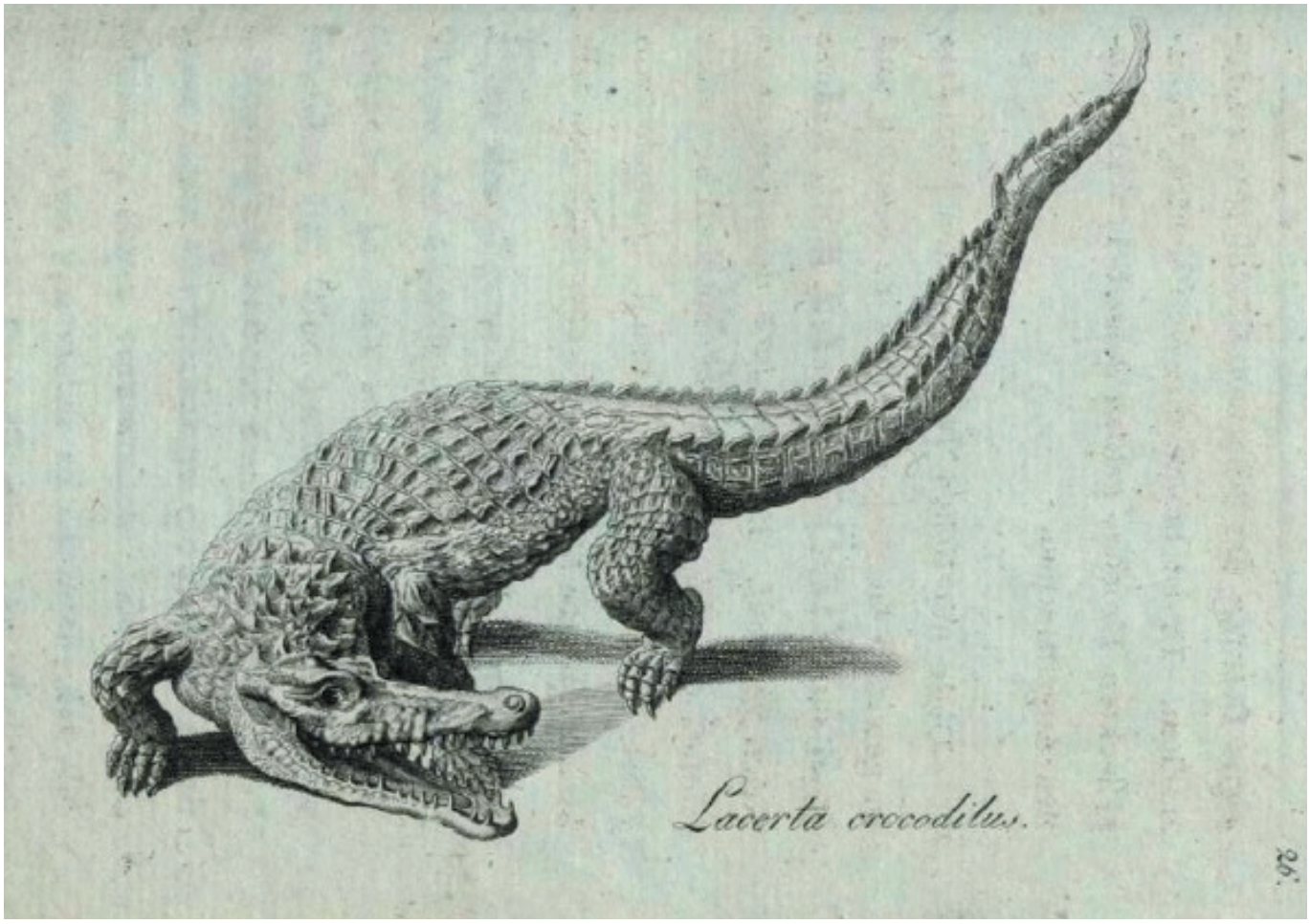
CROCODILE SPECIALIST GROUP NEWSLETTER

VOLUME 32 No. 1 • JANUARY 2013 - MARCH 2013



IUCN • Species Survival Commission

CROCODILE

SPECIALIST

GROUP

NEWSLETTER

VOLUME 32 Number 1
JANUARY 2013 - MARCH 2013

IUCN - Species Survival Commission

CHAIRMAN:
Professor Grahame Webb
PO Box 530, Karama, NT 0813, Australia

EDITORIAL AND EXECUTIVE OFFICE:
PO Box 530, Karama, NT 0813, Australia

Printed by: Uniprint NT
Charles Darwin University, NT 0909, Australia

COVER PHOTOGRAPH: Nile crocodile, Blumenbach's (1798) plate 26 (see pages 36-39).

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

CSG Newsletter Subscription

The CSG Newsletter is produced and distributed by the Crocodile Specialist Group of the Species Survival Commission (SSC) of the IUCN (International Union for Conservation of Nature).

The CSG Newsletter provides information on the conservation, status, news and current events concerning crocodilians, and on the activities of the CSG. 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.

The CSG Newsletter is available as:

- Hard copy (by subscription - see below); and/or,
- Free electronic, downloadable copy from "http://www.iucncsg.org/pages/Publications.html".

Annual subscriptions for hard copies of the CSG Newsletter may be made by cash ($US55), credit card ($AUD55) or bank transfer ($AUD55). Cheques ($USD) will be accepted, however due to increased bank charges associated with this method of payment, cheques are no longer recommended. A Subscription Form can be downloaded from "http://www.iucncsg.org/pages/Publications.html".

All CSG communications should be addressed to:
CSG Executive Office, P.O. Box 530, Karama, NT 0813, Australia.
Fax: (61) 8 89470678. E-mail: csg@wmi.com.au.

PATRONS

We thank all patrons who have donated to the CSG and its conservation program over many years, and especially to donors in 2011-2012 (listed below).

Big Bull Crocs! ($15,000 or more annually or in aggregate donations)

Japan, JLIA - Japan Leather & Leather Goods Industries Association, CITES Promotion Committee & All Japan Reptile Skin and Leather Association, Tokyo, Japan.
Heng Long Leather Co. Pte. Ltd., Singapore.
Hermes Cuirs Precieux, Paris, France.
Singapore Reptile Skin Trade Association, Singapore.

Friends ($3000 - $15,000)

Mainland Holdings, Lae, Papua New Guinea.
Phillip Cunliffe-Steel, New Zealand/Australia.
Enrico Chiesa, Italhide, Italy.
La Ferme aux Crocodiles, Pierrelatte, France.
United Leather Product Co. Ltd., Thailand.
Yee Tai Leather Enterprise Ltd., Hong Kong.

Supporters ($1000 - $3000)

Crocodile Conservation Institute, SC, USA
William Belo, Coral Agri-Venture Farm, Philippines.
Shaun Foggett, Crocodiles of the World, Witngy, Oxon, UK.
J. Perran Ross, Gainesville, FL, USA.
Florida Power & Light Inc., FL, USA.
George Saputra, IRATA, Jakarta, Java, Indonesia.

St. Augustine Alligator Farm, Florida, USA.
Yosapong Temsiripong, "Sriracha Moda" and "Crocodile & Ostrich Cooperative of Thailand", Thailand.
Virginia Aquarium and and Marine Science Center Foundation, Virginia Beach, VA, USA.
N. Wall Consulting, USA.

Contributors ($250 - $1000)

Alligator Adventures, SC, USA.
East Coast Zoological Society (Brevard Zoo), FL, USA.
Carl Camden, Kelly Services Inc., USA.
Simone Comparini, Pantera S.R.L., S. Croce s/Arno, Italy.
James Hennessey, Reptile Village Zoo, Ireland.
Indonesian Crocodile Farmers Association, Indonesia.
Vic Mercado, Microlab, Philippines.
The Ebey family, New Mexico, USA.
Nao Thouk, Phnom Penh, Cambodia.

Editorial

The 16th Meeting of the Conference of the Parties to CITES (CoP16) was held in March 2013, together with the 64th meeting of the CITES Standing Committee (SC64). The meetings were attended by 26 CSG members, participating on Party delegations or as non-government and inter-government organisations, including myself, Deputy Chairman Alejandro Larriera and Executive Officer Tom Dacey.

At SC64, the current suspension in trade of *Crocodylus niloticus* from Madagascar was again subject to discussion and review by the Working Group allocated to this task. Again, progress had been made by Madagascar, but only with some of the recommendations. Hence the suspension was not lifted. At CoP 16, amendment proposals seeking the transfer of *C. porosus* and *C. siamensis* in Thailand from Appendix I to Appendix II was not approved by the Parties. Similarly, a proposal to transfer a Colombian population of *C. acutus* from Appendix I to Appendix II was not approved. The Parties also agreed to amend Resolution Conf. 9.24 (Rev. CoP15), so that the ranching resolution [Resolution Conf. 11.16 (Rev. CoP15)] remained a serparate pathway to Appendix II. A detailed summary on CoP16 and SC64 is provided on pages 4-6.

Following on from discussions at the 21st CSG meeting (May 2011), an American Crocodile Workshop was held in Miami, Florida, in February 2013. With over 80 people from four countries and four US States participating, the workshop resulted in a successful exchange of information that can assist NGOs and Government authorities in Jamaica to address conservation and management issues with *C. acutus*. A summary of the workshop is on pages 6-7.

In February 2013 the CSG received information from the Madras Crocodile Bank Trust on the die-off of around 15 Gharials (*Gavialis gangeticus*) in the Chambal River. All three State Forestry Departments in India were alerted immediately, and several CSG members working in the area offered their services if required. Although the cause of the die-off has yet to be confirmed, it appears that it was an isolated event without significant repercussions for the Gharial population as a whole.

The CSG Regional Chair for East and Southeast Asia, Dr. Toshinori Tsubouchi, advised that the defence counsel in a recent court case involving the importation of crocodiles from Thailand to Japan claimed that the species was a hybrid (*C. siamensis* x *C. porosus*), and therefore CITES regulations did not apply. However, hybrids are regulated by CITES through Resolution Conf. 10.17 (Rev. CoP14) *Animal hybrids*. Where at least one of the lineages of a hybrid is included in Appendix I, then the specimen shall be deemed to be on Appendix I. Where both lineages are on Appendix II, then the specimen shall be deemed to be on Appendix II.

Around 15,000 crocodiles from the Rakwena Crocodile Farm in South Africa were released amid heavy rains and flooding. The farm owners were forced to open the gates to prevent a storm surge. Many of the crocodiles have been re-caught, but a significant number remain at large. One crocodile turned up on a school rugby pitch some 120 km away.

On 22 March 2013, Crocodylus Porous Philippines Inc. (CPPI) reintroduced 36 Philippine Crocodiles (*C. mindorensis*) into Paghongawan Marsh, near Jaboy village, on Siargao Island. This is the first stage of a long-term reintroduction program aimed at re-establishing *C. mindorensis* populations in the wild. The crocodiles were captive-bred by CPPI members, and were around 0.6 m TL in size. The reintroduction site was chosen after extensive assessment of potential areas, in terms of ecological and social (people) factors. Saltwater crocodiles (*C. porosus*) are known to inhabit coastal areas of the island, but no *C. mindorensis* are known to have been there previously. A detailed report on this important program is on pages 15-17.

It is good to see new distribution records for the Philippine crocodile in the highlands of Lake Sebu (southern Mindanao) (see pages 13-15) and the American crocodile (*C. acutus*) on the Isla del Rey (Panama) (see pages 10-13). Sadly, in February 2013 we learned that Lolong, the largest Saltwater crocodile in captivity, had died at the Bunawan Eco-Park, Agusan del Sur, Southern Philippines (see page 15).

Fauna & Flora International (FFI) has launched an emergency public appeal to raise funds to save a portion of the wild Siamese crocodile population in Cambodia. The influx of workers and roads associated with the construction of a hydropower dam in Western Cambodia's Cardamom Mountains is seen as a major threat to a small breeding population of *C. siamensis*. It is proposed that crocodiles be relocated from the area and monitored by radio-telemetry and surveys to assess the success of relocations. The construction of the dam will greatly expand the amount of aquatic habitat available for Siamese crocodiles, and could represent a future site for reintroduction of the species. These types of projects have led to increased crocodilian populations elsewhere (eg Australia, Zimbabwe, Egypt).

The Chelonia Association has launched a website (http://caimanllanero.jimdo.com) to disseminate information on the natural history and other aspects of the Orinoco crocodile (*C. intermedius*), and at the same time inform the public about the conservation status of the species and actions being undertaken to recover the wild populations. This initiative is part of the project "Conservation of the Orinoco Crocodile (*Crocodylus intermedius*) in the Eastern Llanos of Colombia", implemented by the Chelonia Association together with the Regional Autonomous Corporation of the Orinoco (Corporinoquia) and in collaboration with the Natural Protected Areas Corporation and the Conservation and Forestry Development Foundation. The project, initiated in 2010, is co-sponsored by the Biodiversity Foundation (Spain) and the Fonds pour la Biodiversité Dotation-FDB (France), within the latter's "Save Your Logo" program which is supported by the Lacoste company.

The proceeds of the auction held at the 21st CSG meeting in Manila ($5275) were forwarded to CREDI-ONG (Benin) in February 2013, to contribute towards two projects: "Assessment of Dwarf Crocodile (*Osteolaemus tetraspis*) Populations in the Sitatunga Natural Reserve (Benin)"; and, "Crocodile Behaviour and Crocodile Habitat Use in Agro-pastoral Dams in Northern Benin".

Consideration is being given to the holding of a 3rd CSG West Africa Regional meeting later this year. Dates and the venue will be advised once they have been confirmed.

Again, I urge CSG members to consider attending the 22nd CSG Working Meeting to be held in Negombo, Sri Lanka, 20-23 May 2013. The closing date for abstracts is 10 April 2013, and for manuscripts, extended abstracts for publication in the Proceedings is 23 May 3013. In conjunction with the meeting, a Veterinary Techniques Workshop will be held at the Dehiwala Zoological Gardens on 19 May 2013. Details can be found on the meeting website (www.csgsrilanka.com).

Professor Grahame Webb, *CSG Chairman*.

22nd CSG Working Meeting

Colombo, Sri Lanka, 20-23 May 2013

The 22nd CSG Working Meeting will be held in Colombo, Sri Lanka, from 20-23 May 2013.

With a "Living with Crocodilians" theme, we encourage people to participate in what will be the first CSG Working Meeting in the South Asia and Iran region since 1978.

Details on the meeting are now available at <csgsrilanka.com>.

16th Conference of the Parties to CITES
(3-14 March 2013)
and
64th Meeting of the CITES Standing Committee
(2 March 2013)

The 16th Meeting of the Conference of the Parties to CITES (CoP16) was held on 3-14 March 2013, in Bangkok, Thailand. It was preceded on 2 March 2013 by the 64th meeting of the CITES Standing Committee (SC64).

The current suspension in trade of *Crocodylus niloticus* from Madagascar was discussed at SC64. The working group on this issue (Japan, USA, France, Germany, CITES Secretariat, CSG) met with the Malagasy delegation to discuss progress made on the SC62 recommendations on the conservation and management of *C. niloticus* in Madagascar. Although progress had clearly been made with some of the recommendations, others had yet to be addressed completely, and so the working group felt that the suspension could not be lifted at this time. Although additional information had been submitted by Madagascar immediately before SC64, there was insufficient time for it to be translated, nor for the working group to evaluate it in detail. It was agreed that the working group would work intersessionally by e-mail to assess any additional documents submitted by Madagascar prior to SC65 (2014), and if compliance with the SC62 recommendations warranted the lifting of the trade suspension, this would be done through postal vote to SC members.

Twenty-six (26) CSG members attended CoP16, from 16 countries [Australia (4), Colombia (3), Indonesia (3), USA (1), Mexico (1), Argentina (1), United Kingdom (2), Italy (1), Japan (2), Cambodia (1), Thailand (4), China (1), Singapore (1), Germany (1)], as members of Party delegations or participating as non-government or intergovernmental organisations (eg IUCN). CSG Chairman Grahame Webb, CSG Deputy Chairman Alejandro Larriera and CSG Executive Officer Tom Dacey were all in attendance.

Three proposals to amend the appendices of CITES for crocodilians were debated at CoP16.

