood smear. Hb was 9.8 gm % and TLC was 2,86,250 cells/mm^3. The lungs were congested and hyperaemic, the spleen was slightly enlarged, and the liver was swollen and with necrotic foci.

Another Gharial (No. 14 in Table 1; Fig. 3) was examined while still alive. Events surrounding this animal are outlined below:

Figure 3. (a) Indisposed juvenile Gharial; (b) quarantine pool dug onsite to confine the animal to enable medical examination; (c) collection of faeces; (d) regurgitated stomach contents. Photographs: Suyash Katdare.

18 February 2013: Patrolling team comes across a group of basking Gharials at 26° 37' 05.7" N, 79° 00' 33.2" E at 1400 h. While the rest of the Gharials slip into the river, one juvenile stays put. Closer examination revealed the animal to be immobile and indisposed (Fig. 3a). A shallow, quarantine pool (Fig. 3b) is dug onsite to confine the animal and enable medical examination.

19 February 2013: Preliminary examinations: Female; Good musculature, robust tail, no prominence of skeletal structure; teeth clean and white; no algal deposits on the body or teeth; belly clean; overall body condition very good; and no visible signs of injury. No audible signs of respiratory distress (no gurgling noises); TBL= 178 cm, SVL= 99 cm, HL= 33 cm, girth behind forelimbs= 48 cm, maximum girth= 60 cm, girth at base of tail (immediately behind hindlimbs)= 45 cm; blood samples collected, but hemolyzed.

20 February 2013: More samples collected - blood; faeces (Fig. 3c); stomach contents; synovial fluid; oral, ear and cloacal swabs. While the abdomen was being palpated in an attempt to obtain faecal samples, the animal regurgitated a reddish, congealed mass (Fig. 3d), which may have indicated internal bleeding.

21 February 2013: Laboratory results inconclusive. Animal released into the river on veterinarian's recommendation.

1 March 2013: Putrefied carcass (4-5 days old) of a similar-sized animal was found close to above location; likely to be the same individual.

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Nepal

30 GHARIALS RELEASED INTO CHTWAN NATIONAL PARK, NEPAL, FEBRUARY-APRIL 2013. Thirty Gharial (*Gavialis gangeticus*; 11M, 9F), hatched in 2007 and raised at the Gharial Conservation Breeding Center (GCBC) were released into the Rapti River on 2 February (N=10; World Wetland Day), 24 March (N= 10) and 20 April 2013 (N= 10; Wildlife Week). The introduction program was initiated in 1981, and since that time 891 Gharial have been released into the wild. The Nepalese population was estimated as around 124 Gharials in the Narayani, Rapti, Babai and Karnali Rivers (DNPWC and WWF Nepal 2013).

The Gharial were an average of 176.5 cm long (range 160 to 200 cm) and 15.7 kg in weight (range 9.5 to 20 kg). Transport and release methods have been described previously (eg Khadka 2010, 2012).

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West and Central Africa

Morocco

CROCODILE PARK FOR MOROCCO. Many CSG members may recall the visit during the 18th CSG working meeting to La Ferme aux Crocodiles, in Pierrelatte, France, which organized and sponsored the meeting. Luc Fougeirol, owner of La Ferme aux Crocodiles at the time, has announced that he is moving to Agadir, Morocco (his birthplace), to supervise the construction of a new crocodile park in that country. This will be Luc's fifth project of this type, which also includes the Planète des Crocodiles (France), Djerba Explore Park (Tunisia) and Dubai Crocodile Park (Dubai).

Crocodiles were present in Morocco less than a century ago, and the development of this park will at least see crocodiles "return" in some way. It is hoped that the project will support crocodilian conservation activities, as has La Ferme aux Crocodiles through its "SOS Crocodiles" program.

Latin America and the Caribbean

Mexico

CROCODILES AS OFFERINGS TO THE AZTEC GODS. The archaeological excavations that led to the discovery of the ruins of the "El Templo Mayor" (The Main Temple) in the historical center of Mexico City began in 1978. The Main Temple (known in Náhuatl, the Aztec language, as "Huey Teocalli") was the site of the Aztecs' religious and political life. It was the most important building in the ancient city of Tenochtitlán (today's Mexico City), composed of a large platform, a four-sided pyramidal base, a double staircase and two worship altars on the top part. The northern altar was dedicated to the god of rain and agriculture, Tláloc, with the southern one was for the god of war and of the sun, Huitzilopochtli (Matos-Moctezuma 1998; Fig. 1).

Figure 1. Main facade of The Main Temple showing the heads of two snakes. The steps leading to the altar of the temple devoted to the god Tláloc can be seen at the left of the photo. The modern building in the background is El Templo Mayor Museum.

The presence of these gods allows us to suppose that the existence of The Main Temple was related to the economic support of the Aztecs, since their economy depended fundamentally on agricultural production (Tláloc) and on war as way of imposing a tax on conquered groups (Huitzilopochtli). In accordance with Aztec myth, The Main Temple was built on a site where the four points of the compass and the three vertical levels of the cosmos meet: the sky, the surface of the ground and the lower world. That is why its location could not change and it was always rebuilt in the same place; that is, every new enlargement partially or completely covered the previous one (Olmo 2013; Fernández 1992; Matos-Moctezuma 1998; López-Luján and Chávez-Balderas 2010).

The temple was built and enlarged in 13 stages, beginning possibly at the time when the Aztecs arrived and founded the city, around 1325, until 1500-1521. The Main Temple, along with another series of structures like buildings, altars, the tzompantli (the structures where they placed the heads of

captured warriors as trophies) or ball games, compose what is known today as the sacred enclosure of Tenochtitlán, the capital of the Aztec empire (Olmo 2013; Matos-Moctezuma 1998)

The Main Temple encompasses the Aztec cosmic vision, thus it was the right place for ancient Mexicans to give thanks to their deities by means of their offerings. One hundred and fifty-three offerings have been discovered there, consisting of sets of carefully ordered objects. Some were discovered in stone boxes under the buildings, while others were lying directly in the ground. Among the most outstanding items, sculptures were found representing deities, artifacts with symbolic connotations (scepters, pectoral shields, masks, earmuffs, flutes, whistles, drums, sacrificial instruments, etc.). Certain offerings also included remnants of decapitated people, traces of flora and bones of various animals. And among the identified fauna were crocodiles, jaguars, pumas, lynxes, snakes, as well as a large variety of birds, fish, scallops and marine snails (Matos-Moctezuma 1998; Jiménez-Badillo 2009).

One of the crocodile offerings (Offering 7) held at the museum located near the archaeological zone is the skull of an American crocodile *Crocodylus acutus* (Álvarez *et al*. 1982; Álvarez and Ocaña 1999) surrounded by corals, arrowheads, snails, stone accounts, knives, oysters and shells of freshwater turtles (Fig. 2). This specimen surely comes from the Pacific coast, a region where the species is abundant nowadays. The morphologic characteristics that allowed it to be recognized were the thin and elongated head (Cedeño-Vázquez *et al*. 2011). This offering dates back to the period 1469-1481, and was under the platform of the south facade of The Main Temple, corresponding to the god Huitzilopochtli. In this offering, the crocodile skull, the fish scales and the turtle shells form a layer of rough texture that symbolizes the Earth's surface (Fig. 2).

Figure 2. Offering 7 in El Templo Mayor Museum contains the skull of an American crocodile as well as other objects related to the marine setting to honor the god Tláloc.

In another offering, the skull and the osteoderms of a Morelet's crocodile *C. moreletii* (Álvarez and Ocaña 1999) (Fig. 3), another species of crocodile that inhabits the country. This crocodile is abundant in the Caribbean, part of the coast of the Gulf of Mexico and in the northern zone of the State of Chiapas. The skull of Morelet's crocodile is much wider and less elongated than in the American crocodile (Cedeño-Vázquez *et al*. 2011). In the south of Mexico, along the coast of the Pacific Ocean; there is also a species of caiman (*Caiman crocodilus chiapasius*).

Figure 3. Skull and osteoderms of a Morelet's crocodile in exhibition at El Templo Mayor Museum.

Thus the presence of crocodiles among the offerings is related to a mythical animal which the Aztecs called "cipactli" (crocodile) and, according to legend, the creator gods used its body to give form to the universe. It is said that its head occupies the skies, its trunk the ground and its tail the lower world. Thus the crocodile is a reminder of the union of man with his deities, the mundane and the great beyond. The crocodile represents a means for the flow of celestial forces and of the world of the dead that influence directly the destiny of human lives on Earth (Fernández 1992; Cifuentes and Cupul 2004).

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Panama

TRAINING WORKSHOP ON PARTICIPATORY RESEARCH AND EDUCATION APPLIED TO UNDERSTAND AND CONSERVE THE AMERICAN CROCODILE IN COIBA NATIONAL PARK, PANAMA. Conservation is defined by Fiedler and Jain (2002) as "the management and sustainable use of the natural environment and natural resources for ethical reasons and the benefit of humanity". For conservation efforts/programs to be successful, it is imperative to reconcile the interests of politicians, decisions makers, researchers and the general public. In our experience, "Participatory Research and Education" (PRAE) is a valuable approach if the major research goal is to succeed in conserving biodiversity. The PRAE philosophy employs most sectors of the population to help identify problems, set priorities, and develop knowledge that can be applied to improve the quality of life of the community. In a number of more conventional research projects and extensions inappropriate recommendations frequently follow a failure to take local priorities, processes, and perspectives into account.

In contrast, PRAE emphasizes a "bottom-up" approach with a focus on locally defined priorities and local perspectives. In our experience, PRAE can significantly reduce both development time and resources associated with projects and also improved our understanding of nature and the delivery of the scientific knowledge. In conserving biodiversity, experience has shown that people are invested to conserve only what they know and what is useful for them. The primary purpose of this article is to present the major results of our successful experiences in PRAE applied to understand and conserve populations of American crocodiles in one of the most ecologically complex Natural World Heritage Sites in the Tropical Eastern Pacific Marine Corridor, Coiba National Park (CNP) and its nearby continental buffer zone.

Since 2010, there has been an ongoing long-term research and monitoring program which is aimed at conserving American crocodile populations in CNP and its continental buffer zone. This project is a collaborative effort among the Smithsonian Tropical Research Institute (STRI), Texas Tech University (TTU), and the IUCN-SSC Crocodile Specialist Group (CSG), and is supported by the Panamanian National Secretariat for Science, Technology and Innovation (SENACYT). As a part of this ongoing project, we have trained and worked both directly or indirectly with national and international students, wildlife rangers, police officers, local people, environmentalists, politicians and decision makers to identify problems, set priorities and develop knowledge for a program that will strive to conserve crocodiles in our study area. These groups are referred to as the "participatory research and community education groups" (Fig. 1). The PRAE included workshops in which we developed 'knowledge for action'. Workshops included an evaluation of the experimental design and action plan of the crocodile conservation project, field work, analysis of field work results, and project redesign (based on input from the PRAE groups and experiences gained).

Figure 1. Part of the participatory research and community education group, 2013.

Between 20 January and 4 February 2013, STRI and TTU collectively hosted the Second Central America Crocodile Telemetry and Genetics Workshop at CNP. Ten international students from Malaysia, Italy, Puerto Rico and Colombia,

and 22 Panamanians (included graduate and undergraduate students), ANAM rangers, members of the National Ecological Police of Panama, and local stakeholders (conservationists, fishermen, etc.) from neighboring islands and the mainland attended the workshop.

During these two weeks, participants had the opportunity to learn how to design their own crocodile catching tools, to capture crocodiles in the wild, and to collect and analyze ecological, genetic and telemetry data. The first week of the workshop took place at three different sites in CNP: the STRI field station on Coibita Island, the ANAM field station on Coiba Island, and at Playa Blanca in the southern part of Coiba Island. The second week of the workshop took place at the STRI Naos Island marine molecular laboratories.

Designing and Applying Methodology

PRAE-based methodology for the training workshop in 2013 was designed in 2010 as a part of operating strategy of the SENACYT PNCOIBA08-011 project, entitled "Population Structure and Habitat Use of *Crocodylus acutus* in Coiba Island and the Gulf of Montijo: Genetics and Telemetry". The PRAE is represented in a flowchart (Fig. 2) and includes three main steps: First, students have to design and write a preproposal based on a biological question posed by the project's Principal Investigators; second, the PRAE group is called to a workshop where students and other members of the group carry out the field work data collection; third, the group, based on their collective field work experiences, evaluates the experimental design and action plan of the project and establishes priorities and actions to be included in the overall context project, which is to conserve crocodiles and their habitats in the study area. The primary goal of the 2013 workshop was to evaluate and redesign the 2012 research action plan of the American crocodile project using the flowchart as part of the PRAE project strategy.

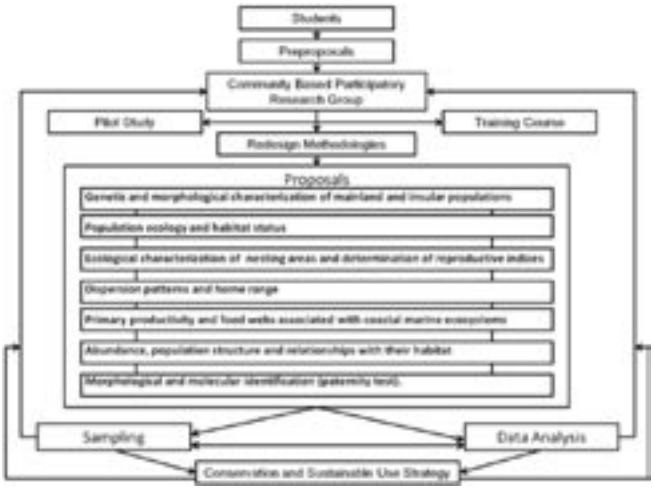

Figure 2. Flowchart representing operating module of PRAE workshop.

Major Accomplishments of the Workshop

Making crocodile capturing tools: Commercially available poles and harpoons used to capture crocodiles are expensive and not easy to find in Panamanian markets. Participants were taught to the make tools and equipment necessary to safely capture crocodiles using locally and readily available materials such as PVC pipe and steel fishing line/cable. These locally-made tools are both affordable and efficient, and therefore could be vital in the development of research projects and management of crocodiles in remote areas. The approximate cost of making these tools locally is $US15 compared to the $US400 for the commercially purchased tools.

Capturing and sampling crocodiles: Participants were provided with firsthand experience in capturing wild crocodiles (using the previously made tools as above) . They were also trained to physically restrain crocodiles to allow tagging, and how to take different morphological measurements and collect tissue samples for genetic analyses. Each crocodile captured has a unique tag and geographic, morphological, and ecological information were registered in an Excel database. The Coiba American crocodile project uses single scales on the tail as units, right double tail scales as tens, and left double tail scales as a hundreds. During the workshop, 11 crocodiles were captured.

VHF telemetry: To gather information on the home range, movement and dispersal patterns of American crocodiles based on size class, age, sex, and season, we fitted "Telenax" VHF radios on 5 crocodiles in 2010 and on 11 crocodiles in 2013. From our 2010 pilot study (Fig. 3) we found that the best method was to attach the transmitter to the nuchal scales by two independent bonds made with 3 mm thick plastic-coated steel wire. Wire tips were attached together with mini coopers of double sleeve. Crocodiles were tracked manually using an antenna and receiver in a routine fashion by participants. Our pilot study in 2010 also pointed towards a need to change our tracking strategy to include time of the day, moon phase, and transect length. Thus, to redesign the tracking strategy the experience of the people of the community and ANAM rangers was very important.

Figure 3. VHF telemetry session, 2010.

