CROCODILE SPECIALIST GROUP NEWSLETTER

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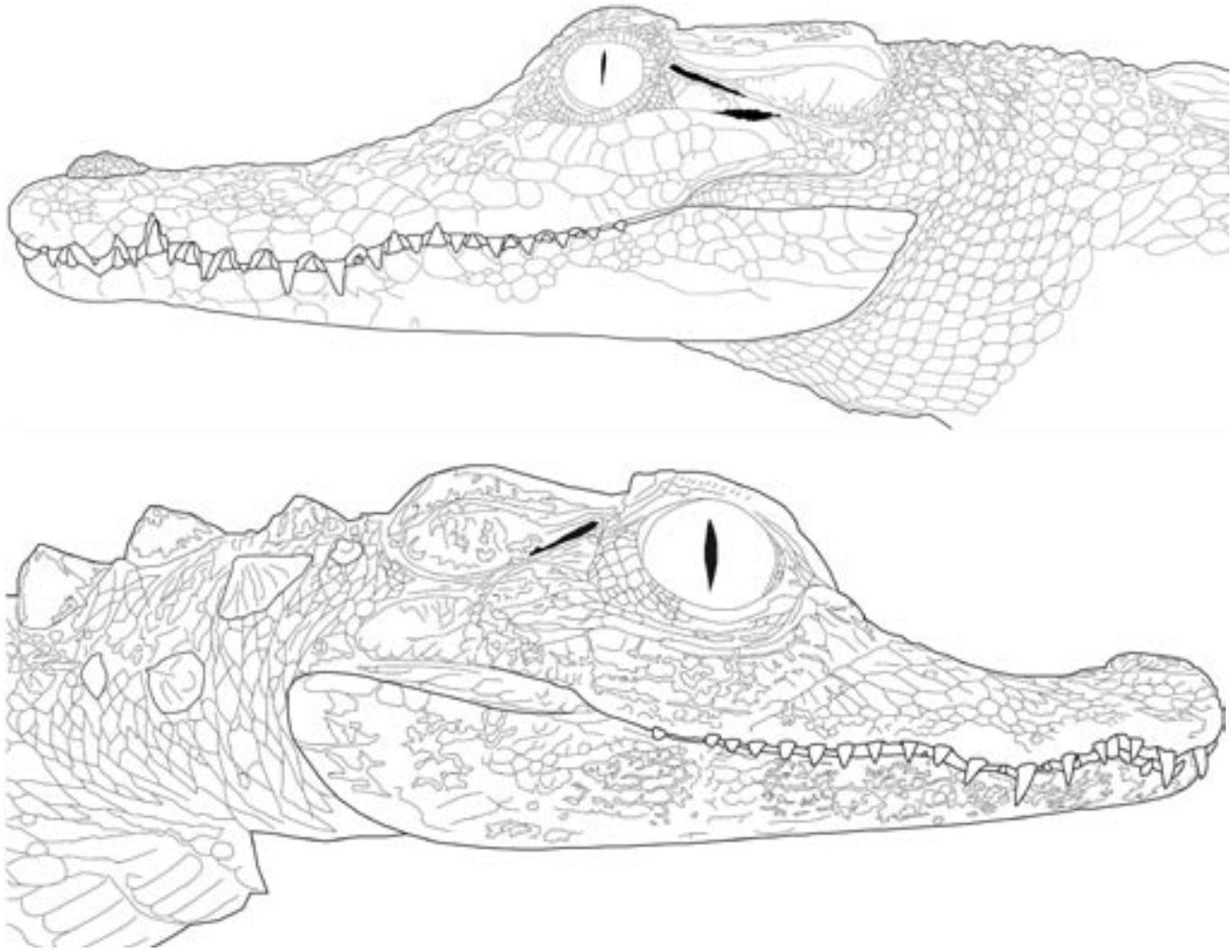

IUCN • Species Survival Commission

CROCODILE

SPECIALIST

GROUP

NEWSLETTER

VOLUME 30 Number 1
JANUARY 2011 - MARCH 2011

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COVER PHOTOGRAPH: Digital images produced from high resolution photographs using Illustrator program from Adobe Creative Solution. Top: *Crocodylus porosus*; Bottom: *Paleosuchus trigonatus*. Credits: Alvaro Velasco.

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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

In October 2010, a Swiss television documentary on the snake (*Python reticulatus*) and lizard (*Varanus salvator*) trade in Indonesia was shown in Europe. This documentary showed snakes and lizards moving after they had been killed - just as crocodiles do - which was misinterpreted as indicating the animals were being skinned alive. This in turn raised concerns amongst consumers, manufacturers and fashion houses, about the product chain for reptile skins (snakes, lizards and crocodilians), and whether it involved sufficient levels of humane and ethical treatment to meet the corporate social responsibility commitments of some fashion houses.

This is not a new issue for people involved in the reptile trade generally or in crocodile farming. But it is a complex one for the CSG to address. I am preparing a discussion paper to act as a focal point for more discussion.

I wrote to the Indian Minister of Environment and Forests, Mr. Jairam Ramesh, congratulating him on a new Indian initiative to reinvigorate Gharial conservation on the Chambal River [see CSGN 29(4): 11 and page 15 in this issue].

Lacoste, through its "Save Your Logo" program, and in cooperation with French NGO "Fonds de Dotation pour la Biodiversite" (FDB), have agreed to allocate €118,000 to the Mabuwaya Foundation (Philippines) over the next four years. We are delighted with this outcome, as it provides much-needed financial support to the Mabuwaya Foundation's conservation program for the Philippine crocodile (*Crocodylus mindorensis*) in the northern Philippines.

The International Association of Crocodile Specialists (IACS) has been incorporated in Australia to manage the financial affairs of the CSG. A bank account has been opened (details are available from Tom Dacey, csg@wmi.com.au).

The Sarawak Forestry Corporate Office has advised that the Second International Human-Crocodile Conflict workshop, to be held in Sarawak, Malaysia, has been deferred to 19-21 October 2011 (see below).

Further to the last editorial (CSGN 29(4): 3), the CSG has provided a special grant of $US1000 to Dr. Simon Pooley to assist him in undertaking a project to research and document the history of the CSG (1960-2010).

Professor Grahame Webb, *CSG Chairman.*

CSG Student Research Assistance Scheme Update

The CSG Student Research Assistance Scheme has provided funding to two students so far in 2011:

1. Thai Kabbuda, Khon Kaen University, Thailand: Cloning and expression of crocodile (*Crocodylus siamensis*) haemoglobin.
2. Agata Staniewicz, University of Bristol, UK: Diet and demography of *Tomistoma schlegelii* in Mesangat Lake, East Kalimantan, Indonesia.

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

Meetings

CITES Animals Committee (18-22 July 2011)

The 25th meeting of the CITES Animals Committee (AC25) will be held in Geneva, Switzerland, 18-22 July 2011. The provisional agenda can be viewed at www.cites.org/eng/com/AC/25/index.shtml.

2nd International HCC Workshop (19-21 October 2011)

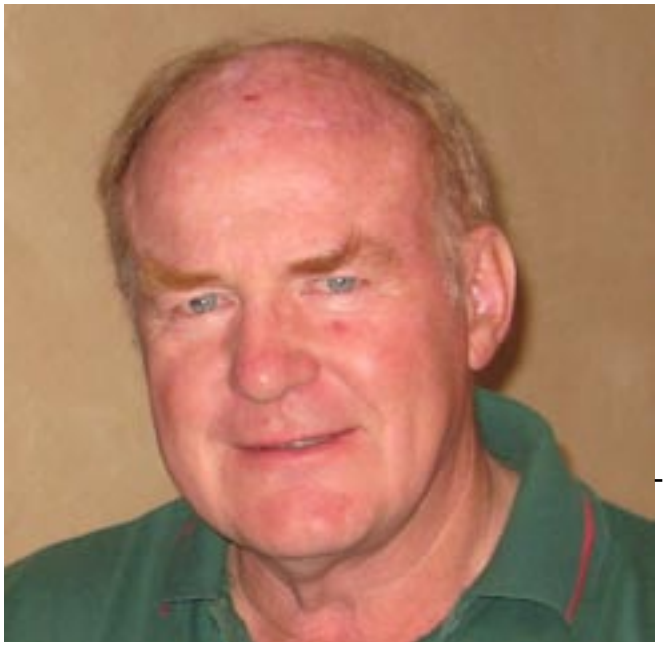
The Sarawak Forestry Corporation has agreed to host the Second International Human-Crocodile Conflict Workshop in Bako National Park, outside Kuching, Sarawak, Malaysia, on 19-21 October 2011. Specific details on venue, agenda, etc. have yet to be determined.Enquiries can be directed to Oswald Braken Tisen (oswaldtisen@sarawakforestry.com).

21st CSG Working Meeting (22-25 May 2012)

The 21st CSG Working Meeting will be held at the National Museum of the Philippines, Manila, Philippines, 22-25 May 2012. The working meeting will be preceded by a CSG Steering Committee meeting on 21 May 2012. Details are now available on the meeting website, <csgmanila.com>.

Obituary

Dr. Herbert O. Penzhorn (66 y) died tragically on his crocodile farm in Kroondal, South Africa, after falling into his Nile Crocodile breeding dam. Herbert was a well-known crocodile farmer, conservationist, hunter and general surgeon. He studied medicine at Stellenbosch University (South Africa) and Glasgow University (Scotland), and spent some time at the Mayo Clinic in the USA. He was a close personal friend and enjoyed many visits to Zimbabwe, hunting and learning more about crocodiles. Herbert is survived his wife, Riki, and children, Egon, Annalise and Clarissa. He was a long-serving member of the CSG and we join to offer our condolences to his family.



Kevin van Jaarsveldt, <*kvj@mweb.co.za*>.

Regional Reports

West and Central Africa

Niger

POPULATION OF NILE CROCODILES (*CROCODYLUS NILOTICUS*) IN THE NORTHERN PART OF PARK W, NIGER. The aim of this study was to determine the population of Nile crocodiles (*Crocodylus niloticus*) in a 1.5-km section of the Tapoa River, Tapoa Gorge, and Bata, Nyafarou and Moussiémou Ponds, of Park W in Niger.

Figure 1. Tapoa River, Niger.

Tapoa River: Six observation points (P1-P6, Table 1) were chosen along a 1.5-km stretch of the river (Fig. 1), from which crocodiles were counted. The location of these points allowed the entire 1.5 km to be covered. Counts were carried out using a spotlight, every evening over a 7-day period (2-8 May 2010). The presence of lions on Day 1 meant that no counts could be made at observation point 4. On Days 2 and 5, thunderstorms resulted in cool ambient conditions, which affected counts.

Numbers of crocodiles sighted at each site over the 7-day period varied considerably, even if the two days in which thunderstorms were experienced are excluded (Table 1). Given the relatively short stretch of river involved, it is likely that movement within the river contributed to this variation. The survey on Day 7 provides the highest total count (79), which corresponds to a relative density of 52.7 ind/km.

Several hatchlings (30-40 cm long) were observed on the river bank at Observation Point 3 on several days (Table 1). These animals were grouped together around the same burrow by the water, and may reflect a crèche from a nearby nest (Fig. 2).

The proportion of the *C. niloticus* population that was not sighted during the survey is unknown. Assuming that the relative density recorded in the 1.5-km section of the river that was surveyed is representative of the full length of the river at the end of the dry season (3.5 km), then the population is estimated to consist of a minimum of 191 crocodiles.

Figure 2. Hatchlings sighted at Observation Point 3.

During the warm season, crocodiles dig burrows to protect themselves from heat and sun. These burrows are useful for population management, as they are reliable indicators of

Table 1. Spotlight and burrow counts recorded at each observation point on the Tapoa River. Numbers in brackets with counts indicate numbers of hatchlings positively identified. *= presence of lions did not allow count to be made; #= thunderstorms. Averages were calculated using data from surveys unaffected by thunderstorms or other factors (1, 3, 4, 6, 7).

Point	Lat./Long.	Day 1	Day 2 #	Day 3	Day 4	Day 5 #	Day 6	Day 7	Average (range)	No. of Burrows
1	12.46869N, 2.41423E	2	3	5	9	3	9	8	6.6 (2 to 9)	1
2	12.46778N, 2.41249E	6	3	0	4	2	7	9	5.2 (0 to 9)	3
3	12.46700N, 2.41150E	18 (10)	10 (9)	19 (10)	14	5	18 (2)	13 (2)	16.4 (13 to 19)	12
4	12.46447N, 2.40870E	*	3	11	8	3	11	19	12.5 (8 to 19)	12
5	12.46268N, 2.40608E	20	10	13	24	8	15	17	17.8 (13 to 24)	13
6	12.46118N, 2.40477E	16	5	19	8	5	13	13	13.8 (8 to 19)	5
All		**62**	**34**	**67**	**67**	**26**	**73**	**79**	**-**	**46**

the presence and the number of adult crocodiles. Crocodile tracks and imprints of legs and ventral scales on the ground, excreta, and osteoderms, bones and teeth of dead animals are also indicators that can be recorded.

To quantify the number of burrows, three parallel transects, spaced 20 m apart, were established on each side of the survey area (T1-T6). These transects were walked, and the locations of burrows plotted accordingly (Fig. 3).

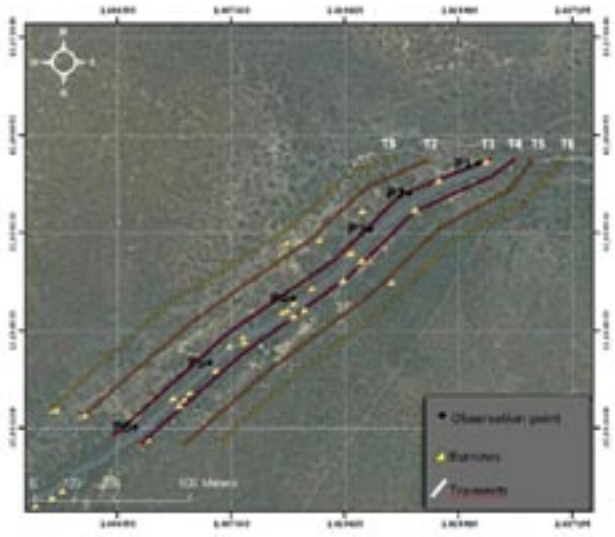


Figure 3. Locations of crocodile burrows recorded along established transects on the Tapoa River.

Of the 46 burrows located, 37 (80.4%) were within 10 m of the river (ie between T1 and T4), 4 (8.7%) were 10-30 m from the river, and 5 (10.9%) were 30-50 m from the river (see Fig. 3). The burrows were distributed along the full length of the survey area (Fig. 3).

Linear regression analysis between the number of burrows and mean number of crocodiles (hatchlings excluded) at each observation point revealed a non-significant relationship (r^2= 0.60; p= 0.069; N= 6), although the trend was clearly towards higher numbers of burrows in river sections where the highest numbers of crocodiles were recorded (see Table 1).