1. Colombia proposed the transfer of the Cispata Bay population of *C. acutus* from Appendix I to Appendix II. The population outside Cispata Bay would remain on Appendix I, and be managed accordingly. The proposal was modified with an annotation to include a zero export quota, and although the modified proposal gained a high level of support (53.3% of votes) in Committee I, the proposal did not receive the necessary two-thirds of votes required for adoption. In particular, the European Union were concerned that: the population did not meet the criteria for Appendix-II listing [Resolution Conf. 9.24 (Rev. CoP15); the appropriate safeguards were not yet in place; and, the proposal represented a split-listing of a population at a national level. The Cispata Bay project represents a

change in direction for Colombia, away from captive breeding and towards a ranching operation through which local communities benefit. It was thus disappointing that the proposal was not accepted, as it could have provided the necessary impetus for the project to continue and to attract investment for further development.

2. The proposal to transfer the Thai population of *C. siamensis* from Appendix I to Appendix II was not approved in Committee I. Although gaining 58.5% of the votes, it did not receive the necessary two-thirds, and was therefore not adopted. Although the population still meets the criteria for Appendix-I listing, it is unlikely that the wild population in Thailand will ever be large. There are small amounts of available habitat, and due to the long absence of wild crocodiles, people are not accustomed to having them around and are therefore not highly supportive of the introduction of crocodiles back into the wild. Thailand re-opened the debate on this proposal in Plenary, but again did not get the necessary two-thirds of the votes for adoption.

3. Thailand also proposed the transfer of its *C. porosus* population from Appendix I to Appendix II. The proposal gained 53.0% of the votes and was not adopted. The population still meets the criteria for Appendix-I listing, and is very small. Like *C. siamensis*, the ability to re-establish large wild populations of *C. porosus* in Thailand is greatly constrained by the extent of suitable habitat.

The opportunity was taken to discuss various conservation and management issues with some Parties:

4. Ethiopia: Two crocodile ranches are currently in operation, both based on the collection of *C. niloticus* hatchlings from Lake Chamo. The Ethiopian population was down-listed to Appendix II, initially under Resolution Conf. 5.21 (1990; CoP7) as a temporary measure in order to export rapidly accumulating ranched products, and later under Resolution Conf. 3.15 (1992; CoP8), for the purposes of ranching and limited trophy hunting. Ranching has continued, but trophy hunting was recently prohibited, although the basis of this decision is now being re-examined. The policy of returning a percentage of ranched crocodiles back into the wild also merits re-examination in light of the current status of the population. Discussions with the Ethiopian delegation at CoP16 also included the possibility of a CSG review with recommendations.

5. Thailand: A reintroduction project for *C. siamensis* has been approved, and will involve collaboration between the crocodile farming industry, the Fisheries Department, and the National Parks Department. The proposed dam construction in Pang Sida National Park is likely to result in increased habitat for reintroduced Siamese crocodiles. Few areas in Thailand are considered suitable for the reintroduction of crocodiles.

6. Costa Rica: The status of *C. acutus* in the Tempisque River area has prompted an assessment of options to reduce HCC, perhaps integrated with a sustainable use program. This issue will be discussed further through the CSG's Latin America and the Caribbean office, with the relevant Costa Rican authorities and NGOs involved in research and management of the species in that country.

7. Israel: Authorities are looking for a "home" for some 200 sub-adult and adult *C. niloticus*, of South African origin, from Crocoloco Crocodile Farm. The facility has been forced to close, and relocation is considered the most desirable outcome for these animals.

8. Uganda: The status of a research project being undertaken at Murchison Falls was discussed with members of the Ugandan delegation. The CSG was thanked for providing "crocodilian" literature, which greatly assisted the researchers in that country.

9. Rwanda: There is interest by Government in developing a sustainable use program for Nile crocodiles.

The following CoP16 agenda items were of relevance to the CSG:

10. Many crocodilian species have been transferred to Appendix II through the ranching resolution [Resolution Conf. 11.16 (Rev. CoP15)]. However, changes to Resolution Conf. 9.24 (Rev. CoP15) meant that ranching proposals, in addition to satisfying Resolution Conf. 11.16 (Rev. CoP15), also had to meet the criteria of Annex I of Resolution Conf. 9.24 (Rev. CoP15) for inclusion in Appendix II.

    The intent of the ranching resolution, to be able to transfer an Appendix-I population to Appendix II where it did not meet the criteria of Resolution Conf. 9.24 (Rev. CoP15) for Appendix-II listing, but where there were clear conservation benefits to the population in doing so, was lost.

    At CoP15, the Parties adopted Decison 15.51, which directed the CITES Animals Committee to:

    "a) Evaluate the merit of reinstating the ability to transfer suitably qualified populations that continue to meet the criteria in Resolution Conf. 9.24 (Rev. CoP15), Annex 1, for transfer from Appendix I to Appendix II pursuant to Resolution Conf. 11.16 (Rev. CoP15) or Resolution Conf. 9.20 (Rev.); and

    b) If merit is found, draft a revision of paragraph A. 2 in Annex 4 of Resolution Conf. 9.24 (Rev. CoP15) to eliminate the requirement that downlisting proposals pursuant to Resolution Conf. 11.16 (Rev. CoP15) or Resolution Conf. 9.20 (Rev.) must also meet the criteria in Annex 1 of Resolution Conf. 9.24 (Rev. CoP15)."

    CoP16 adopted revisions to paragraph A. 2 of the Precautionary Measures in Annex 4 to Resolution Conf. 9.24 (Rev. CoP15) proposed by the CITES Animals

Committee (CoP16 Doc. 72), which separate Resolution Conf. 11.16 (Rev. CoP15) as a 'stand alone' alternative mechanism to submit down-listing proposals.

In addition, although it was recognised that there was merit in merging Resolution Conf. 11.16 (Rev. CoP15) and Resolution Conf. 9.20 (Rev.) (ranching of sea turtles), it was not considered a pressing issue at this time. The CITES Secretariat suggested that the Conference of Parties waits to see whether the changes to Resolution Conf. 9.24 (Rev. CoP15) leads to renewed interest in ranching proposals before proceeding further with this issue.

11. At SC61 (August 2011) the European Union introduced document SC61 Doc. 27, drawing attention to problems of implementation of the Convention in relation to captive-bred and ranched specimens. The CITES Standing Committee recognized that there were some problems and established a working group under the chairmanship of the USA, to identify the problems and to recommend solutions at SC62.

    The Standing Committee requested the CITES Secretariat to issue a Notification to the Parties (No. 2011/037), to seek information on the experience of Parties, and which could to be used as a basis for discussions of the working group. At SC62 (July 2012), the Standing Committee considered the working group's report (SC62 Doc. 26), which provided examples of specimens in trade that were possible cause for concern, and which may warrant further examination. Trade in *Caiman crocodilus fuscus* skins from Colombia was listed.

    The Standing Committee recommended that CoP16: a) agree that Decisions 15.52 and 15.53, regarding development and review of a guide on the use of source codes, remain in effect following CoP16; and b) adopt a number of draft decisions (including an evaluation of concerns identified in examples in document SC62 Doc. 26) (CoP16.48).

12. A document on CITES and Livelihoods (CoP16.19), prepared by the Chair of the Working Group on CITES and Livelihoods (Peru) on behalf the Standing Committee, with assistance from Colombia, UNEP-WCMC, Alejandro Larriera and the CITES Secretariat, was submitted to CoP16 in response to Decision 15.6.

    A draft resolution on CITES and Livelihoods was discussed and adopted by Committee II. A number of decisions were also directed to the Parties, the Standing Committee and the CITES Secretariat.

    A side event on CITES and Livelihoods featured the Cispata Bay project with *C. acutus* in Colombia as one of the case studies. Clara Sierra Diaz provided an excellent presentation on how this project has the potential to benefit rural communities and crocodile conservation.

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

American Crocodile Workshop
(15 February 2013)

Over 80 people from 4 countries and four US states assembled in Miami on 15 February 2013 for a workshop on American crocodile (*Crocodylus acutus*) issues in Florida and Jamaica. The meeting was convened and organized by Joe Wasilewski, Frank Mazzotti and Perran Ross as a direct outcome of discussions on the Jamaican crocodile crisis at the 21st CSG Working Meeting in Manila (Ross *et al*. 2012; Henriques *et al*. 2012).

Financial support from the Crocodile Conservation Institute (Sam Seashole), Florida Light and Power Company (FPL), Lacoste-Save Your Logo (through a grant to Frank Mazzotti) and an anonymous donor allowed 5 Jamaican participants to attend the workshop: Ricardo Miller, National Environment and Planning Agency (NEPA); Damion Whyte, Urban Development Corporation (UDC); Professor Byron Wilson, University of West Indies; Dr. Leo Douglas, Columbia University; and, Lawrence Henriques (Fig. 1).

Figure 1. Jamaican participants at the American Crocodile Workshop; from left, Ricardo Miller (NEPA), Damion Whyte (UDC), Dr. Leo Douglas (UWI), Prof. Byron Wilson (UWI) and Lawrence Henriques. Photograph: Bruce Shwedick.

A morning session presented results of American crocodile's recovering status in Florida (Mike Cherkiss), movements (Jeff Beauchamp), the FPL extensive land management and conservation activities at Turkey Point (Jim Lindsay), management of increasing human-crocodile conflict in Florida's coastal suburbs (Lindsey Hord), and an analysis of impacts of climate change and sea level rise on crocodiles in Florida and Jamaica (Laura Brandt).

In the afternoon, Ricardo Miller (NEPA) and Damion Whtye (UDC) outlined the structure, activities and some constraints of their agencies crocodile management programs. Byron Wilson detailed the current threats and his research in the Hellshire Hills region and Lawrence Henriques provided a spatial overview of the very limited and threatened area of habitat for crocodiles in Jamaica and his own work on rescue and rehabilitation of crocodiles. A lively discussion

ensued, lamenting the very disturbing increase in threats (habitat loss and illegal hunting for meat), limited resources and capacity and the economic and social drivers of this looming conservation crisis. A number of proposals for response were suggested including mobilizing international concerns and applying pressure to the Jamaican Government for more action, a media and educational program to shift public opinion and support, fundraising, seeking corporate and local 'Champions' for Jamaican crocodile conservation, research focused on management and conservation needs and developing an action plan coordinated among the Jamaican and external interests, including CSG. Following the workshop, several discussions with Jamaican participants developed an outline for next steps to draft and promote this plan.

Following the workshop, our Jamaican guests and several participants participated in a field trip on 16 February to the Florida Power and Light conservation mitigation and conservation area and the cooling canals of the power generation plant. Extensive habitat improvement, water flow and salinity management, exotic plant control and development of artificial nesting sites has established this 6000 acre area as well protected stronghold and most productive reproduction area for *C. acutus* in Florida and provides a model for enlightened involvement of the private sector in crocodile conservation. We are optimistic that the follow up from this workshop will empower and assist crocodile conservation in Jamaica and provide a plan, a model and support for ensuring the long term persistence of Jamaica's crocodiles.

Literature Cited

Henriques, L., Wilson, B. and Ross, P. (2012). Jamaican crocodile conservation. Crocodile Specialist Group Newsletter 31(3): 6-7.

Ross, P., Woodward, A. and Wasilewski, J. (2012). Summary report of Jamaican Crocodile Working Group. Pp. 255-256 *in* Crocodiles. Proceedings of the 21st Working Meeting of the IUCN-SSC Crocodile Specialist Group. IUCN: Gland, Switzerland.

Perran Ross *(University of Florida; pross@ufl.edu),* Joe Wasilewski *(jawnatsel@bellsouth.net)* and Frank Mazzotti *(University of Florida; fjma@ufl.edu).*

Student Research Assistance Scheme Update

Three SRAS proposals were accepted in January-March 2013.

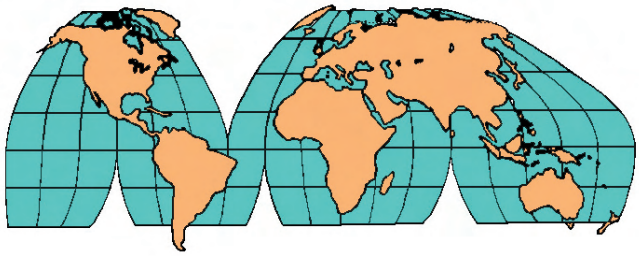
1. Evelyn Lopez (Argentina): Evaluation of chromosomal and micronucleus aberrations in *Caiman latirostris* embryos exposed to insecticides.

2. Betzaida Rivera (Panama): Abundance, demographic structure and relationship with habitat for the American crocodile (*Crocodylus acutus*) in Coiba National Park, Panama.

3. Jose Antonio Nobrega (Brazil): Diet, body condition and blood biochemistry of breeding female *Caiman crocodilus* in Central Amazonia.

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

Regional Reports



Latin America and the Caribbean

Belize

AMERICAN CROCODILE SURVEY OF NORTHERN AND SANDBORE CAYES, LIGHTHOUSE ATOLL, BELIZE. The American Crocodile (*Crocodylus acutus*) is depleted throughout most of its range. It is recognized as "threatened" by the Belize Department of Fisheries, is listed as "Vulnerable" by the International Union for the Conservation of Nature (IUCN), and with the exception of Cuba, all other national populations of *C. acutus* are on Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (McField *et al.* 1996; Thorbjarnarson 2010; Platt *et al.* 2004; Platt and Thorbjarnarson 2000a; Rainwater and Platt 2009). Despite being fully protected by *The Belize Wildlife Protection Act (Chapter 220)*, the American crocodile is considered to be declining in Belize due to destruction of major nesting grounds, low hatchling survival rates, needless killings, and an insufficient capacity to adequately enforce protection laws (Platt and Thorbjarnarson 2000a). The *C. acutus* population in Belize has been estimated to comprise less than 1000 non-hatchlings (Platt and Thorbjarnarson 2000a; Platt *et al.* 2004; Rainwater and Platt 2009).

Destruction of Belize's most significant nesting beaches for development, such as in Northern Caye, Turneffe Atoll (Fig. 1), is one of the greatest threats to the continued viability of the Belize population of *C. acutus* (Platt *et al.* 2004). In 2000- 2004 Turneffe Atoll was reported as having the highest concentration of American crocodiles and the most active nesting grounds in the country (Platt and Thorbjarnarson 2000a; Platt *et al.* 2004). But in 2009 researchers recorded reduced numbers and reduced nesting activity, largely due to the alteration of crocodile nesting habitats for development (Rainwater and Platt 2009). In view of this competition for land use between crocodiles and humans, this report documents the results of a survey of the crocodile population

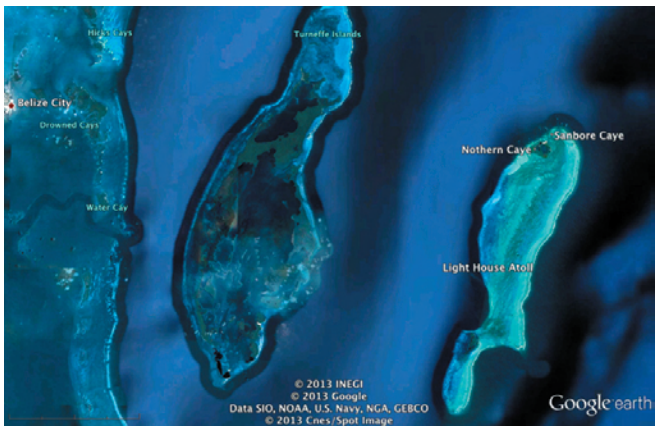


Figure 1. Turneffe and Lighthouse Atolls.

Figure 2. Sandbore and Northern Cayes, Lighthouse Atoll, showing survey routes (#1-5; see Table 1 for decription) and locations and estimated sizes of crocodiles sighted.

in two nearby locations, Sandbore and Northern Cayes, on Lighthouse Atoll (Figs. 1 and 2), in January 2013.

Located approximately 35 km east of Turneffe Atoll and 75 km east of Belize City, at least 95% of Lighthouse Atoll lays beneath the surface of the Caribbean Sea (Platt *et al*. 1999). With an estimated surface area of 126 km^2, this atoll includes four cayes: Northern, Sandbore, Long and Half-Moon Cayes (Stoddart 1962; Platt *et al*. 1999). Northern and Sandbore Cayes are located on the most northern tip of Lighthouse Atoll (Fig. 1). Northern Caye consists primarily of red mangrove (*Rhizophora mangle*) and Black mangrove (*Avicennia germinans*) (Platt *et al*. 1999), and harbors the remains of an abandoned resort with a usable airstrip. Additionally, two sizable interior lagoons are accessible by kayak from the northeastern side of the island (Fig. 2). Sandbore Caye is a coral sand island lying 0.9 km northeast of Northern Caye. Containing an active lighthouse, Sandbore Caye consists primarily of Red mangrove and Coconut palms (*Cocos nucifera*). Currently, both cayes are privately owned and the only occupant is an elderly watchman who resides on Northern Caye.