Molecular analyses: One of the main goals of this workshop was to introduce participants to the basics of molecular analyses. Participants were trained to extract total genomic

DNA from the tissue samples collected in the field by CTAB-phenol-chloroform technique (Sambrook *et al*. 1989; Palumbi *et al*. 1996), gene amplification by Polymerase Chain Reaction, and automated Sanger sequencing. Total genomic DNA was extracted from tissue samples collected from 11 crocodiles caught in the field. Six hundred base pair fragments of the mitochondrial gene Cytochrome oxidase subunit I (COI) was sequenced using an ABI 3100 Avant genetic analyzer (Applied Biosystems, Forester City, CA) based on primers and the protocol published by Venegas *et al*. (2008). Generated sequences were analyzed using various phylogenetic software packages; only a single haplotype was recovered from all 11 samples at STRI molecular laboratories.

By adopting PRAE methodology in our projects, we were able to: (a) involve all the concerned stakeholders in a collective effort to conserve American crocodiles in our study area; (b) convince politicians and decision makers about the importance of conserving American crocodiles in particular and overall biodiversity in general, by involving them in the entire process of project development and execution; (c) redesign methodologies incorporating feedback from all of the stakeholders; and, (d) develop the technical capacity necessary for the management of telemetric technologies and molecular genetics for crocodile population conservation. Based on our experience over the past three years, participatory research and education has proven to be both a viable and a valuable practice if we want to succeed in conserving biodiversity.

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AMERICAN CROCODILE (*CROCODYLUS ACUTUS*) POPULATION SURVEY IN AMBERGRIS CAYE, BELIZE. Two species of crocodilian occur in Belize, Morelet's crocodile (*Crocodylus moreletii*) and the American crocodile (*C. acutus*). Although the status of *C. moreletii* population warranted downlisting of the species in Mexico and Belize to Appendix II of CITES in 2010, the situation with *C. acutus* in Belize may be more tenuous. Despite being fully protected by *The Belize Wildlife Protect Act (Chapter 220)*, the *C. acutus* population is estimated to be less than 1000 non-hatchlings (Platt and Thorbjarnarson 2000a; Platt *et al*. 2004; Rainwater and Platt 2009). Presently, the foremost pressures affecting crocodile populations are illegal hunting and fragmentation and loss of habitat (Platt and Thorbjarnarson 2000a; Thorbjarnarson *et al*. 2006; Rainwater and Platt 2009). Thus, the preservation of the species is ultimately contingent on sustainable wetland habitat protection, particularly successful nesting areas, and enforcement of wildlife protection laws. Here, we present the results of the first systematic survey of *C. acutus* on Belize's largest offshore caye, Ambergris Caye (Fig. 1).

Figure 1. Ambergris Caye, Black dots indicate general start areas of 12 survey sections (see Table 1).

Formed during the Pleistocene some 135,000 years ago, Ambergris Caye is a karst limestone ridge surrounded by shallow water, calcareous sediments that were colonized by mangroves (Grimshaw and Paz 2004). A flat, coral sand island, Ambergris Caye stretches 40 km south from the southern most tip of the Yucatan Peninsula, and ranges in width from just over a 100 m to well over 6 km (Fig.1). While the island's east coast is protected by the Mesoamerican Barrier Reef System, its west coast is composed primarily of Red Mangrove (*Rhizophora mangle*) and fresh, brackish, and saltwater lagoons.

Between 28 April and 26 May 2013, population data was collected via random spotlight surveys, and nest counts (Bayliss 1987). Depending on the type of habitat and its accessibility, surveys were carried out from either: a 5.5 m fiberglass, flat bottom, Carolina skiff with a 70hp outboard motor ("Swamp Thing"); a 3.6 m aluminum skiff powered by a 15hp outboard motor ("Sea acutus"); a gas-operated "Bobcat Club Cart" golf-cart; or, a canoe. The average speed of both skiffs and the cart was 2.5 kph, and 1.33 kph by canoe. Surveyed areas included mangrove shorelines, canals, brackish water lagoons, waterways, and immediate beachfront, shoreline areas from the northern tip of Laguna de Cayo Frances south to Boca Chica, the southernmost tip of the Ambergris Caye (Fig. 2). Unfortunately, due to an extremely dry season, exceptionally low water levels limited access to Laguna de Cayo Frances, and thus it was not included in this census.

Spotlight surveys typically began 15-30 minutes after sunset, and were only conducted during times of optimal visibility, avoiding heavy rains and windy nights when possible. All start and endpoints, the length of survey routes, and crocodile locations, were recorded with handheld GPS (Garmin Rhino 530HCx). Crocodiles were detected using one of three types of flashlight: a 22,000 candlepower maglite; a 28 Lumens, halogen, underwater, handheld flashlight; or, a Q-beam

Table 1. Survey results of spotlight surveys in Ambergris Caye, Belize (28 April-26 May 2013). *development with man-made canals throughout the mangrove; * sewage ponds were surveyed with Southeast roadside Waterways.

Survey Area	Start/Stop Lat/Longs	H	J	SA	A	EO	Total	km	ind/km
North roadside waterways	18° 03' 24.4" N, 87° 53' 19.0" W								
- golf cart	17° 58' 26.8" N, 87° 55' 38.5" W	3	3	0	3	0	9	19.9	0.45
Grand Belizean Estates*	17° 58' 13.3" N, 87° 56' 53.8" W								
- golf cart	17° 55' 57.8" N, 87° 57' 26.7" W	3	4	4	5	4	20	15.5	1.29
Northeast coast seaside	18° 01' 22.0" N, 87° 54' 09.6" W								
- Swamp Thing	17° 55' 49.3" N, 87° 57' 24.8" W	0	0	1	0	0	1	13.6	0.07
Northeast interior lagoons	17° 57' 36.1" N, 87° 57' 00.1" W								
- Sea acutus	17° 56' 02.7" N, 87° 57' 34.9" W	3	2	0	0	4	9	12.4	0.73
Southeast coast seaside	17° 52' 27.6" N, 88° 01' 12.0" W								
- Swamp Thing	17° 55' 50.1" N, 87° 57' 26.4" W	0	0	0	3	2	5	20.5	0.24
Southeast roadside Waterways**	17° 52' 32.4" N, 88° 01' 14.1" W								
- golf cart	17° 53' 49.6" N, 87° 59' 25.0" W	0	1	5	5	6	17	10.8	1.58
Sewage ponds**	17° 53' 49.6" N, 87° 59' 25.0" W								
- golf cart	17° 53' 49.5" N, 87° 59' 26.0" W	8	0	1	7	7	23	1.4	16.43
Southwest roadside waterways	17° 53' 44.3" N, 87° 59' 43.2" W								
- golf cart	17° 54' 06.9" N, 87° 58' 59.0" W	0	0	0	4	1	5	1.7	2.94
Ambergris Lake, closed pond	17° 54' 25.6" N, 87° 58' 34.9" W								
- canoe	17° 54' 25.6" N, 87° 58' 34.9" W	0	0	0	1	1	2	0.6	3.33
Southwest Pruett's roadside	17° 54' 56.4" N, 87° 58' 11.6" W								
- golf cart	17° 54' 38.4 N, 87° 58' 40.1" W	0	0	0	1	0	1	1.1	0.90
South Laguna del San Pedro	17° 55' 38.8" N, 87° 57' 32.1" W								
- Swamp Thing	17° 55' 55.7" N, 87° 58' 18.9" W	0	0	1	0	1	2	16.1	0.12
North Laguna del San Pedro	17° 55' 58.8" N, 87° 58' 17.0" W								
- Swamp Thing	17° 55' 50.0" N, 87° 57' 28.6" W	0	0	0	0	0	0	13.0	0.00
Southwest coast seaside and	17° 53' 08.7" N, 88° 01' 47.5" W								
Ciega Lagoon - Sea acutus	17° 54' 10.2" N, 87° 59' 36.1" W	0	0	0	0	5	5	12.2	0.41

3,000,000 candlepower, handheld spotlight. Each crocodile eyeshine sighted was confirmed by two of three observers before it was recorded. Once crocodiles were detected, efforts were made to approach the animal as close as possible to estimate total length (TL). Crocodiles were classified by their total length (TL) as hatchlings (<30-70 cm); juveniles (70-90 cm); sub-adults (90-180 cm); and, adults (>180 cm). To account for observer bias in estimating crocodile size (Webb and Choquenot 1987), total length was estimated by the same observer (Vincent Rose) each time, whose level of accuracy was documented to be ±8 cm consistently based on comparing estimated TLs to measured TLs of captured crocodiles. If TL could not be estimated reliably, the sighting was recorded as "eyes only" (EO).

A total of 76 *C. acutus* were recorded in the 137.4 km of channel/canal surveyed [relative density (RD)= 0.55 ind/km], and 23 were sighted at the San Pedro Sewage Treatment Plant (RD= 16.43 ind/km) (Table 1). The latter sightings (8H, 1SA, 7A, 7EO) may have moved to the sewage ponds due to nearby developments that have resulted in loss of habitat and an increase in salinity of the nearby lagoons resulting (from dredging). Observers have documented the same adult crocodiles in these sewage ponds numerous times over the past 3 years.

A high proportion (31%) of sightings were eyeshines, but most were juveniles or sub-adults. The population thus contains a high proportion of adults (at least 30%). Hatchlings (around 11 months of age) were sighted at four sites, and comprised 17% of the sighted population (Table 1).

It is difficult to extrapolate these results to the entire island, as most crocodiles were sighted in and around human residences rather than in the wild. This skewed distribution is considered to be created by the improper disposal of food wastes attracting fish and raccoons, which in turn attract crocodiles, and the direct feeding of wild crocodiles by residents. Nonetheless, the surveys provide baseline data with which the recovery of the population can be assessed over time. Future surveys will focus on the western coast and Laguna de Cayo Frances, which are less developed than those areas surveyed so far.

Recognised by The Belize Department of Fisheries as threatened (McField *et al*. 1996; Platt and Thorbjarnarson 2000a; Rainwater and Platt 2009), *C. acutus* is the primary apex predator, apart from man, inhabiting Ambergris Caye. The species is listed as a critical species in terms of need for conservation and as a high priority crocodilian requiring wild population recovery, management, and nest site protection in Belize (Ross 1998).

The preservation of Belize's critical wetland habitats and mangrove ecosystems is crucial to ensuring the recovery of the *C. acutus* population in Ambergris Caye. Only through collective efforts of attaining current information concerning crocodile populations and hatchling survival rates, in conjunction with investigating habitat conditions which are deemed vital to hatchlings' survival (Mazzotti and Cherkiss 2003), can one realize and implement the provisions essential for this critically vulnerable species, *C. acutus*, to once again become self-sustained.

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Europe

Germany

FIRST BREEDING OF THE PHILIPPINE CROCODILE (*CROCODYLUS MINDORENSIS*) IN EUROPE. Cologne Zoo (CZ) has long been engaged in the keeping and breeding of crocodilians. In 1980 the first worldwide zoo breeding of *Paleosuchus palpebrosus* occurred at the zoo. More recently, in mid-July 2013, the first breeding of the Philippine crocodile, *Crocodylus mindorensis*, occurred at Cologne Zoo Aquarium, which represents the first successful breeding of the species in Europe. The Philippine crocodile is one of the most endangered of the world's crocodilians, and the CSG has placed the species high on its priority list for conservation action and has recommended *ex-situ* management due to its fragile status in the wild.

The two adult Philippine crocodiles at CZ [Mindo (F), 15 years; Pinoy (M), 13 years] were imported from the Palawan Wildlife Rescue and Conservation Center (PWRCC) in the Philippines in 2006. At that time, 15 crocodiles were transferred to 6 zoos in Europe (see Banks *et al*. 2009), based on a Memorandum of Agreement which stated that they remain the property of the Philippine Government, and that the hosting institutions are obliged to support the Mabuwaya Foundation, a small non-profit organization dedicated to the conservation of the species in its natural habitat.

At first, from 2007 onwards, the two crocodiles at CZ were held in a newly created, spacious, off-exhibit facility at the CZ Aquarium. In May 2011 they were moved to a new public exhibit. In both facilities the pair was kept separated for most of the time due to somewhat aggressive behaviour. However, due to the manifold separable facility construction (Ziegler *et al*. 2011) and continued target training the pair could be selectively brought together from time to time.

First copulations occurred in early 2012, but egg deposition did not take place. Copulation between February and May 2013 was followed by egg deposition. Eggs discovered on 2 May 2013 were probably laid around 25 April 2013. The clutch comprised 10 eggs, one of which was broken (78 x 46 mm), 4 were deformed (distorted, constricted: 67.0-83.0 x 14.0-37.2 mm) and 5 (70-74 x 41-43 mm; mean 71.7 and mean 42.2 mm) which were artificially incubated.

Artificial incubation involved 28.5-29.5°C (3 eggs) and 31.5-32.5°C (2 eggs) with humidity up to 97%. When discovered, at least two of the artificially incubated eggs showed distinct banding (ca. 25 % of the egg length) and one egg had no opaque band.

On 13 July hatchling calls were heard coming from two eggs incubated at 28.5-29.5°C (the remaining one proved to be infertile), and we opened the egg from which we heard the loudest calls. The following day the second egg was opened. Here, the hatchling had already begun pipping the egg shell on the evening of 13 July, but had failed to get out.
Total incubation time is estimated as 79 and 80 days for the two eggs respectively. Both hatchlings ("Una" and "Pangalawa") have so far proved to be healthy. The individual which hatched first had a total length of about 230 mm about one week after hatching.

Figure 1. "Una" at one month of age (13 August 2013). Photograph: Thomas Ziegler.

The two eggs incubated at 31.5-32.5°C were opened in mid-August - both contained dead embryos. One embryo was in very early stage of development, and the other was far more advanced with a total length of 164 mm (snout-vent length 91 mm, tail length 73 mm).

This event represents the first successful reproduction of the Philippine crocodile in Europe. It is a significant contribution to the European studbook (ESB) population, as it is the first breeding after the initiation of the ESB, which is coordinated by CZ (Ziegler *et al*. 2013). CZ is also engaged with ethological research on Philippine crocodiles; so far four student theses dealing with social (in particular reproductive) behaviour and spatial use have been conducted at the zoo through direct observations as well as video camera recordings, and are being processed now for publication. Prior to copulation attempts a genetic screening of Philippine crocodiles held in Europe was conducted with the assistance of Braunschweig University, to confirm purity of animals and identify (and exclude) potential hybrids from the conservation breeding program (Hauswaldt *et al*. 2013). Besides financial support

of *in-situ* crocodile conservation activities in the Philippines, CZ also implements *in-situ* natural history research with the Critically Endangered Siamese crocodile (*C. siamensis*) in Vietnam (Cat Tien National Park) and Indonesian Borneo (Mesangat Lake) (Sommerlad *et al*. 2010).

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North America

USA

2012 CHRISTMAS CROCFEST. The 2012 Christmas CrocFest, a fundraiser for crocodilian conservation, took place on 8 December 2012 at Shawn and Jen Heflick's facility in Palm Bay, Florida, USA, raising a record $US15,000 for critically endangered Orinoco crocodiles (*Crocodylus intermedius*). CrocFest is an annual, grass-roots fundraiser supported by private individuals, businesses, and zoos, all with a common interest in conserving crocodilians. The funds raised at this year's event will be directed to Asociación Chelonia, a Madrid-based NGO that has made great progress in getting a comprehensive conservation program underway for Orinoco crocodiles in Colombia. 100% of the funds donated go to the cause, as all event expenses are covered by organizers Shawn Heflick, Flavio Morrissiey, Colette Adams and Curt Harbsmeier.

CrocFest has evolved into a family-friendly event, and attracted some 150 attendees who were treated to live animal displays and presentations (courtesy of Gator Adventure Productions), live music (courtesy of Daniel and Lisa Parker), BBQ (prepared fresh, on-site), libations, fishing, kayaking, a silent auction and finally, a rousing live auction conducted by Joe Wasilewski and Shawn. Event-goers were also treated to a tour of Shawn's lab, where scenes in episodes of National Geographic Wild's Python Hunters have been filmed. Finally, Luis Sigler from Dallas World Aquarium timed his delivery of two juvenile Orinoco crocodiles to Shawn's facility so that CrocFest attendees could witness their uncrating and see and study Orinoco crocodiles up close!