Numerous tracks, faeces (up to 1 excrement/m^2; Fig. 4), imprints of legs, ventral scales and tail, were observed, mainly on the riverbanks. No osteoderms, bones or teeth or other evidence of dead crocodiles was noted.

Figure 4. Dried (left) and fresh (right) crocodile exreta. Black bars indicate 10 cm.

Tapoa Gorge: A spotlight survey was carried out on foot along 2 km of the gorge (Fig. 5) every evening over a 4-day period (10-13 May 2010).

Figure 5. Tapoa Gorge.

Two observation points were designated on the basis of crocodile sightings: at Point A (12.4765N, 2.43318E) one

crocodile was seen one each of the 4 days, and at Point B (12.47618N, 2.43583E) 5 crocodiles were counted on Days 1 and 4, and 3 crocodiles counted on Days 2 and 3. These data indicate a minimum of 6 crocodiles in the gorge (relative density= 3.0 ind/km). The rocky nature of the gorge is not suitable for the excavation of burrows and the steep banks become very hot - the area is not considered to be optimum habitat for crocodiles. The relatively low density of crocodiles and the presence of osteoderms and teeth supports this contention.

Bata, Nyafarou and Moussiémou Ponds: No tracks or crocodiles were observed at the three ponds, although burrows were found at Nyafarou and Moussiémou Ponds (2 and 5 burrows respectively; Fig. 6).

Bata (800 m^2 of water surface area when full) and Nyafarou (12,000 m^2) are equipped with solar powered pumps, and it is planned to equip Moussiémou Pond (12,000 m^2). However, these installations do not provide a sufficient flow to maintain water levels, and all of the ponds will dry out completely by the end of the dry season, forcing any crocodiles there to look for alternative sites.

Figure 6. Crocodile burrow at Moussiémou Pond. Black bar indicates 20 cm.

Hamissou and Abdou (2007) also did not record any crocodiles in Bata and Nyafarou Ponds, but did observe burrows at the latter. Djibey (2010) did not record any crocodiles in any of the three ponds.

The highest concentrations of crocodiles were recorded in permanent waterways that had ample fish stocks and were protected areas within Park W. The Tapoa River is a remarkable habitat because of the presence of water throughout the year, and the protection it receives as a result of its proximity to the Tapoa base (Ranger Headquarters, Guides Association and hotel infrastructure at entrance to the park), which dissuades the two activities responsible for the quasi-total disappearance of crocodiles from the Niger River, namely fishing and poaching.

Previous spotlight surveys have covered 3.0-3.5 km of the Tapoa River, which in each case included the same section surveyed here. These surveys indicate relative densities of 52.0 ind/km (3.5 km, November 2007; Shirley and Eaton 2008) and 55.3 ind/km (3.5 km, April 2010; Djibey 2010), similar to the density reported here (52.7 ind/km). Notwithstanding any differences in survey methodology between this survey and previous ones (Shirley and Eaton 2008; Djibey 2010), the population is considered to be stable. The presence of hatchlings indicates successful nesting and potential recruitment into the river.

In conclusion, the Tapoa River provides a favorable environment for crocodile populations and comprises a biodiversity sanctuary that must be protected.

Acknowledgements

I thank Omar Wali, an experienced and devoted guide and head of the Tapoa Guides Association, who made these surveys possible, my cousin Christian Noirard for his welcome in Niger, Soumaila Sahailou, Conservator of Park W, and Frédéric Modi, boss of the Tapoa Hotel. I thank the University of Liège for its training and financial support. I also thank Jean-Luc Hornick, Samuel Martin, Christine Lippai, and esspecially Charlie Manolis for their collaboration in the development of this article.

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Benin

POSSIBLE EFFET OF CLIMATE CHANGE ON CROCODILE DISTRIBUTION AND RISK OF HUMAN-CROCODILE CONFLICT IN SOUTHERN BENIN. The West African country of Benin has several rivers and tributaries throughout its territory. Altitude varies between 1 and 65 m above sea level in the south, and between 300 and 700 m in the north. This difference in altitude gives Benin a sloping shape, which results in rainwater run-off from the north flowing very

quickly towards the large reservoirs of southern basins. In the south, lagoons, lakes and other wetlands occupy more than 60% of the surface area of some Departments (eg Atlantique, Littoral, Ouémé and Couffo Departments).

These large areas of water in the south have shaped the traditions and culture of many local peoples living there. For example, the "Toffins" people are a sedentary group living around the freshwater Lake Nokoué. For decades, this population has lived peacefully in huts on stilts, relying on artisanal fishing and seasonal agricultural products. However, the quietude of the Toffins, or at least a part of the community, was shaken recently. Since April 2010, 6 of the 12 villages have been affected by the sudden appearance of Nile (Crocodylus niloticus) in Lake Nokoué. The Toffins community has never seen Nile crocodiles in their immediate environment, and so are terrified. The reason for this appearance of Nile crocodiles in southern waters is not understood, but a possibility is the effect of climate change on habitats in the north of the country.

The range of the Nile crocodile in Benin is largely restricted to northern river basins, with a few populations in the tributaries of the centrally located Ouémé River (Fig. 1). In recent years, the seasons have been atypical. During the rainy season, torrential rains have deeply eroded and filled the beds of rivers in the northern and central parts of the country. However, dry seasons have been longer than usual, and higher ambient temperatures have contributed to higher evaporative losses, resulting in some waterbodies and swamps drying out.

Figure 1. Map showing possible migration routes (arrows) from main areas of distribution of Nile crocodiles (circled) to Lake Nokoué .

The effect of these dry conditions may have resulted in the migration of Nile crocodiles to Lake Nokoué - the closest population is around 250 km away (Fig. 1). Atypical flooding over the last few years may have assisted such movements, although the primary reason is considered to the the "loss" of dry season wetland habitats.

The effect on the Toffins people has been significant. They remain very suspicious and reluctant to venture into the water, saying "an enemy attack it is worrisome, but an enemy that disappears is expressly disturbing to allude to the sneaky eyes of the crocodile before his diving ...". Another anxiety is that crocodiles will settle in Lake Nokoué because the traditional fishing methods ("Akadja") may be advantageous to crocodiles. The method involves the creation of "quiet" artificial habitat that attracts fish for feeding, breeding, etc. - these areas are left untouched for 6 months, and then fish are caught on the one day. Two Nile crocodiles (one was 2.21 m long) have already been caught in the Sô River, a tributary to Lake Nokoué.

The socio-economic impacts on the human population due to this occurrence are still unknown, but may become significant if the current trends in movement of Nile crocodiles continues in the future, and/or if crocodile populations becomes established in the area.

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Mauritania

STATUS OF NILE CROCODILES IN THE LOWER SENEGAL RIVER BASIN. A recent review on the status of Nile crocodiles (*Crocodylus niloticus*) in Mauritania indicated several fragmented populations, mostly restricted to rock pools (locally known as "guelta") in the mountains of Tagant, Assaba and Affolé (Brito *et al*. 2011). Despite the general isolated character of mountain populations, the study found evidence of movement between gueltas. The authors also suggested that dispersal from mountains to the lower Senegal River basin may occur through the Gorgol el Abiod, Gorgol el Akhdar and Garfa River basins, but supporting evidence was needed. Despite the lack of recent sampling, it is thought that accidental death in fishnets and direct harvesting may have severely reduced *C. niloticus* populations along the Senegal River, and restricted crocodiles to local suitable areas, such as the National Parks of Diawling in Mauritania and Djoudj in Senegal (National Research Council 1981; Nickel 2003; Deodatus 2004). Therefore, an updated assessment of population status for Nile crocodiles along the Senegal River was needed for conservation planning.

A 9-day field mission was undertaken in 2010 (29 October to 5 November). Localities along the Senegal River were visited and enquiries were made to local fishermen about crocodile presence and rituals associated with crocodile hunting. Status of populations was ranked in three categories: present (crocodiles observed during surveys); transient (locals

reported that crocodiles used to be present but currently are rare and only found passing through); and, extinct (when locals reported that crocodiles are no longer seen and surveys also found no evidence of their presence). Coordinates of localities were gathered from a Global Positioning System (GPS).

The surveys provided distribution data for 9 localities (Fig. 1), with distinct population status:

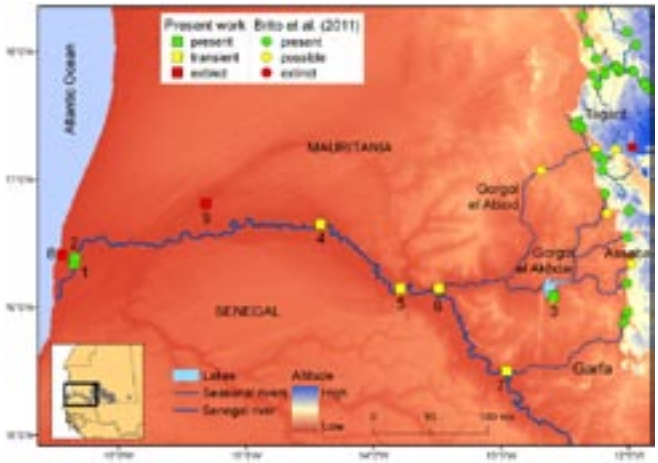

Figure 1. Distribution of crocodile localities (numbered) along the lower Senegal River basin. Coloured squares/ dots indicate status (green= present, yellow= passage only, red= extinct). Squares refer to localities detected during present work, circles refer to localities identified by Brito *et al*. (2011).

"Present" status localities

Locality 1 - Diawling (16.3444 N, 16.3473 W), 30 Oct 2010: one adult (about 2.0 m long) and one sub-adult (about 1.5 m) observed during daylight.

Locality 2 - Diawling (16.3829 N, 16.3406 W), 30 Oct 2010: one adult observed during daylight, and fishermen mentioned that one old, large individual makes periodic movements from the Diawling watershed to the Senegal River.

Locality 3 - M'bout barrage (16.0856 N, 12.5877 W), 4 Nov 2010: crocodiles were reported in the surroundings of M'bout, about 70 km southwest of Assaba, in the 1930s (Joleaud 1933). The locality was not visited by Brito *et al*. (2011). During the current survey crocodiles were not observed, but locals indicated that they are present. A skin sample from a specimen allegedly collected in 2008 was presented.

"Transient" status localities

Locality 4 - Ndirof (16.6501 N, 14.4119 W), 22 Nov 2010: permanent populations were present until the 1980s, but currently crocodiles are rarely observed while moving downstream.

Locality 5 - Mbagne (16.1461 N, 13.7878 W), 2 Nov 2010: permanent populations are no longer present, and crocodiles are occasionally observed while descending from the mountains via the Gorgol River. The last specimen observed passing was in 2008.

Locality 6 - Kaédi (16.1488 N, 13.4890 W), 3 Nov 2010: permanent populations do not exist but crocodiles are frequently observed descending the Gorgol River during the rainy season. Since 2008, 3 specimens have been captured upstream of the concrete gates regulating water flow from the Gorgol River to the Senegal River. The 2008 and 2009 specimens were killed, and bone remains alleged to be from the 2008 specimen were presented. The third specimen, captured in 21 October 2010, was released alive downstream of the gate.

Locality 7 - Ngouye (15.5004 N, 12.9564 W), 5 Nov 2010: Fishermen at Maghama village mentioned that crocodile observations are rare, and that they are usually observed as move downstream. In 2008, one adult was captured and killed.

"Extinct" status localities

Locality 8 - Marigot de Bileyit (16.4091 N, 16.4464 W), 29 Oct 2010: crocodiles were present in the area before the construction of the Diama Dam at the mouth of the Senegal River.

Locality 9 - Rkiz Lake (16.8120 N, 15.3135 W), 1 Nov 2010: crocodiles were present until the 1970s, but are believed to have become extinct afterwards due to severe droughts that affected the region.

While local beliefs of the Moor ethnic group protect mountain-ranging crocodiles (Shine *et al*. 2001; Nickel 2003; Lluch 2006; Wabnitz 2007; Brito *et al*. 2011), the southern Mauritania ethnic groups hunt them for skins, organs and meat, along the Senegal River and major tributaries (Villiers 1958; Nickel 2003).

The present work collected further information on rituals associated with crocodile hunting. Organised hunting used to be a common practice in April and May, during the peak of the dry season when water levels were low, and the hunt would congregate several villages along the river (Fig. 2). Fishermen at Mbagne established that the day prior to the hunt, a medicine man (locally known as "marabout") would go to the forest to collect special leaves, fruits and roots. These collections were then thrown into the water and the pattern of air bubbles erupting at the surface was taken as an indicator on how many crocodiles were present, how many would be captured, and if someone would get hurt during the following day hunt. In the 1958 hunt, a child was apparently warned not to enter the water the following day, but disobedience would eventually cost him a toe during the crocodile hunt.

On the hunting day, several boats would try to pull crocodiles to shallow waters, and the fishermen would capture crocodiles with a harpoon (Figs. 2 and 3), although firearms were also

used. The crocodile body would be divided among participants: the head for the fisherman, a part for the marabout, and the remainder to the villagers. Organised hunting was held in Mbagne until 1958, in Kaédi until the 1970s, and in Ngouye until the 1980s. Nowadays, the ritual of crocodile hunting along the Senegal River has been abandoned.

Figure 2. Ritual crocodile hunting at Ngouye (Locality 7) during the 1980s. Photograph: José Brito, from a printed picture.

Figure 3. Former crocodile hunters with a harpoon at Mbagne (Locality 5). Photograph: F. Martínez-Freiría.

While the anthropological interest of organised crocodile hunting rituals is undeniable, these activities have contributed to the extirpation of population and local extinction. Presently, permanent Nile crocodile populations are only found in the Diawling National Park. Despite the reduced number of crocodiles along the lower Senegal, hunting probably continues whenever opportunities arise. Environmental education campaigns are much needed to increase local public awareness about the vulnerability and relict value of crocodile populations. Interestingly, a former crocodile hunter in Ndirof now dedicates to the awareness of young Mauritanians (Fig. 4). Development of alternative attitudes towards crocodiles (eg Kaboré 2008) might increase activities with potential local revenue, such as eco-tourism - the Diawling National Park has the potential for making that change (Ly and Zein 2009).

Figure 4. Crocodile paintings for environmental education at Ndirof (Locality 4). Photograph: José Brito.

Surveys in mountains have suggested that Mauritanian crocodiles form a metapopulation, where loss of genetic diversity in gueltas could be attenuated by the occasional migration of individuals (Brito *et al.* 2011). The data collected in the present study allows the formulation of a complementary hypothesis that mountain populations may be acting as source of individuals that disperse along the Gorgol and Garfa Rivers, to the sink-populations along the Senegal River. The use of molecular markers is needed to quantify genetic variability, population sub-structure, and gene flow between mountain and lower populations.

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South Asia and Iran

Iran

FIRST RECORD OF COMPLETELY INFERTILE MUGGER NEST IN IRAN. In Iran, Mugger crocodiles (*Crocodylus palustris*) nest in May (Mobaraki 2002, 2006). Nests are usually placed under thick vegetation and close to water. Hatching occurs in July (Mobaraki *et al*. 2006). Various natural factors threaten crocodiles, nests and hatchlings during the reproductive season, of which drought and flooding are the most significant.