Spotlight surveys began 20-35 minutes after sunset, and were conducted from: a 7.92 m (26') skiff powered by a 60hp Yamaha outboard (average speed= 5 km/h); a 2-person kayak (average speed= 3 km/h); or, by foot (average speed= 0.6 km/h) when fringing vegetation was too dense or water too shallow to allow boat/kayak access. Two researchers spotted crocodiles simultaneously, one using a 0.5 million candlepower Q-beam spotlight, and the other a 22,000 candlepower Maglite with the assistance of Atlas 8 x 42 binoculars. It has been the experience of the observers that crocodiles spotted with such intense candlepower as a 0.5 million spotlight, even from a distance, can immediately submerge and often be overlooked. Hence, the use of a weaker light combined with the use of binoculars enables one to see deeper into the mangrove and limits the probability of "missing" crocodiles. Once sighted, crocodiles were approached as closely as possible and total length (TL) estimated. Crocodiles were categorized on the basis of estimated TL as: hatchlings (<30 cm); juveniles (30-90 cm); sub-adults (90-180 cm); or, adults (>180 cm). A Garmin Rino 520-530HCX handheld Global Positioning System was used to record start and endpoints of all census areas and the distances surveyed in kilometres.

On 21 January 2013, the navigable coastline around Sandbore Caye was surveyed by skiff, and on foot when waters were not passable. The team then departed Sandbore Caye and traveled southwest 0.9 km to the visible Northern Caye. No crocodiles were encountered. Surveying continued along the seaward coast of Northern Caye where two adult crocodiles were encountered. Two more adult crocodiles were encountered in the interior eastern lagoon that was surveyed using a kayak. The 4 crocodiles were encountered along a survey route of 11.2 km (encounter rate= 0.4 crocodiles/km) (Table 1).

On 22 January 2013, the interior western lagoon of Northern Caye was surveyed by kayak. Two adult crocodiles were spotted together within the northern edge of the lagoon. When approached, both moved quickly to the southern most edge of the same lagoon. Next, two additional, separate, mangrove swamp areas were accessed using a machete and surveyed on foot. Both areas opened up such that a 180° view was surveyable from a single spot. No crocodiles were spotted at either location. The two crocodiles spotted along the 2.5 km survey route equate to an encounter rate of 0.8 crocodiles/km) (Table 1).

Due to the onset of inclement weather, limited navigability, and impassible foot access, Northern Caye's southernmost shores were not surveyed by spotlight during this expedition. While the sandy beaches of Sandbore Caye could provide suitable nesting substrate, there were no interior freshwater lagoons for hatchlings. Northern Caye appears to have marginal crocodile nesting habitats.

With the exception of one sub-adult crocodile sighted while waiting for sunset (Table 2), no other crocodiles were sighted during daylight reconnaissances of Sandbore Caye's entire perimeter (21 January 2013) and Northern Caye's western, leeward shore and airstrip area (22 January). Nor were any signs of crocodiles observed on either caye (eg tracks, trails, tail drags, scats), or any other usual evidence of wildlife activity, except for Black Spiny-tailed iguanas (*Ctenosaura similis*).

Table 1. Results of surveys on Sandbore and Northern Cayes, 21-22 January 2013. All crocodiles (N) sighted during spotlight surveys were considered to be adults, and one sub-adult (1.7 m TL) was sighted during the day, before the survey started (see text). #1-#5= route numbers (see Fig. 2). Specific sighting locations for crocodiles are on Figure 2.

Date	Start-Stop	Survey Area	GPS Location of Survey Area	Location; Estimated TL	N	km
21 Jan	1824-1948 h	#1; Sandbore Caye coastal and to Northern Caye	17° 27'50"N, 87° 29'18"W 17° 27'15"N, 87 29'59" W		0	4.4
21 Jan	2048-0022 h	#2; Northern Caye Coastal and East Interior Lagoon	17° 27'15"N, 87° 29'59"W 17° 26'52"N, 87 29'41" W	Northeastern coast, 2.3, 2.45 m East Lagoon, 2.75, 3.05 m	4	6.8
22 Jan	1810-1846 h	#3; Northern Caye West Interior Lagoon	17° 26'50"N, 87° 30'15"W 17° 26'53" N, 87 30'09" W	West Lagoon, 2.75, 3.05 m	2	2.1
22 Jan	2055-2117 h	#4; Northern Caye Northwest Swamp	17° 27'11"N, 87° 30'02"W 17° 27'08"N, 87 30'11" W		0	0.3
22 Jan	2127-2150 h	#5; Northern Caye Northeast Swamp	17° 27'10"N, 87° 30'02"W 17° 27'07"N, 87° 30'01" W		0	0.1
22 Jan	1636 h	Canal between East and West Lagoons		1.70 m sub-adult	1	-

On 16 February 2013 (1251 to 1300 h), an aerial survey was conducted over Northern and Sandbore Cayes using a single engine Cessna 206. During this flight, special care was taken to fly over the southern shores of Northern Caye which were not spotlight surveyed, and which comprise a dense wall of protective Red mangrove. The aerial survey, at an average altitude of 100 m, did not yield any crocodile sightings or signs of crocodile activity on either caye, but did provide useful information on the location of an interior swamp area just south of the eastern lagoon in Northern Caye. Future explorations should include this area. Finally, there was no evidence of any interior lagoons on Sandbore Caye; however, dense foliage could possibly obscure small pools of water.

This census represents the first systematic spotlight survey of Northern and Sandbore Cayes. In July 1997, one adult (ca. 210 cm TL) and one hatchling (<30 cm TL) were sighted during the day in a man-made freshwater pond south of the airstrip (Platt *et al*. 1999). During our survey the watchman stated that he often saw a small crocodile in this same "abandoned well", but we did not detect any signs of crocodile during the two nights.

Additionally, it is possible that the two crocodiles sighted on the second night may have been the same crocodiles sighted the previous evening, as suggested by their estimated sizes (Table 2). If so, the population is possibly smaller than initially thought. Against this, due to the inherent variable of sampling bias during spotlight surveys (Bayliss 1987) some individuals may not have been detected (Platt *et al*. 2004).

In conclusion, the lack of suitable nesting habitat, the limited food sources and small population comprising almost all adults, suggests that crocodiles at Lighthouse Atoll could be transients from nearby Turneffe Atoll. It is recommended that one more reconnaissance be undertaken during the nesting season, with closer attention to water quality (eg salinity) of all interior lagoons that could impact on the ability of hatchlings to survive in those areas. Through collective efforts of obtaining current information on crocodile populations and hatchling survival rates, in conjunction with assessment of habitat conditions considered vital to hatchling survival (Mazzotti and Cherkiss 2003), we can realize and implement the provisions essential for this species.

Acknowledgements

This project was funded via a grant from The Rufford Small Grants Foundation and private anonymous donors. The property owners and The Belize Forest Department, Ministry of Forestry, Fisheries, and Sustainable Development, Belmopan, Belize, provided permission for the surveys. Aerial surveying and photographs were made possible with the assistance of LightHawk. Binoculars were donated by Optics for the Tropics. Additional co-operation was provided by Thomas Rainwater. Charlie Manolis is thanked for his considerable support and assistance in the preparation of this article. Vince Rose and Chris Summers of ACES/American Crocodile Education Sanctuary contributed invaluable field efforts.

Literature Cited

Bayliss, P. (1987). Survey methods and monitoring within crocodile management programmes. Pp. 157-175 *in* Wildlife Management: Crocodiles and Alligators, ed. by G.J.W. Webb, S.C. Manolis and P.J. Whitehead. Surrey Beatty and Sons: Chipping Norton.

Mazzotti, F. J. and Cherkiss, M.S. (2003). Status and Conservation of the American Crocodile in Florida: Recovering an Endangered Species While Restoring an Endangered Ecosystem. University of Florida, Fort Lauderdale Research and Education Center, Tech. Rep. 2003, p. 41.

McField, M., Wells, S. and Gibson, J. (1996). State of the Coastal Zone Report, Belize, 1995. Coastal Zone Management Programme, United Nations Development Programme and Global Environmental Facility. Project No. Bze/92/G31. Government Printing Office: Belmopan, Belize.

Ross, J.P. (ed.). (1998). Crocodiles: Status Survey and Conservation Action Plan, 2nd Edition. IUCN-SSC Crocodile Specialist Group: Gland, Switzerland.

Platt, S.G. and Thorbjarnarson, J.B. (2000a). Status and conservation of the American crocodile, *Crocodylus acutus*, in Belize. Biological Conservation 96: 13-20.

Platt, S.G. and Thorbjarnarson, J.B. and Rainwater, T.R. (1999). Occurrence of the American Crocodile in Lighthouse Atoll, Belize. Caribbean Journal of Science 35(3-4): 316-318.

Platt, S.G., Rainwater, T.R. and Nichols, S. (2004). A recent population assessment of the American Crocodile (*Crocodylus acutus*) in Turneffe Atoll, Belize. Herpetological Bulletin 89: 26.

Rainwater, Thomas R. and Platt, S.G. (2009). Possible decline of an American Crocodile (*Crocodylus acutus*) population on Turneffe Atoll, Belize. Herpetological Bulletin 107: 3-11.

Stoddart, D.R. (1962). Three Caribbean atolls: Turneffe Islands, Lighthouse Reef, and Glovers Reef, British Honduras. Atoll Res. Bulletin 87: 151.

Thorbjarnarson, J.B. (1992). Crocodiles: An Action Plan for their Conservation. IUCN-SSC Crocodile Specialist Group: Gland, Switzerland.

Thorbjarnarson, J.B. (2010). American Crocodile Crocodylus acutus. Pp. 46-53 *in* Crocodiles. Status Survey and Conservation Action Plan. Third Edition, ed. by S.C. Manolis and C. Stevenson. Crocodile Specialist Group: Darwin.

Cherie Chenot-Rose and Vincent Rose, *American Crocodile Education Sanctuary, Ambergris Caye, Belize, <acesnpo@hughes.net>.*

NEW RECORDS OF *CROCODYLUS ACUTUS* (CUVIER, 1807) ON ISLA DEL REY AND A REVIEW OF THE SPECIES' DISTRIBUTION IN LAS PERLAS ARCHIPELAGO, PANAMA. The biology of the American crocodile (*Crocodylus acutus*) has been extensively studied over the last two centuries. Due to its widespread occurrence throughout the Americas, its conspicuous size, and concerns about human-crocodile conflict, the species' distribution is particularly well documented. While populations throughout its distribution suffered from some 50 years of unregulated hunting during the 20th Century, recovering populations now face severe challenges presented by habitat loss (Mazzotti and Cherkiss 2003; Ponce-Campos *et al*. 2012).

The biodiversity of Panama is well studied and populations of *C. acutus* thrive throughout the rivers and coastal mangroves of the country. The establishment of long-term research initiatives on Coiba Island has stimulated frequent biodiversity monitoring research and genetic analyses on American crocodiles that generate interest in conducting similar research on the population genetics of other islands (Garcia 2010; Bashyal 2012). One gap in current knowledge of Panamanian natural history is Las Perlas Archipelago, located in the Gulf of Panama (Fig. 1), where the flora and fauna remain poorly studied.

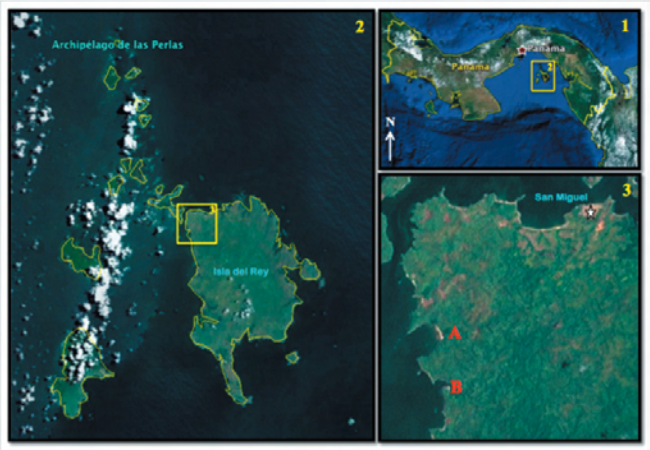


Figure 1. Isla del Rey (3) in relation to Panama (1) and Las Perlas Archipelago (2). A, B= sites where *C. acutus* were observed. Images courtesy of Google Earth (© Google 2013, U.S. Geological Survey, NASA, U.S. Dept. of State Geographer).

Isla del Rey, the largest island in Las Perlas and the second largest in Panama after Coiba, is a necessary location to initiate similar studies. Considering the island's more substantial isolation from the mainland, continuous conversion and extraction of mangroves, and the inevitable plans for tourism development, the status of Isla del Rey's American crocodiles is a severe conservation concern. Yet, until now, *C. acutus* has never been reported from Isla del Rey.

Past herpetological studies in Las Perlas

Cochran (1946) published herpetological records from the 1944 expedition led by A. Wetmore and J.P.E. Morrison to San José and Pedro González Islands of Las Perlas. This collection included three *C. acutus* specimens from San José Island, which according to E.R. Dunn were the first records of

the species for Las Perlas Archipelago (Cochran 1946). Since then, reptile checklists for the islands of Las Perlas have included the American crocodile (citing Cochran 1946). One additional specimen was collected on the eastern coast of San José Island in 1962. Although the latter specimen has not been referenced in published literature, all four specimens from San José are located in the Smithsonian National Museum of Natural History. Aside from these records, herpetology field surveys in Las Perlas have failed to report additional records of *C. acutus*.

Barbour (1906) reported on the herpetofauna recorded by W.W. Brown Jr. on Isla del Rey (then termed "San Miguel Island") and Saboga Island in 1904. Despite its conspicuous appearance, the species was not observed during Brown's excursions to either island. More than one century later, Neal (2007) conducted an assessment of the herpetological diversity on Isla del Rey in order to generate an updated species inventory for future biodiversity monitoring programs. Interestingly, records of American crocodiles were also absent from this study. While inland transects were primarily surveyed on the northern extent of the island, three diurnal and nocturnal mangrove swamp transects were also surveyed on the western coast of El Rey near the settlement of La Guinea (Neal 2007). Despite the absence of *C. acutus* in the study by Neal (2007) and the one previous known herpetology study on Isla del Rey (Barbour 1906), Neal compiled all known reptile and amphibian species lists throughout Las Perlas and inferred this compilation's application as a list for Isla del Rey. Due to the poor documentation of the biodiversity of Las Perlas, generalized checklists for the entire archipelago are frequently utilized for policy (UNDP 2005), which has been referenced in the construction of current species distributions for the American crocodile (Britton 2009). Isla del Rey is larger in area than the approximately 200 other islands and islets in Las Perlas combined. Although at present it provides a tentative species list for the largest island in Las Perlas, the majority of past studies were conducted on other more frequently visited islands in the 1500 km^2 archipelago.

Considering the number of marine studies conducted throughout Las Perlas and the abundance of American crocodiles elsewhere in Panama, it is possible that observations of American crocodiles occur, but are perceived as ordinary occurrences and left unreported. However, the absence of *C. acutus* in herpetology assessments of Isla del Rey indicate that populations may be restricted to isolated areas of the island. Additionally, the lack of literature concerning *C. acutus* in Las Perlas has contributed to much confusion for the species' distribution in the Gulf of Panama (Britton 2009). Crocodile tracks could provide greater insight into the locations of established breeding populations on the island, but given their mobility, individual tracks on beaches would be less informative to this end. Due to similarities in foot structure between crocodiles and iguanas (Brinkman 1980), tracks made by smaller crocodiles should be reliably identified. One would also suspect that *C. acutus* should be sighted on nearby islands and islets that are not large enough to sustain breeding populations. Thus, where breeding populations cannot be directly confirmed, they may be inferred in areas of high female abundances and/or their offspring.

Crocodylus acutus on Isla del Rey

Neal worked with local assistants throughout the duration of his 2007 study, who provided information on prior knowledge of species not encountered during that study. Similar to my conversations with residents on Isla del Rey, crocodiles were not mentioned. In July 2010, I traveled to Isla del Rey for one month as a Visiting Research Scientist at the Smithsonian Tropical Research Institute (STRI) to investigate genetic variation and island biogeography of invertebrates. Observations presented here were recorded during this expedition.