Rapport between Joe and Shawn made for a very entertaining and profitable live auction. Everyone enjoyed great food and camaraderie while bidding on unique items, including authentic items from Colombia (provided by Asociación Chelonia), and items donated by zoos, businesses and individuals throughout Florida and other parts of the country.

We want to thank all of the individuals, businesses and zoos which supported this fundraising event, including but not limited to: Jen Heflick, Thorne Heflick, Paul Bodnar, Perran Ross, Kent Vliet, Bill Ziegler, Joe Wasilewski, Shawn Heflick, Flavio Morrissiey, Curt Harbsmeier, Colette Adams, Norman Benoit, Swamp Men: Cattail and OneBear, Iris Doyle, Emily Maple, Katrene Click, Matt Shirley, Randal Berry , Woody Woodward, Denise Abreu, Terry Cullen, Brandon Greaves, Carlos Rofa, Mike Tietgen, Josh Zarmoti, Tom Crutchfield, Patty Porter Allington, Erin Smestad, Trace Hardin, Andy Reeves, Forest Fanning, Don Kaye, Marty Penny, Shawn Tripala, Kevin Earley, Paul Owen, Robin Moniz, Kevin Oppenheimer, George Cera, Charles Alexander, Kim Titterington, Nancy and Ernie Little, Clay Ferrara, Kevin Albin, Bruce Shwedick, James Murphy, Pat Burchfield, Eric Thiss, Gary Johnson, Steve Conners, Virginia Aquarium (Mark Swingle and Chip Harshaw), Bronx Zoo (New York Zoological Society/WCS; Don Boyer), Crocodile Conservation Institute, Ellen Trout Zoo (Gordon Henley), Black Hills Reptile Gardens (Terry Phillip), Central Florida Zoo (Joe Montesano), Jacksonville Zoo (Dino Ferri), Florida Association of Zoos & Aquariums, Tampa's Lowry Park Zoo (Larry Kilmar), Busch Gardens (Mike Malden), Dallas World Aquarium (Luis Sigler), Zoo Atlanta (Dwight Lawson), Wildlife Discovery Center at Elawa Forest (Rob Carmichael), San Antonio Zoo (Bekky Muscher), St. Augustine Alligator Farm (John Brueggen), Brevard Zoo, Palm Beach Zoo, Agritoxins (Jack Facente), Incredible Pets, Indigenous Arts (David Kledzick), Metal Artz, ZooMed, C.A.R.E. Foundation, Gator Made, Gatorama (Alan Register).

About the Supported Conservation Program

Commercial hunting of the Orinoco crocodile began around

1929, and from that time to 1960 it is estimated that between 2 and 4 million crocodiles were killed in Venezuela and Colombia. Until very recently, parts of Colombia have not been safe for western scientists. For this reason, less is known about the status of Orinoco crocodiles in the wild in Colombia versus Venezuela. Surveys now reveal that the total wild population of Orinoco crocodiles in Colombia is possibly as low as 130 adults, down from an estimated 780 in 1974-75. That is why Asociación Chelonia's work is so important now.

The majority of the remaining population of this species in Colombia is located in the area where the work of Asociación Chelonia is taking place. Its program, initiated in 2010, began with surveys of the wild population in conjunction with evaluation of the crocodiles' ecosystems. With much of the groundwork for this project already laid, its proposed activities over the next two years include the following:

- Identify an adequate site for a headstart and release program, with accessibility for follow-up and enforcement of protection laws in mind.
- Work with landowners to create a private reserve for a pilot reintroduction program.
- Continue to conduct local and national education campaigns, including the development of web pages for children, educators and biologists.
- Develop publications on the 6 species of crocodilians in Colombia and distribute these free-of-charge to educational, environmental and conservation-based entities.

The budget that has been developed to conduct these activities is $US194,404. Not including the proceeds of Christmas CrocFest 2012, over $US120,000 has already been raised with support from such organizations as the Endowment Fund for Biodiversity (France), the Biodiversity Foundation (Spain), and ANP-Natural Protected Areas (Colombia).

About Asociación Chelonia

Dedicated to the creation of scientific conservation partnerships for sustainable human development and the conservation of nature, Asociación Chelonia was formed in 1997 by the Students of Biological Sciences, Madrid. It is established at 10 sites within Spanish territories and has permanent offices in 6 other countries. In addition to its work with Orinoco crocodiles in Colombia, its focus areas include amphibian decline, climate change and sea turtle conservation. In 2010, Asociación Chelonia entered into a 5-year cooperative agreement with Corporinoquia (the Government environmental authority in Colombia) to work together on Orinoco Crocodile conservation. Additionally, this first-ever targeted-release program was included as one action item in the 1998-2008 National Program for the Conservation of Orinoco Crocodiles in Colombia.

SUMMER CROCFEST 2013. Summer CrocFest 2013, a fundraiser for crocodilian conservation, took place on Saturday, 29 June 2013 from 4 pm until 10 pm, at Reptile World Serpentarium in St. Cloud, Florida, USA. The event raised $US11,000 for Jamaican crocodiles, *Crocodylus acutus*. CrocFest is a biannual, cooperative, grass-roots fundraiser supported by private individuals, businesses, and zoos, all with a common interest in conserving crocodilians. The funds raised at this year's event will be directed toward a festival to be held in Jamaica to raise public awareness and support for Jamaican crocs, as well as surveys, population monitoring, public awareness building, habitat protection/enhancement and education programs. All (100%) of the funds raised at the event will go to the cause, as expenses were covered by organizers Shawn Heflick, Flavio Morrissiey, Colette Adams and Curt Harbsmeier, with generous contributions from underwriters Gator Adventure Productions and Ship Your Reptiles/The Reptile Report.

Figure 1. Jamaican crocodile, *Crocodylus acutus*.

CrocFest is a family-friendly event, and it attracted some 125 attendees who were able to meet and spend time with world-famous venomous snake expert, George Van Horn. For the price of admission, guests were allowed to venture through the live reptile exhibits at Reptile World Serpentarium. They were also treated to live alligator presentations (courtesy of Gator Adventure Productions), live Jamaican music, authentic Jamaican cuisine, libations, and finally, a rousing live auction conducted by Joe Wasilewski and Shawn Heflick.

Figure 2. MacKenzie Warren and her father, Craig Warren, with a young Jamaican crocodile.

Prior to the commencement of the auction, internationally renowned crocodile expert and the CSG's IUCN Red List Authority, Dr. Perran Ross, addressed the crowd, outlining

the need for an organized effort on behalf of crocodiles in Jamaica. Afterwards, rapport between Joe and Shawn made for a very entertaining and profitable live auction. Everyone enjoyed great food and camaraderie while bidding on unique items donated by zoos, businesses and individuals throughout Florida and other parts of the country.

We want to thank all of the individuals, businesses and zoos that supported this fundraising event, including but not limited to: George Van Horn, Megan and Nick Terry, Wendy Morrissiey, Paul Bodnar, Perran Ross, Kent Vliet, Bill Ziegler, Joe Wasilewski, Shawn Heflick, Flavio Morrissiey, Curt Harbsmeier, Colette Adams, Norman Benoit, Otter Johns WL Shaw, Lonnie McCaskill, Patty Scanlan, Josh Walton, Jerry Tuttle, Mike Mangine, Marty Penny, Adam Shockey, Joey Forfield, Russell Lawson, Candace Donato, Rachel Arnott, Wayne Hill, Arianna Bailey, Patrick Delany, Bruce Shwedick, Jeremy Maley, John Segerstedt, Tom Crutchfield, Ty Park, Ft. Worth Zoo (Mike Fouraker and Tarren Wagener Wiggans), Jacksonville Zoo (Dan Maloney and Steve Gott), Busch Gardens (Mike Malden), Wildlife Discovery Center at Elawa Forest (Rob Carmichael), Virginia Aquarium (Mark Swingle and Chip Harshaw), The Florida Aquarium (John Than), Central Florida Zoo (Joe Montesano), Albuquerque Bio Park (Matt Eschenbrenner), Florida Teaching Zoo, Gator Adventure Productions, Ship Your Reptiles/The Reptile Report, Crocodile Manor, Shawn Heflick Reptiles, Florida Reptile Room, Pet Supermarket, Indigenous Arts (David Kledzick), Metal Artz, Gator Made.

Figure 3. From left: Shawn Heflick, Curt Harbsmeier, Colette Adams, Danae Vaccianna and Flavio Morrissiey.

About the Supported Conservation Program

Working in cooperation with Jamaica's National Environmental and Planning Agency (NEPA), the Urban Development Corporation (UDC), the Caribbean Coastal Area Management Foundation (C-CAM), The Caribbean Wildlife Alliance (CWA), and the University of the West Indies (UWI), funds raised will support the following: field work, including surveys and nest area enhancement; public awareness, including a crocodile festival in Jamaica to engage local support; and, the production and distribution of educational materials for children.

The prospectus for a Crocodile Conservation Action Plan for Jamaica was recently drafted by Perran Ross (CSG/ University of Florida) after a meeting held on 16 February 2013 in Homestead, Florida. Some 80 individuals attended the meeting, including representatives from governmental agencies, universities, zoos, and members of the private sector. Also in attendance were representatives of NEPA, UDC, and UWI. They discussed the dire situation of *C. acutus* in Jamaica [see CSG Newsletter 31(3): 6-7], as well as 6 broad areas of activity required for the conservation of the species. These are: research; public relations; institutional coordination and capacity building; fundraising; legislation; and, priority areas.

Mike Fouraker, Executive Director of Ft. Worth Zoo and President of the Caribbean Wildlife Alliance (CWA), a non-profit NGO based in Ft. Worth, Texas, has agreed to manage the funds raised at Summer Croc Fest 2013 though CWA. CWA's management will include banking, accounting, and leveraging funds as matching monies to increase the projects' coffers. Currently, CWA manages 8 conservation accounts, including accounts for Jamaican amphibians, the Jamaican iguana, the Puerto Rican Crested Toad Recovery Project, the Cryptobranchid Interest Group, and a Jamaican botanical study for the Botanic Research Institute of Texas.

East and Southeast Asia

Philippines

NATIONAL ACADEMY OF SCIENCE AND TECHNOLOGY PHILIPPINES SUPPORTS A RESOLUTION FOR THE CROCODILE (*CROCODYLUS POROSUS*) SKIN INDUSTRY IN THE PHILIPPINES. The National Academy of Science and Technology Philippines (NAST) presented a resolution summarizing the recommendations of the 35th NAST Annual Scientific Meeting (10-11 July 2013) to the Department of Trade and Industry (DTI) and the Department of Science and Technology (DOST). The Crocodylus Porosus Philippines Incorporated (CPPI) presentation on the "Status of Crocodile Industry in the Philippines" has been favorably accepted by NAST as part of their resolution for the DTI to provide the necessary fiscal and regulatory framework to support emerging industries, including the crocodile skin industry.

Within the theme of the meeting "Harnessing Science and Tecnology: Reversing the Decline of the Manufacturing Sector in the Philippines", CPPI recommended that Government support CPPI's attempt to access more competitive technology for skin production, increase social acceptability of crocodile meat as an alternative protein source, support the development of by-products for therapeutic use, and

provide the legal framework and necessary documentation for the sale of products. CPPI also suggests that an increase in Government support for conservation research would provide direct benefits to the Filipino people through community-based sustainable ecotourism as source of livelihoods for local communities. The increase in the wild population of crocodiles would also increase the productivity of wetlands, thus benefiting those fishing villages with crocodiles in the wild.

The following Executive Summary was presented by CPPI during the Technical Session on Biological Sciences (chaired by NAST Academician Dr. Angel C. Alcala).

State of Crocodile Industry in the Philippines

The crocodile farming industry in the Philippines is strictly regulated by CITES for the use of *Crocodylus porosus* in closed-cycle breeding upon production of second or F2 generation, making commercial international trade of their product less regulated. With the establishment of the Department of Environment and Natural Resources (DENR) RP-Japan Crocodile Farming Institute (CFI), Palawan in 1988 (renamed "Palawan Wildlife Rescue and Conservation Center, PWRCC), farming technology for crocodiles in the Philippines was developed. This technology has been transferred to private entities which passed through a stringent screening process (Manolo and Alcala 2013; Mercado 2008).

Thus, in 1999, the DENR issued the Department Administrative Order (DAO) 99-45 or the Rules and Regulation on the SALE AND FARMING OF SALTWATER CROCODILE. This legal framework defined the stringent selection process for choosing competent private poultry and piggery farms that would utilize their original *C. porosus* founder stock from the Philippine Government CITES registered facility for the leather industry and direct trade for animals produced in commercial farms.

Inception of crocodile farming

In 2000, 6 commercial farms out of nearly 80 applicants successfully passed the evaluation process conducted by Government. These 6 farms (3 in Luzon, 3 in Mindanao) pioneered this non-traditional industry and participated in commercial crocodile farming to develop local capability on Saltwater Crocodile farming. This was the birth of the crocodile industry in the Philippines.

Crocodile farmers or "Cooperators" (DAO 99-45), obtained young crocodiles from the Government for grow-out until commercially available size. After 2-3 years of rearing, the skin quality was judged substandard by the international industry due to inappropriate rearing facility for producing quality, Class "A" skins. The "Cooperators" had no choice but to retain the stocks and convert to close system breeding in order to utilize rapidly maturing crocodiles. They became "accidental" crocodile breeding farms.

Industry development and economic contribution

In order to strengthen ties between crocodile breeding farms, CPPI, a coalition of the 6 legitimate crocodile farms, was created. In coordination with the Philippine Government, CPPI pioneered the crocodile skin industry in the Philippines. CPPI likewise aims for conservation through sustainable use and management or value-driven conservation of the two crocodile species in the Philippines. Commercial farms were developed by integrating large-scale supply of culled layer, grower chickens and unwanted mortalities from piggeries and poultry operations as crocodile feeds, converting operational loss into cash commodity and ensuring non-competition with humans for food consumption.

After 8 years of high capital expenditures on infrastructure development and painstaking husbandry consultation to resolve farm issues and some capital errors, CPPI farms have obtained the most current and "State of the Art" technology. CPPI has significantly advanced the local crocodile farming industry to the extent of bringing in new technology and research outcomes on farm designs, innovations on husbandry practices, provisions of slaughterhouses, CITES recognition, introduction of meat products, and the near perfection of leather industry, bringing it closer to the achievement of international standards for crocodile farming and conservation.

To date, CPPI associated farms have approximately 25,000 crocodiles housed in a variety of facilities depending on their needs. Crocodile breeding cycle consists of four stages: breeding, incubation and hatching, nursery, and two phases of grow-out for skin production.

Commercial utilization of *C. porosus* for the production of valuable skins is the primary product of the industry. Of secondary importance is the introduction of crocodile meat as protein source for humans. Philippine crocodile farms started its contribution to the world crocodilian trade in 2008. With this small developing industry of 6 registered farms, two of which have processing facilities, there were about 4000 *C. porosus* skins have been exported in 2008-2012 for the leather industry. At present, frozen and processed meat products are slowly contributing to the local economy, an average of almost a ton of meat per month, equivalent to 45% of annual meat productions are consumed for domestic use. Other by-products (such as crocodile oil and blood) are being developed for pharmaceutical purposes.

It is projected that a total of 10,000 raw salted *C. porosus* skins will be exported by CPPI associated farms over the next 5 years.

Support for conservation

Crocodile Farming Industry in the Philippines is not mainly geared towards generating income for individual farms. CPPI is also working towards the conservation of two species of crocodile in the wild, focusing primarily in three priority sites in Mindanao: (1) Siargao Island Protected Landscape and Seascape in which 36 juvenile *C. mindorensis* have been

released back to natural habitat; (2) Agusan Marsh Wildlife Sanctuary where it aims to provide a long-term management plan that will address issues on human-crocodile coexistence; and (3) Ligawasan Marsh Game Refuge & Wildlife Sanctuary where it targets further research and development of a conservation action plan to uphold the possible increase in the population of both species. With these efforts, CPPI recognizes that the commercial crocodile industry in the Philippines has a responsibility to the Filipino people and its future generations to help conserve these two species of crocodiles in the natural habitat. This highly regulated industry can be a model for commercial and conservation partnership.