In Pishin Dam, flooding causes some crocodiles to be swept into the dam's overflow pool (Mobaraki 2006). These crocodiles need to be captured and released back into the dam, as there is no path for the crocodiles to move back by themselves (Abtin *et al*. 2007). Some crocodiles trying to move back to the reservoir from other ponds also fall into the overflow pool - movement is a usual behavior for Muggers in the area (Mobaraki and Abtin 2007). To manage this situation, Dargas Station has been used as a rehabilitation and rearing center (Abtin 2008).

On 1 May 2008, Pishin Dam guards observed that a 2.2 m long Mugger which had fallen into the overflow pool, had laid eggs on the concrete land area of the pool. The 21 eggs were moved to the DOE office in Rask and Chabaha, where they were kept in sand, but failed to hatch. Insufficient information is available to ascertain whether the eggs were infertile or whether they failed to develop due to exposure to high temperatures after being laid. Mean egg weight was 78.11 g, mean length was 76.87 mm and mean width was 48.03 cm (N= 19).

Figure 1. Female Mugger (2.2 m TL) relocated from Pishin Dam overflow pool to Dargas Station. Photograph: Asghar Mobaraki.

The female Mugger was captured from the overflow pool and transferred to Dargas Station, where she was maintained together with 4 smaller, juvenile Muggers, one of which was an immature 1.6 m long male. In late February 2010 the female was observed displaying courtship and aggressive behaviours towards the male, which died two days later from pneumonia. There were no signs of serious external injuries on the male, except for two small bites on his back. The female did not direct any aggressive behavior toward the other three crocodiles in the pond, only towards the male. It was not clear whether the female had a desire to mate with the male or whether the aggression was related to defence of territory.

Three months later, in late May, the female laid 18 eggs. The eggs were similar in size (mean length 77.80 mm, mean width 48.28 mm, mean weight 105.04 g) to the clutch laid at the overflow pool. The nest was left undisturbed for two months but failed to hatch. Examination of the eggs did not reveal any signs of opaque band or embryonic development, indicating they were infertile.

The possible attempt of the female Mugger to mate with a juvenile male is an interesting observation. This is the first record of a completely infertile clutch of Mugger eggs in Iran.

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Nepal

GHARIAL AND MUGGER MONITORING IN THE NARAYANI AND RAPTI RIVERS OF CHITWAN NATIONAL PARK, NOVEMBER 2010. In November 2010, surveys were carried out in the Rapti and Narayani Rivers of Chitwan National Park (CNP), with the aim of obtaining updated information on the status and distribution of Gharial (*Gavialis gangeticus*) and Muggers (*Crocodylus palustris*), and assessing current threats being faced by both species.

Surveys were undertaken from a wooden dugout canoe, with counts being made between 1030 and 1650 h. Foggy weather in the mornings prevented earlier starts, and partly cloudy conditions prevailed throughout the survey period (15-21 November 2010). In Nepal, winter begins around mid-September, and with decreasing temperatures crocodilians are often basking during the day.

Crocodilians were observed using 7 x 35 Olympus DPSR binoculars, and their size classified on the basis of size, as hatchlings (<90 cm), juveniles (90-180 cm), sub-adults (181-300 cm) or adults (>300 cm), and body condition was "assessed" at the same time. Adult male Gharials were distinguishable by the prominent "ghara" on their snout.

Gharial

A total of 58 Gharial were observed; 29 in a 50 km section of the Rapti River (Khagendramali to Rapti/Narayani confluence) and 29 in 100 km of the Narayani River (Sigrauleghat to Amaltari) (Table 1). Most (57%) individuals sighted were sub-adults (Table 1). On the basis of previous field observations, Gharials longer than 250 cm are likely to be mature females or sub-adult males, which were recorded at Sauraha (1), Khoreamuhan (2), Laugain (1), Sheri (2) and Kathauna (1) (Table 1). With the exception of two sub-adults that appeared weak and thin, at Itchami Tappu and Kasara respectively, all Gharials sighted appeared healthy.

Adults in the Nayanari and Rapti Rivers are generally smaller than breeding adults at the Gharial Conservation Breeding Centre (GCBC), which were hatched from eggs collected from the Narayani River in 1978 and the length of adult male is 525 cm now. The 12 juvenile Gharials sighted were scute-clipped, and represent the 20 head-started juveniles released into the Rapti River in 2010, in front of the GCBC (Khadka 2010). One of these juveniles was located at Kathauna, 75 km downstream of the release site.

Three Gharial had cattle tags attached to their tails - 14 Gharials released in February 2009 at Dumaria Ghat, Rapti

River, had cattle tags attached on the tail. Two of these tagged animals were about 10 km and 3 km upstream of Itcharni Tappu and Charahara, respectively.

Only 4 hatchlings were recorded during the surveys (Table 1), and were the result of natural recruitment. Three hatchlings were found at Belsar Island, where two hatched nests were located in June 2010, and 16 hatchlings collected and transferred to the GCBC (Khadka 2010). One hatchling was found at a sand bank at Ratnpur in the Narayani River, 40 km downstream from Belsar Island - it is unknown whether this animal originated from these same nests.

Muggers

A total of 53 Muggers were observed; 21 in the Rapti River, and 32 in the Narayani River (Table 2). Most (74%) individuals sighted were adults - no hatchlings were observed.

Conclusions

Gharials and Mugger crocodiles were mostly sighted at river confluences and shaded forest areas. The higher concentrations of fish at confluences between the river mainstreams and various tributaries and creeks, may be a factor influencing the

Table 1. Results of Gharial counts in the Rapti and Nayanari Rivers, November 2010. * one male was 4.0 m long.

River/Location of sightings	km	Hatchlings	Juveniles	Sub-adults	Adults (M.F)	Totals
Rapti River						
Itchami Tappu		-	-	2	-	2
Jaya Mangala ghole		-	2	2	-	4
Khagendarmali-Sauraha	*17.0*	-	*2*	*4*	-	*6*
Sauraha		-	-	1	-	1
Bodhnighat, near Khorsor		-	-	1	-	1
Dudhaura		-	-	2	2 (0.2)	4
Charahara		-	-	1	1 (0.1)	2
Belsar		3	1	-	-	4
Below Ghatgain		-	1	-	-	1
Gharial ghat, Kasara		-	-	1	-	1
Sauraha-Gharialghat	*15.0*	*3*	*2*	*6*	*3*	*14*
Kasara		-	1	1	-	2
Below Kasara Bridge		-	-	1	-	1
Kerunga confluence		-	1	1	-	2
Telauli Ghat		-	1	-	-	1
Meghauli Ghat		-	-	1	-	1
Rew confluence		-	-	1	-	1
Rapti/Narayani confluence		-	1	-	-	1
Kasara-Rapti/Naryani confluence	*18.0*	-	*4*	*5*	-	*9*
Total Rapti River	**50.0**	**3**	**8**	**15**	**3 (0.3)**	**29**
Narayani River						
Bhagani	-	-	-	2	-	2
Khorea Muhan		-	2	4	4 (2.2) *	10
Sigrauli-Amaltari (South)	*30.0*		*2*	*6*	*4*	*12*
Laugain		-	-	2	-	2
Bhosar Ghat		-	-	1	-	1
GMCghat				1	-	1
Amaltarighat		-	-	2	-	2
Sigrauli-Amaltari (North)	*30.0*	-	-	*6*		*6*
Ratnpur		1	-	-	-	1
Batkholi, below Sheri		-	1	-	-	1
In front of Sheri post		-	-	2	-	2
Lunaha, near Materi		-	-	1	-	1
Amaltari-Baguban	*20.0*	*1*	*1*	*3*		*5*
Kathauna		-	1	3	-	4
Bhelauji		-	-	-	2 (0.2)	2
Baguban-Tribeni	*20.0*	-	*1*	*3*	*2*	*6*
Total Narayani River	**100.0**	**1**	**4**	**18**	**6 (2.4)**	**29**
Grand Total	**150.0**	**4**	**12**	**33**	**9 (2.7)**	**58**

distribution of Gharial in such areas. During the hot season, the water of shaded forest areas is cooler, and during winter the water is warmer than the main rivers. Such areas may assist with thermoregulation for Gharial and Muggers at different times of the year. Fish are also abundant in these areas.

Gharials and Muggers were usually seen together in the river, but they appear to have different preferences for basking sites. Gharials always bask on sand while Muggers bask on mudflats or other muddy areas.

Prior to 1960, Gharials were most abundant in the Narayani and Rapti Rivers (Maskey 1989). In 1977, 57 Gharial were estimated to be in CNP, all within the Narayani River - none were in the Rapti River (GCBC 1998; Dhruvajyoti Basu, pers. comm. 2009). Hundreds of Gharials were observed in the lower Narayani River prior to construction of the dam on the river near the Indo-Nepalese border in 1964.

GCBC has established in 1978 and Gharial releases started in 1981 (Ballouard *et al*. 2010). Through the release program, Gharials gradually inhabited the Rapti River. The number of Gharial recorded in the Rapti River in this survey (29) was higher than that recorded in 2008 (24) (Khadka *et al*. 2008). Given the variability that can occur from year to year in survey counts, no significance can be attributed to this increase at this time.

In the early 1950s, about 235 Gharials were estimated to occur between Narayanghat and Tribeni along the Narayani River, with the population being most concentrated in the Sikrauli-Khoria and Materi-Tribeni sections. This translates into a relative density of 5.88 ind/km. This area of the river is dissected by numerous channels that provide suitable habitat for basking, feeding and nesting (Maskey 1989). But now, due to anthropogenic activities, habitat has decreased and Gharial remain in the some isolated remnant populations. This survey indicated relative densities of 0.58 and 0.29 ind/km for the Rapti and Nayarani Rivers respectively.

A monitoring survey in 2008 indicated 41 individuals, of which 34 individuals were directly sighted and 7 were indirectly counted in the Narayani River, and 24 individuals were directly counted in the Rapti River (Wildlife Nepal Newsletter 2008). Mishara (2002) counted 12 Gharial in Sauraha-Kasaraghat

Table 2. Results of Mugger counts in the Rapti and Nayanari Rivers, November 2010.

River/Location of sightings	km	Juveniles	Sub-adults	Adults (M.F)	Totals
Rapti River					
Itcharni Tappu		1	2	-	3
Khagendarmali-Sauraha	*17.0*	*1*	*2*	-	*3*
Khorsor Ghat		-	1	-	1
Shankar Ghat		1	1	-	2
Dudhaura		-	1	-	1
Charahaara		-	-	2 (1.1)	2
Dumaria Ghat		1	-	-	1
Belsar		-	-	2 (1.1)	2
Sauraha-Gharial Ghat	*15.0*	*2*	*3*	*4*	*9*
Kasara		1	-	7 (2.5)	8
Budhanagar Ghat		-	-	1 (0.1)	1
Kasara-Rapti/Naryani confluence	*18.0*	*1*	-	*8*	*9*
Total Rapti River	**50.0**	**4**	**5**	**12 (4.8)**	**21**
Narayani River					
Mardighole		-	-	1 (1.0)	1
Sigrauli-Amaltari (South)	*30.0*			*1*	*1*
Lagauin		-	-	3 (1.2)	3
Laukhani, near island resort area		-	1	7 (2.5)	8
Sigrauli-Amaltari (North)	*30.0*	-	*1*	*10*	*11*
Batkholi		-	-	3 (1.2)	3
Amaltari-Baguban	*20.0*				*3*
Bhimbandh		-	-	4 (1.3)	4
Bhelauji		-	2	5 (1.4)	7
Simaradar		-	-	1 (0.1)	1
Kanamanaha		-	2	3 (1.2)	5
Baguban-Tribeni	*20.0*		*4*	*13*	*17*
Total Narayani River	100.0	-	5	27 (8.19)	32
Grand Total	**150.0**	**4**	**10**	**39 (12.27)**	**53**

in the Rapti River (compared with 14 sighted during this survey) and estimated a minimum of 50 Gharials in the Narayani River (based on CNP staff information). Ballouard and Cadi (2005) counted 49 individuals in December of 2005, compared to 38 and 34 in 2003 and 2004 respectively, in the same section of river.

The establishment of the GCBC and the Gharial head-starting program are considered significant actions that have prevented the extinction of *G. gangeticus* in Nepal. The centre is maintaining the Gharial population in Nepal and also India, as Gharial migrate downstream from Nepal into India.

There are no historical survey data on *C. palustris* in CNP, and this survey represents the first attempt to quantify status and distribution. The Mugger population appears to be increasing. Ten years ago, the incidence of Muggers moving into village fish ponds or rice/paddy fields during the rainy season was very low. Now, Muggers are now regularly rescued from such areas during the rainy season, and human-mugger conflict is likely to increase in CNP. This survey only took into account riverine habitat, but there are 40 other wetland areas in CNP, including lakes, small streams, waterholes and marshes, which potentially could be occupied by Muggers. The Mugger population in CNP is estimated to be around 300 individuals. Although hatchlings were not sighted during this survey, they have been sighted in small tributaries and waterholes.

In areas that are frequented by tourism-related activities, both wild Gharials and Muggers appear to become more tolerant "disturbance", and basking animals can be approached much more closely. Sauraha is the main entrance for tourists, and where there are many tourism activities (eg elephant ride, jungle drive, nature walk and canoeing). In areas such as Bhelaugi and Kathauna (Narayani River), far from human settlement and tourism activities, crocodilians are only seen from a distance, and quickly go into the water when approached.

Potential threats to the Gharial and Mugger populations in the area include:

1. Intensive sand mining in the Rapti River, comparatively less in the Narayani River.
2. The spread of Water Hycianth (*Eichnornia crassipes*) and Pond Weed (*Potamogeton nodosus*) on sand banks, mudflats and shingle (stony banks/beach) banks on the Rapti River, from below Sauraha to the Rapti/Narayani confluence.
3. Litter (eg plastic bottles, plastics and other rubbish) spreading onto the sand banks, mudflat and shingle banks of the Narayani River.
4. Introduction of gill-net fishing practices by local fishermen. This is potentially harmful to Gharials, which become entangled in the nets.
5. Pollution of the river with industrial sewage.
6. Other anthropogenic activities (eg clothes washing, bathing, spread of charcoal from funeral pyres, litter associated with funerals), have led to Gharials, freshwater turtles and birds shifting to other parts of the Rapti and Narayani Rivers. Official unpublished CNP data indicate collection of 12 Gharial nests about 10 years ago, but now no nests are evident, presumably due to anthropogenic activities in the eastern and western channels of the Narayani River.

Chitwan National Park managers/authorities have engaged local fishing communities along the rivers through:

1. Launching of conservation awareness programs.
2. Awareness and increased enforcement activities with respect to use of illegal gill-nets.
3. Employment in government and hotel/tourism sectors in and around the park is a priority.
4. Providing training for development of skills knowledge (eg motor mechanic, carpenter, electrical, kitchen, gardening and tourist guide training).