In the town of San Miguel, residents informed me that Isla del Rey lacked any animals of concern to humans, specifically including crocodiles. After two weeks of trekking through the island's interior, I ventured towards the western coast. After 2030 h, I observed in total 30 *C. acutus* in a 50 m (5 m wide) stretch of river flowing into the mangroves lining the coast (A on Fig. 1). From one vantage point near the river mouth, 20 individuals were easily seen. Crocodiles varied in size up to more than 2 m total length. One individual was captured and photographed, confirming the species (Fig. 2). Due to the depth of the water, limited visibility and the abundance of crocodiles, further investigation upriver was difficult. Accordingly, I suspect that additional individuals could be found further inland to the extent that favorable habitat permits. This population was observed every night for one week in similar numbers from the same point.

Figure 2. American crocodile captured for photographic documentation. Total length was approximately 1 m.

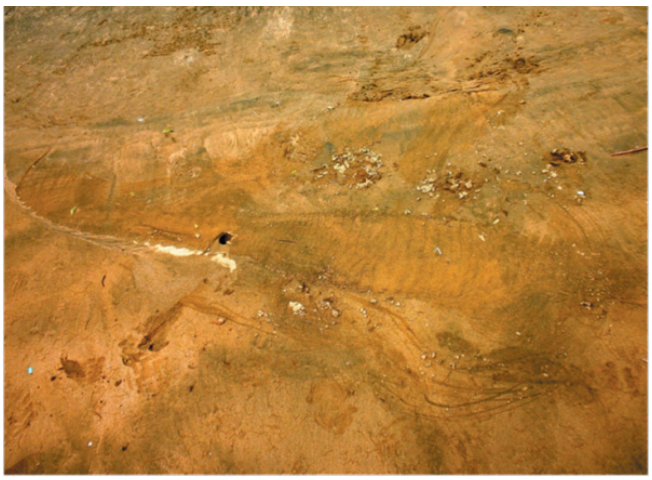


Figure 3. Imprint of *C. acutus* on a riverbank. Total length estimated to be 2-2.5 m.

At the end of the week, I relocated to a new campsite near a larger river, where *C. acutus* of greater size were sighted on the opposite riverbank (B on Fig. 1). Relative density was difficult to assess due to the width of the river (around 75 m), but more than 20 crocodiles greater than 2 m length were sighted within 200 m of the ocean. Imprints and tracks were recorded at low tide when traversing the river (Fig. 3).

Time was limited on this expedition, and thus additional coastal sites were not visited. Fortunately, assessments of land cover on Isla del Rey provide insight into areas of the island that contain potential habitat for *C. acutus* (see Guevara 2005; McGowan *et al*. 2010). McGowan *et al*. (2010) report a loss of 931.9 ha of mangrove cover between 1974 and 2000 from anthropogenic extraction and agricultural expansion on Isla del Rey. It is also possible that crocodiles once existed near human settlements and were eradicated because of conflicts, or hunted for their skins. However, this would have happened some time ago, as current residents do not have knowledge of crocodiles.

Much like the pearl industry for which the archipelago earned its name, market demand for crocodile skins could have driven the local *C. acutus* population to near extinction. However, it is also possible that Isla del Ray never had a large population of *C. acutus*, which is supported by the lack of observations by scientists visiting the island and by local residents. Notwithstanding the current lack of local knowledge of crocodiles on the island, crocodiles could have been more abundant historically throughout the entire archipelago.

Endemism, population genetics, and conservation

Though few studies have been conducted on the terrestrial fauna of Las Perlas, high levels of endemism have been reported. While genetic analyses are necessary to confirm the validity of some of the endemics, the following have been proposed: one frog species, one boa subspecies, six mammal subspecies, and at least 16 subspecies of birds (UNDP 2005). In addition, the archipelago is a critical nesting area for numerous species of aquatic birds and 5 species of endangered marine turtles (UNDP 2005).

Ongoing population genetics studies conducted by Texas Tech University and STRI have generated interesting results from *C. acutus* on Coiba Island that also should be investigated in Las Perlas. Although crocodiles are mobile across expanses of sea water, Coiba's separation from the mainland appears to have resulted in reduced gene flow and lower genetic variation in the island populations (Garcia 2010; Bashyal 2012). The shortest distance between Isla del Rey and the mainland is 35 km, 15 km farther than that of Coiba. Bashyal (2012) also indicates locations of dispersal corridors to the mainland as well as more isolated populations, all of which are useful in informing areas of conservation priority for this 'Vulnerable' species (Thorbjarnarson *et al*. 2006). While a hydrological reserve was recently gazetted on Isla del Rey, the area does not encompass coastal mangroves vital to *C. acutus*. Combined with the potential for genetic isolation, plans to develop Isla del Rey for tourism necessitate the urgent documentation and prioritization of coastal areas of conservation importance for the American crocodile and other endangered and/or endemic taxa.

Acknowledgements

Funding was provided by a PURA grant awarded to PRH by The Johns Hopkins University in 2010. ANAM issued the permits necessary to work in Las Perlas. Information regarding the specimens collected on San Jose Island (USNM 157957 and USNM 120686-120688) provided with the permission of the National Museum of Natural History, Smithsonian Institution, 10th and Constitution Ave. N.W., Washington, DC 20560-0193 (http://www.nmnh.si.edu/). I greatly appreciate the guidance of G.F. Ball while at JHU, valuable discussions with numerous staff members at STRI while in Panama, and the unconditional support of A.P., M.B. & T.J. Houlihan. Thanks to A. Aiello and M.J. West-Eberhard for recommendations to conduct fieldwork on the understudied Isla del Rey, which consequently led to these discoveries. This manuscript benefited from valuable comments by C. Manolis.

Literature Cited

Barbour, T. (1906). Vertebrata from the savanna of Panama: IV. Reptilia and Amphibia. Bulletin of the Museum of Comparative Zoology at Harvard College, XLVI. 12: 224-230.

Bashyal, A. (2012). Population genetics of the American crocodile in Coiba National Park, Panama. M.Sc. Thesis, Department of Zoology, Texas Tech University, Lubbock, Texas, USA. 60 pp.

Brinkman, D (1980). Structural correlates of tarsal and metatarsal functioning in Iguana (Lacertilia; Iguanidae) and other lizards. Canadian Journal of Zoology 58: 277-289.

Britton, A. (2009). Current distribution of *Crocodylus acutus*. <http://crocodilian.com/cnhc/cst_cacu_dh_map.htm>. Accessed 31 March 2013.

Cochran, D.M (1946). Notes on the herpetology of the pearl islands, Panama. Smithsonian Miscellaneous Collections 104(4): 1-8.

Garcia-Jimenez, L.M. (2010). Population Structure of the American Crocodile (*Crocodylus acutus*) in Coiba Island, Panama, inferred from Morphometric Measurements and Microsatellite Markers. M.Sc. Thesis, Department of Zoology, Texas Tech University, Lubbock, Texas, USA. 81 pp.

Guevara Cordoba, J.M. (2005). Changes in land use and cover in Archipelago Las Perlas: A proposal for a protected area. M.Sc. Thesis, Marine Resource Development and Protection Department, Heriot-Watt University, Edinburgh, Scotland, UK. 88pp.

Mazzotti, F.J. and Cherkiss, M.S. (2003). Status and Conservation of the American Crocodile in Florida: Recovering an Endangered Species While Restoring an Endangered Ecosystem. University of Florida, Ft. Lauderdale Research and Education Center, Tech. Rep. 2003. 41 pp.

McGowan, T., Cunningham, S.L., Guzman, H.M., Mair, J.M., Guevara, J.M. and Betts, T. (2010). Mangrove forest composition and structure in Las Perlas Archipelago, Pacific Panama. Revista Biologica Tropical 58(3): 857-869.

Neal, S. (2007). An Assessment of the Herpetofaunal Biological Diversity of the Hydrological Reserve on Isla del Rey, Las Perlas Archipelago, Panama. M.Sc. Thesis, Dept. of Geography, University College London, London.

Ponce-Campos, P., Thorbjarnarson, J. and Velasco, A. (2012). *Crocodylus acutus*. *In*: IUCN 2012. IUCN Red List of Threatened Species. Version 2012.2. <www.iucnredlist.org>. Downloaded on 20 March 2013.

Thorbjarnarson, J., Mazzotti, F., Sanderson, E., Buitrago, F., Lazcano, M., Minkowski, K., Muniz, M., Ponce, P., Sigler, L., Soberon, R., Trelancia, A.M. and Velasco, A. (2006). Regional habitat conservation priorities for the American crocodile. Biological Conservation 128: 25-36.

UNDP (2005). Integrating Biodiversity Conservation in the Productive Sector of Las Perlas Archipelago, Panama. UNDP Project Initiation Document.

Peter R. Houlihan, *Department of Biology and the McGuire Center for Lepidoptera and Biodiversity, Florida Museum of Natural History, University of Florida, Gainesville, FL 32611, USA, <phoulihan@ufl.edu>*.

East and Southeast Asia

Philippines

SOFT RELEASE INTRODUCTION OF THE PHILIPPINE CROCODILE (*CROCODYLUS MINDORENSIS*, SCHMIDT 1935) IN PAGHONGAWAN MARSH, SIARGAO ISLAND PROTECTED LANDSCAPE AND SEASCAPE, SOUTHERN PHILIPPINES. On 22 March 2013, 36 healthy juvenile Philippine Crocodiles (*Crocodylus mindorensis*) were introduced into freshwater marsh habitat on Siargao Island. The release site, Paghongawan Marsh, is located at Barangay Jaboy, Municipality of Pilar, Province of Surigao Del Norte at the north-central region of Siargao within the Siargao Island Protected Landscape and Seascape (SIPLAS). SIPLAS is one of the key biodiversity areas of the Philippines and was declared as a protected area by virtue of Presidential Proclamation 902 in October 1996.

Historically, the Philippine Crocodile is not known from Siargao Island, or any of the islands off eastern Mindanao. The released crocodiles were maintained under soft-release conditions for almost two years at Pag-asa Farms (a JK Mercado-Protected Areas and Wildlife Bureau-Silliman University Project) in Kapalong, Davao Del Norte. They comprised the progeny of Philippine crocodiles that were held in semi-wild conditions without any supplementary feeding since they were transferred from Silliman University Crocodile Breeding Facility in Dumaguete, Negros Oriental, in 2006 and the Palawan Wildlife Conservation Center (PWRCC; formerly Crocodile Farming Institute) in Puerto Princesa, Palawan (Cruz *et al*. 2012) in 2007. Also part of this project, three captive-bred adult *C. mindorensis* had been acclimated to wild conditions prior to reintroduction into a large swamp area at New Katipunan, Sto. Tomas, Davao Del Norte, Mindanao (Van Weerd *et al*. 2011) in 2009.

Figure 1. Paghongawan Marsh, Bgy. Jaboy, Pilar, Siargao Island Protected Landscape and Seascape, Surigao del Norte.

Scientific research on the release site indicated that Paghongawan Marsh was an ideal habitat for Philippine crocodiles. Critical resources such as food and microhabitats are naturally available. This freshwater marsh is considered likely sustain the requirements of a small population of crocodiles. The site is a natural limestone depression and the limestone karst hills around the boundary of the marsh essentially serve as a natural barrier to the movements of the introduced crocodiles in the area. Although water level fluctuates depending on season, the marsh remains waterlogged all year round, and water is replenished primarily by rainfall, which averages 513 mm per month between October and April.

Figure 2. Vic Mercado (CPPI) assists Mayor Lucio Gonzales, Chairperson Narda Trigo and Provincial Board member Cesar Bagundol with the release of juvenile *C. mindorensis* (approximately 0.6 m total length).

Potential Benefits

This benign introduction of the Philippine Crocodile will help ensure the long-term survival of the species in a secure site. It will likewise present an opportunity for various ecological studies to be conducted through sustained monitoring of the introduced population. The presence of this globally threatened species also presents some potential benefits to the eco-tourism industry on Siargao Island and Surigao Del Norte Province. The Philippine Crocodile is expected to attract numerous groups of people, ranging from scientists to the general public, who appreciate observing crocodiles and other wildlife species in their natural environments. This scenario could also provide economic benefits to local communities of Siargao and to the region.

In addition, various scientific studies that will be conducted in Paghongawan Marsh and surrounding habitats will be utilized to improve and/or develop biodiversity research and conservation programs of local government offices. Furthermore, the empirical data generated may be used to enhance local eco- and nature-based tourism activities. Paghongawan Marsh presents a perfect venue for local school children to learn about freshwater ecosystems, the need for watersheds, and the productivity of estuarine and freshwater areas. And as emphasized, the project would likely be a watershed for various ecological studies for students, researchers, and scientists.

It is projected that after the first three years, the local government of Pilar and their surrogates will encourage small-scale tourist concession(s) at the release site. The critically endangered conservation status of this species would be highlighted and portion of the proceeds from this endeavor would be earmarked for crocodile monitoring and/or interaction programs on the site.

Multi-Agency Cooperation

This successful release is part of the Philippine Crocodile Research and Conservation Program of Crocodylus Porosus Philippines Inc. (CPPI), which was established in 2006. A series of surveys and reconnaissance trips to Siargao Island began in August 2010 to assess the suitability of Paghongawan Marsh and its immediate vicinities. A habitat and biodiversity survey was conducted in September 2011 by a team of researchers and scientists from the National Museum of the Philippines, University of Santo Tomas, Father Saturnino Urios University and the Department of Environment and Natural Resources (DENR). These field surveys also resulted in the discovery of the Siargao Limestone Forest Frog (*Platymantis* sp.) which is new to science, and other species of flora and fauna were recorded from Siargao for the first time and represent significant species range extensions.

Figure 2. James Chan, Michael Vincent Cruz, Darrel Blatchley, Heintje Limketkai, Vincente Mercado, Tom Dacey, Arvin Diesmos, Rainier Manalo, Benedict Solco and "Toy" Mercado.

A series of public consultations were conducted in the impact areas (Jaboy and San Roque villages) which were attended by local officials and resident communities who subsequently endorsed (Bgy. Jaboy Res. No. 10, series of 2012 and Bgy. San Roque Res. No. 13, series of 2012) the Philippine Crocodile release program in Paghongawan Marsh. Information, education and communication activities were undertaken in nearby tertiary schools prior to release. Post-release activities will focus on three major aspects: scientific studies; public education/biodiversity information dissemination campaigns; and, assistance to local tourism efforts.

The crocodile research and conservation efforts in SIPLAS mark another milestone in the history of Philippine Crocodile conservation. It represents a partnership between CPPI, DENR through the Protected Areas and Wildlife Bureau, the National Museum of the Philippines and the Silliman University-Angelo King Center for Research and Environmental Management. It is endorsed by the SIPLAS Protected Area Management Board (Resolution No. 2012-21), the Municipality of Pilar (Resolution No. 145, series of 2012), and had secured the clearance of DENR Secretary Ramon JP. Paje (signed on 18 March 2013).

This release of Philippine Crocodiles is dedicated to the late Dr. Charles "Andy" Ross (1953-2011), who envisioned the project. In memory of Andy, the CPPI Student Grant Program (Mercado 2010) was re-established into the "Charles Andy Ross Conservation Fund for Siargao Island" to actively solicit project proposals and generate funding assistance for student research dealing with crocodiles in the Philippines".

Acknowledgements

We extend our sincere thanks to following persons and institutions for their support to the project: Hon. Lucio Gonzales, Municipal Mayor of Pilar; Hon. Alfredo Coro, Jr., Municipal Mayor of Del Carmen; Hon. Rosalinda Penera and Hon. Renato Virtudazo, Municipal Mayor and Vice-Mayor of Sta. Monica; Hon. Narda Trigo, Chairperson of Bgy. Jaboy; DENR-PAWB Director Dr. Mundita Lim and Assistant Director Nelson Devanadera, Dr. Esteven Toledo, Nermalie Lita, Dr. Glenn Rebong, DENR Caraga Regional Executive Director Nonito Tamayo, Regional Technical Director Mario Eludo, Milafe Noharra, Celsa Espadero and CENRO-Dapa Staff; DOT Caraga Director Leticia Tan; National Museum of the Philippines Director Dr. Jeremy Barnes; Severino Mercado and Michael Vincent Cruz of JK Mercado & Sons Inc., Benedict Solco of Coral Agri-venture Farms Inc., James Chan of Golden Acres Farm, Heintje Limketkai of Philippine Ostrich and Crocodile Farm Inc., Daniel Barlis of Valderrama Lumber and Aquaculture Farms and Alfonso Oposa of Pulunan Farm; MENRO Gina Barquilla, Alex Tiu, Faith Guinto, Donna Tiu, Jonas Virtudazo, Maruji Manalo, Aquino Garcia, Richard Nogalo, Darrell Blatchley and Abner Bucol. Likewise to the members of technical team Alfonso Biñan, Jr., Pedro Mendoza, Ray Brian Avance, Julius Mugot and Jovenar Pelotos. Most especially to Tom Dacey, CSG Executive Officer.