Acknowledgements

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STATUS OF INTRODUCED PHILIPPINE CROCODILES (*CROCODYLUS MINDORENSIS*) IN PAGHONGAWAN MARSH, SIARGAO ISLAND, PHILIPINES. On 5-12 June 2013, about three months after the successful soft-release of 36 healthy juvenile Philippine Crocodiles on 22 March 2013 in Paghongawan Marsh on the island of Siargao (Mercado *et al*. 2013), researchers from Silliman University-Angelo King Center for Research and Environmental Management (SUAKCREM) were deployed in Siargao Island to begin a long-term study on the potential role of Philippine Crocodiles on the productivity of wetlands. The study will cover two freshwater marshes in Siargao Island: Paghongawan Marsh (Fig. 1) in the municipality of Pilar (Experimental Site); and, Sangay-Lilaw Marsh in the municipality of Burgos (Control Site). These sites were chosen due to their similarity in physical features. This study is part of a nationwide collaborative project being implemented by Crocodylus Porosus Philippines, Inc. (CPPI) and SUAKCREM to test a long-standing hypothesis proposed by Fittkau (1970) (known as the Fittkau Hypothesis). According to this hypothesis, crocodilians play a major role in the nutrient regime of a freshwater body, which may have an impact on the local fishery.

Figure 1. Siargao Island Protected Landscapes and Seascapes, Surigao Del Norte, Philippines showing Paghongwan Marsh Philippine Crocodile release site.

Siargao is an ideal site to test whether or not Philippine Crocodiles, which were once common in Philippine freshwater bodies but has a declining population, has a critical role in enhancing the productivity, both primary (via phytoplankton production) and secondary (through fishery yield). At present, the data gathered can be interpreted only as baseline while the subsequent data after about a year and onwards will ultimately determine as to what extent crocodilians impact the productivity of Paghongawan Marsh.

The initial results of the baseline study are presented below:

Aquatic Primary Productivity

Figure 2 shows the Gross Primary Productivity (GPP) values determined using the light and dark bottles method. It should be noted that mean GPP values were higher in Paghongawan Marsh (9.91±2.97 mgC/m^3/hour and 15.55±0.64 mgC/m^3/hour in the first and second ponds, respectively), compared to that in San Mateo [3.18±0.99 mgC/m^3/hour (Sangay) and 4.46±1.49 mgC/m^3/hour (Lilaw)].

Because it was only three months since the crocodiles were released, the increased aquatic primary productivity in Paghongawan Marsh might be attributed to several factors such as abundance of phytoplankton and water clarity. Nutrient level of the water (probably derived from decomposition of plant materials and from upstream sources such as cattle excreta and runoff) did not differ significantly between sites. Nitrate concentration mean values were determined

as follows: 5.96±1.04 µmol/L and 10.76±5.06 µmol/L in Paghongawan Marsh; and, 11.99±6.52 µmol/L and 7.70±2.08 µmol/L in Sangay and Lilaw in San Mateo, respectively.

Although we assume that at this stage that the excreta of the small, recently introduced Philippine Crocodiles may have contributed only a small amount of nutrients in the water, it is possible that they help enhance the nutrient level in the water column as they scour the substratum (including attached algae or periphyton) when they forage at night.

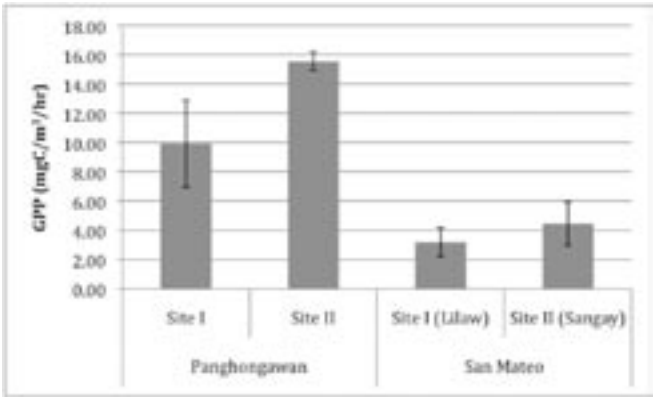

Figure 2. Gross aquatic productivity (mg C/m^3/hour) values in Paghongawan Marsh compared with Sangay-Lilaw Marsh (June 2013).

Fishery Assessment

The highest total catch (in one hour of fishing) was recorded at the release site (Ka-Caesar) in Paghongawan with 28.34 kg of fish and mean catch-per-unit effort (CPUE) of 9.44±7.62 kg/net/hour while in the adjacent pond, only 4.58 kg were recorded (mean= 1.53±0.77 kg/net/hour). In Sangay-Lilaw Marsh, mean CPUEs of 2.29±1.46 kg/net/hour and 0.36±0.23 kg/net/hour were recorded, respectively (Fig. 3). The increased CPUE in the release site in Paghongawan might be attributed to reduced fishing pressure in the area as the local fishers tend to concentrate their fishing activities in the second pond. It is probably too early to attribute fish abundance to aquatic productivity.

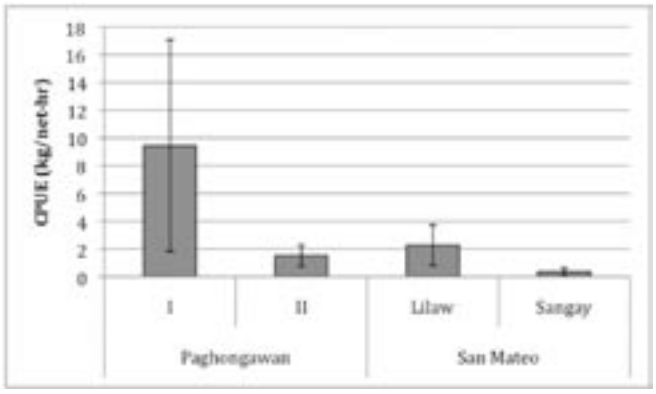

Figure 3. CPUE of gill net in Paghongawan compared with Lilaw-Sangay Marsh (June 2013).

Because of the relatively low abundance of other potential prey items of Philippine Crocodiles in Paghongawan Marsh such as wading birds, reptiles, and frogs, fishes might be the main food source of the growing crocodiles in the near future. It is therefore necessary that the local fishery be managed properly.

In Panghongawan, a total of 245 fishes (6 species) were sampled, comprised of; Nile Tilapia *Oreochromis niloticus* (199), Common Carp *Cyprinus carpio* (19), Catfish *Clarias macrocephalus* (15), Climbing Perch *Anabas testudineus* (8), Snakehead *Channa striata* (3), and Giant-Mottled Eel *Anguilla* cf *marmorata* (1). In San Mateo, only 98 individuals were sampled which consisted of 4 species, as follows: *Oreochromis mossambicus* (40), *Oreochromis niloticus* (39), *Channa striata* (17), and *Anabas testudineus* (2).

Aside from determining the productivity of the study areas, visual surveys (standard spotlight) were also conducted on two separate occasions (7-9 June and 6-7 August). Local residents and barangay (village) officials participated in the night observations and spotlight counting of crocodiles.

Monitoring and Protecting Philippine Crocodiles with Local Residents

On 10 June 2013, about 10 individuals were spotted in the release site while only 5 individuals were regularly counted on three nights in the adjacent secondary pond (now isolated from the latter by a dry grassy area due to reduced water level during the dry season) - thus an estimated 15 individuals were recorded (Fig. 4). While on 7 August 2013, a total of 26 individuals were recorded in different locations in the entire marsh where most of the observation were found within the release site. None of the crocodiles were sighted in the water near the village (about 1 km from the release site). Two crocodiles were confirmed dead and retrieved by local residents and village watchmen. Knowledge on the accidental catch leading to death of crocodiles has reached the municipal local government of Pilar which immediately respondes to investigate the case. According to the locals, these crocodiles were trapped by gillnets installed at night by fishers from an adjacent barangay. This event provides a basis for the barangay council to pass an ordinance prohibiting the use of fishing nets and regulating the use of hook-and-line fishing in Paghongawan Marsh. Along with these regulations, the majority of the locals organized themselves into an association named Jaboy Ecotourism and Conservation Organization (JECO), with the primary goal to protect and promote the Philippine Crocodile as a flagship for threatened species conservation.

It is interesting to note that at the release site, 5-6 crocodiles were found resting on near-water vegetation at a closer distance of less than 5 m, sometimes reaching about a foot with each other while foraging at night. Of at least 10 close encounters with each other, aggressive behavior was not evident, contrary to previous reports in other localities. At least two crocodiles approached our boat, probably curious of the bright red LED light, leading to closer photographs (Fig. 4).

Figure 4. Philippine Crocodiles observed during spotlight survey of Paghongawan Marsh.

On several occasions, these crocodiles were observed foraging, beginning at about 1800 h. On one occasion, one crocodile searched for food under a limestone ledge with surrounding vegetation. Possible prey items include birds (*Amaurornis phoenicurus*, *Porzana cinerea*, *Gallirallus torquatus*), fish (*Cyprinus carpio*, *Channa striata*, *Oreochromis niloticus*), and frogs (*Limnonectes grandocula*).

The Paghongawan Marsh is being organized for Community-based Sustainable Tourism featuring its natural serene landscape and rich biodiversity through Crocodile Night Watch as main attractions. Other potential attractions in the area may include guided observations of several endangered and endemic fauna such as the Philippine Tarsier (*Tarsius syrichta*), Philippine Duck (*Anas luzonica*), Mindanao Tarictic Hornbill (*Penelopides affinis*), and Rufous Hornbill (*Buceros hydrocorax*).

Acknowledgments

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Abner A. Bucol[1], Paulina S. Aspilla[2], Carl P. Dipaling[2], Rainier I. Manalo[3], Philip C. Baltazar[3], Angel C. Alcala[1,2,3], Vicente P.Mercado[3], William T. Belo[3] and Salvador S. Chan[3]: *[1]Silliman University-Angelo King Center for Research & Environmental Management, AC Alcala Environment & Marine Sciences Laboratories, Bantayan, Dumaguete City 6200 (abner.muraenesoxbeth@gmail.com, suakcrem@yahoo.com); [2]Silliman University-Chemistry Department, SU-Science Complex, Dumaguete City 6200 (paulina.aspilla@yahoo.com); [3]Crocodylus Porosus Philippines Incorporated (philip pinecrocodile@yahoo.com).*

Science

Recent Publications

Moyle, B. (2013). Conservation that's more than skin-deep: alligator farming. Biodiversity and Conservation (doi: 10.1007/s10531-013-0501-9).

Abstract: Wildlife farming is a contentious conservation measure. In Louisiana alligator farming has generated significant conservation gains. This case study is used to test several assumptions employed in debates about wildlife farming. These include whether farming 'floods' the market to depress prices and deter poaching, whether it encourages wild harvest and whether it can compete against wild harvest. Data from over three decades is used to model harvest behaviour with OLS and SUR models. This shows strong separation between the market between farmed and wild alligator skins. Immense rises in farmed output have not caused prices to collapse, however poaching has collapsed. This highlights that farming can have important non-price effects on poaching. Assumptions that are commonly used to debate wildlife farming are not supported in this example. Such assumptions, including open-access of the wildlife, inert and exogenous wildlife managers and excluding indirect benefits of wildlife farming tend to bias policy away from farming. Using these assumptions makes it harder to identify cases where wildlife farming could assist conservation objectives.

Jablonicky, C.A. (2013). Spatial Distribution of the Nile Crocodile (*Crocodylus niloticus*) in the Mariarano River System, Northwestern Madagascar. MSc thesis, University of Southern California, California, USA.

Abstract: Little is known about the Nile crocodile (*Crocodylus niloticus*) population in Madagascar; however, its population is believed to be in decline resulting from hunting and

habitat loss. This study maps the distribution of the Nile crocodile population in the Mariarano River in Northwestern Madagascar during the dry season (May-October) using the maximum entropy model Maxent. Four biophysical factors are included in the first model and the second model includes two additional anthropogenic factors of distance from roads and distance from villages to observe the effect of humans on suitable habitat for crocodiles. Data were collected in June-August 2011 and 2012. Model performance was assessed using the Receiving Operating Curve (ROC) and Area under the Curve (AUC), using 10 replicates of both models. Both models adequately predicted species occupancy using the test data: the anthropogenic model receiving model performance rating of excellent and the biophysical factor-only model receiving a rating of average. While the results initially indicated that the distance from roads was the most important variable to the model, other possible anthropogenic influences such as boat activity on the river and mangrove destruction were not included. The distribution map produced for the model can be used as a baseline for Nile crocodile distribution within the river and aid in conservation management decisions about the Nile crocodile in the region.

Platt, S.G., Elsey, R.M., Liu, H., Rainwater, T.R., Nifong, J.C., Rosenblatt, A.E., Heithaus, M.R. and Mazzotti, F.J. (2013). Frugivory and seed dispersal by crocodilians: an overlooked form of saurochory? Journal of Zoology (doi: 10.1111/jzo.12052).

Abstract: Saurochory (seed dispersal by reptiles) among crocodilians has largely been ignored, probably because these reptiles are generally assumed to be obligate carnivores incapable of digesting vegetable proteins and polysaccharides. Herein we review the literature on crocodilian diet, foraging ecology, digestive physiology and movement patterns, and provide additional empirical data from recent dietary studies of *Alligator mississippiensis*. We found evidence of frugivory in 13 of 18 (72.2%) species for which dietary information was available, indicating this behavior is widespread among the Crocodylia. Thirty-four families and 46 genera of plants were consumed by crocodilians. Fruit types consumed by crocodilians varied widely; over half (52.1%) were fleshy fruits. Some fruits are consumed as gastroliths or ingested incidental to prey capture; however, there is little doubt that on occasion, fruit is deliberately consumed, often in large quantities. Sensory cues involved in crocodilian frugivory are poorly understood, although airborne and waterborne cues as well as surface disturbances seem important. Crocodilians likely accrue nutritional benefits from frugivory and there are no a priori reasons to assume otherwise. Ingested seeds are regurgitated, retained in the stomach for indefinite and often lengthy periods, or passed through the digestive tract and excreted in feces. Chemical and mechanical scarification of seeds probably occurs in the stomach, but what effects these processes have on seed viability remain unknown. Because crocodilians have large territories and undertake lengthy movements, seeds are likely transported well beyond the parent plant before being voided. Little is known about the ultimate fate of seeds ingested by crocodilians; however, deposition sites could prove suitable for seed germination. Although there is no evidence for a crocodilian-specific dispersal syndrome similar to that described for other reptiles, our review strongly suggests that crocodilians function as effective agents of seed dispersal. Crocodilian saurochory offers a fertile ground for future research.

Greenwold, M.J. and Sawyer, R.H. (2013). Molecular evolution and expression of Archosaurian β-keratins: diversification and expansion of Archosaurian β-keratins and the origin of feather β-keratins. J. Exp. Zool. (Mol. Dev. Evol.) (doi: 10.1002/jez.b.2251).

Abstract: The archosauria consist of two living groups, crocodilians, and birds. Here we compare the structure, expression, and phylogeny of the beta (β)-keratins in two crocodilian genomes and two avian genomes to gain a better understanding of the evolutionary origin of the feather β-keratins. Unlike squamates such as the green anole with 40 β-keratins in its genome, the chicken and zebra finch genomes have over 100 β-keratin genes in their genomes, while the American alligator has 20 β-keratin genes, and the saltwater crocodile has 21 β-keratin genes. The crocodilian β-keratins are similar to those of birds and these structural proteins have a central filament domain and N- and C-termini, which contribute to the matrix material between the twisted β-sheets, which form the 2-3 nm filament. Overall the expression of alligator β-keratin genes in the integument increases during development. Phylogenetic analysis demonstrates that a crocodilian β-keratin clade forms a monophyletic group with the avian scale and feather β-keratins, suggesting that avian scale and feather β-keratins along with a subset of crocodilian β-keratins evolved from a common ancestral gene/s. Overall, our analyses support the view that the epidermal appendages of basal archosaurs used a diverse array of β-keratins, which evolved into crocodilian and avian specific clades. In birds, the scale and feather subfamilies appear to have evolved independently in the avian lineage from a subset of archosaurian claw β-keratins. The expansion of the avian specific feather β-keratin genes accompanied the diversification of birds and the evolution of feathers.