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India

FIRST MEETING OF TRI-STATE COMMITTEE. During a recent visit to the Madras Crocodile Bank [CSGN 29(4): 11], the Indian Minister for Environment and Forests, Mr. Jairam Ramesh (Fig. 1), briefed media on the Ministry's new initiative for Gharial conservation, and the formation of a National Tri-State Chambal Sanctuary Management and Coordination Committee. The committee is a three tier decentralised mechanism, formed to: look into the entire range of issues (from socio-economic to monitoring and research protocols); devise an institutional framework to ensure proper coordination among all stakeholders; and, develop better coordination amongst the States and Centre for concerted conservation initiatives with focus on involvement of local community.

The first meeting of the committee was inaugurated by Minister Mr. Jairam Ramesh on 22 February 2011. A booklet on Gharial for the general public was also released on the day. The first tier of the National Steering Committee, chaired by Additional Director General of Forests, Mr. Jagdish Kishwan, took several key decisions with clear deadlines and implementable action. The Gharial Management Plan will be developed in consultation with experts, local communities, State forest departments and other Ministries, and Chief Wildlife Wardens and Divisional Forest Officers of the three States will be involved in its preparation. This first meeting and this initiative has provided an excellent platform for concerted conservation action in our efforts to save Gharial.

Figure 1. Minister Jairam Ramesh (left) with Rom Whitaker (right) at Madras Crocodile Bank on 27 December 2010 [see CSGN 29(4): 11]. Photograph: K. Ganesh.

Source: *http://moef.nic.in/downloads/public-information/gharial_conservation_press_release.pdf*

SALTWATER CROCODILE NUMBERS IN BHITARKANIKA CONTINUE TO INCREASE. The latest survey results from Bhitarkanika indicate the number of Saltwater crocodiles (*Crocodylus porosus*) continues to increase. The 2011 count was 1654, compared with 1610 in 2010 and 1572 in 2009. Of the 1654 counted, 531 were hatchlings, 377 were yearlings, 304 juveniles, 166 sub-adults and the remainder were adults.

The steady rise in the number of crocodiles has led to increased human-crocodile conflict in villages near Bhitarkanika. Retaliation by villagers has resulted in the killing of some crocodiles.

Source: *OneIndiaNews 16 January 2011 (http://news.oneindia.in/2011/01/16/numberof-estuarine-crocodiles-in-bhitarkanikaincreases-aid0126.html).*

North America

USA

SIAMESE CROCODILE CONSERVATION EXHIBIT AT CAPE MAY COUNTY ZOO. A captive-born, 1.8 m long female Siamese crocodile (*Crocodylus siamensis*) was exhibited for 3 months at the Cape May County Zoo, New Jersey, USA, during the summer of 2010.

Photograph: Christy Gotwols.

The specimen was provided on temporary exhibit loan from Crocodile Conservation Services based in Plant City, Florida. Exhibit graphics focused on the status of wild Siamese crocodile population and the conservation efforts of Flora and Fauna International (FFI). A donation station located outside the exhibit allowed zoo visitors to make monetary contributions for Siamese crocodile conservation. Public donations were matched by the Cape May County Zoo Chapter of the American Association of Zoo Keepers (AAZK). The exhibit resulted in a new visitor experience, additional experience for zoo staff in captive crocodilian husbandry,

and $US500 was sent to FFI in support of the Cambodian Crocodile Conservation Programme. We also hope the exhibit was successful in improving public awareness of this critically endangered crocodilian.

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Australia and Oceania

Australia

RARE FRESHWATER CROCODILE ATTACK. The Australian Freshwater crocodile (*Crocodylus johnstoni*) is generally considered to be harmless, and almost all cases where people have been bitten are considered to have been provoked (eg accidental contact, mistaken identity, attempted capture). A recent publication (Hines and Skroblin 2010) describes an atypical situation involving two Freshwater crocodiles in the Kimberley region of Western Australia.

The female victim was swimming, when she bumped into a 2-m long crocodile, which within seconds latched onto her knee and attempted to "death roll". Attempts to free herself were unsuccessful, and the woman had to "drag" the crocodile with her to the water's edge, where a colleague gouged the crocodile's eyes, forcing it to release its grip. Before the victim could climb out of the water, a smaller (1 m) freshwater crocodile bit her on the arm. Injuries included puncture wounds to both hands, right arm and left knee.

[Hines, K. and Skroblin, A. (2010). Australian Freshwater crocodile (*Crocodylus johnstoni*) attacks on humans. Herpetological Review 41(4): 430-433.]

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Latin America and the Caribbean

Puerto Rico/USA

CROCODILIANS WATCH OVER DRUGS. A caiman has been used to guard drugs in Puerto Rico. Authorities investigating an abandoned oceanfront building for drug activities came across the caiman. It was tied near 200 bags of cocaine, 30 bags of heroin and an unknown quantity of marijuana.

More recently, on 9 March, in Riverside County, California, officers found a $1.5 million marijuana-growing operation being guarded by a 1.2-m long alligator named "Wally".

Sources: *Hispanically Speaking News, 5 January 2011 (http://www.hispanicallyspeakingnews.com/notitas-de-noticias/details/killer-caiman-found-protecting-hundreds-of-bags-of-cocaine-heroin-and-marij/4014/); Miami Herald (http://www.miamiherald.com/2011/03/09/2105540/calif-pot-growers-use-alligator.html).*

Belize

AMERICAN CROCODILE POPULATION AND HABITAT VIABILITY ASSESSMENT AND CONSERVATION IN AMBERGRIS CAYE, BELIZE. Ambergris Caye is a flat, coral sand island, stretching 40 km south from the southernmost tip of the Yucatan Peninsula with widths ranging from a few hundred metres to over 6 km. Protected by the Mesoamerican Barrier Reef System on the east, the island's west coast is composed primarily of red mangrove (*Rhizophora mangle*), and fresh, brackish and saltwater lagoons. These critical wetland habitats are home to the threatened American crocodile (*Crocodylus acutus*), and an important habitat to a wide variety of migratory birds.

Based on the American Crocodile Education Sanctuary's (ACES) annual crocodile rescues, confiscations, and relocations over the past 4 years,human-crocodile conflicts on Ambergris Caye are steadily increasing due to indiscriminate and unregulated development; deliberate illegal crocodile feeding to attract tourists; indirect crocodile feeding via improper discarding of fish scraps and inadequate waste disposal; an increase in poaching for meat, trophy skulls, and teeth for souvenirs; and finally, needless crocodile killings out of fear. Furthermore, several large, wild *C. acutus* on the island have been found lacking teeth and generally in poor health. While this could be due to several factors, ill apex predators are an indicator of an environmental disturbance. The first step to addressing all of these factors is to assess the crocodile population in the said region.

Funded by the Rufford Small Grants Foundation for Nature Conservation, the fundamental goals of this research project are to quantify the *C. acutus* population and assess viable wetland habitat availability on Ambergris Caye through population surveys (daytime, spotlight, nest); crocodile tagging; and, habitat survey and assessments. Crocodile surveys commenced with the onset of the dry season (December 2010) and will continue through the mating and nesting seasons, and end shortly after the hatching season (July 2011). The data collected will be utilized to generate a population structure and distribution for the Belize Forest Department. Results from this project shall foster the development and implementation of an effective sustainable management program for the conservation of *C. acutus* and it's bio-diverse, mangrove wetland habitats in Ambergris Caye.

A broader long-term impact resulting from this project is an increase in public awareness about crocodiles and the need for their conservation. The ability to work closely with communities during data collection presents the opportunity to educate the populace on the importance of crocodiles in Belize's ecosystems and how to safely coexist with them; thus

expectantly, reducing croc-human conflicts and nonsensical crocodile killings in Belize.

Random spotlight and daylight surveying explorations are being conducted from a powered skiff and golf-cart. Survey areas include waterways, lagoons and immediate waterfront areas on the island. Crocodiles are captured by protocol and marked by scute-clipping, and photo ID recorded. Data include: date and Global Positioning System (GPS) locations of all sightings, captures/recaptures, and nest sites; cloacal sexing when possible/feasible; health (determined by eye clarity, absence/presence of skin discolorations/lesions, and absence/presence/brittleness of teeth and claws); behaviour (eg aggression); and size [total length (measured or estimated), snout length, head length, snout-vent length (anterior and posterior)]. Crocodiles were classified in accordance with previous American crocodile research in Belize, as: hatchlings (<61 cm), juveniles (61-90 cm), sub-adults (90-180 cm), and adults (>180 cm).

Thus far, from December 2010 to February 2011, 113 *C. acutus* were observed during spotlight and daylight surveys of a 72.42 km survey route (1.56 ind/km) through coastal, mangrove, and lagoon habitats. Of these, 32 (28.3%) were classified as 'eye-shine only' (EO), and the remaing 81 (71.7%) were classified as hatchlings (20; 24.7%), juveniles (7; 8.6%), sub-adults, (26; 32.1%) and adults (28; 34.6%). Of the 23 tagged crocodiles, 12 (52.2%) were males and 11 (47.8%) were females. Scute clippings have been preserved in a freezer for future DNA and toxicity testing. Furthermore, 9 of these crocodiles were relocated due to one of the following factors: problem/nuisance or mature female whose nesting area is about to be developed. Since 27 February no more females have been nor shall be relocated for any reason until post-hatching season.

On 11 March 2011, a flyover of the entire island of Ambergris Caye at an elevation of 150 m, courtesy of LightHawk, enabled surveys of critical wetland habitats which were otherwise inaccessible. While much of the island is still undeveloped, suitable crocodile habitat appears to be limited primarily to the south end of the island. The majority of the lagoon areas in the middle regions of the island appear very seasonal - at the time of the flight most were completely dry or exceptionally shallow. Shallow waters are likely to become hypersaline, and possibly heat up beyond crocodile tolerance levels. Fortunately, the Bacalar Chico National Park and Marine Reserve protects the limited wetland habitats suitable for crocodiles in the northern region of Ambergris Caye. The availability of nesting habitat was less than anticipated. Most of the mangrove lagoon habitats spotted across the island lacked high enough dry land areas to keep nests out of the water in the event of heavy rains; and the prime nesting habitats in the south are being minimized due to impending development. GPS data was also gathered on developments currently established or developing in mangrove areas island-wide as baselines.

Of particular interest, one captured *C. acutus* exhibited intermittent ventral scales (post-cloacal, rows 3 and 5). While this lends to the possibility of a *C. acutus* and *C. moreletii* hybrid, DNA testing is required for confirmation. Another *C. acutus* had a 'marbled eye' (Fig. 1) - its vision did not appear to be impaired.

Figure 1. American crocodile with "marbled" eye.

The American Crocodile Education Sanctuary (ACES) is currently seeking donations of a refractometer, a colorimeter, and fencing for the new crocodile sanctuary in Ladyville, Belize. Tax-deductible donations can be made through ACES 501(c)(3) partner 'The Belize Economic & Ecological Development Fund' at www.BEEDFund.com.

Cherie Chenot-Rose, Vince Rose and Chris Summers, *ACES, No. 5 Conch Shell Street, Boca Del Rio, San Pedro, Ambergris Caye, Belize, <acesnpo@hughes.net, americancrocodilesanctuary.org>.*

Science

Recent Publications

Fujisaki, I., Mazzotti, F.J., Dorazio, R.M., Rice, K.G., Cherkiss, M. and Jeffry, B. (2011). Estimating trends in alligator populations from nightlight survey data. Wetlands (doi: 10.1007/s13157-010-0120-0).

Abstract: Nightlight surveys are commonly used to evaluate status and trends of crocodilian populations, but imperfect detection caused by survey- and location-specific factors makes it difficult to draw population inferences accurately from uncorrected data. We used a two-stage hierarchical model comprising population abundance and detection probability to examine recent abundance trends of American alligators (*Alligator mississippiensis*) in subareas of Everglades wetlands in Florida using nightlight survey data. During 2001-2008, there were declining trends in abundance of small and/or medium sized animals in a majority of subareas, whereas abundance of large sized animals had either demonstrated an increased or unclear trend. For small and large sized class

animals, estimated detection probability declined as water depth increased. Detection probability of small animals was much lower than for larger size classes. The declining trend of smaller alligators may reflect a natural population response to the fluctuating environment of Everglades wetlands under modified hydrology. It may have negative implications for the future of alligator populations in this region, particularly if habitat conditions do not favor recruitment of offspring in the near term. Our study provides a foundation to improve inferences made from nightlight surveys of other crocodilian populations.

Arif, A.S.M., Hashim, M.A., Runa, R.A., Chowdhury, E.H., Rahman, M.S. and Song, H.J. (2010). Prevalence of surgical affections with their clinical management in crocodiles (*Crocodylus porosus*) in Bangladesh. Korean J. Vet. Serv. 33(3): 313-317.

Abstract: This study was conducted in the saltwater crocodile (*Crocodylus porosus*) for the occurrence of various surgical affections with their clinical management. During the period of January 2006 to June 2008, a total of 68 adult crocodiles were considered as reference population from the Reptiles Farm Ltd. at Bhaluka, Mymensingh. The occurrence of surgical affections of adult female (88.9%) was significantly (P/0.01) higher than male (11.1%). Prevalence of common surgical affections were wound: 72.2%, fibroma: 11.1% abscess: 5.6%, fracture: 5.6%, tail necrosis: 2.8%, myiasis: 2.8%. Wound was the highest among the affections. Among the identified wounds, biting wound was higher. In summer (57.7%) the occurrence of wound was higher compared to other seasons. In winter season(7.7%) the occurrence of abscess, myiasis, fibroma were higher compared to other seasons. Wounds and fibroma are the major surgical affections in saltwater crocodile. The most common site of surgical affection was recorded in crocodile's tail (30.6%). It was suggested that minimal stress, allowing constant and easy access to water, removal of roots of the tree in the basking land of crocodiles pen, basking land of the pen is better filling up by sand, clinical surgical managements are essential for better health and production.

Pata, S., Yaraksa, N., Daduang, S., Temsiripong, Y., Svasti, J., Araki, T. and Thammasiriraka, S. (2011). Characterization of the novel antibacterial peptide Leucrocin from crocodile (*Crocodylus siamensis*) white blood cell extracts. Developmental and Comparative Immunology (doi:10.1016/j.dci.2010.12.011).

Abstract: Four novel antibacterial peptides, Leucrocin I–IV from Siamese crocodile white blood cell extracts were purified by reverse phase high performance liquid chromatography (RP-HPLC). Leucrocins exhibit strong antibacterial activity towards *Staphylococcus epidermidis*, *Salmonella typhi* and *Vibrio cholerae*. The peptides were 7-10 residues in length with different primary structure. The amino acid sequence of Leucrocin I is NGVQPKY with molecular mass around 806.99 Da and Leucrocin II is NAGSLLSGWG with molecular mass around 956.3 Da. Further, the interaction between peptides and bacterial membranes as part of their killing mechanism was studied by fluorescence and electron microscopy. The outer membrane and cytoplasmic membrane was the target of action of Leucrocins as assayed in model membrane by release of β-galactosidase due to the membrane permeabilization. Finally, the hemolytic effect was tested against human red blood cell. Leucrocin I, III and IV showed less toxicity against human red blood cells than Leucrocin II.