Literature Cited

Cruz, M.V., Mendoza, Jr., P. and Biñan, Jr., A.G. (2012). Successful breeding of *Crocodylus mindorensis* under soft release conditions. Crocodile Specialist Group Newsletter 31(3): 10-11.

Diesmos, A.C., Guinto, F.M., Manalo, R.I. and Mercado, V.P. (2012). Philippine Crocodile *Crocodylus mindorensis* Schmidt release program in Siargao Island Protected Landscape and Seascape. Project proposal. Crocodylus Porosus Philippines, Inc. Protected Areas and Wildlife Bureau, Department of Environment and Natural Resources, Silliman University-Angelo King Center for Research and Environmental Management, and National Museum of the Philippines.

Mercado, V. (2010). Request for student proposals: crocodile biology and natural history. Crocodile Specialist Group Newsletter 29(2): 14-15.

Van Weerd, M., Balbas, M., Telan, S., Rodriguez, D., Guerrero, J. and Van de Ven, W. (2011). Philippine Crocodile Reintroduction Workshop. Crocodile Specialist Group Newsletter 30(2): 10-12.

Vicente Mercado1, Angel Alcala[1,2], William Belo[1], Rainier Manalo[1], Arvin Diesmos[1,3] and Josephina De Leon[4]; *[1]Crocodylus Porosus Philippines Inc., Pag-asa Farms, Kapalong, Davao Del Norte, Philippines (philippinecrocodile@yahoo.com); [2]Silliman University-Angelo King Center for Research and Environmental Management, Dumaguete City, Negros Oriental, Philippines (suakcrem@yahoo.com); [3]National Museum of the Philippines, Ermita, Manila, Philippines (arvin.diesmos@gmail.com); [4]DENR-Protected Areas and Wildlife Bureau, Diliman, Quezon City, Philippines (deleon.josefina@gmail.com).*

LARGEST CROCODILE IN CAPTIVITY DIES. Lolong, the largest Saltwater crocodile (*Crocodylus porosus*) in captivity, died on 10 February 2013. Captured in Agusan Marsh, in Agusan del Sur, Mindanao, on 3 September 2011, Lolong was housed in a special enclosure at the Bunawan Eco-Park and Research Center. The cause of his death is unclear. One report suggested that Lolong had been ailing since swallowing a nylon cord 3 weeks ago prior to his death. The autopsy that was carried out may shed some light on possible causes.

Source: Ben Serrano, The Philippine Star, 11 February 2013.

PHILIPPINE CROCODILE (*CROCODYLUS MINDORENSIS*, SCHMIDT 1935) POPULATION RECORDED IN HIGHLANDS OF LAKE SEBU, SOUTHERN MINDANAO, PHILIPPINES. The presence of *Crocodylus mindorensis* in isolated geologic depressions such as highland crests and seasonal lakes in Seven Lake, Barangay Ned, Municipality of Lake Sebu, South Cotabato, is new to science, and was investigated for the first time in November 2012. The presence of this species, known locally as K'wangkug (a T'-boli tribe local language for small crocodile living in lakes), has long been common knowledge to the indigenous people in the highlands of Lake Sebu. Reports of crocodile hunting for local consumption prompted a survey of the area, as part of the diversification program of Crocodylus Porosus Philippines Inc. (CPPI) in Mindanao, in partnership with the DENR-Protected Areas and Wildlife Bureau (PAWB) of the Department of Environment and Natural Resources (DENR), Philippine Crocodile Rescue and Breeding Center (PCRBC), and the Environment and Livelihood Organization for Advancing Development (ELOAD).

Parts of crocodiles slaughtered by locals in 2007 and 2009 were examined and photographed in Sitio Tinugas. Sun-dried skins from an adult and a juvenile crocodile were displayed in the residences of their captors, Mr. Enrique Besa and Mr. Ama Gugo respectively. The skull from the adult crocodile, in the possession of Mr. Triveth Tupas, was collected by the research team through the authority of PAWB. These crocodiles were captured in Pugwan Lake (798 m asl) and Pangalman Lake (753 m asl), both of which are part of a land reform settlement area that is permanently inundated. The area had been subjected to logging operation previously, and was converted into agricultural land that produced slightly turbid surface water draining towards a larger adjacent lake.

Figure 1. Rainier Manalo (CPPI), Dr. Cayetano Pomares USM (top) and local informant Triveth Tupas (bottom), with sun-dried skin and skull of an adult crocodile taken from Lake Pugwan in 2009.

A local informant led the team to an area in Lake Pugwan where nests were located in 2007 and 2009. The area is located on the sloping areas of the marginal upland forest on the northeastern side, situated about 25 m uphill from the water's edge. It was recorded at a slope of 40° at an elevation of 801 m asl. This nesting site is characterized as mixed secondary and primary forest and karsts limestone formation. Parts of the lake were converted into farmlands utilizing surface water for agriculture. The nests were located approximately 10 m away each other, albeit laid in different years. Interviews revealed that local residents collect crocodile eggs for food.

Description of crocodile specimens

The dorsal scalation of the adult hornback skin from Lake Pugwan comprised of 17 transverse dorsal scale rows, 10 dorsal midbody scale rows (PC 10-15), and ossified dorsal armor. The condition of the skin did not allow counting of the ventral scale row, but the ventral scales were relatively large.

In Lake Pangalman, the sun-dried hornback skin (76 cm dorsal length) of a juvenile crocodile was inspected. It comprised 18 transverse dorsal scale rows, 10 dorsal midbody scale rows (PC 9-14), 25 large ventral scale rows from the cloaca to the thoracic collar, and ossified dorsal armor. The animal was estimated to be around 1.1 m long.

Figure 2. Informant Ama Gugo (left), Dr. Cayetano Pomares (USM) and Rainier Manalo (CPPI) with sun-dried skin of a juvenile crocodile taken in Lake Pangalman in 2007.

Both sun-dried skin specimens had incomplete caudal scale rows and lacked the nuchal cluster (PC 19-23) and post-occipital or occipitals (PC 24-26).

The skull showed a massive structure, distinctively broader and short snout of prominent maxillary angulation, prominent lachrymal groove, antorbital or maxillary ridge high and abrupt laterally, pronounced festooning of maxillary teeth, more rounded premaxillary with 5 teeth sockets, and the palatine-pterygoids suture nearly transverse (Fig. 3). Based on skull measurements, information on relative growth (Hall 1989), and total length estimate method of Bellairs (1969), the

specimen was determined to be a *C. mindorensis* of around 2.62 m total length (head length= 34.4 cm).

Surveys of 21 of the more than one hundred highland crests and inundated basins or small lakes revealed no crocodiles, including 8 lakes where crocodiles were reportedly sighted between 2007 and 2010. A further spotlight survey of Lake Ubodan in Seven Lake, Bgy. Ned, Municipality of Lake Sebu, revealed 7 eyeshines of non-adult crocodiles congregating at the shallow water's edge. These populations were presumed to be an extant population of Philippine Crocodiles.

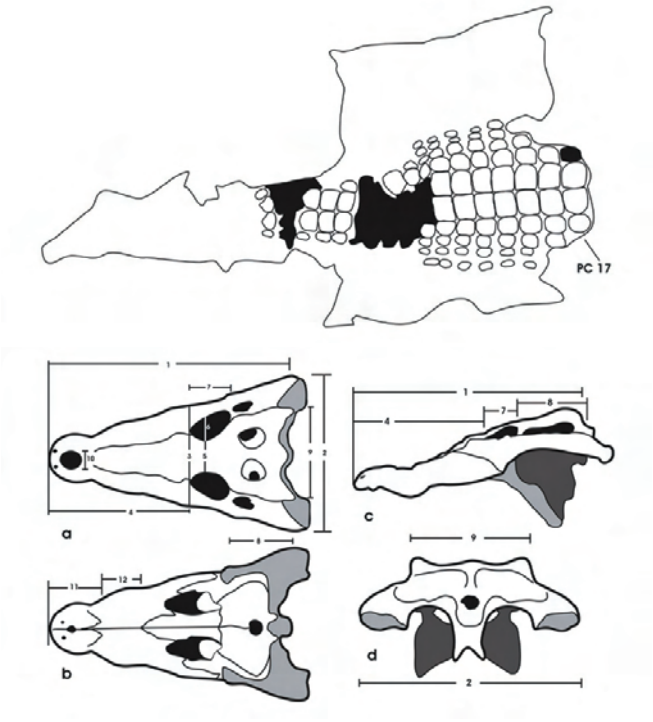


Figure 2. Sketch of dorsal scalation (above) and skull showing (a) dorsal, (b) palatal, (c) lateral, and (d) posterior views of *Crocodylus mindorensis* from Lake Pugwan, Bgy. Ned, Lake Sebu, Philippines. Numbers represent cranial indices of skull by Hall (1989).

Combining the results of these preliminary surveys with interviews of key informants, there is an estimated 18 *C. mindorensis* (11 adult, 7 non-adult) in the 5 inundated basins of Lake Sebu, between 740 and 840 m asl.

Community awareness and perceptions

Local residents of the study site recognized only one type of crocodile, describing it as small in size, with a yellowish back and white belly. Locals are aware that the lush vegetation of their wetland habitats contributed to the abundance of species in isolated lakes in the past. They are very much aware on the specific location where crocodiles appear to thrive. The remote and farthest community of Lake Sebu was converted to settlement sites and mono-crop plantations. Habitat conversion extends up to margins of the lake, and crocodiles are exposed for curiosity and target shooting.

Residents understand that the crocodiles are wary and do not attack humans. This characteristic of *C. mindorensis* contributes to the locals' interest in crocodiles, including their utilization as a protein source. These hunting practices have resulted to the decline in the crocodile population and thus fewer interactions with humans. However, the common misconception about crocodiles generally showing aggression to humans and their livestock still persists.

This new distribution record of *C. mindorensis* in this region is a significant, particularly in light of the altitude. The existence of this supposedly "lowland" species in the highlands of Lake Sebu in southern Mindanao and in Cordillera Central, Abra Province, Luzon Island (recorded in 2002), suggests that altitude may not be a constraining factor when searching for potential habitat of this. Follow-up research and conservation efforts are planned by CPPI.

Acknowledgements

We would like to thank our local informants/guides, Trivetth Tupas, Enrique Besa and Romy Baay, students of the University of Southern Mindanao, Julius Gil and Armel Delante, for their assistance with this survey. We also like to thank the DENR-Protected Areas & Wildlife Bureau for their support in the retrieval of specimen.

Literature Cited

Hall, P. M. (1989). Variation in geographic isolates of the New Guinea crocodile (*Crocodylus novaeguinae* Schmidt) compared with the similar, allopatric Philippine crocodile (*C. mindorensis* Schmidt). Copeia 1989: 71-80.

Bellairs, A. (1969). The Life of Reptiles, Volume I. Weidenfeld and Nicolson: London.

Rainier Manalo[1], Cayetano Pomares[2], Vicente Mercado[1], William Belo[1] and Gregorio Saljay[3]; *[1]Crocodylus Porosus Philippines Inc., Pag-asa Farms, Kapalong, Davao Del Norte, Philippines, <philippinecrocodile@yahoo.com>; [2]University of Southern Mindanao, Kabacan, North Cotabato, Philippines, <pomarescayetano@yahoo.com>; [3]Environment and Livelihood Organization for Advancing Development, Pigcawayan, Cotabato, Philippines.*

HUSBANDRY AND CONSERVATION AT THAKETA CROCODILE FARM, MYANMAR. In 1978 the Government of Myanmar (formerly known as Burma) established a crocodile farm on 16 ha in Thaketa, a suburb on the eastern outskirts of Yangon (Aung Moe 1994). Initially under the administration of the People's Pearl and Fishery Corporation, operation of the farm was later transferred to the Department of Fisheries, which continues to manage it (Aung Moe 1993; Thorbjarnarson *et al*. 2006). According to Aung Moe (1994) the original objectives of the farm were: commercial skin production; conservation and research; and, tourism. Between 1978 and 1999 over 4000 *Crocodylus porosus* (primarily juveniles, but also some adults) were collected from the wild to stock the farm (Thorbjarnarson *et al*. 2006). The provenance of these wild-caught animals is vague, but

most probably originated from coastal swamps of Rakhine State and the lower Ayeyarwady Delta (Caughley 1980; FAO 1985; Thorbjarnarson *et al*. 1999). Over-collection of juveniles to stock the farm is thought partially responsible for the decline of crocodile populations in the Ayeyarwady Delta (Thorbjarnarson *et al*. 2000).

Adult crocodiles on the farm began breeding in 1982-83 and 3087 hatchlings were produced between 1982 and 1990 (Thorbjarnarson *et al*. 1999, 2006). It rapidly became apparent to farm managers that commercial skin production for the international leather market was uneconomical and efforts to this end were soon abandoned (Aung Moe 1994; Thorbjarnarson *et al*. 2006). Emphasis thereafter shifted to the production of founder stock for export to farms in other countries. From 1978-1990 at least 3660 live crocodiles were exported from Myanmar to farms in Thailand and Singapore, with a small number (about 30) going to China (Aung Moe 1994). Head-starting and release of large juveniles into protected areas was apparently never undertaken (Thorbjarnarson *et al*. 1999, 2006).

Inventory at the Thaketa Crocodile Farm (TCF) has varied widely over the years. However, approximately 1000 crocodiles of all size classes were being held in 1999 (Thorbjarnarson *et al*. 1999, 2006). An assessment conducted at that time documented a multitude of problems, including repeated disease outbreaks, poor nutrition owing to inadequate food sources, stress-related disorders among the breeding stock, low egg viability, and high mortality of hatchling and juvenile crocodiles (Thorbjarnarson *et al*. 1999). Thorbjarnarson *et al*. (2006) concluded "the crocodile farm has made no significant contributions to conservation; ... [it]... lacks even a rudimentary public education program and no farm-raised crocodiles have ever been released into the wild". We reassessed conditions at the TCF during multiple visits in 2011-13. Below we summarize our findings, and address husbandry and conservation issues relevant to the farm.

The TCF is currently being operated as a "farm", that is, a closed system where breeding adults are maintained, eggs are incubated (usually artificially), and offspring raised to a commercially viable size. As such, farms generally have minimal conservation value because their continued operation is not dependent on the maintenance of viable wild populations (Thorbjarnarson 1992). The TCF remains the only crocodile farm in Myanmar, although small groups of crocodiles are also exhibited at the Yangon Zoological Gardens and Hlawga Park. It is open to the general public and foreigners can visit without obtaining prior permission from the Fisheries Department. Local school groups often tour the farm and three educational signboards describing the natural history and conservation of crocodilians are prominently displayed.

In March 2013 the TCF maintained 500-600 crocodiles ranging in size from hatchlings to large adults, a slight increase over the 496 crocodiles reportedly held during October 2011, but less than half the number present in 1999 (Thorbjarnarson *et al*. 1999). Most of the crocodiles currently on the farm appear to be *C. porosus*, which is the only crocodilian known to occur in Myanmar (Thorbjarnarson *et al*. 2006). However, we recently learned that during the 1970s, the Government of Cambodia presented three Siamese crocodiles (*C. siamensis*) to General Ne Win, the former ruler of Myanmar. A shortage of pen space led to these animals being placed in a communal breeding pen (see below) with *C. porosus*. The three Siamese crocodiles can no longer be accounted for and it is unknown if these individuals hybridized with the more numerous *C. porosus*. *Crocodylus porosus* and *C. siamensis* readily hybridize in captivity and produce fertile offspring (Suvanakorn and Youngprapakorn 1987; Platt *et al*. 2011). Because *C. siamensis* × *C. porosus* hybrids cannot be distinguished solely on the basis of morphology (Fitzsimmons *et al*. 2002; Starr *et al*. 2009), every crocodile on the farm, excepting the wild-caught founders must therefore be regarded as a potential hybrid.