Zheng, X., O'Connor, J., Huchzermeyer, F., Wang, X., Wang, Y., Wang, M. and Zhou, Z. (2013). Preservation of ovarian follicles reveals early evolution of avian reproductive behaviour. Nature 495: 507-511.

Abstract: The two groups of archosaurs, crocodilians and birds, form an extant phylogenetic bracket for understanding the reproductive behaviour of dinosaurs. This behaviour is inferred from preserved nests and eggs, and even gravid individuals1. Data indicate that many 'avian' traits were already present in Paraves-the clade that includes birds and their close relatives - andthat the early evolution of the modern avian form of reproduction was already well on its way. Like living neornithine birds, non-avian maniraptorans had daily oviposition and asymmetrical eggs with complex shell microstructure, and were knownto protect their clutches.

However, like crocodilians, non-avian maniraptorans had two active oviducts (one present in living birds), relatively smaller eggs, and may not have turned their eggs in the way that living birds do. Here we report on the first discovery of fossilized mature or nearly mature ovarian follicles, revealing a previously undocumented stage in dinosaur reproduction: reproductively active females near ovulation. Preserved in a specimen of the long bony-tailed *Jeholornis* and two enantiornithine birds from the Early Cretaceous period lacustrine Jehol Biota in northeastern China, these discoveries indicate that basal birds only had one functional ovary, but retained primitive morphologies as a result of their lower metabolic rate relative to living birds. They also indicate that basal birds reached sexual maturity before skeletal maturity, as in crocodiles and paravian dinosaurs. Differences in follicular morphology between *Jeholornis* and the enantiornithines are interpreted as forming an evolutionary gradient from the reproductive condition in paravian dinosaurs towards neornithine birds. Furthermore, differences between the two enantiornithines indicate that this lineage might also have evolved advanced reproductive traits in parallel to the neornithine lineage.

Excurra, M.D., Butler, R.J. and Gower, D.J. (2013). 'Proterosuchia': the origin and early history of Archosauriformes. Geological Society, London, Special Publications, 379 (doi:10.1144/SP379.11).

Abstract: The earliest history of Archosauriformes is mainly represented by members of Proterosuchidae and Erythrosuchidae, which are known worldwide from latest Permian to Middle Triassic beds. These two groups were historically combined within 'Proterosuchia', with approximately 30 nominal species. Two morphotypes have been recognized among proterosuchians: proterosuchids with a generally more sprawling gait and elongated and low skulls with an overhanging premaxilla, and the more heavily built erythrosuchids, with a probably less sprawling gait and large, presumably hypercarnivorous, skulls. The systematics of 'Proterosuchia' was relatively chaotic throughout most of the twentieth century, but currently there exists consensus regarding the non-monophyly of proterosuchians and their phylogenetic position outside all other archosauriforms. In contrast, the delimitation and taxonomic content of Proterosuchidae and Erythrosuchidae remain unstable. Few studies of proterosuchian palaeobiology have been carried out. Current lines of evidence favour a predominantly terrestrial lifestyle for proterosuchians. Limb bone histology indicates rapid continuous growth rates in *Proterosuchus* and *Erythrosuchus* before reaching sexual maturity. A better knowledge of proterosuchian anatomy, systematics, evolution and ecology is important for advancing understanding of the origin and early radiation of Archosauriformes and the patterns of biotic recovery following the Permo-Triassic mass extinction event. There remains much research to be carried out in proterosuchian palaeobiology.

Weber, R.E., Fago, A., Malte, H., Storz, J.F. and Gorr, T.A. (2013). Lack of conventional oxygen-linked proton and anion binding sites does not impair allosteric regulation of oxygen binding in dwarf caiman hemoglobin.

Abstract: In contrast to other vertebrate hemoglobins (Hbs), whose high intrinsic O_2 affinities are reduced by red cell allosteric effectors (mainly protons, CO_2, organic phosphates and chloride ions), crocodilian Hbs exhibit low sensitivity to organic phosphates and high sensitivity to bicarbonate (HCO_{3^-}), which is thought to augment Hb-O_2 unloading during diving and postprandial 'alkaline tides' when blood HCO_{3^-} levels as well as metabolic rates increase. Examination of α- and β-globin amino acid sequences of dwarf caiman (*Paleosuchus palpebrosus*) revealed a unique combination of substitutions at key effector binding sites compared to other vertebrate - and crocodilian - Hbs: β82Lys -> Gln, β143His ->Val, and β146His -> Tyr. These substitutions delete positive charges and - along with other distinctive changes in residue charge and polarity - may be expected to disrupt allosteric regulation of Hb-O_2 affinity. Strikingly, however, *P. palpebrosus* Hb shows a strong Bohr effect, as well as marked deoxygenation-linked binding of organic phosphates (ATP and DPG) and of CO_2 as carbamate (contrasting with HCO_{3^-} binding in other crocodilians). Unlike other Hbs, it polymerizes to large complexes in the oxygenated state. The highly unusual properties of *P. palpebrosus* Hb align with a high content of His residues (potential sites for oxygenation-linked proton binding) and distinctive surface Cys residues that may form intermolecular disulfide bridges upon polymerization. Based on its singular properties, *P. palpebrosus* Hb provides a unique opportunity for studies on structure-function coupling and the evolution of compensatory mechanisms for maintaining tissue O_2 delivery in Hbs that lack conventional effector-binding residues.

Osia, A. (2013). The evolution of jaw mechanism and dental function in heterodont crocodyliforms. Historical Biology: An International Journal of Paleobiology (doi: 10.1080/089 12963.2013.777533).

Abstract: Heterodont dentition sometimes including multicuspid crowns appeared in numerous fossil forms through all main lineages of the Crocodyliformes. Teeth in these complex dentitions frequently bear wear facets that are exclusive indicators of tooth-tooth occlusion. Besides, dental features, specialisations of the jaw apparatus, jaw adductors and mandibular movement can be recognised, all reflecting a high variability of jaw mechanism and of intraoral food processing. Comparative study of these features revealed four main types of jaw mechanism, some of which evolved independently in several lineages of Crocodyliformes. Isognathous orthal jaw closure (precise jaw joint, rough wear facets) is characteristic for heterodont protosuchians and all forms possessing crushing posterior teeth. Proal movement (protractive powerstroke) occurred independently in *Malawisuchus* and *Chimaerasuchus* is supported by the antagonistic, vertically oriented carinae. Developed external adductors are the main indicators of palinal movement (retractive powerstroke) that evolved at least two times in various South American

taxa. The fourth type (in *Iharkutosuchus*) is characterised by lateromedial mandibular rotation supported by extensive horizontal wear facets. This evolutionary scenario resembles that of the masticatory system of mammals and suggests that the ecological roles of some mammalian groups in North America and Asia were occupied in Western Gondwana by highly specialised crocodyliforms.

Campbell, H.A, Dwyer, R.G., Irwin, T.R. and Franklin, C.E. (2013). Home range utilisation and long-range movement of Estuarine crocodiles during the breeding and nesting season. PLoS ONE 8(5): e62127 (doi:10.1371/journal.pone.0062127).

Abstract: The estuarine crocodile (*Crocodylus porosus*) is the apex-predator in waterways and coastlines throughout south-east Asia and Australasia. *C. porosus* pose a potential risk to humans, and management strategies are implemented to control their movement and distribution. Here we used GPS-based telemetry to accurately record geographical location of adult *C. porosus* during the breeding and nesting season. The purpose of the study was to assess how *C. porosus* movement and distribution may be influenced by localised social conditions. During breeding, the females (2.92±0.013 metres total length (TL), mean ± S.E., n= 4) occupied an area <1 km length of river, but to nest they travelled up to 54 km away from the breeding area. All tagged male *C. porosus* sustained high rates of movement (6.49±0.9 km d^{-1}; n= 8) during the breeding and nesting period. The orientation of the daily movements differed between individuals revealing two discontinuous behavioural strategies. Five tagged male *C. porosus* (4.17±0.14 m TL) exhibited a 'site-fidelic' strategy and moved within well-defined zones around the female home range areas. In contrast, three males (3.81±0.08 m TL) exhibited 'nomadic' behaviour where they travelled continually throughout hundreds of kilometres of waterway. We argue that the 'site-fidelic' males patrolled territories around the female home ranges to maximise reproductive success, whilst the 'nomadic' males were subordinate animals that were forced to range over a far greater area in search of unguarded females. We conclude that *C. porosus* are highly mobile animals existing within a complex social system, and mate/con-specific interactions are likely to have a profound effect upon population density and distribution, and an individual's travel potential. We recommend that impacts on socio-spatial behaviour are considered prior to the implementation of management interventions.

Marks, C., Eme, J., Elsey, R.M. and Crossley, D.A. (2013). Chronic hypoxic incubation blunts thermally dependent cholinergic tone on the cardiovascular system in embryonic American alligator (*Alligator mississippiensis*). Journal of Comparative Physiology B (doi: 10.1007/s00360-013-0755-2).

Abstract: Environmental conditions play a major role in shaping reptilian embryonic development, but studies addressing the impact of interactions between chronic and acute environmental stressors on embryonic systems are lacking. In the present study, we investigated thermal dependence of cholinergic and adrenergic cardiovascular tone in embryonic American alligators (*Alligator mississippiensis*) and assessed possible phenotypic plasticity in a chronic hypoxic incubation treatment. We compared changes in heart rate (f_H) and mean arterial blood pressure (P_M) for chronically hypoxic and normoxic-incubated embryos after cholinergic and adrenergic blockade following three different acute temperature treatments: (1) 30°C (control incubation temperature), (2) acute, progressive decrease 30-24°C then held at 24°C, and (3) acute, progressive increase 30-36°C then held at 36°C. f_H progressively fell in response to decreasing temperature and rose in response to increasing temperature. P_M did not significantly change with decreasing temperature, but was lowered significantly with increasing acute temperature in the normoxic group at 90% of development only. Propranolol administration (β adrenergic antagonist) produced a significant f_H decrease at 24, 30, and 36°C that was similar at all temperatures for all groups. For normoxic-incubated embryos at 90% of development, atropine administration (cholinergic antagonist) significantly increased f_H in both 24 and 36°C treatments, but not in the 30°C control treatment. This atropine response at 24 and 36°C demonstrated acute thermally dependent cholinergic tone on f_H late in development for normoxic-incubated, but not chronically hypoxic-incubated embryos. Collectively, data indicated that cardiovascular control mechanisms in embryonic alligators may be activated by thermal extremes, and the maturation of control mechanisms was delayed by chronic hypoxia.

Charruau, P., Henaut, Y. and Alvarez-Legorreta, T. (2013). Organochlorine pesticides in nest substratum and infertile eggs of American crocodiles (Reptilia, Crocodylidae) in a Mexican Caribbean atoll. Caribbean Journal of Science 47(1): 1-12.

Abstract: As top predators, crocodilians can bioaccumulate high concentrations of persistent organochlorine pesticides (OCPs) that may have adverse effects on their physiology and health. Recent and illegal uses of OCPs in Mexico could affect populations of the American crocodile (*Crocodylus acutus*), already threatened by other factors. We analyzed 16 OCP compounds using gas chromatography with electron capture detection in 7 infertile eggs and in the substratum of 9 nests of American crocodiles in Banco Chinchorro, an atoll off the Mexican coast of the Yucatan Peninsula. Nest type, clutch size and distance from nests to nearest lagoon were also recorded, while total length of the females attending each nest was measured directly or estimated. Although Banco Chinchorro is isolated from the mainland and from known sources of contamination, OCP residues were detected in egg and nest substratum samples collected from the atoll. OCP concentrations in eggs (range: 0.002-4.000 ppb) and nest substrata (range: 0.01-1.82 ppb) are ten to thousands times lower compared to other studies. Total OCP concentration (sum of all OCPs) in nest substrata decreased with increasing distance from the shore, suggesting that eggs deposited

farther from the shore were less exposed to OCP absorption from substratum. Total OCP concentrations in eggs were positively correlated with total length of females and thus with their age. We speculate that maternal transfer from laying females is likely the major source of contaminants in eggs. Future investigations are needed to identify the origin of contaminants in Banco Chinchorro.

Latorre, M.A., Lopez Gonzalez, E.C., Larriera, A., Poletta, G.L. and Siroski, P.A. (2012). Effects of *in vivo* exposure to Roundup on immune system of *Caiman latirostris*. J. Immunotoxicol. (doi: 10.3109/1547691X.2012.747233).

Abstract: The present study aimed to evaluate the effect of Roundup (RU, glyphosate-based formulation) on some parameters of the immune system and growth of *Caiman latirostris*. Seventy-two caimans (20-day-old) from Proyecto Yacare (Gob. Santa Fe/MUPCN) were used. Two groups were exposed for 2 months to different concentrations of RU (11 or 21 mg/L; taking into account the concentration recommended for its application in the field), while one group was maintained as control. The RU concentration was progressively decreased through the exposure period to simulate glyphosate degradation in water. Animals were measured and weighed at the beginning and end of the experiment, and blood samples taken after exposure to determine total and differential white blood cell (WBC) counts as well as total protein concentration (TPC), and for performing protein electrophoresis. The results showed that, compared against control hosts, there was a decrease in WBC counts, a higher percentage of heterophils, a higher TPC (with a low percentage of F2 protein fraction), and a negative effect on growth in the young caimans exposed to RU. These results demonstrate that *in vivo* exposure to RU induced alterations in the selected immune parameters, plasma proteins, and growth of caimans, thereby providing relevant information about the effects of this type of pesticide in this important species in the Argentinian wetlands.

Brien, M.L., Webb, G.J.W., Lang, J.W. and Christian, K.A. (2013). Intra- and interspecific agonistic behaviour in hatchling Australian freshwater crocodiles (*Crocodylus johnstoni*) and saltwater crocodiles (*Crocodylus porosus*). Australian Journal of Zoology (http://dx.doi.org/10.1071/ZO13035).

Abstract: We examined agonistic behaviour in hatchling Australian freshwater crocodiles (*Crocodylus johnstoni*) at 2, 13 and 50 weeks after hatching, and between *C. johnstoni* and saltwater crocodiles (*Crocodylus porosus*) at 40-50 weeks of age. Among *C. johnstoni*, agonistic interactions (15-23 s duration) were well established by 2 weeks old and typically involved two and occasionally three individuals, mostly between 17:00 and 24:00 hours in open-water areas of enclosures. A range of discrete postures, non-contact and contact movements are described. The head is rarely targeted in contact movements with *C. johnstoni* because they exhibit a unique 'head raised high' posture, and engage in 'push downs'. In contrast with *C. porosus* of a similar age, agonistic interactions between *C. johnstoni* were conducted with relatively low intensity and showed limited ontogenetic change; there was also no evidence of a dominance hierarchy among hatchlings by 50 weeks of age, when the frequency of agonistic interactions was lowest. Agonistic interactions between *C. johnstoni* and *C. porosus* at 40-50 weeks of age were mostly low level, with no real exclusion or dominance observed. However, smaller individuals of both species moved slowly out of the way when a larger individual of either species approached. When medium- or high-level interspecific interactions did occur, it was between similar-sized individuals, and each displayed species-specific behaviours that appeared difficult for contestants to interpret: there was no clear winner or loser. The nature of agonistic interactions between the two species suggests that dominance may be governed more strongly by size rather than by species-specific aggressiveness.