Villamarín, F., Boris Marioni, John B. Thorbjarnarson, Bruce W. Nelson, Robinson Botero-Arias and William E. Magnusson (2011). Conservation and management implications of nest-site selection of the sympatric crocodilians *Melanosuchus niger* and *Caiman crocodilus* in Central Amazonia, Brazil. Biological Conservation (doi:10.1016/j.biocon.2010.12.012).

Abstract: Management of crocodilians is often based on source-sink dynamics, protecting breeding habitat and concentrating hunting in other areas. Nest distributions shed light on habitat use by breeding populations, which might be used as a basis for monitoring and management. The heterogeneous spatial distribution of *Melanosuchus niger* and *Caiman crocodilus* in Amazonia has been suggested to reflect past hunting pressure, often underestimating the natural ecological peculiarities of these species. Ground nest surveys combined with satellite imagery allowed us to evaluate whether nest-site use by *M. niger* and *C. crocodilus* reflects environmental constraints or is a result of hunting pressure. Our results indicate that there is little evidence that hunting pressure shapes nest-site use of these species in our study areas. *M. niger* nests mainly on the shores of stable, temporally impounded floodplain lakes isolated from the early stages of the annual rising water of main rivers. This behavior facilitates the identification of suitable nesting sites using moderate-resolution remote-sensing tools and should guide monitoring efforts and the protection of these areas. In contrast, *C. crocodilus* is a generalist species, able to nest hundreds of meters inside the forest far from permanent water. This makes the occurrence and distribution of nesting-sites unpredictable using Landsat images. Although nests of this species can be found around lakes where nests of M. niger also occur, the protection of these sites might help to preserve only a small portion of *C. crocodilus* nesting females. Thus, conservation strategies for *C. crocodilus* should probably be based on different approaches.

Grant, P.B.C. and Lewis, T.R. (2010). High speed boat traffic: a risk to crocodilian populations. Herpetological Conservation and Biology 5(3): 456-460.

Abstract: Injuries related to boat traffic have been documented as a major source of human-related injuries and deaths in many aquatic species but have not been documented in crocodilians. We examined the proportion of boat-related injuries in Spectacled Caiman (*Caiman crocodilus fuscus*) in

the Tortuguero region of Costa Rica within waterways with enforced speed limits and those without. No boat injuries were documented in waterways with speed limits; however, in waterways without speed limits, 36.6% of caimans we captured retained old scars or fresh lacerations related to boat propellers, including two mortalities. Presence of enforced speed zones was positively associated with lower rates of collisions, boat propeller related injuries, and mortalities. Slower boat speed may provide sufficient time for caimans to avoid oncoming boats. Increasing boat traffic in the region due to increasing ecotourism and a rapidly expanding local community may increase the vulnerability of this crocodilian species to boat related injuries and population reduction. Imposing enforced speed limits within non-essential transportation routes is a reasonable mitigation measure to help protect this species.

Harriss, C.B., Barnier, A.J., Sutton, J. and Keil, P.G. (2010). How did you feel when "The Crocodile Hunter" died? Voicing and silencing in conversation influences memory for an autobiographical event. Memory 18(2): 185-197.

Abstract: Conversations about the past can involve voicing and silencing; processes of validation and invalidation that shape recall. In this experiment we examined the products and processes of remembering a significant autobiographical event in conversation with others. Following the death of Australian celebrity Steve Irwin, in an adapted version of the collaborative recall paradigm, 69 participants described and rated their memories for hearing of his death. Participants then completed a free recall phase where they either discussed the event in groups of three or wrote about the event on their own. Finally, participants completed the original questionnaire again, both 1 week and 1 month after the free recall phase. Discussion influenced later memories for hearing of Irwin's death, particularly memories for emotion and shock. Qualitative analysis of the free recall phase suggested that during conversation a shared understanding of the event developed, but that emotional reactions to the event were silenced in ways that minimised the event's impact. These findings are discussed in terms of the processes and consequences of sharing public and personal memories in conversation.

Urushitani, H., Katsu, Y., Miyagawa, S., Kohno, S., Ohta, Y., Guillette, L.J. Jr. and Iguchi, T. (2010). Molecular cloning of anti-Müllerian hormone from the American alligator; *Alligator mississippiensis*. Mol. Cell. Endocrinol.

Abstract: Anti-Müllerian hormone (AMH) plays an important role in male sex differentiation in vertebrates. AMH produced by Sertoli cells of the fetal testis induces regression of the Müllerian duct in mammalian species. In alligators, sexual differentiation is controlled by the temperature during egg incubation, termed temperature-dependent sex determination (TSD). The TSD mechanism inducing sex differentiation is thought to be unique and different from that of genetic sex determination as no gene such as the SRY of mammals has been identified. However, many of the genes associated with gonadal differentiation in mammals also are expressed in the developing gonads of species exhibiting TSD. To clarify the molecular mechanisms associated with gonad formation during the temperature-sensitive period (TSP), we have cloned the full length AMH gene in the alligator, and quantitatively compared mRNA expression patterns in the gonad-adrenal-mesonephros (GAM) complex isolated from alligator embryos incubated at male and female producting temperatures. The deduced amino acid sequence of the alligator AMH cDNA showed high identity (59 to 53%) to avian AMH genes. AMH mRNA expression was high in the GAM of male alligator embryos at stage 24 (immediately after sex determination) and hatchlings, but suppressed in the GAM of estrogen-exposed hatchlings incubated at the male-producing temperature. In the alligator AMH proximal promoter, a number of transcriptional factors (for SF-1. GATA, WT-1 and SOX9) binding elements were also identified and they exhibit a conserved pattern seen in other species. SOX9 up-regulates transcriptional activity through the amAMH promoter region. These results suggested that AMH and SOX9 play important roles in TSD of the American alligator.

Johnston, M.A. (2010). American Alligator Fecal Coliform and Pathogen Identification, Genotypic Fingerprinting, and REP-PCR Bacterial Source Tracking in South Carolina. University of South Carolina Theses and Dissertations. Paper 196. http://scholarcommons.sc.edu/etd/196.

Abstract: Research for this study was performed to assess numerous coastal nonpoint source pollution components from poikilothermic (i.e. cold-blooded) wildlife sources, including fecal coliform identification, genotypic fingerprinting, and bacterial source tracking. The overall goals were to identify, fingerprint, and detect American alligator (*Alligator mississippiensis*) fecal coliform bacteria in surface waters, as alligators may be an unrecognized source of fecal pollution and/or potential pathogens in coastal South Carolina surface waters. The research was divided into three sections, where each component improves our knowledge of the contribution of fecal bacteria from poikilothermic animals. The first research component determined the accuracy of two Enterobacteriaceae identification techniques, the API 20E biochemical test system and 16S rRNA gene sequencing methods, in the identification of alligator cloacal isolates. The second component evaluated the ability of Repetitive Extragenic Palindromic PCR (REP-PCR) to produce identifiable, unique, and stable genomic fingerprints from alligator fecal coliform and potential pathogenic bacteria. The final component determined if alligator fecal coliform and potential pathogenic bacteria contributed to water quality degradation in coastal South Carolina surface waters using REP-PCR as a source tracking tool. Results from this research show that when 16S rRNA gene sequencing methods are utilized, the predominant enteric bacteria identified from alligator fecal samples include: *Aeromonas* spp., *Citrobacter freundii*, *Edwardsiella tarda*, *Enterobacter* spp., *Escherichia coli*, *Plesiomonas shigelloides*, and *Salmonella enterica*. Alligator fecal coliform bacteria can also be genotypically

characterized with REP-PCR using the BOX A1R primer. Finally, alligators are a source of fecal coliform bacteria in South Carolina surface waters, as alligator REP-PCR fingerprints were similar to bacteria fingerprints isolated from surface waters. By attempting to identify, characterize, and match alligator bacterial fingerprints to those found in surface water samples, this research increases our understanding of bacterial sources and source tracking tools, indicating that alligators are a pollution source of enteric bacteria and potential pathogens in coastal surface waters in the southeastern United States. This research will hopefully demonstrate that there is a continued need to study and develop effective bacterial source tracking tools and indicators to help identify and manage sources that contribute to fecal pollution in coastal surface waters.

Watling, J.I., Brandt, L.A., Romañach, S.S., Fujisaki, I., Escribano, Y., Pifer, E., Curtis, M.J., Mazzotti, F.J., De Angelis, D. and Pearlstine, L.G. (2010). Climate-based distribution models for the American Crocodile, *Crocodylus acutus*: Illustration of methodological challenges and management opportunities. *In* Proceedings of the 95th Annual Meeting of Ecological Association of America. Pittsburgh, Pennsylvania, August 2010.

Abstract: Climate change is expected to result in shifts in the spatial distribution of habitats and the species that occupy them, and responding to these shifts will be an important focus of applied conservation in the 21st century. Climate envelope models provide one tool that may be used to inform management activities relating to assessment and adaptation to future climate change. As part of a larger effort to create climate envelope models for 21 species of threatened and endangered vertebrates occurring in southern Florida, we present a prototype model for the American crocodile (*Crocodylus acutus*) that illustrates both limitations and challenges associated with species distribution modeling, as well as how management recommendations can emerge from models of projected future distributions. When modeling the contemporary climate envelope for a species, the often arbitrary selection of a geographic study area can have important implications for the differentiation of "suitable" and "unsuitable" climate space. We compare models bounded by the entire western hemisphere with models bounded by a more realistic climate space determined by observed distributions of other New World crocodilians. We explore projected future distributions of *C. acutus* in the year 2080 under high and low CO_2 emissions scenarios. The high-emissions scenario projects a 70% expansion of suitable climate space for *C. acutus* from approximately 860,000 km^2 at present to 1.46 million km^2 in 2080. The projected future climate envelope for *C. acutus* under a low-emissions scenario suggests a 45% expansion in area to approximately 1.25 million km^2, although the low-emissions scenario predicts a more northerly expansion of suitable climate space in Florida than the high-emissions scenario. Both scenarios predict suitable climate space for *C. acutus* in Florida, but the high emissions scenario also predicts an expansion of suitable climate space into coastal portions of the northern Gulf of Mexico. These data coupled with projections of sea level rise and land use changes provide information that will be useful in assessing the vulnerability of *C. acutus* to climate change and identifying opportunities for future protection for *C. acutus*.

Northfield, J.K. and McMahon, C.R. (2010). Crikey! Overstating the conservation influence of the Crocodile Hunter. Science Communication 32(3): 412-417.

Abstract: As humans recognise their environmental responsibilities, it is timely to investigate the influence celebrities have on social causes, including conservation. Recently, Brown explored the conservation influence of Steve Irwin. In our commentary, we argue that Irwin was not a conservation champion but an environmental celebrity. His style, while entertaining, was intrusive and his knowledge of biodiversity limited. Nonetheless, his effects to conserve wildlife through land acquisition and popularise conservation will be long lasting. Awareness is key to conservation, and Irwin brought issues to the fore. However, his role in imparting knowledge and respect for animals is debateable.

Keenan, S.W. and Engel, A.S. (2010). Inferring ancestral Crocodylamorpha-microbe symbioses based on the American alligator (*Alligator mississippiensis*) gut microbiome. Geological Society of America Abstracts with Programs 42(5): 89.

Abstract: The vertebrate gastrointestinal (GI) microbiome represents a complex symbiotic network developed over geological time, specialized in each host for specific host-dependent metabolic processes. Recent advances in gene sequencing now allow for nearly exhaustive evaluation of bacterial 16S rRNA genes from distinct regions along vertebrate GI tracts. The GI bacterial phyla from diverse animals (predominately farm-raised pigs, chickens, and pythons) are dominated by *Firmicutes* and *Bacteroidetes*. Despite knowing that these modern tetrapods and their ancestors have occupied a wide range of present and past ecological niches, and have affected biogeochemical cycles and ecosystem level processes in their habitats as a consequence of dietary requirements, notably absent are studies of wild animals or investigations of Reptilian symbioses. Reptiles, crocodylians in particular, have persisted in semi-tropical to tropical regions for over 200 million years, leaving behind a diverse and prolific fossil record. Therefore, this study focused on understanding the GI microbiome of the wild American alligator (*A. mississippiensis*), an extant member of Crocodylamorpha, found today across the southeast of North America. The phylum-level microbiome composition of *A. mississippiensis* (averaged for all samples from the mouth to the colon) was strikingly different than previously examined animals: *Proteobacteria* (~61%), *Fusobacteria* (~22%), *Bacteroidetes* (~13%), *Firmicutes* (~3%). Changes to gut bacterial composition occur as a consequence of changes in diet and environment. The dominance of *Proteobacteria* (*Gammaproteobacteria*) and *Fusobacteria* is unique among

studied vertebrates, and may indicate a suite of ancestral symbioses present in basal crocodylians partially controlled by host-microbe genetic evolution.

Thomas, B., Holland, J.D. and Minot, E.O. (2010). Home range and movement patterns of an estuarine crocodile '*Crocodylus porosus*': a satellite tracking pilot study. Northern Territory Naturalist 22: 60-74.

Abstract: The number of Estuarine Crocodiles *Crocodylus porosus* in the Northern Territory, Australia, is increasing. This has led to an increase in interaction with humans and livestock. Whilst there have been a number of studies on the distribution and movement of crocodiles in Australia, little has been recorded detailing movement patterns, and less evaluating the technical effectiveness of employing satellite tracking technology on this species. We attached an Argos satellite transmitter to a 4.2 m male estuarine crocodile captured in the Adelaide River, approximately 100 km east of Darwin, Northern Territory, Australia. During the 6-month study period (July to December 2005), the crocodile showed definite signs of home range fidelity, staying within a Minimum Convex Polygon of 63 km^2 and a 95% kernel area of 8 km^2. The average daily movement was 5.9 $km.day^{-1}$ with increased movement during the month of December. A high percentage of useable locations (65%) were received from the Platform Terminal Transmitter, with an increased number of location readings occurring between 2000 and 0700 h. Given the aggressiveness of this species and the hostile environments in which they live, the Argos system is a useful method for tracking their movement. The results of this study have provided preliminary information improving our understanding of the home range and behaviour of a large male crocodile.

La Grange, L.J., Maruccia, G. and Pozio, E. (2010). *Trichinella zimbabwensis* in a naturally infected mammal. Journal of Helminthology 84: 35-38.

Abstract: *Trichinella zimbabwensis* has been detected in wild and farmed Nile crocodiles (*Crocodylus niloticus*) and in wild monitor lizards (*Varanus niloticus*) of several African countries, but it has never been detected in mammals in nature, in spite of its infectivity to rodents, pigs, foxes and monkeys under laboratory conditions. The aim of this work was to describe the first detection of *T. zimbabwensis* in a naturally infected lion (*Panthera leo*) of the Kruger National Park (KNP) of South Africa. The sequence of the expansion segment V, a highly variable non-coding sequence of the large subunit ribosomal RNA of the genus *Trichinella*, of larvae from the lion was identical to that of larvae of *T. zimbabwensis* collected from a Nile crocodile originating from the same locality as the lion, suggesting a possible transmission of this parasite between mammals and reptiles. The KNP proves to be a very interesting area for parasites of the genus *Trichinella* since three taxa (*Trichinella nelsoni, Trichinella T8* and *T. zimbabwensis*) circulate among the wildlife of this protected area.