During our visits we observed a number of smaller crocodiles with prominent post-occipital scales, a trait not usually evident in *C. porosus* (Brazaitis 1973). Whether this represents hitherto unreported phenotypic variation among individuals of a wide-ranging species (*C. porosus*) or evidence of hybridization with *C. siamensis* cannot be determined without genetic analyses.

A breeding group of about 100 adult crocodiles are maintained in an expansive communal enclosure (135 × 107 m) containing an earthen pool, traversed by elevated wooden walkways, and enclosed by a masonry wall (Fig. 1). The earthen pool was 3 m deep when first excavated in the late 1970s, but has since filled with sediment to a depth of <1 m.

Figure 1. Communal breeding enclosure at the Thaketa Crocodile Farm housing about 100 adult *Crocodylus porosus*. Nesting occurs in heavily vegetated areas along the periphery of the pond.

Because the pond is rain-fed, crocodiles become concentrated in several deeper holes during the dry season, exacerbating dominance conflicts and resulting in stress-related problems among breeding adults. A gap in the perimeter wall leads to an adjacent densely vegetated enclosure (similar in size to

the principal breeding enclosure) containing four small ponds and hosting a large aggregation of roosting egrets and night herons. Two sections of the perimeter wall surrounding the breeding enclosure collapsed during a flood in 2011 and the gaps have since been covered with wire mesh fencing. According to the farm, no large crocodiles escaped during the flood, but local reports of at least one adult in a nearby river suggest otherwise. The breeding enclosure contains 27 nesting stalls, although these are no longer used to confine individual females.

Crocodiles nest in thickly vegetated areas of both enclosures and approximately 20 clutches (500-1000 eggs) are deposited each year. Courtship and mating occurs in March-April, and laying begins late in the dry season (May) and continues through the early wet season (July). Clutch size ranges from 20 to 70 eggs with an average of about 40 eggs. Farm staff are given "hazard duty pay" to remove eggs from the nests for artificial incubation. In some cases egg collection is deemed too risky owing to the aggressive demeanor of a particular female, so a small number of clutches are left in the pen to incubate naturally. Upon collection, eggs are either placed in wire baskets filled with rice straw or artificial nest mounds of the same material, and incubated within an enclosed shed. The farm has no way to regulate temperatures so incubation occurs under ambient conditions.

Hatching begins in August and continues through late October. The hatching rate is low, ranging from 35 to 40%. This is not unexpected as poor hatching success is commonplace when *C. porosus* are housed in communal breeding pens (Luxmoore 1992). The fate of those clutches left to incubate naturally in the breeding enclosure is unknown. Few eggs hatched successfully in 2012 because excessive tidal flooding from an adjacent river inundated much of the farm (including the incubation area) during the wet season. The artificial incubation area has since been elevated above the 2012 flood crest.

Hatchling crocodiles are reared in concrete brooding chambers with heat (29.5-30.0°C) provided by electric lights (Fig. 2). Most hatchlings are moved into outdoor concrete pens within 6 months, although weaker individuals are kept in the brooders for longer periods. First year survival is estimated to be less than 20%. As crocodiles mature, they are moved through a series of progressively larger concrete pens. Most of these pens lack sufficient water for crocodiles to completely submerge beneath the surface (Fig. 3). According to farm staff, the concrete foundation of the pens is porous or cracked and cannot retain water for more than 5-6 hours.

Crocodiles at the TCF are fed a diet consisting of unmarketable marine fish donated by a local fish company and freshwater fish skins (with attached skeleton and adhering bits of meat) obtained as waste from a nearby processing facility. Visitors can also purchase carp skins and small marine fish to feed to the breeding adults; the latter were found to be rancid during several of our visits. The diet of hatchlings consists of freshwater prawns with a fish oil supplement, while a mixture of freshwater prawns and marine fish is provided to larger

Figure 2. Brooding chambers for hatchling crocodiles with small electric lights as a heat source. Hatchlings remain in brooders for 6 months or longer.

Figure 3. Juvenile and sub-adult crocodiles are housed in concrete pens that lack sufficient water for the animals to submerge.

juveniles. Poultry is a far more satisfactory diet for crocodiles (Elsey *et al.* 1993), but the farm lacks sufficient funds to purchase chicken parts because these have a ready market with Japanese dog food companies and hence, are relatively expensive.

This diet is clearly inadequate and may be partly responsible for the poor hatching success and high hatchling mortality reported on the farm. Poor nutrition can result in reduced growth rates, especially among hatchlings and small juveniles, increased susceptibility to diseases, and decreased reproductive success among male and female crocodiles (Hunt 1980; Joanen and McNease 1987; Elsey *et al.* 1993; Noble *et al.* 1993). Additionally, a diet consisting largely of marine fish can predispose crocodiles to various nutritional disorders, including steatitis which results from a diet high in unsaturated fatty acids and low in vitamin E (Wallach and Hoessle 1968). Steatitis is of particular concern when crocodiles consume rancid marine fish (Wallach and Hoessle 1968). While most adult crocodiles on the farm appeared to

be in relatively good physical condition, numerous small individuals were suffering from the effects of a chronically poor diet. Among this group we noted a number of emaciated animals and others that were unable to hold the posterior-most part of their tails erect ("floppy tail syndrome"). There also appears to be an extremely high prevalence of physical deformities among the smaller crocodiles, although these could result from suboptimal incubation conditions rather than diet (Ferguson 1985).

In conclusion, the problems initially identified by Thorbjarnarson *et al*. (1999) at the TCF have yet to be addressed. Husbandry remains substandard and farm infrastructure is deteriorating. The diet provided to crocodiles is clearly inadequate owing to the lack of a nutritionally suitable food source that is also affordable given the economic constraints under which the farm operates. Additionally, hatching success and hatchling survival are extremely low and have not improved in the years since our original assessment was conducted. We urge the farm to rectify these problems as soon as possible. As a start, we suggest the farm cease incubating eggs as there seems little reason to continue producing and stockpiling crocodiles that cannot be properly maintained. We further recommend that the TCF concentrate solely on public education for it is within this arena that the farm is most likely to make a significant contribution to regional crocodile conservation.

Finally, because of the likelihood that hybrid crocodiles are present on TCF, it is imperative to reconsider our earlier recommendation to augment *C. porosus* populations in protected areas of the Ayeyarwady Delta with captive-bred juveniles (Thorbjarnarson *et al*. 1999, 2000). Given this possibility, under no circumstances should any crocodiles from the farm be released into the wild without prior genetic screening to identify and eliminate hybrid individuals. To do otherwise risks contaminating a genetically pure population of *C. porosus* with *C. siamensis* genes.

Acknowledgments

We thank U Than Oo (Assistant Director) for granting us permission to visit the Thaketa Crocodile Farm, and U Than Htun, U Khin Ohn, and other staff for their hospitality, answering our many questions, and escorting us through the facility on multiple occasions. We also thank Colin Poole, U Than Myint, U Saw Htun, Rob Tizard, and the Wildlife Conservation Society Myanmar Program. Ruth Elsey, Thomas Rainwater and Madeline Thompson provided several literature references, and Lewis Medlock and Thomas Rainwater reviewed an early draft of this report.

Literature Cited

Aung Moe, B.K. (1993). Conservation, management and farming of crocodiles in the Union of Myanmar. Pp. 9-11 *in* Crocodiles. Proceedings of the 2nd Regional (Eastern Asia, Oceania, Australasia) Meeting of the IUCN-SSC Crocodile Specialist Group. IUCN: Gland, Switzerland.

Aung Moe, B.K. (1994). The status of crocodiles in Myanmar. Pp. 24-27 *in* Crocodiles. Proceedings of the 12th Working Meeting of the IUCN-SSC Crocodile Specialist Group. IUCN: Gland, Switzerland.

Brazaitis, P. (1973). The identification of living crocodilians. Zoologica 58: 59-101.

Caughley, G. (1980). Crocodiles in Burma. Report to FAO, Rome.

Elsey, R.M. (1993). Captive breeding of alligators and other crocodilians. Pp. 2-41 *in* Crocodiles. Proceedings of the 2nd Regional (Eastern Asia, Oceania, Australasia) Meeting of the IUCN-SSC Crocodile Specialist Group, IUCN: Gland, Switzerland.

FAO. (1985). Burma: Survey Data and Conservation Priorities. Nature Conservation and National Parks: FO: DP/BUR/80/006 Technical Report 1. FAO: Rome.

Ferguson, M.W.J. (1985). Reproductive biology and embryology of the crocodilians. Pp. 329-492 *in* Biology of the Reptilia, ed. by C. Gans, F. Billet, and P.F.A. Maderson. John Wiley and Sons: New York.

Fitzsimmons, N.N., Buchan, J.C., Lam, P.V., Polet, G., Hung, T.T., Thang, N.Q. and Gratten, J. (2002). Identification of purebred *Crocodylus siamensis* for reintroduction in Vietnam. Journal of Experimental Zoology 294: 373-381.

Hunt, R.H. (1980). Propagation of Morelet's crocodile. Pp. 161-165 *in* Reproductive biology and Diseases of Captive Reptiles, ed. by J.B. Murphy and J.T. Collins. Society for the Study of Amphibians and Reptiles: Lawrence, Kansas.

Joanen, T., and McNease, L. (1987). Alligator farming research in Louisiana, USA. Pp. 329-340 *in* Wildlife Management: Crocodiles and Alligators, ed. by G.J.W. Webb, S.C. Manolis, and P.J. Whitehead. Surry Beatty and Sons: Sydney.

Luxmoore, R.A. (1992). Directory of Crocodilian Farming Operations. IUCN-The World Conservation Union: Gland, Switzerland.

Noble, R.C., McCartney, R, and Ferguson, M.W.J. (1993). Lipid and fatty acid compositional differences between eggs of wild and captive-breeding alligators (*Alligator mississippiensis*): an association with reduced hatchability? Journal of Zoology (London) 230: 639-649.

Platt, S.G., Monyrath, V., Sovannara, H., Kheng, L. and Rainwater, T.R. (2011). Nesting phenology and clutch characteristics of captive Siamese crocodiles (*Crocodylus siamensis*) in Cambodia. Zoo Biology 30: 1-12.

Starr, A., Daltry, J., and Ratanapich, N. (2009). DNA study reveals pure Siamese Crocodiles at Phnom Tamao Wildlife

Rescue Centre, Cambodia. Crocodile Specialist Group Newsletter 28: 5–7.

Suvanakorn, P., and Youngprapakorn, C. (1987). Crocodile farming in Thailand. Pp. 341-343 *in* Wildlife Management: Crocodiles and Alligators, ed. by G.J.W. Webb, S.C. Manolis, and P.J. Whitehead. Surry Beatty and Sons: Sydney.

Thorbjarnarson, J. (1992). Crocodiles: An Action Plan for their Conservation. IUCN Publications: Gland, Switzerland.

Thorbjarnarson, J.B., Platt, S.G. and Saw Tun Khaing. (1999). Ecological Reconnaissance of Meinmahla Kyun Wildlife Sanctuary and Vicinity, Southern Ayeyarwady Delta, Myanmar. Working Paper No. 12. Wildlife Conservation Society: Bronx, New York.

Thorbjarnarson, J., Platt, S.G. and Saw Tun Khaing. (2000). A population survey of the estuarine crocodile in the Ayeyarwady Delta, Myanmar. Oryx 34: 317-324.

Thorbjarnarson, J.B., Platt, S.G. Win Ko Ko, Khin Myo Myo, Lay Lay Khaing, Kalyar, and Holmstrom, B. (2006). Crocodiles in Myanmar: Species diversity, historic accounts, and current population status and conservation. Herpetological Natural History 10: 77-89.

Wallach, J.D. and Hoessle, A.A. (1968). Steatitis in captive crocodilians. Journal American Veterinary Medical Association 153: 845-847.

Steven G. Platt, Win Ko Ko, and Khin Myo Myo; *Wildlife Conservation Society-Myanmar Program, Office Block C-1, Aye Yeik Mon 1st Street, Hlaing Township, Yangon, Myanmar (sgplatt@gmail.com).*

South Asia and Iran

Iran

ESTIMATE OF MUGGER POPULATION IN IRAN. Sistan and Baluchestan Provinces in southeastern Iran represent the western-most global range of the Mugger crocodile (*Crocodylus palustris*). The Mugger population in Iran is divided into several sub-populations along the main rivers and existing habitats, as well as being scattered throughout the distributional area. Mobaraki (2000) estimated the total population as around 200-300 individuals, through a range of natural and artificial waterbodies (Mobaraki 2002).

After years of change in the area caused by drought, flooding and construction of dams along the rivers, and a lack of reliable information on size of the Mugger population, a survey program was conducted over a 10-day period in May 2012 (postponed from February-March 2012 due to administrative delays). The program was funded by the Natural Environment Deputy and conducted with the cooperation of the Biodiversity and Wildlife Bureau and DOE provincial office of Sistan and Baluchestan Provinces (staff from Chabahar, Nikshahr and Rask participated). A key feature of the program was that local people, in cooperation with DOE, were engaged directly in the survey activities. As a capacity-building initiative, basic information on survey methodology was extended to them, and the results were quite satisfactory.

Crocodiles were counted by direct observation during the day and night. Most available habitats were visited at night, and spotlights used to locate and identify crocodiles. Given the capacity-building and training aspects of the program, and limited experience of some spotters, crocodiles were categorised as small (<1 m), medium (1-1.5 m) and large (>1.5 m). The smallest individuals were approached closely by experienced personnel, and were identified as yearlings from the 2011 season.

Potential habitats along the Nahang River were excluded, as well as some remote ponds in the area, due to uncertainty of water availability at the time of survey. Of the sites visited, crocodiles were sighted at 43 of them. Sites were located from Firooz Abad pond near Rask, and along the Sarbaz and Bahookalat Rivers to Djoor, close to Govatr Bay. Some parts of the Kajo River were also included. The area of each site was estimated from maps, and taking into account current water levels due to the prevailing drought conditions. Except for river mainstreams and ponds associated with them, other important habitats visited were artificial ponds and reservoirs close to villages, mainly in "Gando Protected Area" (around 465,000 ha).

A total of 326 crocodile sightings was recorded, with Pishin Dam Reservoir (120 crocodiles) and Shirgovaz Regulatory Dam Reservoir (35 crocodiles; Fig. 1) reporting the highest counts (Table 1). Most crocodiles were juveniles or adults, with almost all crocodiles in Pishin Dam Reservoir being of large size. As surveys were carried out just before the nesting season that usually starts in late May, no hatchlings were sighted. Yearlings were observed at Shirgovaz and Dempak (Table 1), where nests have been located in the past.

Figure 1. Large Mugger crocodile sighted during spotlight survey of Shirgovaz Dam, May 2012. Photograph: Asghar Mobaraki.

Relative density at sites containing crocodiles ranged from 0.04 to 35.00 individuals/ha. A lack of equipment (eg boats),

together with thick vegetation in some areas, are likely to have affected the sighting of crocodiles, particularly small animals. The areas surveyed are considered to reflect around 80% of the available habitat for Muggers. Given that only a portion of crocodiles present were detected during the surveys, and that not all habitats were surveyed, the count (326) is considered an underestimate of the total population. The entire area of distribution of Muggers in Iran has been under severe drought over the past year, with low water levels in most of the habitats. This may have helped to concentrate crocodiles and assisted surveys, but may also have had a negative impact through mortality.

Considering the situation and available habitats, the Iranian Mugger population is estimated to be about 500 non-hatchlings. The previous estimate of 200-300 crocodiles (Mobaraki 2000, 2002) was made after 6 years of prolonged drought, and based on some key areas. It appears that the population is increasing. That the local people respect the crocodiles in the area and never hunt or harm them, could be one of the main reasons for the persistence of this small Mugger population in the country, and contributes to the potential for conservation of the species in Iran.

Acknowledgments

We would like to acknowledge DOE guards in Gandou Protected Area, especially Bashir Arbabi and Laalbakhsh Nooraki for their very reliable cooperation in the field. Special thanks to: Deputy for Natural Environment and Biodiversity and Biodiversity and Wildlife Bureau for funding the program; the DOE office in Sistan and Baluchestan Province; the DOE office in cities of Chabahar, Nikshahr and Rask. Our great thanks to the local people in the crocodile habitats for their cooperation and hospitality and kind assistance. Thanks to Mr. Behnam Karimi for his assistance.

Literature Cited

Mobaraki, A. (2000). Status of Muggers in Iran. Crocodile Specialist Group Newsletter 19(3): 8.