Britton, A.R.C., Britton, E.K. and McMahon, C. (2013). Impact of a toxic invasive species on freshwater crocodile (*Crocodylus johnstoni*) populations in upstream escarpments. Wildlife Research (http://dx.doi.org/10.1071/WR12215).

Abstract: Spread of the invasive cane toad (*Rhinella marina*) across northern Australia is of concern. Predator species, including the freshwater crocodile (*Crocodylus johnstoni*), are susceptible to cane toad toxins when ingested. Upstream populations of freshwater crocodiles are smaller than downstream counterparts because of limited resources. We measured the impact of cane toad arrival on densities of these upstream populations. Our aim was to determine whether the influx of cane toads had a negative impact on populations of upstream 'stunted' freshwater crocodiles. Population surveys for crocodiles were conducted in three upstream creek systems, using day- and night-based survey methods, before the arrival of cane toads in the area. These surveys were repeated under similar conditions following the arrival of cane toads, to compare the distribution and densities of freshwater crocodiles and, hence, measure the impact of cane toads. There were significant declines in crocodile density at two survey sites following the arrival of cane toads, and we found dead crocodiles and cane toad carcasses with crocodile bite marks. The third site showed no change in density. There was a decline in mean density across all sites from 3.0 crocodiles km^{-1} to 1.1 crocodiles km^{-1} following the arrival of cane toads. There was an overall decrease in crocodile densities and a reduction in distribution following the arrival of cane toads into the survey area. Dead crocodiles and evidence of their having eaten cane toads strongly suggest that these declines were caused directly by the arrival of cane toads into the area. One site showed no apparent change other than an increase in wariness, which may reflect the distribution of available feeding and shelter resources among the three sites. These results suggest that upstream freshwater crocodile populations are highly susceptible to cane toad toxins, and that impacts on their population can include local extirpation. Considering their morphological and possibly genetic distinctiveness, the loss of these unique populations is of conservation concern.

Wan, Q.H., Pan, S.K., Hu, L., Zhu, Y., Xu, P.W., Xia, J.Q., Chen, H., He, G.Y., He, J., Ni, W.W., Hou, H.L., Liao, S.G., Yang, H.Q., Chen, Y., Gao, S.K., Ge, Y.F., Cao, C.C., Li, P.F., Fang, L.M., Liao, L., Zhang, S., Wang, M.Z., Dong, W. and Fang, S.G. (2013). Genome analysis and signature discovery for diving and sensory properties of the endangered Chinese alligator. Cell Research (doi: 10.1038/cr.2013.104).

Abstract: Crocodilians are diving reptiles that can hold their breath under water for long periods of time and are crepuscular animals with excellent sensory abilities. They comprise a sister lineage of birds and have no sex chromosome. Here we report the genome sequence of the endangered Chinese alligator (*Alligator sinensis*) and describe its unique features. The next-generation sequencing generated 314 Gb of raw sequence, yielding a genome size of 2.3 Gb. A total of 22 200 genes were predicted in *A. sinensis* using a de novo, homology- and RNA-based combined model. The genetic basis of long-diving behavior includes duplication of the bicarbonate-binding hemoglobin gene, co-functioning of routine phosphate-binding and special bicarbonate-binding oxygen transport, and positively selected energy metabolism, ammonium bicarbonate excretion and cardiac muscle contraction. Further, we elucidated the robust *A. sinensis* sensory system, including a significantly expanded olfactory receptor repertoire, rapidly evolving nerve-related cellular components and visual perception, and positive selection of the night vision-related opsin and sound detection-associated otopetrin. We also discovered a well-developed immune system with a considerable number of lineage-specific antigen-presentation genes for adaptive immunity as well as expansion of the tripartite motif-containing C-type lectin and butyrophilin genes for innate immunity and expression of antibacterial peptides. Multifluorescence *in situ* hybridization showed that alligator chromosome 3, which encodes DMRT1, exhibits significant synteny with chicken chromosome Z. Finally, population history analysis indicated population admixture 0.60-1.05 million years ago, when the Qinghai-Tibetan Plateau was uplifted.

Morgan, G.S. and Albury, N.A. (2013). The Cuban crocodile (*Crocodylus rhombifer*) from Late Quaternary fossil deposits in the Bahamas and Cayman Islands. Bulletin of the Florida Museum of Natural History 52(3):161-236.

Abstract: Late Quaternary fossil deposits from The Bahamas, Cayman Islands, and Cuba contain fossils of the Cuban crocodile *Crocodylus rhombifer*. This species survives today only in Cuba and Isla de la Juventud (formerly Isla de Pinos); the populations in The Bahamas and Cayman Islands are locally extinct. Large fossil samples, including skulls, are known from underwater caves (blue holes) on Abaco in the northern Bahamas and organic peat deposits on Grand Cayman. Diagnostic cranial characters shared by the fossil crocodile skulls from Abaco and Grand Cayman and recent skulls of *C. rhombifer* from Cuba are: short, broad, and deep rostrum; prominent orbit; concave interorbital region and cranial roof; strong ridge on internal margin of the orbit and lateral margin of the cranial table; large, rounded protuberance on the posterolateral corner of the squamosal; premaxillary-maxillary suture on the palate transverse at the level of the first maxillary tooth; and 13 teeth in the maxilla. Using a ratio derived from living crocodylians of head length (premaxilla to parietal) to total length of about 1:7.2, approximate total lengths for fossil specimens of *C. rhombifer* from Abaco range from 1.3-2.3 m (mean 1.9 m) and Grand Cayman from 1.6-2.0 m (mean 1.7 m). Quaternary crocodylian remains are known from many other islands in The Bahamas, including Acklins, Crooked Island, Eleuthera, Grand Bahama, Mayaguana, New Providence, and San Salvador; however, most of these fossils are not complete enough for a species identification. Shells of an extinct species of the land tortoise *Chelonoidis* from Abaco and Mayaguana with crocodylian bite marks, jaws and teeth of capromyid rodents from Grand Cayman that appear to have been digested by a crocodylian, and data from carbon ($^{13}C/^{12}C$) isotopes derived from crocodile bones, as well as the lack of large freshwater vertebrates, suggest that *C. rhombifer* in The Bahamas and Cayman Island had a diet primarily consisting of terrestrial vertebrates. Evidence from stomach contents and behavioral ecology of extant Cuban crocodiles from Cuba further supports the terrestrial feeding habits of *C. rhombifer*. Radiocarbon (^{14}C) dates on crocodile postcranial bones from Sawmill Sink and Dan's Cave on Abaco range from 2780-3680 years Before Present (BP). Radiocarbon dates on peat associated with fossils of *C. rhombifer* from the Crocodile Canal site on Grand Cayman range from 375-860 years BP. These dates confirm that Cuban crocodiles survived into the late Holocene on Abaco and into the historic period on Grand Cayman. Evidence from a variety of sources, including radiocarbon dates, fossil and archaeological sites, and historical records confirms that the local extinction of crocodiles in The Bahamas and Cayman Islands occurred within the past 500 years, probably resulting from overhunting by humans. Fossils of *C. rhombifer* on Grand Cayman and Abaco, and probably throughout The Bahamas, verify that the Cuban crocodile was considerably more widespread in the West Indies during the Late Quaternary.

Piras, P., Buscalioni, A.D., Teresi, L., Raia, P., Sansalone, G., Kotsakis, T. and Cubo, J. (2013). Morphological integration and functional modularity in the crocodilian skull. Integrative Zoology (doi: 10.1111/1749-4877.12062).

Abstract: We explored the morphological organization of the skull within Crocodylidae analyzing functional and phylogenetic interactions between its two constituent functional modules: the rostrum and the postrostrum. We used geometric morphometrics to identify localized shape changes, focusing on the differences between the major clades of the crown-group Crocodylia: Alligatoridae and Crocodylidae. We used published bite performance data to correlate rostral function with postrostral morphology. The skull modules appear more integrated within Alligatorida than within Crocodyliade. Phylogenetic effects on shape variation are more evident in Alligatoridae than in Crocodylidae, where functional parameters concerning the rostral morphology are proportionally more important than phylogeny. Long snouted species are characterized by low structural performance,

which is significantly associated with a reduction of the pterygoid-quadrate cranial nipper, suggesting that the nipper is important to the ingestion of large food items in generalist species. This functional association is coupled with a significant evolutionary allometry at the clade level, while Alligatoridae and Crocodylidae show different degrees of evolutionary allometry for entire shape and rostrum. The postrostrum is more conservative than the rostrum in terms of morphospace occupation, evolutionary allometry and phylogenetic signal.

Tokita, M., Chaeychomsri, W. and Siruntawineti, J. (2013). Skeletal gene expression in the temporal region of the reptilian embryos: implications for the evolution of reptilian skull morphology. SpringerPlus 2013 2:336.

Abstract: Reptiles have achieved highly diverse morphological and physiological traits that allow them to exploit various ecological niches and resources. Morphology of the temporal region of the reptilian skull is highly diverse and historically it has been treated as an important character for classifying reptiles and has helped us understand the ecology and physiology of each species. However, the developmental mechanism that generates diversity of reptilian skull morphology is poorly understood. We reveal a potential developmental basis that generates morphological diversity in the temporal region of the reptilian skull by performing a comparative analysis of gene expression in the embryos of reptile species with different skull morphology. By investigating genes known to regulate early osteoblast development, we find dorsoventrally broadened unique expression of the early osteoblast marker, Runx2, in the temporal region of the head of turtle embryos that do not form temporal fenestrae. We also observe that Msx2 is also uniquely expressed in the mesenchymal cells distributed at the temporal region of the\head of turtle embryos. Furthermore, through comparison of gene expression pattern in the embryos of turtle, crocodile, and snake species, we find a possible correlation between the spatial patterns of Runx2 and Msx2 expression in cranial mesenchymal cells and skull morphology of each reptilian lineage. Regulatory modifications of Runx2 and Msx2 expression in osteogenic mesenchymal precursor cells are likely involved in generating morphological diversity in the temporal region of the reptilian skull.

Murray, C.M., Easter, M., Merchant, M., Cooper, A. and Crother, B.I. (2013). Can reproductive allometry assess population marginality in crocodilians? A comparative analysis of Gulf Coast American alligator (*Alligator mississippiensis*) populations. Copeia 2013(2): 268-276.

Abstract: This study uses the American Alligator (*Alligator mississippiensis*) to assess the use of reproductive allometry as a tool to infer crocodilian population marginality based on conformation to advantageous life-history strategies. It is hypothesized that reproductive allometry, a morphometric relationship between mother's size and her reproductive output, varies intraspecifically between populations and that this variation reflects population marginality based on size, stress, temporal exploitation, habitat fragmentation, and/or the presence of social hierarchy. This hypothesis is tested using relative comparisons of allometric correlation between a marginal population inundated with saline storm surge from Hurricane Ike in southeastern Texas and a hypothesized unstressed core population in southeastern Louisiana. Heterophil to lymphocyte ratios fail to falsify the hypothesis of a saline stressor. The number of significant morphometric correlations between various parameters, degree of correlation (R^2), and slope of correlation between mother and her respective nest and clutch varied greatly between study sites. Reproductive allometry, as a measure of relative population marginality, may provide a cost effective way to prioritize management with local support for crocodilian taxa.

Ngwenya, A., Patzke, N., Spocter, M.A., Kruger, J.L., Dell, L.A., Chawana, R., Mazengenya, P., Billings, B.K., Olaleye, O., Herculano-Houzel, S. and Manger, P.R. (2013). The continuously growing central nervous system of the Nile crocodile (*Crocodylus niloticus*). Anatomical Record (doi: 10.1002/ar.22752).

Abstract: It is a central assumption that larger bodies require larger brains, across species but also possibly within species with continuous growth throughout the lifetime, such as the crocodile. The current study investigates the relationships between body growth (length and mass) and the rates of growth of various subdivisions of the central nervous system (CNS) (brain, spinal cord, eyes) in Nile crocodiles weighing between 90 g and 90 kg. Although the brain appears to grow in two phases in relation to body mass, initially very rapidly then very slowly, it turns out that brain mass increases continuously as a power function of body mass with a small exponent of 0.256, such that a 10-fold increase in body mass is accompanied by a 1.8-fold in brain mass. Eye volume increases slowly with increasing body mass, as a power function of the latter with an exponent of 0.37. The spinal cord, however, grows more rapidly in mass, accompanying body mass raised to an exponent of 0.54, and increasing in length as predicted, with body mass raised to an exponent of 0.32 (close to the predicted 1/3). While supporting the expectation formulated by Jerison that larger bodies require larger brains to operate them, our findings show that: (1) the rate of increase in brain size is very small compared to body growth; and (2) different parts of the CNS grow at different rates accompanying continuous body growth, with a faster increase in spinal cord mass and eye volume, than in brain mass.

Seymour, R.S. (2013). Maximal aerobic and anaerobic power generation in large crocodiles versus mammals: Implications for dinosaur gigantothermy. PLoS ONE 8(7): e69361.

Abstract: Inertial homeothermy, the maintenance of a relatively constant body temperature that occurs simply because of large size, is often applied to large dinosaurs. Moreover, biophysical modelling and actual measurements show that

large crocodiles can behaviourally achieve body temperatures above 30°C. Therefore it is possible that some dinosaurs could achieve high and stable body temperatures without the high energy cost of typical endotherms. However it is not known whether an ectothermic dinosaur could produce the equivalent amount of muscular power as an endothermic one. To address this question, this study analyses maximal power output from measured aerobic and anaerobic metabolism in burst exercising estuarine crocodiles, *Crocodylus porosus*, weighing up to 200 kg. These results are compared with similar data from endothermic mammals. A 1 kg crocodile at 30°C produces about 16 watts from aerobic and anaerobic energy sources during the first 10% of exhaustive activity, which is 57% of that expected for a similarly sized mammal. A 200 kg crocodile produces about 400 watts, or only 14% of that for a mammal. Phosphocreatine is a minor energy source, used only in the first seconds of exercise and of similar concentrations in reptiles and mammals. Ectothermic crocodiles lack not only the absolute power for exercise, but also the endurance, that are evident in endothermic mammals. Despite the ability to achieve high and fairly constant body temperatures, therefore, large, ectothermic, crocodile-like dinosaurs would have been competitively inferior to endothermic, mammal-like dinosaurs with high aerobic power. Endothermy in dinosaurs is likely to explain their dominance over mammals in terrestrial ecosystems throughout the Mesozoic.

De Bakker, M.A.G., Fowler, D.A., Den Oude, K., Dondorp, E.M., Navas, M.C.G., Horbanczuk, J.O., Sire, J.Y., Szczerbinska, D. and Richardson, M.K. (2013). Digit loss in archosaur evolution and the interplay between selection and constraints. Nature (doi:10.1038/nature12336).

Abstract: Evolution involves interplay between natural selection and developmental constraints. This is seen, for example, when digits are lost from the limbs during evolution. Extant archosaurs (crocodiles and birds) show several instances of digit loss under different selective regimes, and show limbs with one, two, three, four or the ancestral number of five digits. The 'lost' digits sometimes persist for millions of years as developmental vestiges. Here we examine digit loss in the Nile crocodile and five birds, using markers of three successive stages of digit development. In two independent lineages under different selection, wing digit I and all its markers disappear. In contrast, hindlimb digit V persists in all species sampled, both as cartilage, and as Sox9- expressing precartilage domains, 250 million years after the adult digit disappeared. There is therefore a mismatch between evolution of the embryonic and adult phenotypes. All limbs, regardless of digit number, showed similar expression of sonic hedgehog (Shh). Even in the one-fingered emu wing, expression of posterior genes Hoxd11 and Hoxd12 was conserved, whereas expression of anterior genes Gli3 and Alx4 was not. We suggest that the persistence of digit V in the embryo may reflect constraints, particularly the conserved posterior gene networks associated with the zone of polarizing activity (ZPA11). The more rapid and complete disappearance of digit I may reflect its ZPA-independent specification, and hence, weaker developmental constraints. Interacting with these constraints are selection pressures for limb functions such as flying and perching. This model may help to explain the diverse patterns of digit loss in tetrapods. Our study may also help to understand how selection on adults leads to changes in development.