Dunham, K.M., Ghiurghi, A., Cumbi, R. and Urbano, F. (2010). Human-wildlife conflict in Mozambique: a national perspective, with emphasis on wildlife attacks on humans. Oryx 44: 185-193.

Abstract: Human-wildlife conflicts are common across Africa. In Mozambique, official records show that wildlife killed 265 people during 27 months (July 2006 to September 2008). Crocodile *Crocodylus niloticus*, lion *Panthera leo*, elephant *Loxodonta africana* and hippopotamus *Hippopotamus amphibius* caused most deaths but crocodiles were responsible for 66%. Crocodile attacks occurred across Mozambique but 53% of deaths occurred in districts bordering Lake Cabora Bassa and the Zambezi River. Hippopotamus attacks were also concentrated here. Lion attacks occurred mainly in northern Mozambique and, while people were attacked by elephants across the country, 67% of deaths occurred in northern Mozambique. Attacks by lions, elephants or hippopotamuses were relatively rare but additional data will probably show that attacks by these species are more widespread than the preliminary records suggest. Buffalo *Syncerus caffer*, hyaena *Crocuta crocuta* and leopard *Panthera pardus* were minor conflict species. Good land-use planning, a long-term solution to many conflicts, is particularly relevant in Mozambique, where the crocodile and hippopotamus populations of protected areas are often in rivers that border these areas, and cause conflicts outside them, and where people commonly live within protected areas. Poverty may prompt fishermen to risk crocodile attack by entering rivers or lakes. The high incidence of conflicts near Limpopo and South Africa's Kruger National Parks (both within the Great Limpopo Transfrontier Conservation Area) highlights the problems created for people by facilitating the unrestricted movement of wildlife between protected areas across their land.

Balaguera-Reina, S.A. and González-Maya, J.F. (2010).Local perceptions and knowledge of crocodilians and relations with human populations in the Vía Parque Isla de Salamanca and buffer zone, Caribbean region of Colombia. Revista Latinoamericana de Conservación 1(1): 53-63. [in Spanish].

Abstract: The understanding of the interactions between wildlife and human communities is important due to its potential impact on the conservation and human perceptions of key species. During August 2006, semi-structured interviews were carried out in order to evaluate the perceptions, knowledge, and relationships between crocodilians (*Caiman crocodilus fuscus* and *Crocodylus acutus*) and human communities in the of the Vía Parque Isla de Salamanca (VIPIS National Park) and its buffer zone located in the Magdalena department, Caribbean region of Colombia. A total of 67 interviews were conducted, demonstrating a broad knowledge about morphology, ecology and distribution within the community. Greater knowledge about the species was found in older people (>40 years old) than younger people (<30 years old) who also held more negative opinions of crocodilians. According to the data provided by inhabitants and fisherman in the area, it can be concluded that these species continue to be harvested, both directly (hunting) and indirectly (by-

catch). In addition, conflict was reported, resulting from the competition for resources (fish and domestic fauna) and space. Most interviewees discussed the importance of these species from an economic perspective, while few recognized their ecological role.

De La Ossa, V.J., Vogt, C.R. and Rudge-Ferrara, C. (2010). *Melanosuchus niger* (Crocodylia: Alligatoridae) as opportunistic turtle consumer in its natural environment. Rev. Colombiana cienc. Anim. 2(2): 244-252.

Abstract: The present work observations were driven of potential natural predators of existent chelonians in the Negro River, municipality of Barcelos, Amazonas, Brazil. We worked in two areas of the municipality of Barcelos: Igarapé of the Rio Negro Lodge and Arirá. For the scientific capture of the chelonians were used meshes and net traps, in which fish and some black caiman were also caught because entered to eat, they were registered visually and for the evidence of damage caused in the turtles. In general the Crocodylia includes in their diet turtles, being *Melanosuchus niger* (Black caiman) registered for the first time for this work area as predator of turtles: *Podocnemis erythrocephala* (red-headed river turtle) and especially of *Peltocephalus dumerilianus* (big head Amazon turtle). The existent relationship between predator and prey in this case shows few documentation, in spite of existing a wide variety of related studies.

Botha, H., Van Hoven, W. and Guillette Jr, L.J. (2011). The decline of the Nile crocodile population in Loskop Dam, Olifants River, South Africa. Water SA 37(1): 103-108.

Abstract: The apparent decline in the number of Nile crocodiles present in the Loskop Dam prompted a study to determine the number, size and distribution of Nile crocodiles now present in the reservoir. The number of crocodiles in the Loskop Dam was surveyed using aerial counts and spotlight counts. Surveys revealed the presence of a very low total number of crocodiles and also a poor distribution of crocodiles in the different size classes over almost 30 years since 1981. Eight surveys carried out between 2001 and 2010 revealed that the distribution pattern of crocodiles in the Loskop Dam did not vary between winter and summer. These distribution patterns indicate that crocodiles occur most frequently in the eastern and western inlets and not in the main basin of the dam. Thirteen crocodiles were re-introduced into the daAugust 2009 spotlight survey results indicated that none of these animals had survived.

Santos, C.M., Abidu-Figueiredo, M., Teixeira, M.J., Nascimento, A.A. and Sales, A. (2011). Light microscopic and immunohistochemical study of the trachea of the broad-snouted caiman (*Caiman latirostris*). Veterinarni Medicina 56(1): 48-54.

Abstract: The purpose of this study was to examine the tracheal structure of the crocodile *Caiman latirostris* using light microscopy, histochemical and immunocytochemical techniques. The tracheal epithelium of *C. latirostris* consists of a ciliated pseudostratified columnar epithelium with goblet cells. The respiratory epithelium also includes endocrine cells immunoreactive to serotonin. The histochemical techniques demonstrated the presence of neutral and sulphated mucins secreted by goblet cells. The lamina propria consists of connective tissue with many reticular fibres. The elastic fibres are interspersed among collagen bundles, forming the border between the mucosa and the submucosa. The submucosal layer consists of connective tissue similar to that found in the lamina propria. Serous or mucous glands were not observed. The predominant characteristic in the adventitia is the presence of an incomplete hyaline cartilage ring, in the form of a circle. Dense connective tissue fills the space between the extremities of each cartilage ring. Serotonin-immunoreactive cells frequently had an apical cytoplasmic process directed towards the lumen, and were therefore classified as open type. The α-actin immunohistochemistry revealed smooth muscle cells only in blood vessel walls, confirming the absence of a tracheal muscle.

Ballouard, J-M., Priol, P., Oison, J., Ciliberti, A. and Cadi, A. (2010). Does reintroduction stabilize the population of the critically endangered gharial (*Gavialis gangeticus*, Gavialidae) in Chitwan National Park, Nepal? Aquatic Conservation: Marine and Freshwater Ecosystems (doi: 10.1002/aqc.1151).

Abstract: Despite conservation programmes (India 1975, Nepal 1978) gharial populations (*Gavialis gangeticus*) have declined over their entire distribution range. Information about the current status and main threats is needed to implement effective conservation measures. This study presents a survey (2003/2004) of the largest Nepalese gharial population in the Chitwan National Park that has benefited from regular re-introduction of young gharials since 1981. Population size estimates fluctuate between 34 (2003) and 38 (2004). The reintroduction programme, although of limited success has helped to maintain the gharial population. Gharials bask preferentially in large sand banks, and these sites must be protected. The main threats are from a dam that causes fish depletion and flushes gharials from the protected area, sand mining and grazing that destroy basking sites, fishing that causes food shortage, drift nets that kill gharial, and water pollution. Improvement in the survival of reintroduced gharials is needed. Strict protection of preferred basking sites and prohibition of fishing in the main settling zones are the principal conservation measures while in the long term, education and participatory management by local people are also necessary.

Abdel-Maksoud, G. and Abdel-Hadya, M. (2011). Effect of burial environment on crocodile bones from Hawara excavation, Fayoum, Egypt. Journal of Cultural Heritage (doi:10.1016/j.culher.2010.12.002).

Abstract: Many different archaeological materials were

found in Hawara (Fayoum, Egypt) during the excavation of the Egyptian-Polish mission in 2008. A complete crocodile skeleton, and many incomplete crocodiles were found in this area. The skeletons of these crocodiles suffered from salt crystallization, erosion, pitting, change of the color, etc. This study focuses on the mechanism of deterioration processes that affects bone and tusks. Surface modification, change of color, study of soil components and bone crystallinity, degradation of collagen, pH, bone histology, and the surface morphology were investigated by visual examination, UV spectrophotometry, X-ray diffraction, FTIR, pH meter, polarized light microscope (PLM) and scanning electron microscope (SEM), respectively. The results revealed that soluble salt (sodium chloride) and insoluble salt (calcium sulfate) played an important role in the deformation of bone. FTIR proved that archaeological bones undergo changes in their chemical stability. Differing colors, and cracks on the surface of the bones indicate that they were exposed to different temperatures.

Moore, B.C., Milnes, M.R., Kohno, S., Katsu, Y., Iguchi, T., Woodruff, T.K. and Guillette Jr., L.J. (2011). Altered gonadal expression of TGF-β superfamily signaling factors in environmental contaminant-exposed juvenile alligators. The Journal of Steroid Biochemistry and Molecular Biology (doi:10.1016/j.jsbmb.2011.01.004).

Abstract: Environmental contaminant exposure can influence gonadal steroid signaling milieus; however, little research has investigated the vulnerability of non-steroidal signaling pathways in the gonads. Here we use American alligators (*Alligator mississippiensis*) hatched from field-collected eggs to analyze gonadal mRNA transcript levels of the activin-inhibin-follistatin gene expression network and growth differentiation factor 9. The eggs were collected from Lake Woodruff National Wildlife Refuge, a site with minimal anthropogenic influence, and Lake Apopka, a highly contaminated lake adjacent to a former EPA Superfund site. The hatchling alligators were raised for 13 months under controlled conditions, thus limiting differences to embryonic origins. Our data reveal sexually dimorphic mRNA expression in 13-month-old alligator gonads similar to patterns established in vertebrates with genetic sex determination. In addition, we observed a relationship between lake of origin and mRNA expression of activin/inhibin subunits α and βB, follistatin, and growth differentiation factor 9. Our study suggests that embryonic exposure to environmental contaminants can affect future non-steroidal signaling patterns in the gonads of a long-lived species.

Meganathan, P.R., Dubey, B., Batzer, M.A., Ray, D.A. and Haque, I. (2011). Complete mitochondrial genome sequences of three Crocodylus species and their comparison within the Order Crocodylia. Gene (doi:10.1016/j.gene.2011.01.012).

Abstract: *Crocodylus* is the largest genus within the Order Crocodylia consisting of 11 species. This paper reports the complete mitochondrial genome sequences of three *Crocodylus* species, *Crocodylus moreletii*, *Crocodylus johnstoni* and *Crocodylus palustris*, and compares the newly obtained mitochondrial DNA sequences with other crocodilians, available in the public databases. The mitochondrial genomes of *C. moreletii, C. johnstoni* and *C. palustris* are 16827 bp, 16851 bp and 16852 bp in length, respectively. These mitochondrial genomes consist of 13 protein coding genes, two ribosomal RNA genes, 22 transfer RNA genes and a non-coding region. The mitochondrial genomes of all the *Crocodylus* species, studied herein show identical characteristics in terms of nucleotide composition and codon usage, suggestive of the existence of analogous evolutionary patterns within the genus *Crocodylus*. The synonymous and non-synonymous substitution rates for all the protein coding genes of *Crocodylus* were observed in between 0.001 to 0.275 which reveal the prevalence of purifying selection in these genes. The phylogenetic analyses based on complete mitochondrial DNA data substantiate the previously established crocodilian phylogeny. This study provides a better understanding of the crocodilian mitochondrial genome and the data described herein will prove useful for future studies concerning crocodilian mitochondrial genome evolution.

Simpson, B.K. and Mediyansyah (2009). A preliminary wet season assessment of the tomistoma (*Tomistoma schlegelii*) in the Lake Siawan-Belida area, upper Kapuas River, West Kalimantan, Indonesia. Fauna & Flora International: Jakarta.

Abstract: This report documents the results of a preliminary survey for the endangered crocodilian, tomistoma (*Tomistoma schlegelii*), in the upper Kapuas River basin, West Kalimantan, Indonesia. The study focused in and around the proposed Ecosystem Restoration Concession of the Lake Siawan-Belida peat swamp forest and was undertaken over a two week period during the wet season, in November-December 2009. Objectives were to document the presence, status and threats to the tomistoma, and provide potential follow-up conservation interventions. Tomistoma are restricted to Indonesia (Sumatra and Kalimantan) and Malaysia (Peninsular and Sarawak) however this is the first such survey in the Siawan-Belida area. Very little is known of the ecology or habits of the tomistoma, however it is considered to be a peat swamp specialist occurring in low densities. The work carried out under the auspices of the preparation of program sustainability of Fauna & Flora International (FFI) with funding from Macquarie Group. A total of 190 km of spotlight surveys were carried out in the Lake Siawan-Belida area over 11 nights. A very low number of tomistoma were seen, with only 3 individuals being discovered, representing a density of 0.02 crocs/km for the surveyed area. All 3 individuals (2 hatchlings and a small juvenile) were seen in a clustered group over a 7 km stretch of the Batang Bunut River, just outside the proposed concession area. Extremely high water levels however rendered spotlighting techniques ineffective in the flooded forests, and as such, these results may not represent densities that may possibly be obtained at drier times of the year, when conventional crocodile surveys are usually undertaken. Considerable effort was devoted to gathering information from local residents, and more

than 30 casual, semistructured interviews were undertaken. Informants indicate that tomistoma were more abundant historically than is the case today. It was reported that tomistoma are still found throughout the area, however more recent reports were obtained from the western side of the proposed concession (on the Batang Bunut, Siawan and Tuan Rivers) than from the Manday River in the east. We did not receive any indication that tomistoma were "common" in the area, and they probably occur in low densities. *Crocodylus porosus* were also said to occur historically, however are now rarely seen, and their current status is unclear. We did not receive any credible information to indicate the presence of other crocodile species. A breeding population was confirmed from the Siawan-Belida area after hatchling tomistoma were discovered during spotlight surveys near Kuala Buin village on the Batang Bunut River. Dry season nest sites were also reported from a number of other locations; on the Batang Siawan, Batang Bunut and Batang Tuan Rivers (or their associated lakes and oxbows). Nesting was said to occur towards the end of the dry season (as is the case in other areas in Kalimanta) in the more remote, permanent lakes and rivers. Such areas no doubt represent a significant habitat for tomistoma conservation and will need to be identified and incorporated into any management plan for the species. Tomistoma face numerous threats throughout their distribution range, the most significant of which is the loss of peat swamp nesting habitat from deforestation. While the current survey detected little in the way of forest loss, it must be noted that the high water levels and brevity of time available meant that the possibility of detecting such activities was minimal. Other serious threats to the species include intensive fishing, forest fire, fish poisoning and high disturbance levels, which usually have significant impacts during the dry season, and thus were not seen during this wet season survey. Further work is needed in the dry season to fully document the nature and extent of the threats facing tomistoma in the Siawan-Belida area. There is currently no commercial crocodile trade in the area. This survey must be seen as a preliminary assessment, and a prelude to further, more detailed work if conservation management actions are to be undertaken in the area. Results have so far confirmed however that a breeding population exists in the Siawan-Belida area, and that the area is of significant conservation value for Tomistoma. Key sites will now need to be identified before protection and management strategies can be implemented and crocodiles conserved for the long term.