Mobaraki, A. (2002). Mugger crocodile study in Iran. Pp. 253-256 *in* Crocodiles. Proceeding of the 16th Working Meeting of the IUCN-SSC Crocodile Specialist Group. IUCN: Gland, Switzerland.

Asghar Mobaraki[1] and Elham Abtin[2]: *[1]Department of Environment, Wild life and Aquatic affairs Bureau, P.O. Box 14155-7383, Tehran, Iran <amobaraki@yahoo.com>; [2]Department of Environment, Sistan and Baluchestan Provincial Office, Zahedan, Iran <ala_saly@yahoo.co.uk>.*

Table 1. Numbers of Muggers in different size classes sighted during spotlight surveys of 43 areas. An unrecorded number of additional sites had no sightings. RD= relative density (crocodiles/ha).

No.	Site	Area (ha)	Small (Yearlings)	Medium (Juveniles)	Large (Adults)	Total Sighted	RD
1	Pishin Dam Reservoir	250	-	-	120	120	0.48
2	Shirgovaz Dam	24	5	10	18	33	1.37
3	Zirdan Dam	300	-	-	12	12	0.04
4	Dempak	0.2	3	2	2	7	35.00
5	Pishin Dam pond	2	-	7	8	15	7.50
6	Nehbakhsh	3	-	-	9	9	3.00
7	Seyed Abad Dam	10	-	4	5	9	0.90
8	Rahpeyma Dam	11	-	5	3	8	0.72
9	Azadi	2	-	-	6	6	3.00
10	Dargas Dam	9	-	2	3	5	0.55
11	Ahmad Abad	3	-	-	4	4	1.33
12	Bahookalat	2.7	-	7	4	11	4.07
13	Dargas ponds	2.5	-	3	2	5	2.00
14	Kastak pond	0.2	-	2	3	5	25.00
15	Shekar Jangal	1.5	-	3	1	4	2.66
16	Garmbit Dam	8	-	-	3	3	0.37
17	Sartap Pond	2	-	5	-	5	2.50
18	Talari Pond	2.5	-	5	-	5	2.00
19	Hodar Pond	1.5	-	1	2	3	2.00
20	Baftan	1	-	1	2	3	3.00
21	Hoot Gat	3	-	3	4	7	2.33
22	Riko kash Rearing Center	0.5	-	7	5	12	24.00
23	21 ponds with 1-2 crocodiles	59.7	-	21	14	35	0.58
	All survey areas (N= 43)	699.3	8	88	230	326	0.47

Nepal

POPULATION TRENDS FOR GHARIAL AND MUGGERS IN THE NARAYANI AND RAPTI RIVERS OF CHITWAN NATIONAL PARK, NEPAL. We report here on annual monitoring surveys (2012) and population trends for Gharial (*Gavialis gangeticus*) and Mugger (*Crocodylus palustris*) in the Rapti and Narayani Rivers of Chitwan National Park (CNP) (Fig. 1). Methodology for daytime surveys and areas surveyed were the same as those in November 2010 and February 2012 (Khadka 2011, 2012; Khadka *et.al*. 2008; DNPWC and WWF Nepal 2011.).

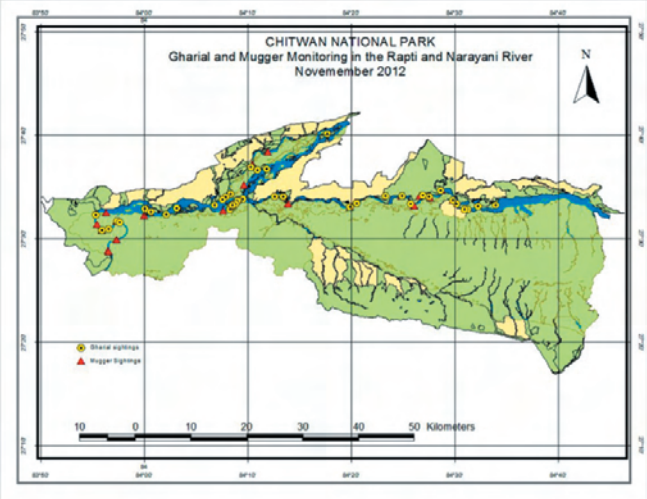


Figure 1. Locations of Gharial and Mugger sighted during daytime surveys of the Rapti and Narayani Rivers, November 2012.

Gharials

During the most recent survey (November 2012), 87 Gharial were sighted [Rapti River (35), Narayani River (52); Table 1, Fig. 1). The previous comparable survey (in terms of survey areas and time of year) was carried out in November 2010, when 58 Gharial were sighted at that time.

Table 1. Size structure of Gharial sighted during daytime surveys of the Rapti and Narayani Rivers, 2008-2012. H= hatchlings, J= juveniles, SA= sub-adults, A= adults.

Date	km	H	J	SA	A	Total
Jan 2008	153.4	0	-	-	-	58
Nov 2010	150	4	12	33	9	58
Feb 2011	147.4	5	27	27	22	81
Feb 2012	150	1	15	43	15	74
Nov 2012	150	4	15	50	18	87

The relationship between numbers of Gharial sighted during daytime surveys and absolute numbers is unknown. Likewise, the relationship between sightings in November and the following February is unclear, as there is only one set of surveys with corresponding data (November 2010-February 2011). However, it certainly appears that the non-hatchling Gharial population has increased in size since 2010, but there are insufficient data to clarify whether is has stabilized (Fig. 2) - ongoing monitoring will confirm long-term population trends.

Despite some natural recruitment of hatchlings (Table 1), and the reintroduction of 645 captive-raised juvenile Gharials since 1981 (Narayani 399; 208 in 1981-90, 121 in 1991-2000, 70 in 2001-10; Rapti 246; 5 in 1981-90, 12 in 1991-2000, 119 in 2001-10, 110 in 2011-12), the current population represents a relatively low proportion (<20%) of the number of Gharial that have entered the Narayani-Rapti River system over a 30-year period.

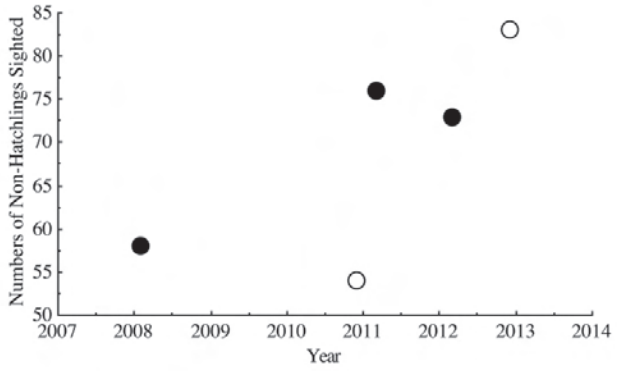


Figure 2. Numbers of non-hatchling Gharial sighted over time. Closed circles= November surveys; open circles= January-February surveys.

That some 35% of the non-hatchling and 50% of the hatchling Gharial sighted were at Khorea Muhan, in the Narayani River, suggesting that this is an important area.

Notwithstanding the relatively short period of systematic monitoring, a number of factors are possibly implicated in the observed results:

1. The sighting of only one mature male during the survey, at Khorea Muhan, is of interest. A low number of males relative to females may be implicated in completely infertile nests that were located at Bhelauji, one of the main nesting areas on the Narayani River, in 2011 and 2012 (3 and 2 nests respectively) (CNP 2011, 2012). Bhelauji is one of the major nesting sites for Gharials, and is located 40 km from Khorea Muhan where the observed male resides. Nesting in the Rapti River occurs at Dumari, some 40 km from Khorea Muhan.

2. Gharial are known and/or suspected to be killed directly or indirectly through fishing activities by local fishermen. Dead Gharials have been reported at different times since 2004: February 2004, 1.76 m TL, Amaltari Ghat (Narayani), entangled in net; May 2007, 3.76 m TL, Sitamysthan (Rapti), hook in stomach; April 2009, 3.52 m TL, Sauraha (Rapti); May 2010, 1.75 m TL, Baguban

(Narayani), recently released animal; and, May 2011, 2.1 m TL, Kasara (Rapti).

3. There is "leakage" of Gharial from Nepal into India (Khadka 2011), and potentially from India to Nepal. For example, on 19 October 2012 a juvenile Gharial was rescued from Kalaiya (Nepal), having travelled 136 km from Tribeni Dam on the Nepal-India border, via the Gandak irrigational canal.

Muggers

A total of 41 Muggers (all non-hatchlings) was sighted in the Narayani and Rapti Rivers during the latest survey (Table 2; Fig. 3). The most comparable previous survey in terms of time of year was two years earlier (November 2010), when 53 non-hatchling Muggers were sighted (Khadka 2011). Given the variability that can exist with survey counts between years, there are insufficient data with which to predict trends with any precision. However, given the significant increase in human-crocodile conflict (HCC) over the last 10 years, it is likely that the Mugger population has increased since the early 2000s, despite some anthropogenic losses.

Table 2. Size structure of Muggers sighted during daytime surveys of the Rapti and Narayani Rivers, 2010-2012. H= hatchlings, J= juveniles, SA= sub-adults, A= adults. See Figure 3 for breakdown of sightings per river.

Date	km	H	J	SA	A	Total
Nov 2010	150	0	4	10	39	53
Feb 2012	150	4	7	6	38	55
Nov 2012	150	0	2	11	28	41

Figure 3. Numbers of Mugger sighted in the Narayani and Rapti Rivers during daytime surveys, 2010-2012.

Two Muggers are known to have been killed and one is suspected of being killed by local fish farmers between 2005 and 2012 (CNP, unpublished data). The reasons for the killings may be linked to the dispersal of Muggers from natural wetlands into village fishponds, and improved public awareness and the establishment of rescue teams may be required to reduce HCC (Shankar Dahal, pers. comm. 2012). Nine juvenile Muggers were rescued from local fish farms in the CNP Buffer Zone between July 2012 and December 2012, during the rainy season. The bodyweight of these rescued animals ranged between 1 and 7 kg. With some 500 fishponds (300 ha) in the Buffer Zone, this is a potential attractant for Muggers. Interestingly, Gharial have not been found in fish ponds.

The Buffer Zone consists of forests and private lands, including human settlements, surrounding the park boundary (see Fig. 1). The park and local people jointly initiate community development and conservation activities and manage the natural resources in the Buffer Zone. The National Parks and *Wildlife Conservation Act 1973* has a provision for ploughing back 30-50% of the park's revenue into community development and conservation of the Buffer Zone.

In their natural habitat, Muggers have also reportedly killed a cow and three goats (2007-2012) and four local villagers, including two CNP staff, were injured by Muggers (2000-2012).

Conclusions

In 1977 the Gharial population in CNP was estimated to be 57 animals, all of which were in the Narayani River (Khadka 2011). The current population in the Narayani-Rapti Rivers system is also distributed in the Rapti River. The Gharial Conservation Center was established in 1978, with the aim to maintain a viable wild Gharial population through the reintroduction of head-started Gharial, and the reintroduction program is considered to have been beneficial to the recovery of the wild population from extremely low levels in the late 1970s. On the basis of the available survey data, the population appears to have stabilized, at a mean relative density of 0.52 non-hatchlings/km, although ongoing monitoring will confirm whether this changes in the future. The correction factors required to estimate absolute population size are not known, but the current population represents a low proportion of the animals that have been released into the system, raising some questions on the factors that may be contributing to this observation.

Spotlight surveys may provide a better estimate of the size structure of the population, and research into the movement of Gharial between foraging and nesting areas merits consideration. Survey results suggest that there may be long distance movement to nesting areas, but this remains to be confirmed.

The Mugger population in CNP is also considered to have increased in size, as have levels of HCC. This situation may necessitate the implementation of public awareness programs directed at local people.

Acknowledgements

I wish to thank Charlie Manolis for his valuable comments on this paper, and Dr. Jhamak Bahadur Karki, Chief Warden of Chitwan National Park. The author is gratefully to Baburam Lamichane and Basant Devkota for his contribution of GIS mapping and all of my assistants who helped me during the survey.

Literature Cited

Khadka B.B. (2011). Gharial and Mugger monitoring in the Narayani and Rapti Rivers of Chitwan National Park, November 2010. Crocodile Specialist Group Newsletter 30(1): 11-14.

Khadka, B.B. (2012). 100 Gharial Released into Chitwan National Park, Nepal, January to April 2012. Crocodile Specialist Group Newsletter 31(2): 14-16.

Khadka, M., Thapaliya, B.P. and Kafley, H. (2008). Gharial Crocodile Monitoring in Nepal. Report Submitted to WWF Nepal and Department of National Parks and Wildlife Conservation (DNPWC), Kathmandu, Nepal.

Chitwan National Park (2011). Annual Report 2067/068.

Chitwan National Park (2012). Annual Report 2068/069.

Department of National Park & Wildlife Conservation and WWF Nepal (2011). Population Status and Distribution of Gharial in Nepal.

Bed Bahadur Khadka, *Assistant Conservation Officer, Chitwan National Park, Nepal, (bed.khadka@gmail.com).*

Science

Recent Publications

Britton, A.R.C., Whitaker, R. and Whitaker, N. (2012). Here be dragons: Exceptional size in a saltwater crocodile (*Crocodylus porosus*) from the Philippines. Herpetological Review 43(4): 541-546.

Gramentz, D. (2012). On the distress call of hatchling *Tomistoma schlegelii* (Muller, 1838). Sauria, Berlin 34(3): 19-24.

Seymour, R.S., Gienger, C.M., Brien, M.L., Tracy, C.R., Manolis, S.C., Webb, G.J. and Christian, K.A. (2012). Scaling of standard metabolic rate in estuarine crocodiles *Crocodylus porosus*. J. Comp. Physiol. B.

Abstract: Standard metabolic rate (SMR, ml O(2) min(-1)) of captive *Crocodylus porosus* at 30°C scales with body mass (kg) according to the equation, SMR= 1.01 M(0.829), in animals ranging in body mass of 3.3 orders of magnitude (0.19-389 kg). The exponent is significantly higher than 0.75, so does not conform to quarter-power scaling theory, but rather is likely an emergent property with no single explanation. SMR at 1 kg body mass is similar to the literature for *C. porosus* and for alligators. The high exponent is not related to feeding, growth, or obesity of captive animals. The log-transformed data appear slightly curved, mainly because SMR is somewhat low in many of the largest animals (291-389 kg). A 3-parameter model is scarcely different from the linear one, but reveals a declining exponent between 0.862 and 0.798. A non-linear model on arithmetic axes overestimates SMR in 70% of the smallest animals and does not satisfactorily represent the data.

Vergne, A.L., Aubin, T., Martin, S. and Mathevon, N. (2012). Acoustic communication in crocodilians: information encoding and species specificity of juvenile calls. Anim. Cogn. 15(6): 1095-1109.

Abstract: In the Crocodylia order, all species are known for their ability to produce sounds in several communication contexts. Though recent experimental studies have brought evidence of the important biological role of young crocodilian calls, especially at hatching time, the juvenile vocal repertoire still needs to be clarified in order to describe thoroughly the crocodilian acoustic communication channel. The goal of this study is to investigate the acoustic features (structure and information coding) in the contact call of juveniles from three different species (Nile crocodile *Crocodylus niloticus*, Black caiman *Melanosuchus niger* and Spectacled caiman *Caiman crocodilus*). We have shown that even though substantial structural differences exist between the calls of different species, they do not seem relevant for crocodilians. Indeed, juveniles and adults from the species studied use a similar and non-species-specific way of encoding information, which relies on frequency modulation parameters. Interestingly, using conditioning experiments, we demonstrated that this tolerance in responses to signals of different acoustic structures was unlikely to be related to a lack of discriminatory abilities. This result reinforced the idea that crocodilians have developed adaptations to use sounds efficiently for communication needs.

Chowfin, S.M. and Leslie, A.J. (2013). A preliminary investigation into nesting and nest predation of the critically endangered, gharial (*Gavialis gangeticus*) at Boksar in Corbett Tiger Reserve, Uttarakhand, India. International Journal of Biodiversity and Conservation 5(2): 54-57.

Abstract: The gharial, *Gavialis gangeticus*, is an endemic crocodilian of the north Indian subcontinent and is also found in the Corbett Tiger Reserve. Surveys in Corbett National Park in 1974 recorded only 5 gharial whereas current estimates are 42 adults inclusive of 10 adult males and 59 individuals of smaller size classes. This study confirms that the expanded population in the Kalagarh Reservoir is breeding, although nests appear to be subject to significant predation, thought to be by *Varanus bengalenis*. Varanids are serious predators on crocodilian eggs in a number of countries. In this case, it is unclear whether such high predation levels are natural

situations that apply when they live in a free-flowing river environment, or whether it is a derived state linked to the lake-type environment in which they now reside.