Straková, H., 2013. Molecular Identification of Purebredness and Kinship of the Philippine Crocodile (*Crocodylus mindorensis*) and Cuban Crocodile (*C. rhombifer*) for *Ex Situ* Conservation Management. Mgr. Thesis, University of South Bohemia, Czech Republic. 35pp.

Abstract: The current status of crocodilians recognizes them as a group under serious threat due to their habitat destruction and illegal poaching for their lucrative products. In addition to previous threats, the elimination of spatial and temporal boundaries through modern anthropogenic pressures has facilitated hybridization in crocodiles by bringing together crocodilian species that would otherwise not breed due to a lack of opportunity. Here analyzed crocodiles, Philippine crocodile (*Crocodylus mindorensis*) and Cuban crocodile (*C. rhombifer*), are critically endangered and listed in CITES Appendix I. This study deals with a significant portion of Philippine and Cuban crocodile captive population in Europe based on mtDNA and microsatellites. The species purity of 12 out of 13 specimen of *C. mindorensis* on the ground of testing maternally inherited mitochondrial gene cytochrome b was determined as well as purity of 11 out of mentioned 13 individuals on the basis of several (7) microsatellite loci, while confirming hybrid origin of two crocodiles with mixed morphotype. Then a purity of one representative sample of the Cuban crocodile was verified with cyt b gene and nuclear purity of all 7 tested individuals with 14 microsatellites. Based on the obtained genetic characters I proceeded a likely kinship of the two groups of crocodiles and subsequently suggested optimal breeding management within the *ex-situ* conservation.

Núñez-Otaño, N.B., Piña, C.I., Gonçalves Portelinha, T.C. and Arambarri, A.M. (2013). Cloacal mycobiota in wild females of *Caiman latirostris* (Crocodylia: Alligatoridae). Revista Mexicana de Biodiversidad 84: 722-726.

Abstract: There are few reports of cloacal mycobiota on wild reptiles, and in particular, fungal presence and function in *Caiman latirostris* remains unknown. Our objective was to describe the fungal community present in the cloaca of wild female broad-snouted caimans during their reproductive season determine whether the number of fungi has some relationship with the female's corporeal condition. Fungi were found in 9 out of 13 cloacal samples and 14 species of fungi were isolated and identified. Three of the species isolated had the highest occurrence values, and 2 of them are pathogenic. In this case, body condition index had no relationship with fungal frequency; the fungi found in this study may have originated from soil habitat and nest substrate that are in constant contact with the cloaca of the *C. latirostris* females. The findings in this work support the theory that reptiles are

facultative carriers of fungi or their spores.

Espinosa-Blanco, A.S., Seijas, A.E. and Hernandez, O. (2013). Egg collection as a conservation tool of Orinoco crocodile (*Crocodylus intermedius*) in the Cojedes River system, Venezuela. Interciencia 38(5): 358-363.

Abstract: Due to the reduced population size and constrained geographical distribution, *Crocodylus intermedius* has been considered one of the most threatened crocodiles in the world. Frequency of flooding events as well as human and animal predation reduces the amount of eggs and slows the recovery of its populations. The potential for egg collection along the Cojedes River System (CRS) and their incubation under controlled conditions was evaluated. During the 2009 nesting season 13 nests were found along 20.7 km of CRS river bank surveyed. Eight of them were collected for incubation and set in artificial nests away from the river bank; the remaining five were geo-referenced and left in their natural conditions and considered as controls. Hatching success in the five control nests was 36.4% (90 hatchlings were produced), while for those transferred it was 53.5% (197 hatchlings). In addition, 24 additional nests were confirmed in the river section surveyed by the presence of hatchling pods during the hatching season; therefore, at least 37 females nested in the river section surveyed. We estimate conservatively that ~50 nests could be collected every year in the entire CRS, which could guarantee, at least, the production of 1200 hatchlings. The collection of eggs and artificial incubation in locations near the main riveris a successful strategy and could be implemented as part of a conservation program for the species, in which different sectors of society (fishermen, workers, and farm owners) should be involved.

Valencia-Aguilera, A., Cortes-Gomez, A.M. and Ruiz-Agudelo, C.A. (2013). Ecosystem services provided by amphibians and reptiles in Neotropical ecosystems. International Journal of Biodiversity Science, Ecosystem Services & Management (doi: 10.1080/21513732.2013.821 168).

Abstract: Human welfare depends directly or indirectly on the services provided by ecosystems. Amphibians and reptiles represent a high proportion of global species diversity and include species that are widely distributed throughout the world and play a variety of roles that benefit humans. The aim of this study was to identify and describe the ecosystem services provided by amphibians and reptiles in Neotropical ecosystems to evaluate the contribution of these highly diverse groups to human welfare. We conducted a literature review of articles and books from databases and university libraries and collected data from 106 studies. Amphibians and reptiles contributed directly and indirectly to the four types of ecosystem services: provisioning, regulating, cultural, and supporting. Most available studies reported the use of direct services from reptiles and indirect services from amphibians. Although eight ecosystem services were identified, most studies focused on reptiles as seed dispersers and protein sources. Biological pest control and bioturbation were the most widely studied services obtained from amphibians. Further research are necessary to understand the ecological functions involving amphibians and reptiles and their importance in the provision of key ecosystem services for human well-being.

Lewis, J.L., Fitzsimmons, N.N., Jamerlan, M.L., Buchan, J.C. and Grigg, G.C. (2013). Mating systems and multiple paternity in the Estuarine crocodile (*Crocodylus porosus*). Journal of Herpetology 47(1): 24-33.

Abstract: Microsatellite markers were used to investigate the mating system of the Estuarine Crocodile (*Crocodylus porosus*). Three hundred and eighty-six hatchlings from 13 clutches from a wild Northern Territory population, and 364 hatchlings from 21 clutches from a captive North Queensland population, were sampled. All samples were genotyped across five microsatellite loci. Multiple paternity was found in 69% of clutches in the wild population compared to 38% of clutches in the captive population. Up to three possible fathers were indicated in some clutches. Shared paternity was suggested by the presence of a common paternal genotype within two clutches in the wild population and among up to three clutches from a large shared pen in the captive population. The probability of detecting multiple paternity at all loci was high; 95% in the wild population and 98% in the captive population. There was no evidence of increased hatching success in the clutches that indicated multiple paternity compared to single paternity clutches in either population (P= 0.43 to P= 0.67). It is unknown whether the occurrence of multiple paternity in *C. porosus* is a result of multiple mating within the same breeding season or of sperm stored from matings in a previous season. These results suggest the genetic mating system for *C. porosus* is not polygynous but more likely promiscuous, and there is no evidence of dominant alpha males who control paternity in large areas.

Marcili, A., da Costa, A.P., Soares, H.S., Acosta, I.C.L., de Lima, J.T.R., Minervino, A.H.H. and Gennari, S.M. (2013). First report of *Trypanosoma* sp. in Spectacled caiman (*Caiman crocodilus*): morphological and phylogenetic relationships. ISRN Parasitology 2013, Article ID 328794 (http://dx.doi.org/10.5402/2013/328794).

Abstract: In Crocodylidae family three trypanosomes species were described, *T. grayi* in African crocodilian and *T. cecili* and *Trypanosoma* sp. in Caimans species from Brazil. *T. grayi* was transmitted by tsetse flies and the vector of Brazilian caimans trypanosomes is unknown. We characterized first Brazilian trypanosome isolated in spectacled caiman (*Caiman crocodilus*) from Mato Grosso State in Brazil. Morphological findings in epimastigotes forms from axenic culture showed high similarity with *Trypanosoma* sp. described in *Caiman yacare* from Brazilian Pantanal. Phylogenetic studies performed with SSU rDNA and gGAPDH (glyceraldehydes-3-phosphato dehydrogenase glycosomal) clustering in *T. grayi* Clade and together to genotype Cay 01 from *Trypanosoma* unnamed species isolated in *C. yacare*. This is the first isolate

of *Trypanosoma* sp. from *C. crocodilus* and the phylogenetic position with isolates in *C. yacare* from Pantanal region and demonstrates the low host specificity of cayman trypanosomes in Brazil.

Foth, C., Bona, P. and Desojo, J.B. (2013). Intraspecific variation in the skull morphology of the black caiman *Melanosuchus niger* (Alligatoridae, Caimaninae). Acta Zoologica (doi: 10.1111/azo.12045).

Abstract: *Melanosuchus niger* is a caimanine alligatorid widely distributed in the northern region of South America. This species has been the focus of several ecological, genetic and morphological studies. However, morphological studies have generally been limited to examination of interspecific variation among extant species of South American crocodylians. Here, we present the first study of intraspecific variation in the skull of M. niger using a two-dimensional geometric morphometric approach. The crania of 52 sexed individuals varying in size were analysed to quantify shape variation and to assign observed shape changes to different types of intraspecific variation, that is, ontogenetic variation and sexual dimorphism. Most of the variation in this species is ontogenetic variation in snout length, skull depth, orbit size and the width of the postorbital region. These changes are correlated with bite force performance and probably dietary changes. However, a comparison with previous functional studies reveals that functional adaptations during ontogeny seem to be primarily restricted to the postrostral region, whereas rostral shape changes are more related to dietary shifts. Furthermore, the skulls of *M. niger* exhibit a sexual dimorphism, which is primarily size-related. The presence of non-size-related sexual dimorphism has to be tested in future examinations.

Osugi, T., Ohtaki, N., Sunakawa, Y., Son, Y.L., Ohkubo, M., Iigo, M., Amano, M. and Tsutsui, K. (2013). Molecular evolution of Kiss2 genes and peptides in vertebrates. Neuroendocrinology (doi: 10.1210/en.2012-2267).

Abstract: The kiss1 peptide (kisspeptin), a product of the kiss1 gene, is one of the key neuropeptides regulating vertebrate reproduction. In 2009, we identified a paralogous gene of kiss1 in the brain of amphibians and named it kiss2. Currently, the presence of the kiss2 gene and the kiss2 peptide is still obscure in amniotes compared with that in other vertebrates. Therefore, we performed genome database analyses in primates and reptiles to investigate the molecular evolution of the kiss2 gene in vertebrates. Because the mature kiss2 peptide has been identified only in amphibians, we further performed immunoaffinity purification and mass spectrometry to identify the mature endogenous kiss2 peptide in the brains of salmon and turtle that possessed the kiss2 gene. Here we provide the first evidence for the presence of a kiss2-like gene in the genome database of primates including humans. Synthetic amidated human KISS2 peptide activated human GPR54 expressed in COS7 cells, but nonamidated KISS2 peptide was inactive. The endogenous amidated kiss2 peptide may not be produced in primates because of the lack of an amidation signal in the precursor polypeptide. The kiss2-like gene may be nonfunctional in crocodilians because of premature stop codons. We identified the mature amidated kiss2 peptide in turtles and fish and analyzed the localization of kiss2 peptide mRNA expression in fish. The present study suggests that the kiss2 gene may have mutated in primates and crocodilians and been lost in birds during the course of evolution. In contrast, the kiss2 gene and mature kiss2 peptide are present in turtles and fish.

Northcutt R.G. (2013). Variation in reptilian brains and cognition. Brain Behav. Evol. 82: 45-54 (doi: 10.1159/000351996).

Abstract: The class Reptilia is monophyletic, if all synapsid tetrapods are excluded and birds are included. The phylogenetic position of turtles within the reptilian clade is still problematic, but recent microRNA data suggest that turtles are the sister group to lepidosaurians. Brain-body data for approximately 60 reptilian taxa indicate that the relative brain size for a given body weight varies some six-fold among reptiles, with some turtles and lizards having relatively large brains and other turtles and lizards having relatively small brains. Snakes appear to be characterized by relatively small brains, and crocodilians appear to possess the largest brains among living reptiles, with the exception of birds. Data on the relative size of major brain divisions among tetrapods are limited, but the telencephalic and cerebellar hemispheres account for much of the variation. Telencephalic hemispheres in reptiles are approximately twice as large as those in amphibians, and the relative size of the telencephalic hemispheres in monitor lizards and crocodilians approaches that in basal birds and mammals. New data on the relative volumes of telencephalic pallial divisions in tetrapods reveal that the dorsal ventricular ridge, a ventral pallial derivative, accounts for much of the increase in pallial size that characterizes reptiles. Studies of spatial and visual cognition in nonavian reptiles reveal that they learn mazes and make visual discriminations as rapidly as most birds and mammals. Studies of social cognition and novel behavior, including play, reveal levels of complexity not previously believed to exist among nonavian reptiles. Given this level of neural and cognitive complexity, it is possible that consciousness has evolved numerous times, independently, among reptiles.

Wolf, B.C. and Harding, B.E. (2013). Fatalities due to indigenous and exotic species in Florida. Journal of Forensic Science (doi: 10.1111/1556-4029.12261).

Abstract: Florida's climate is suitable for many potentially hazardous animals, including both indigenous and exotic species, which are frequently kept as in zoos or as pets. This has resulted in many unforeseen fatal encounters between animals and the ever expanding human population. While the literature and knowledge pool for more common types of deaths referred to medical examiner/coroner's offices is abundant, the appreciation of wildlife and exotic pet-related

deaths is far less widespread. We report seven animal attack-related deaths that occurred in Florida. The inflicted injuries included blunt and sharp force injuries, asphyxia, drowning, and envenomation. The underlying cause of death, however, was always a result of the human/animal interaction and in many cases related to human error and failure to appreciate the potentially dangerous behavior of nondomesticated species. These cases illustrate the varied circumstances and pathophysiologies associated with deaths due to indigenous and exotic species and the importance of the multidisciplinary approach in the medicolegal investigation of these cases.

Chang, M.S., Gachal, G.S., Qadri, A.H., Khowaja, M. and Sheikh, M.Y. (2013). Ecological status and threats of marsh crocodiles (*Crocodilus palustris*) in Manghopir Karachi. Int. J. Biosci. 3(9): 44-54.

Abstract: This study represents survey data and reviews the threats and ecological status of Marsh crocodiles (*Crocodylus palustris*) in the captive habitat of Manghopir Karachi. In Pakistan, only one crocodilian species of Marsh crocodile recorded. The present study on threats and ecological status of Marsh crocodiles was carried out from 2006 to 2009 during which 116 crocodiles were recorded from MP Karachi. The observation revealed that total number of crocodiles were 116 in the studied areas of MP Karachi among them 80 were adult crocodile, 20 were juveniles and 16 were hatchlings. The most people consider them as a serious and potentially dangerous pest and so do not regret their disappearance from their neighborhood. In Pakistan, the concept of utilization of wildlife is still anathema to a large segment of the crocodile population and they can be ranched. Currently the crocodile population is threatened by environmental deterioration, hazard chemicals in water resources, hunting pressure and loss of habitat.

Chattopadhyay, S., Shee, B. and Sukul, B. (2013). Fatal crocodile attack. Journal of Forensic and Legal Medicine (dx. doi.org/10.1016/j.jflm.2013.09.005).

Abstract: Attacks on human beings by various animals leading to varied types of injuries and even death in some cases are not uncommon. Crocodile attacks on humans have been reported from a number of countries across the globe. Deaths in such attacks are mostly due to mechanical injuries or drowning. Bites by the crocodiles often cause the limbs to be separated from the body. The present case refers to an incident of a fatal attack by a crocodile on a 35 year old female where only the mutilated head of the female was recovered. Multiple lacerated wounds over the face and scalp along with fracture of the cranial bones was detected on autopsy. Two distinct bite marks in the form of punched in holes were noted over the parietal and frontal bones. Injuries on the head with its traumatic amputation from the body were sufficient to cause death. However, the presence of other fatal injuries on the unrecovered body parts could not be ruled out.