Espinosa-Blanco, A.S. and Seijas, A.E. (2010). Variations in habitat use between crocodiles in the Cojedes River System, Venezuela. Latin American Journal of Conservation 1(2): 112-119.

Abstract: Variations in habitat use between crocodiles in the Cojedes River System, Venezuela Abstract The Orinoco Crocodile (*Crocodylus intermedius*) and the spectacled Caiman (*Caiman crocodilus*) are species that coexist in the Cojedes River System, Venezuela. This area is currently home to the largest population of Orinoco Crocodiles found throughout its range. Researchers undertook nocturnal counts and collected microhabitat information about where each species was observed to measure the habitat use of the two species of crocodilians in two sections of the river (20.7 km): Caño de Agua-Confluencia río Sarare (CA-CS) and Merecure-Caño Amarillo (M-CAM). The Spectacled Caiman and the Orinoco Crocodile maintain a mutual competitor-predator relationship. In cases where the caiman is more abundant, negative interactions may contribute to lower the populations of the Orinoco Crocodile. Coexistence is possible due to the marked differences in habitat use by crocodiles and caimans, as observed in this study. During nocturnal spotlight counts, crocodiles are most often found in the river, preferring to be in open waters in the middle of the river and in live and dead vegetation (locally called "caramas") that are found far from the banks of the river. Spectacled Caiman had an opposite pattern, using habitats associated with terrestrial vegetation on the riverbank.

Thomas, N. and Brook, I. (2011). Animal bite-associated infections: microbiology and treatment. Expert Review of Anti-infective Therapy 9(2): 215-226.

Abstract: Human and animal bites may lead to serious infection. The organisms involved tend to originate from the oral cavity of the offending biter, as well as the environment where the injury occurred. A variety of aerobic as well as anaerobic organisms have been isolated from bite wounds, with infection ranging from localized cellulitis to systemic dissemination, leading to severe disease ranging from abscess to bone and joint infection, to endocarditis and brain abscess. Immediate wound management, including recognition of the most commonly associated infectious pathogens, and judicious use of empiric antibiotics are crucial in providing the best care after a bite. Here, we discuss the common animal bite associated infections, and provide the most up to date information regarding their management.

Ávila, F.G. (2010). Condición de Salud en la Población del Cocodrilo de Pantano (*Crocodylus moreletii*) de Río Hondo, Quintana Roo, México. BSc Thesis, Instituto Tecnológico de Chetumal, Quintana Roo, México.

Resumen: Los índices de condición corporal han sido usados ampliamente para describir la salud de numerosos taxones de vertebrados. En los últimos años, los especialistas en la conservación de la vida silvestre han incorporado la dimensión de salud como uno de los factores que están involucrados en el bienestar y conservación de la flora y fauna silvestre. En los meses de junio y septiembre de 2009 así como en febrero de 2010 se tomaron datos morfométricos de la longitud total, longitud hocico-cloaca, ancho de cráneo, perímetro de la base de la cola y peso de ejemplares del cocodrilo de pantano (*Crocodylus moreletii*) con el propósito de conocer el índice de condición corporal en la población del Río Hondo mediante el factor de condición de Fulton. Los muestreos se realizaron a bordo de una lancha pantanera con motor fuera de borda, utilizando lámparas y lazos, para la localización y captura de los cocodrilos. Se analizó la utilidad del factor de condición

de Fulton en 88 cocodrilos capturados, encontrando que la relación entre el peso y el perímetro de la base de la cola (P-PBC), se ajusta a los supuestos de este factor de condición (β=3; σ=0). En términos generales, se observó que la población del cocodrilo de pantano en el área de estudio posee un factor de condición categorizado como bueno; a pesar de esto, se registraron individuos con un factor de condición por debajo de la media en cinco de las seis secciones y por lo tanto con un índice de condición corporal malo; las secciones de Cocoyol y Palmar presentaron cocodrilos con un factor de condición por encima de la media, categorizando como excelente. Respecto a las clases de tallas, se encontró que los cocodrilos de longitud total menor a 30 cm (neonatos) fueron los que presentaron los valores de condición corporal más altos, mientras que los juveniles presentan el valor más bajo. Adicionalmente, se observó que las hembras presentan una mejor condición corporal con respecto a los machos. Por otra parte, con fines comparativos se aplicó el factor de condición de Fulton a 112 cocodrilos que fueron capturados en 2002 en el área de estudio y se compararon los resultados con los obtenidos en 2009-2010. Se observó que en ese año el número de cocodrilos con una condición excelente fue superior a la de 2009-2010 y el porcentaje de individuos con una mala condición corporal fue considerablemente menor que al de fechas recientes. En 2002 los individuos con una longitud total de entre 30 y 50 cm fueron los que presentaron el valor más alto en el índice de condición corporal, mientras que los adultos registraron el valor más bajo; finalmente, en 2002 a diferencia de lo observado en 2009-2010 los machos presentaron una mejor condición corporal que las hembras. Los resultados del presente estudio constituyen los primeros en su tipo para *C. moreletii* en Quintana Roo e indican en general un descenso en los valores de condición corporal en un lapso de ocho años, posiblemente como resultado de un deterioro en la calidad del hábitat de la especie en el área de estudio. Por lo anterior es necesario continuar con el monitoreo poblacional de *C. moreletii* para poder detectar las posibles causas de dichos cambios en la condición corporal de la población, a fin de establecer acciones o medidas de conservación para la especie y su hábitat.

John P. Rafferty (ed.) (2011). Meat Eaters: Raptors, Sharks, and Crocodiles (The Britannica Guide to Predators and Prey). Rosen Educational Services: USA. 256 pp.

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

Abstract: Monitoring of over a two decade period (1987–2007) of mugger (*Crocodylus palustris*) population of River Vishwamitri (Gujarat State, India) indicates the present status of the species in and around Vadodara City to be the most noticeable and unique. The population found in Vishwamitri-Dhadhar River System represents a unique case study of relationship between a crocodilian species and humans. The population of muggers is growing with at the rate of 7.77 animals per year and has reached over 100. Also, mugger conflict is increasing; a total of 292 muggers were rescued from human settlements and translocated, including 38% small (<1 m), 48% large (1-2 m) and 14% huge sized (>2 m) muggers. But few of them returned to the same location in the Vishwamitri River. A total of 14 crocodile attacks were recorded, including six that were fatal. The present study provides recommendations and an action plan for the long-term mugger conservation in the area.

Brazaitis, P. and Watanabe, M.E. (2011). Crocodilian behaviour: a window to dinosaur behaviour? Historical Biology 23(1): 73-90.

Abstract. Modern crocodilians and birds are the only living representatives of the Archosauria, a group that also includes non-avian dinosaurs and pterosaurs. Modern crocodilians originated during the early Cretaceous period and dispersed globally. Examples of physiological similarities between living crocodilians and birds include similar amino acids in b-keratins among crocodiles, turtles and birds; oviduct homologies between crocodilians and birds; similar forelimb structures in crocodiles and other archosaurs and similarities in gene expression in limb development in alligators and chickens. While individual crocodilian species have adapted their behaviours to meet specific strategies for survival in specific habitats, core reproductive behaviours are universal among modern crocodilians and transcend speciation, morphology and geographic distribution. Hard-wired core behaviours include social signals that incorporate chemosensory, auditory and mechanoreception modalities; construction of a temperature stabilising nest chamber to incubate eggs; and parental care of their young. Parental care may reflect a primitive character for archosaurs, including dinosaurs. Crocodilians use integumentary sense organs (ISOs) during courtship and in parental care, and similar structures may have had similar functions in dinosaurs. The presence of numerous foramina (possible ISOs) in the skulls of saurischians, along with the findings of fossilised nests with adults, may indicate similar complex behaviours, including parental care, in dinosaurs.

Campos, Z. and Magnusson, W.E. (2011). Emergence behaviour of yacare caimans (*Caiman crocodilus yacare*) in the Brazilian Pantanal. Herpetological Journal 21: 91-94.

Abstract: We studied the emergence and basking behaviour of Pantanal caimans (*Caiman crocodilus yacare*) in relation to temperature. In the cold season, caimans were exposed to the sun, and air temperatures higher than temperatures suggest that emergence behaviour may be due to thermoregulation. In the dry season, most (66%) emergent caimans were found in the shade between 1000 and 1500 h, and body temperatures rarely exceeded water temperatures. Caimans also emerged at night, although body temperatures were highly correlated ($r= 0.974$, $P<0.001$) with water temperatures, suggesting that emergence is related to factors other than thermoregulation.

Rosenblatt, A.E. and Heithaus, M.R. (2011). Does variation in movement tactics and trophic interactions among American alligators create habitat linkages? Journal of Animal Ecology (doi: 10.1111/j.1365-2656.2011.01830.x).

Abstract: Highly mobile top predators are hypothesized to spatially and/or temporally link disparate habitats through the combination of their movement and feeding patterns, but recent studies suggest that individual specialization in habitat use and feeding could keep habitats compartmentalized. We used passive acoustic telemetry and stable isotope analysis to investigate whether specialization in movement and feeding patterns of American alligators (Alligator mississippiensis) in an oligotrophic subtropical estuary created habitat linkages between marine and estuarine/freshwater food webs. Individual alligators adopted one of the three relatively distinct movement tactics that were linked to variation in diets. Fifty-six per cent of alligators regularly travelled from the upstream (freshwater/mid-estuary) areas into the downstream (marine-influenced) areas where salinities exceed those typically tolerated by alligators. Thirty-one per cent of the alligators made regular trips from the mid-estuarine habitat into the upstream habitat; 13% remained in the mid-estuary zone year-round. Stable isotopic analysis indicated that, unlike individuals remaining in the mid-estuary and upstream zones, alligators that used the downstream zone fed at least partially from marine food webs and likely moved to access higher prey abundance at the expense of salt stress. Therefore, 'commuting' alligators may link marine food webs with those of the estuary and marshes in the coastal Everglades and create an upstream vector for allochthonous nutrient inputs into the estuary. This study lends further support to the hypothesis that large-bodied highly mobile predators faced with trade-offs are likely to exhibit individual specialization leading to habitat linkages, rather than compartmentalization. However, the conditions under which this scenario occurs require further investigation

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Frey, E. and Monninger, S. (2010). Lost in action - the isolated crocodilian teeth from Enspel and their interpretive value. Palaeobio. Palaeoenv. 90: 65-81.

Abstract: Between 1991 and 2009 a total of 50 isolated crocodilian tooth crowns were collected from the Oligocene crater lake Enspel. These tooth crowns are basically conical, with some being channeled and others showing smooth carinae. Due to their insignificant morphology the crown can only be referred to as an Eusuchia indet. All teeth are lacking their roots and therefore are very likely to represent shed teeth. The height range of the Enspel tooth crowns falls within the height variation found for those from extant Eusuchia, such as *Osteolaemus* and *Caiman*, and likely come from eusuchans with a body length of about 2 m. The presence of shed teeth proves that eusuchian Crocodilia lived in the Oligocene Lake Enspel. The taphonomy of the Enspel crocodilian tooth crowns contrasts with that of the early Freshwater Molasse locality Langenau near the City of Ulm, where most of the teeth still have their root and thus fell out post mortem, and with that for the Eocene Lake Messel, where isolated crocodilian teeth occur rarer than fully articulated ones of fragmentary skeletons.

Eme, J., Gwalthney, J., Owerkowicz, T., Blank, J.M. and Hicks, J.W. (2010). Turning crocodilian hearts into bird hearts: growth rates are similar for alligators with and without right-to-left cardiac shunt. J. Exp. Biol. 213: 2673-2680.

Abstract: The functional and possible adaptive significance of non-avian reptiles' dual aortic arch system and the ability of all non-avian reptiles to perform central vascular cardiac shunts have been of great interest to comparative physiologists. The unique cardiac anatomy of crocodilians - a four-chambered heart with the dual aortic arch system - allows for only right-to-left (R-L; pulmonary bypass) cardiac shunt and for surgical elimination of this shunt. Surgical removal of the R-L shunt, by occluding the left aorta (LAo) upstream and downstream of the foramen of Panizza, results in a crocodilian with an obligatory, avian/mammalian central circulation. In this study, R-L cardiac shunt was eliminated in age-matched, female American alligators (*Alligator mississippiensis*; 5-7 months of age). We tested the hypothesis that surgical elimination of R-L cardiac shunt would impair growth (a readily measured proxy for fitness) compared with sham-operated, age-matched controls, especially in animals subjected to exhaustive exercise. While regular exercise caused a decrease in size (snout-to-vent length, head length and body mass), elimination of the capacity for R-L cardiac shunt did not greatly reduce animal growth, despite a chronic ventricular enlargement in surgically altered juvenile alligators. We speculate that, despite being slightly smaller, alligators with an occluded LAo would have reached sexual maturity in the same breeding season as control alligators. This study suggests that crocodilian R-L cardiac shunt does not provide an adaptive advantage for juvenile alligator growth and supports the logic that cardiac shunts persist in crocodilians because they have not been selected against.

Delfino, M. and De Vos, J. (2010). A revision of the Dubois crocodylians, *Gavialis bengawanicus* and *Crocodylus ossifragus*, from the Pleistocene *Homo erectus* beds of Java. Journal of Vertebrate Paleontology 30(2): 427-441.

Abstract: Revision of the two extinct Javanese crocodylian species *Gavialis bengawanicus* Dubois, 1908, and *Crocodylus ossifragus* Dubois, 1908, indicates that only the former is valid and that the latter is a junior subjective synonym of the extant *C. siamensis* Schneider, 1801. *Gavialis bengawanicus* is diagnosed by a relatively small number of maxillary and dentary teeth, a modest maxillary process developed into the lacrimal, a W-shaped maxillo-palatine suture, a planar skull table, occlusal pits present exclusively on the dentaries, and relatively small and subcircular supratemporal fossae at maturity. It is the best-known extinct *Gavialis*, and it probably represents the only valid extinct *Gavialis* species known outside the Indian subcontinent. Both crocodylians from Java have been found exclusively along with the Stegodon-Homo erectus fauna, which is considered to be largely the result of

an Early Pleistocene dispersal from the Siwaliks Hills via the so-called Siva-Malayan route. It is not clear if the dispersal of *Gavialis* from the Indian subcontinent to Java necessarily required the crossing of salt water barriers, but the possible occurrence of *Gavialis* remains in Sulawesi and Woodlark, two islands located east of the Huxley and Wallace lines that were never connected to the mainland, can be explained by inferring a marine dispersal. According to the present knowledge of the past distribution of *Gavialis*, this genus originated in the Indo-Pakistani area in the early Miocene and during the Quaternary dispersed to the Sunda region, possibly reaching western-most Oceania.