Stoker, C., Zayas, M.A., Ferreira, M.A., Durando, M., Galoppo, G.H., Rodríguez, H.A., Repetti, M.R., Beldoménico, H.R., Caldini, E.G., Luque, E.H. and Muñoz de Toro, M. (2013). The eggshell features and clutch viability of the broad-snouted caiman (*Caiman latirostris*) are associated with the egg burden of organochlorine compounds. Ecotoxicology and Environmental Safety (dx. doi.org/10.1016/j.ecoenv.2013.08.022).

Abstract: Organochlorine compounds (OCCs) are toxic and have been identified as endocrine-disrupting chemicals (EDCs). The broad-snouted Caiman (*Caiman latirostris*) is an oviparous species widely distributed in South America with potential to accumulate OCCs. The eggshell is formed during passage of the eggs through the oviduct. Since the oviduct is a target of hormone actions, exposure to OCCs could modify eggshell quality, thus affecting clutch viability. Eight clutches were collected from wetlands of Parana River tributaries, in north-eastern Argentina. Two to four eggs per clutch were used to establish the burden of OCCs, eggshell thickness and eggshell porosity. The remaining eggs were incubated in controlled conditions. Ten days after hatching, hatchling survival was assessed. Organochlorine pesticide residues (OCPs) were found in all clutches, while polychlorinated biphenyls (PCBs) were present in all but one clutch. The principal contributors to the OCP burden were members of the DDT family and oxychlordane. Eggshell thickness was 400.9±6.0 μm and, unexpectedly, no association between eggshell thickness and the OCC burden was found. The number of pores in the outer surface was 25.3±4.3 pores/cm^2. A significant inverse correlation between porosity and OCC burden was found (Pearson r= -0.81, p= 0.01). Furthermore, a decrease in caiman survival with decreased pore density was observed (Pearson r= 0.73, p= 0.04). Our findings highlight another potential negative impact of current and past use of OCCs on wildlife species.

Keula, A. (2013). Embodied encounters between humans and gators. Social & Cultural Geography (doi: 10.1080/14649365.2013.837190).

Abstract: Animal geographies have complicated our understanding of human/nonhuman animal relationships by positioning other animals as recipients of human culture and, more recently, by applying theories of embodiment to illustrate the co-constitution of human-animal worlds. This paper addresses human-alligator relationships in Louisiana by illustrating the history and culture of alligator hide production alongside an analysis of human-alligator encounters through tourism. Alligators have played all sorts of instrumental and symbolic roles in the Atchafalaya River Basin where populations here have been managed as a corollary to the exotic hide industry. More recently, gators have been positioned as the star attractions on swamp tours. Guides, tourists, and alligators share encounters where the nonhumans are anthropomorphized and empowered to shape human perceptions of other bodies. By jumping out of the water for food or simply allowing the tourists' gaze, alligators are positioned both as an exotic body and as a capable agent

in the experience of space. Guides take part in hybridizing the two groups of actors by individuating gators, enticing them to interact with tourists and negotiating the fears of gators and tourists alike to produce what they see as a mutually beneficial experience. These encounters allow for meaningful interactions between distinct yet similar bodies and highlight the animals' power to influence people.

Grant, P.B.C., Woudneh, M.B. and Ross, P.S. (2013). Pesticides in blood from spectacled caiman (*Caiman crocodilus*) downstream of banana plantations in Costa Rica. Environmental Toxicology and Chemistry 32: (in press).

Abstract: Spectacled caiman (*Caiman crocodilus*) are fish-eating crocodilians that inhabit freshwater habitat in tropical regions of the Americas. To assess the exposure of caiman to pesticides from banana plantations, the authors collected whole blood samples (30 mL) from 14 adult caiman that were captured in the North Atlantic region of Costa Rica. Blood samples were analyzed for 70 legacy- and current-use pesticides and breakdown products using newly developed ultra-trace, high-resolution mass spectrometry (HRMS). Caiman accumulated pesticides ranked by concentration as dieldrin > permethrin > mirex > 4,4'-DDE > alpha-endosulfan > heptachlor epoxide > oxychlordane > heptachlor > cypermethrin. Caiman within the high-intensity banana crop watershed of Rio Suerte had higher pesticide burdens relative to other more remote locations (F= 12.79; p= 0.00). Pesticide concentration decreased with distance from upstream banana plantations in this river system (F= 20.76; p= 0.00). Caiman body condition was negatively correlated with total pesticide concentrations (F= 6.23; p= 0.02) and with proximity to banana plantations (F= 5.05; p= 0.04). This suggests that either pesticides elicited toxic effects in caiman, resulting in diminished overall health, or that the quantity or quality of their prey was reduced by pesticides downstream of plantation waterways. The authors' results indicate that pesticide use in banana plantations is impacting a high trophic level species inhabiting one of the most important wilderness areas in Costa Rica (Tortuguero National Park).

Irmis, R.B., Hutchison, J.H., Sertich, J.J.W. and Titus, A.L. (2013). Crocodyliforms from the Late Cretaceous of Grand Staircase-Escalante National Monument and Vicinity, Southern Utah, U.S.S. Pp. 424-444 *in* At the Top of the Grand Staircase, ed. by A.L. Titus and M.A. Loewen. Indiana University Press: Bloomington, Indiana.

Submitted Publications

MUGGER CROCODILE (*CROCODYLUS PALUSTRIS*) PREYING ON INDIAN FLYING FOX (*PTEROPUS GIGANTEUS*). The Mugger (*Crocodylus palustris*) is a widely distributed species compared to other Asian freshwater crocodilian species. It is a highly flexible species, occupying numerous various types of habitats, including hill streams, large manmade reservoirs, seasonal tanks, large rivers and small pools in the wild and irrigation channels (Whitaker and Whitaker 1989).

The Mugger is the apex predator, known for its opportunistic and ambush predation behaviours. The species predates prey ranging from small insects to medium to large sized animals, including fish, amphibians, reptiles, birds and mammals. It also scavenges on dead animals and attacks human beings (Vyas 2012).

A small number of sub-adult to large sized Muggers, originally rescued from Vadodara City (Vyas 2006, 2010) were released in the water reservoir of Targol by the Gujarat State Forest Department. Targol Dam is located on the southwestern fringe of Jambughoda Wildlife Sanctuary near Targol village, Vadodara District, Gujarat.

During a study on the Indian flying fox (IFF: *Pteropus giganteus*), we came across a very interesting observation of Mugger predating IFF at Targol Dam. An IFF roosting colony is located on the edge of the Targol Dam (22° 20' 22.98" N; 73° 39' 14.38" E). It is probably the largest roosting colony of IFF in Gujarat, with more than 11,000 bats roosting at the site (Vyas and Upadhyay, in prep.). It was regularly noticed that about 100-150 adult IFFs fly from the colony and hover over the surface of the reservoir for drinking and possibly for cooling down. The number of bats flying increased gradually from noon to evenings, especially at dusk.

On 3 May 2013, in the early morning, a few IFFs were observed flying over the water surface for drinking. Two or three adult Muggers, about 2 to 2.5 m long (Figs. 1 and 2), were observed making numerous attempts to the catch IFFs - all attempts failed (Fig. 3).

We assumed that there was some success in predating IFFs, especially when they were flying very close to the water's surface, and local villagers and forest guards confirmed that at dusk and in the evenings, Muggers were successful at catching IFFs. It shows the ability of Muggers to catch prey while it is in mid-air, just a few inches away.

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Vyas, R. (2006). Reptilian diversity of Jambughoda Wildlife Sanctuary, Gujarat. Tigerpaper 33(1): 20-23.

Vyas, R. (2010). Mugger (*Crocodylus palustris*) population in and around Vadodara City, Gujarat State, India. Russian Journal of Herpetology 17(1): 43-50.

Vyas, R. (2012). Current status of Marsh Crocodiles *Crocodylus palustris* (Reptilia: Crocodylidae) in Vishwamitri River, Vadodara City, Gujarat, India. J. of Threatened Taxa 4(14): 3333-3341.

Whitaker, R. and Whitaker, Z. (1989). Ecology of the mugger crocodile. Pp. 276-296 *in* Crocodiles. IUCN Publ. (NS) ISBN 2-88032-987-6.

Figure 1. 2 m long Mugger (top) swimming towards flying fox, (middle) close to the flight of flying fox and (bottom) unsuccessful attempting to catch hold of a flying fox. (Photographs: Kartik Upadhyay).

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CROCODYLUS VIRIDIS DENOTES "WESTERN CLADE NILE CROCODILE (NEW)" BETTER THAN *C. SUCHUS* FORMERLY DID. Dacey (2013) reported that "a request has been submitted to IUCN-SSC Red List staff to include an additional taxon *C.* '*suchus*', representing those 'nile crocodiles' found in Central and West Africa". Unfortunately that proposal is based on the false supposition that the type locality of *C. suchus* is "Niger" (= the Senegal River). Rather, the type locality of *C. suchus* is Egypt, at and under the ancient temple at Thebes. The name is based on a skull of a juvenile that was prepared from a mummy.

There were two specimens of *C. suchus* in the type description of the name. The second of these was Michel Adanson's stuffed animal (1.28 m long) from the Senegal River, and it is registered in the herpetological collection of the Museum National d'Histoire Naturelle in Paris, as MNHNP 7524. This is the material basis for the modern version of *C. suchus* from central and northwestern Africa that originated in 1974 and is apparently being currently proposed for Red List recognition and CITES regulation.

We have recently noticed that when Geoffroy-Saint-Hilaire (1823; p. 82) said that "mom Crocodilus suchus fut, dans le principe, établi d'après un crâne retiré d'une momie de Thèbes", he explicitly linked his species-group name from 1807 (suchus) to the individual mummy skull which is registered in the comparative anatomy collection of the MNHNP as Département d'Anatomie Comparée VIII-2353. Thus, the name *C. suchus* has a lectotype (AC VIII-2353) and a paralectotype (MNHNP Erpetologie 7524). These two specimens are from widely separated geographical locations. The species-group name goes with the lectotype. Obversely the paralectotype does not own the name, and thus the concept of *C. suchus* as a taxon whose range does not include the type locality of the name is absurd.

Even more recently, and still also while our esteemed collaborator Mark Van Tomme was alive, we have noticed that the Senegal River specimen (MNHNP 7524) has a species-group name of its own. It is thus the paralectotype of *Crocodilus suchus* Geoffroy-Saint-Hilaire, 1807, and simultaneously the same specimen is the holotype of *Crocodilus viridis* D'Alton & Burmeister, 1854, because *viridis* is based on this one individual specimen collected by Adanson at "Niger", meaning the Senegal River.

When D'Alton and Burmeister (1854; p. 9) said that "auch Adanson's *Croc. viridis* gehört dabin", the name became available to science, and because Adanson's "crocodile vert" is today, and has always been represented by MNHNP 7524, the unavoidable inference is that the Adanson "crocodile vert" specimen in Paris bears the name *C. viridis*. Thus the current proposal to the IUCN-SSC Red List staff should be reworded by substituting *Crocodylus viridis* (D'Alton and Burmeister 1854) for *Crocodylus suchus* (Geoffroy-Saint-Hilaire 1807).

The relevant context of the above short quote from D'Alton and Burmeister (1854) and a translation of it are as follows. "In Westafrika, Senegambien, Guinea und Congo kommen Formen vor, die namentlich im halbwüchsigen Zustande noch schmälere schlankere-Köpfe und dabei wieder, wie die Hauptform, eine ganz ebene Scheitelfläche haben, während zugleich die Kiefer stärkere Unebenheiten zeigen, als bei den vorigen. Das ist der Croc. Suchus Geoffr., den er für die den Aegyptiern heilige Form hält und als Cr. complanatus aus den Mumien herstellte. Auch Adanson's Croc. viridis gehört dabin." There are forms in western Africa (Senegal, Gambia, Guinea and Congo) where the half grown animal has a smaller and skinnier head, and when fully grown it has a very level skull surface. Both ages have strongly uneven jawbones. This is the *Croc. suchus* Geoffr., which was the holy form for the

Egyptians and as *Cr. complanatus* was recovered from the mummies. Also Adanson's *Croc. viridis* belongs here.

Separately there is the biological and pragmatic question of whether or not the Senegal River *Crocodylus* is a species (or subspecies) that is identifiable and capable of being regulated by CITES. We suggest that hypothetically assuming that the northwestern African mesorostrine crocodilian becomes identifiable by means other than just its DNA (which is not available in the field), and hypothetically assuming that it is eventually mapped and that MNHNP 7524 is geographically inside the range of the taxon, it would then become technically correct to propose the adding *C. viridis* (or a subspecies version of it, presumably *C. niloticus viridis*) to the Red List.

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Geoffroy-Saint-Hilaire, É. (1823). Sur le crocodile vivant à Paris en janvier 1823. Bulletin des Sciences par la Société Philomatique, Paris, 1823: 82-83.

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OSTEOLAEMUS SYNTYPE NOSE COUNT WAS TWO. In Ross (2006) one accidental mistake led to another, and cumulatively the result was explicitly misleading. I sincerely apologize for overlooking a piece of information in Cope (1860 = 1861) that had already answered my question about how many heads were in the syntype series of *Osteolaemus tetraspis* Cope, 1861, which is based on two specimens (one "skull" and one "skin").

My 2006 supposition that the skin might have lacked its head was an error. There is a statement in Cope (1860; issued in 1861) which gives the total size of one syntype as 5 feet long, and refers to it as "the entire specimen", clearly meaning that it was the one specimen that was not just a skull, and also meaning that the skin had its head attached to it. Thus the 5 foot length measurement represented a whole animal (head, neck, trunk, pelvis and tail) prepared as a scientific study skin, presumably somewhat flat, but possibly capable of being taxidermied into a stuffed animal.

Resulting from the whole specimen being a hornback skin with its head attached, my 2006 assertion that Cope's description of the head of *Osteolaemus* was possibly based entirely on the skull specimen (sic) is no longer supported, because the "skin" individual must have also exhibited many skull and mandibular characters. The upper and lower dentition data could have partly come from the skin, if (hypothetically) the skull lacked its mandibles. The remarkably large palpebral bones in the upper eyelids were probably present in the skin, but (hypothetically) they could possibly have been lost or damaged on the skull. However, the snout proportions, the presence of a short preocular ridge, the lack of the common cayman's interorbital "spectacle" ridge, and the upper teeth were surely shared by both specimens.

We can safely assume that the skin's head showed the completely ossified external internarial septum through the tightly adhering and thin skin covering it, or alternatively that Cope scraped away the overlying dry epidermis and exposed the bone. Further, there is no evidence that the skull actually lacked its palpebrals or its mandibles. However, it is no longer necessary that the skull individual had them. Science should be searching for a half-grown skull, hopefully with its eyelid bones (palpebrals) still in place, and with one or both of its lower jaws present. The term "half grown" is its size in comparison with the head of the 5-foot long study skin.

Unfortunately there remains an unresolved locality-data problem, because of Cope's wording that "two specimens were exhibited; one a skin brought from the Ogobai River, Western Africa, by Mr. P.B. Du Chailla; the other, the skull of a half grown individual, obtained from the Museum of the Pennsylvania University." It is unclear if the skin and the skull have the same collector and locality data, or alternatively if the skull originated somewhere outside of Gabon. My interpretation is that the Academy of Natural Sciences of Philadelphia (ANSP) owned the skin from Gabon, and that the skull may possibly have been borrowed for the 1860 December meeting. It is also possible that the university had already, or was still in the process of donating the skull to the ANSP. All that was needed for the new genus *Osteolaemus* and its new species *O. tetraspis* to be listed as present in the Philadelphia Academy's museum was the skin.

Despite these few unresolved minor questions, I am much relieved to now understand why Cope knew that both specimens were the same species. Their cranial and dentition characters matched each other convincingly. The cleaned skull likely showed the nose septum most clearly of the two, but there was apparently no evidence contradicting its presence and complete ossification on the rostrum of the head of the "skin" individual.

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