Submitted Articles

POSSIBLE CONSUMPTION OF CORN BY AMERICAN ALLIGATORS AT WILDLIFE FEEDERS IN LOUISIANA, USA. American alligators (*Alligator mississippiensis*) are generally assumed to be obligate carnivores, although plant materials such as fruits, seeds and vegetation have been found among stomach contents (Dowler 1846; Kellogg 1929; Chamberlain 1930; McNease and Joanen 1977; Platt *et al*. 1990; Forkner 1996). The presence of these items is usually attributed to accidental ingestion during prey capture or secondary ingestion [ie the acquisition of items contained in the gut of primary prey (Neill 1971)]. However, Brueggen (2002) observed captive alligators deliberately consuming wild grape (*Vitis* sp.), elderberry (*Sambucus canadensis*), and citrus (*Citrus* spp.) fruit directly from plants, eating fallen fruit below citrus trees, and consuming squash (*Cucurbita* spp.) provided for tortoises inhabiting the same enclosure. Observations of frugivory among wild alligators are rare, which is not surprising given that foraging is often nocturnal and takes place underwater or among dense aquatic vegetation. Nonetheless, *Annona glabra* and *Opuntia* spp. fruits are said to be consumed by wild alligators in Florida (Ridley 1930) and Texas (Vosburgh 1949), respectively. We here report additional observations of possible frugivory by wild alligators.

On two different occasions wild alligators were photographed with motion-sensitive trail cameras at automated wildlife feeders baited with corn (*Zea mays*) in Louisiana, USA. Automated wildlife feeders dispense grain at timed intervals and are widely used by sport hunters to attract game animals in the southern USA, particularly white-tailed deer (*Odocoileus virginianus*) and feral pigs (*Sus scrofa*). The first set of four photographs were posted on a hunting website (www.louisianasportsman.com) in 2009, and show an adult alligator investigating corn scattered on the ground below a feeder. Whether or not the alligator is actually consuming the corn cannot be determined from the images. Stamps on the photographs indicate these were taken on 22 July 2009 over a 32-minute period (2224-2256 h) at air temperatures ranging from 73 to 77°F (ca. 22 to 25°C). Specific locality information does not accompany the photographs.

The second set of photographs was provided to the authors by Mr. Joey Futrell in September 2010. These photographs were taken near Napoleonville in Assumption Parish, Louisiana, on 30 and 31 August 2010, at 2105 and 2038 h respectively. On both dates an adult alligator (estimated total length= 210 to 240 cm) is visible in the photographs standing among corn scattered beneath the feeder. In one photograph (Fig. 1) the head of the alligator is tilted slightly backwards, a posture often assumed by crocodilians when swallowing to facilitate inertial movement of food down the esophagus. While neither set of photographs unequivocally shows alligators consuming corn, we consider the presence of alligators at wildlife feeders noteworthy and strongly suggestive of frugivory. Because trail cameras take photographs at intervals of one to >10 minutes, relatively brief feeding events are likely to be missed; however, the tilted head posture evident in one photograph indicates the alligator was possibly swallowing corn.

Figure 1. Adult American alligator photographed at an automatic wildlife feeder dispensing corn in Assumption Parish, Louisiana, USA. Note the rearward tilt of the alligators head. Photograph courtesy of Mr. Joey Futrell.

It remains unclear how foraging alligators locate wildlife feeders, which are usually placed in semi-cultivated "food plots" established to attract deer or in upland habitats, rather than in close proximity to wetlands. When corn is dispensed, the feeder produces an audible clicking noise that might serve to attract the attention of an alligator causing it to investigate the source of this sound. Although the role of auditory cues in crocodilian foraging behavior is not well-studied, alligators are attracted to splashing sounds (Hartley and Hartley 1977; Lazell and Spitzer 1977), and *Caiman crocodilus* use advertisement calls of anurans to locate these prey (Bernal 2006). Of course, we cannot rule out the possibility that alligators were attracted to the feeders by the presence of potential prey species rather than the availability of corn. White-tailed deer, feral pigs, and raccoons (*Procyon lotor*) are visible in photographs taken at feeders, and all have been reported in the diet of alligators (McIlhenny 1935; Epstein *et al*. 1983; Wolfe *et al*. 1987; Shoop and Ruckdeschel 1990).

These photographs and the reports of others indicate that on occasion alligators deliberately consume fruits, seeds and other plant materials; thus, there is no *a priori* reason to assume the

presence of such items among stomach contents is the result of accidental or secondary ingestion. Indeed, frugivory appears widespread among the Crocodylia; in an ongoing literature review we found evidence of fruit consumption in 10 (55.5%) of 18 species of crocodilians for which dietary information is available (Platt, Elsey and Rainwater, in prep.).

Early research suggested that alligators were unable to metabolize dietary carbohydrates and other plant-based nutrients (Coulson and Hernandez 1983). However, subsequent work demonstrated that crocodilians are capable of digesting carbohydrates, plant-based proteins and vegetable fats (Coulson *et al*. 1987; Staton 1988). Furthermore, supplementing high protein diets with carbohydrates increased food conversion efficiency and growth of captive crocodilians (Staton *et al*. 1990; Smith and Coulson 1992). While much remains to be learned about how crocodilians process carbohydrates and other plant-based nutrients, collectively these studies suggest that frugivory is likely to yield nutritional rewards for crocodilians.

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PREVENTION OF CROCODILE ATTACKS IN SRI LANKA: SOME TRADITIONAL METHODS. Two species of crocodiles, the Mugger (*Crocodylus palustris*) and the

Saltwater crocodile (*C. porosus*), are known to inhabit a variety of aquatic habitats in Sri Lanka (Deraniyagala 1939; Whitaker and Whitaker 1979; Das and de Silva 2005; de Silva and Mahaulpatha 2007). People living along rivers and streams and in the vicinity of tanks (man-made irrigation reservoirs dating from 5th Century BC, ranging in size from 0.25 to several thousand ha) depend on these waterbodies for their domestic needs (eg drinking, bathing, washing clothes) and livelihoods (eg fishing, harvesting aquatic or semi-aquatic edible and non-edible plants).

Both crocodilian species are known to attack humans, livestock and pets (eg dogs), and thus local people and their livelihoods are potentially at risk. It has been natural, therefore, that people have resorted to various forms of prevention against crocodile attacks. This paper describes various methods, both physical and spiritual, that have been practiced in the country for several centuries, and is based on the author's field studies (de Silva 2008, 2010).

Spiritual Practices

Inscribed charms and talismans: A granite stone artefact with an engraved charm and a talisman (Fig. 1) is presently housed in the Dutugemunu Temple at the Sandarawela Rathnasara Privena, in Ganegama at Baddegama (Southern Province). It is irregularly hexagonal in shape and approximately 46 cm in length, width and height. The charm has been inscribed on its four sides, and on the upper surface is an engraving of an intricate talisman. According to Rohanadeera (2007), who has published a translation of this charm with an interpretation of the talisman, this inscribed block of granite (dating from circa 1469-1474 AD) had been found in the Gin Ganga (River) at Baddegama.

The charm starts with salutations to Lord Buddha and various deities and then invokes protection for all humans from male and female crocodiles. It ends with a verse that reads "... this is the crocodile charm that tied the crocodiles and she crocodiles", suggesting that due to this charm the crocodiles will not be able to attack humans, cattle and buffalos in this particular body of water. Rohanadeera (pers. comm. 2010) suggests that this charm and talisman is the work of Ven. Thotagamuwe Rahula, a high priest of the 15th Century. He was a reputed scholar who was well known throughout the country as being well versed in charms and the occult.

Similar charmed stones have apparently been placed in the Nilwala Ganga, at the main bathing spot in Matara town and at Nadulgala, and in a river at Tissamaharama, as reported by a crocodile bite victim during a human-crocodile conflict survey (de Silva 2010). However, these 'charmed' stones have not been discovered.

Protective mantras (charms): Mantras are believed to afford protection from crocodile attacks when recited in the prescribed fashion. Gnanaloka (1954) records two such mantras that one must recite when entering water inhabited by crocodiles. These charms are short, consisting of 4 to 10 words. One example is verse 42: Om Sumas Shri Devane

Figure 1. Talisman of the granite crocodile charm at Gin Ganga. Photograph: Anslem de Silva.

Muka Bandrama (Om Sumas Shri Devane = salutation to god Sumas, Muka Bandrama = tie the mouth of the crocodile = not to bite). These forms of protection, though widely known in the country, are now seldom used. However, a police officer attached to the Mankulam Police Station informed the author recently (May 2010) that in his village in Manampitiya, Polonnaruwa (North Central Province), a man uses charms to protect himself before diving in search of bodies of crocodile victims in the Pali Aru and Kidapuchchan kulam. Crocodile charmers are still popular in Borneo where man-eating crocodiles are common (Ritchie and Jong 2002).

It is of interest to note here that during the early British colonial period, the government had engaged the services of 'shark charmers' to protect the divers harvesting oysters from shark attacks, using charms (Cordiner 1807; Tennent 1861).

Crocodile Repellents

The use of herbal pills as crocodile repellents is known from Sri Lanka. The preparation is called Bhagawath Jeewara Guliya. De Alwis (1948) lists all the plants, seeds and other ingredients needed to prepare this pill, and also describes the mystical traditions that one should follow, such as collecting the ingredients at auspicious times and adhering to other prescribed rites when making this type of medicine. Texts of the ancient Rishis record that if this particular pill is mixed with the juice of the kotakimbula plant (*Ficus hispida*) and the mixture is put into the river or tank where crocodiles

live, no one need fear crocodile attack (de Alwis 1948). The mixture used is possibly a strong crocodile repellent.

The toxic effects of various plants are well known and used by village communities to catch fish, although this practice is prohibited by law. One such product is the unripe fruit of kukuruman (*Randia dumetorum*). Villagers around Kalkudah, in the northeast of the country, make a paste of the unripe fruit and use it to poison fish (Somanader 1963). Somanader (1963) lists several other plants used to catch fish. There are also several plants used as snake repellents, that are recorded in the traditional management of snakebite (de Silva 1998).

Physical Barriers and Warnings

Crocodile Exclusion Enclosures. The crocodile exclusion enclosure (CEE) is known in Sri Lanka as 'kimbul kotuwa'. We studied 70 such enclosures, both abandoned and in use, along the Nilwala Ganga from Modara (Lands End) (5° 56' 42.7" N, 80° 32' 26.0" E) to Paraduwa (6° 4' 9.3" N, 80° 30' 55.0" E) in Matara. These are used by people for bathing and for washing clothes and household utensils. Two types of CEE were identified during the survey; small (approximately 3 x 3 m) enclosures for personal use made by the respective householders, and large enclosures erected by a village or urban council for communal use. A large CEE in the Nilwala Ganga, opposite the main town of Matara, was widely used by many people for several decades, but was completely destroyed during the 2004 tsunami and has not been replaced. The author, as a young boy in the mid-1950s, bathed in this CEE as well as in others in Matara.

Traditional CEEs are constructed of thick kitul palm (*Caryota urens*) planks or long hardwood poles firmly driven into the river bed, the two ends of the enclosure abutting the banks. Enclosures made of kitul palm planks last for many decades; those made of bamboo or by just planting a few poles do not last long and are also not secure (Fig. 2). Since around 2007, enclosures have been fashioned using metal rods and wire mesh (see de Silva 2008).

Figure 2. Insecure crocodile exclusion enclosure. Photograph: Anslem de Silva.

All traditional and metal enclosures had only three sides fenced (Fig. 3), and were open to the bank. De Silva (2008) recommended that an ideal CEE should be fenced on all four sides, with an entrance door from the land side that should be kept closed when the enclosure is not in use. This is to prevent crocodiles entering the enclosure at night and remaining there. Although a rare occurrence, there are anecdotal accounts of crocodiles being found inside CEEs.

Figure 3. Crocodile exclusion enclosures and fences typically have three sides fenced, and are open to the bank. Photograph: Anslem de Silva.

The majority of enclosures that were studied along the Nilwala Ganga were not secure, but were still used (Fig. 2). Interestingly, all crocodile attacks that occurred during the period of this study, involved people who were either bathing, washing clothes or fishing outside an existing CEE or where there was no enclosure at all.

Crocodile Exclusion Fences. Crocodiles occassionally stray into domestic compounds at night, usually to attack pets or poultry. This has resulted in the construction of metal crocodile exclusion fences (CEF) to protect property. De Silva (2008) proposed that where CEFs are installed, sufficient space be left along the bank for crocodiles to use at night.

Warning Signboards. Drawing attention to dangers through warnings on signboards is a simple and important step in any preventive strategy. However, it was observed that warning signboards were not generally displayed, even at the many tanks and rivers where several crocodile attacks have previously taken place.

Discussion

During our study of the HCC problem in the country (de Silva 2010), it was evident that virtually all crocodile attacks were due to the negligence of humans. In 90% of the 131 cases examined (interviewed) the victims were aware of the presence of crocodiles in the water where they were attacked (de Silva 2010). People from the wet zone hill country, who recently settled in the dry zone under the Accelerated Mahaweli Project (Mahaweli Authority of Sri Lanka 1991) were initially ignorant of crocodile habits and therefore vulnerable. Dry zone tanks are the main Mugger habitats.

Based on the accounts of attack victims and witnesses, it appeared that the crocodiles had observed people engaged in water-based activities over a period of time before the attack occurred. This would imply that some attacks were not the result of a casual encounter with potential prey, but reflected directed hunting.

Recommendations

As a result of our island wide survey of selected habitats of *C. palustris* and *C. porosus*, together with inquiries into incidents of attacks on humans at these locations, we make the following recommendations:

- intensive awareness programs among vulnerable populations;
- installation and maintenance of physical protective structures such as CEEs and CEFs; and,
- installation of warning signs in danger prone areas.

Priority should be given to locations where crocodile attacks have occurred.

Responsibility for taking action should lie with the State, through the local authorities. In the case of re-settlement programs, the re-settling authority should take responsibility. Local communities too should be responsible for the safety of their own members; they will have a big part to play in maintaining in good repair and the proper use of structures that are erected. Creating awareness among local community leaders and people with influence would be of prime importance. The place of NGOs in this type of work should not be ignored. Recently (2009) the World Wildlife Fund/ American Red Cross Partnership installed a few 'crocodile-fences' along the Nilwala Ganga in Matara, after a consultancy report by the author (de Silva 2008). The place of herbal and chemical repellents should be investigated with care, so as not to endanger other aquatic fauna, flora or render the water unfit for human use. Its practicability too should be studied.

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