Cheng, G., Gao, Y., Wang, T., Sun, Y., Wei, Z., Li, L., Liming, R., Guo, Y., Hu, X., Lu, Y., Wang, X., Liu, G., Zhang, C., Yu, J., Pan-Hammarström, Q., Hammarström, L., Wu, X., Li, N. and Zhao, Y. (2013). Extensive diversification of IgH subclass-encoding genes and IgM subclass switching in crocodilians. Nature Communications 4(1337): (doi: 10.1038/ncomms2317).

Abstract: Crocodilians are a group of reptiles that are closely related to birds and are thought to possess a strong immune system. Here we report that the IgH locus in the Siamese crocodile and the Chinese alligator contains multiple μ genes, in contrast to other tetrapods. Both the μ2 and μ3 genes are expressed through class-switch recombination involving the switch region and germline transcription. Both IgM1 and IgM2 are present in the serum as polymers, which implies that IgM class switching may have significant roles in humoural immunity. The crocodilian α genes are the first IgA-encoding genes identified in reptiles, and these genes show an inverted transcriptional orientation similar to that of birds. The identification of both α and δ genes in crocodilians suggests that the IgH loci of modern living mammals, reptiles and birds share a common ancestral organization.

Christoffersen, M.L. and De Assis, J.E. (2013). A systematic monograph of the Recent Pentastomida, with a compilation of their hosts. Zool. Med. Leiden 87(1): 1-206

Fukuda, Y., Saalfeld, K., Webb, G., Manolis, C. and Risk, R. (2013). Standardised method of spotlight surveys for crocodiles in the tidal rivers of the Northern Territory, Australia. Northern Territory Naturalist 24: 14–32.

Abstract: Standardised spotlight survey procedures have been an integral part of long-term (1975-2012) monitoring programs for Saltwater Crocodiles *Crocodylus porosus* and Freshwater Crocodiles *C. johnstoni* in tidal rivers of the Northern Territory (NT) of Australia. These programs, implemented four years after depleted Saltwater Crocodile populations were protected from hunting in 1971, have been instrumental in documenting post-protection population recovery and evaluating management interventions. This article describes a standardised method for spotlight survey of crocodiles in tidal rivers, with particular emphasis on practical aspects that were not previously documented. It also shows example survey data and how it is analysed. This practical guide is primarily oriented at maintaining survey standardisation within the NT, but it should help wildlife managers to use standardised spotlight counting as a monitoring tool for crocodilian species in similar habitats elsewhere.

Adams, T.L. (2013). A new neosuchian crocodyliform from the Lower Cretaceous (late Aptian) Twin Mountains Formation of North-Central Texas. Journal of Vertebrate Paleontology 33(1): 85-101.

Abstract: A new fossil crocodyliform, *Paluxysuchus newmani*, gen. et sp. nov., is established on the basis of a nearly complete skull from the Lower Cretaceous (late Aptian) Twin Mountains Formation of north-central Texas. Partially articulated and disarticulated cranial material representing two individuals was recovered from the Jones Ranch locality in close association with the sauropod *Paluxysaurus jonesi*. The holotype skull is nearly complete, missing the premaxillae, left palatine, and pterygoids, and does not preserve the choanal region. This taxon is notable for having its frontal separated medially from the orbital margin, an extremely elongate anterolateral process of the postorbital, large and rounded supratemporal fenestrae, and a narrow, rod-like posterior ramus of the jugal. These features indicate affinities with goniopholidids, pholidosaurids, and thalattosuchians. A phylogenetic analysis places *Paluxysuchus newmani* deep within Neosuchia as the sister taxon to the clade that includes Goniopholididae and Eusuchia.

Kelly, D.A. (2013). Penile anatomy and hypotheses of erectile function in the American alligator (*Alligator mississippiensis*): muscular eversion and elastic retraction. Anatomical Record (Hoboken) 296(3): 488-494.

Abstract: The intromittent organs of most amniotes contain variable-volume hydrostatic skeletons that are stored in a flexible state and inflate with fluid before or during copulation. However, the penis in male crocodilians is notable because its shaft does not seem to change either its shape or bending stiffness as blood enters its vascular spaces before copulation. Here I report that crocodilians may have evolved a mechanism for penile shaft erection that does not require inflation and detumescence. Dissections of the cloaca in sexually mature male American alligators (*Alligator mississippiensis*) show that the cross section of the proximal shaft of the alligator penis contains dense collagenous tissues that do not significantly change shape when fluid is added to the central vascular space. The large amount of collagen in the wall and central space of the alligator penis stiffen the structure so it can be simply everted for copulation and rapidly retracted at its completion. Because no muscles insert directly onto the penis, eversion and retraction must be produced indirectly. My results suggest that the contraction of paired levator cloacae muscles around the anterior end of the cloaca rotates the penis out of the cloacal opening and strains the ligamentum rami that connect the base of the penis to the ischia. When the cloacal muscles relax, the elastic recoil of the ligamentum rami can return the penis to its original position inside the cloaca.

Boggs, A.S., Lowers, R.H., Cloy-McCoy, J.A. and Guillette, L.J. Jr. (2013). Organizational changes to thyroid regulation in *Alligator mississippiensis*: evidence for predictive adaptive responses. PLoS One 8(1): e55515.

Abstract: During embryonic development, organisms are sensitive to changes in thyroid hormone signaling which can reset the hypothalamic-pituitary-thyroid axis. It has been hypothesized that this developmental programming is a 'predictive adaptive response', a physiological adjustment in accordance with the embryonic environment that will best aid an individual's survival in a similar postnatal environment. When the embryonic environment is a poor predictor of the external environment, the developmental changes are no longer adaptive and can result in disease states. We predicted that endocrine disrupting chemicals (EDCs) and environmentally-based iodide imbalance could lead to developmental changes to the thyroid axis. To explore whether iodide or EDCs could alter developmental programming, we collected American alligator eggs from an estuarine environment with high iodide availability and elevated thyroid-specific EDCs, a freshwater environment contaminated with elevated agriculturally derived EDCs, and a reference freshwater environment. We then incubated them under identical conditions. We examined plasma thyroxine and triiodothyronine concentrations, thyroid gland histology, plasma inorganic iodide, and somatic growth at one week (before external nutrition) and ten months after hatching (on identical diets). Neonates from the estuarine environment were thyrotoxic, expressing follicular cell hyperplasia ($p= 0.01$) and elevated plasma triiodothyronine concentrations ($p= 0.0006$) closely tied to plasma iodide concentrations ($p= 0.003$). Neonates from the freshwater contaminated site were hypothyroid, expressing thyroid follicular cell hyperplasia ($p= 0.01$) and depressed plasma thyroxine concentrations ($p= 0.008$). Following a ten month growth period under identical conditions, thyroid histology (hyperplasia $p= 0.04$; colloid depletion $p= 0.01$) and somatic growth (body mass $p<0.0001$; length $p= 0.02$) remained altered among the contaminated sites. This work supports the hypothesis that embryonic EDC exposure or iodide imbalance could induce adult metabolic disease states, thereby stressing the need to consider the multiple environmental variables present during development.

George, I.D. and Holliday, C.M. (2013). Trigeminal nerve morphology in *Alligator mississippiensis* and its significance for crocodyliform facial sensation and evolution. Anatomical Record (Hoboken) (doi: 10.1002/ar.22666).

Abstract: Modern crocodylians possess a derived sense of face touch, in which numerous trigeminal nerve-innervated dome pressure receptors speckle the face and mandible and sense mechanical stimuli. However, the morphological features of this system are not well known, and it remains unclear how the trigeminal system changes during ontogeny and how it scales with other cranial structures. Finally, when this system evolved within crocodyliforms remains a mystery. Thus, new morphological insights into the trigeminal system of extant crocodylians may offer new paleontological tools to investigate this evolutionary transformation. A cross-sectional study integrating histological, morphometric, and 3D imaging analyses was conducted to identify patterns in cranial nervous and bony structures of *Alligator mississippiensis*. Nine individuals from a broad size range were CT-scanned followed by histomorphometric sampling of mandibular and maxillary nerve divisions of the trigeminal nerve. Endocast volume, trigeminal fossa volume, and maxillomandibular foramen size were compared with axon counts from proximal and distal regions of the trigeminal nerves to identify scaling properties of the structures. The trigeminal fossa has a significant positive correlation with skull length and endocast volume. We also found that axon density is greater in smaller alligators and total axon count has a significant negative correlation with skull size. Six additional extant and fossil crocodyliforms were included in a supplementary scaling analysis, which found that size was not an accurate predictor of trigeminal anatomy. This suggests that phylogeny or somatosensory adaptations may be responsible for the variation in trigeminal ganglion and nerve size in crocodyliforms.

Patil, S.R., Atigre, R.H. and Patil, S.V. (2012). First record of Mugger crocodile *Crocodylus palustris* (Lesson, 1831) from River Kadavi at Sarud, Tal, Shahuwadi, Dist. Kolhapur, M.S., India. 2012 4th International Conference on Agriculture and Animal Science 47: 100-104.

Abstract: The paper is about the first record of crocodile *Crocodylus palustris* (Lesson, 1831) from the Kadavi River at Sarud, Tal-Shahuwadi. Dist-Kolhapur, M.S., India. This is the first record of the order Crocodilia and genus *Crocodylus* for River Kadavi and western Maharashtra. In the month of February 2007, one crocodile was observed basking on left bank of river Kadavi near village Sarud of Kolhapur district. In May 2007, nesting of crocodile was also observed on the same place. We have used ground survey method to identify new potential habitat of the animal and to examine the distribution and presence of the species. Field observations indicated that the crocodile is present in river Kadavi-the tributary of river Warana which is the major tributary of river Krishna. River Krishna is a main river of Deccan plateau running from Sahyadri ranges of Maharashtra to Bay of Bengal in east direction. Besides, the presence of crocodile in river Kadavi their movements were observed in river Warana also. Still not any record is available, which confirms the presence of this crocodilian species in river Kadavi and Warana and based on this evidenced study, one more reptilian species - crocodile *Crocodylus palustris* can be added to the list of reptilian fauna of these rivers as well as that of Kolhapur district. This new record of crocodile's presence in the river Kadavi and Warana requires further investigations.

Jaratlerdsiri, W., Isberg, S., Higgins, D. and Gongora, J. (2012). MHC class I of saltwater crocodiles (*Crocodylus porosus*): polymorphism and balancing selection. Immunogenetics 64: 825-838.

Abstract: Saltwater crocodiles are in high demand for the production of luxury fashion items. However, their susceptibility to disease incurs substantial losses and it is hoped to be able to genetically select these animals for disease

resistance. So far, this has only been enabled by phenotypic selection. Investigating the major histocompatibility complex (MHC) could provide insight into the ability of an individual to respond to pathogens acting as a selective pressure on the host. Here, we assessed genetic diversity and a role of selection in shaping the diversity of MHC class I exon 3 among 42 saltwater crocodiles from 9 river basins in the Northern Territory, Australia. We generated 640 sequences using cloning and sequencing methods and identified 43 MHC variants among them. Phylogenetic analyses clustered these variants into two major clades, which may suggest two gene lineages. We found the number of variants within an individual varying between one and seven, indicating that there are at least four gene loci in this species. Selection detection analyses revealed an elevated ratio of nonsynonymous to synonymous substitutions (mean = 1.152 per codon), suggesting balancing selection. Population differentiation analyses revealed that the MHC did not show structuring among the river basins, and there were some shared variants among them. This may be a result of possible gene flow and/or similar selection pressures among populations. These findings provide background knowledge to identify potential MHC markers, which could be used for selecting genetically variable individuals for future disease associations. All MHC class I exon 3 sequences reported in this paper were submitted to the GenBank database with following accession numbers: HQ008785-HQ008789, HQ008791-HQ008798, HQ008808-HQ008815, HQ008824, HQ008826-HQ008830, HQ008835, HQ008839, HQ008842-HQ008850, and JX023536-JX023540.

Jogayya, K.N., Meganathan, P.R., Dubey, B. and Haque, I. (2013). Novel microsatellite DNA markers for Indian Gharial (*Gavialis gangeticus*). Conservation Genetics Resources (doi: 10.1007/s12686-013-9908-6).

Abstract: The present status of existing crocodile species has increased the necessity to develop novel utilities for conservation. We have developed 18 microsatellite loci from the Indian Gharial (*Gavialis gangeticus*) intended for genomic explanation and applied them to study genetic variation. Polymorphism of each locus was assessed in 32 individuals for *G. gangeticus* India. The number of alleles per locus varied from 2 to 8 (mean 5.5) for Indian population. Observed and expected heterozygosity ranged from 0.73 to 1.00 and 0.50 to 0.81, respectively and the average polymorphic information content is 0.565. These selected markers are helpful for assessing population structure, intraspecific difference, and conservation and management of *G. gangeticus*.

Delfino, M. and Smith, T. (2012). Reappraisal of the morphology and phylogenetic relationships of the middle Eocene alligatoroid *Diplocynodon deponiae* (Frey, Laemmert, and Riess, 1987) based on a three-dimensional specimen. Journal of Vertebrate Paleontology 32(6): 1358-1369.

Abstract: We describe a three-dimensionally prepared specimen of *Baryphracta deponiae* from the middle Eocene of Messel (Darmstadt, Germany). Based on a phylogenetic analysis that included the addition of 20 novel scorings for characters previously unavailable for this taxon and the recoding of four additional characters, we found *B. deponiae* to be nested within *Diplocynodon*. We propose the new combination *Diplocynodon deponiae*. The name *Baryphracta* is thus a junior synonym of *Diplocynodon*. The small species *D. deponiae* (1 m total length) shares several features with other species of *Diplocynodon*, including the presence of two subequal alveoli in the maxilla and dentary, exclusion of the splenial from the symphysis, and the shape of the iliac blade. However, it also differs in a few characters, including the presence of molariform teeth and the extension of osteoderms along the limbs and tail. Such osteodermal cover, which developed very early in ontogeny, easily distinguishes even small-sized specimens of *D. deponiae* from the co-occurring *Diplocynodon darwini*. The crocodylian fauna of Messel shows an astonishing diversity including at least 7 taxa, with two belonging to the same genus. The two congeners exhibit differences in dentition and size that likely allowed for niche partitioning that minimized competition, thereby allowing them to be syntopic.

Benga, G. (2013). Comparative studies of water permeability of red blood cells from humans and over 30 animal species: an overview of 20 years of collaboration with Philip Kuchel. Eur. Biophys. J. 42(1): 33-46.

Abstract: NMR measurements of the diffusional permeability of the human adult red blood cell (RBC) membrane to water (P (d)) and of the activation energy (E (a,d)) of the process furnished values of P (d) ~ 4×10^{-3} cm/s at 25°C and ~6.1×10^{-3} cm/s at 37°C, and E (a,d) ~ 26 kJ/mol. Comparative NMR measurements for other species showed: (1) monotremes (echidna and platypus), chicken, little penguin, and saltwater crocodile have the lowest P (d) values; (2) sheep, cow, and elephant have P (d) values lower than human P (d) values; (3) cat, horse, alpaca, and camel have P (d) values close to those of humans; (4) guinea pig, dog, dingo, agile wallaby, red-necked wallaby, Eastern grey kangaroo, and red kangaroo have P (d) values higher than those of humans; (5) mouse, rat, rabbit, and "small and medium size" marsupials have the highest values of P (d) (>8.0×10^{-3} cm/s at 25°C and >10.0×10^{-3} cm/s at 37°C). There are peculiarities of E (a,d) values for the RBCs from different species. The maximum inhibition of diffusional permeability of RBCs induced by incubation with p-chloromercuribenzene sulfonate varied between 0% (for the chicken and little penguin) to ~50% (for human, mouse, cat, sheep, horse, camel, and Indian elephant), and ~60-75% (for rat, guinea pig, rabbit, dog, alpaca, and all marsupials). These results indicate that no water channel proteins (WCPs) or aquaporins are present in the membrane of RBCs from monotremes (echidna, platypus), chicken, little penguin and saltwater crocodile whereas WCPs from the membranes of RBCs from marsupials have peculiarities.

Mauger, L.A., Velez, E., Cherkiss, M.S., Brien, M.L., Boston, M., Mazzotti, F.J. and Spotila, J.R. (2012). Population assessment of the American crocodile, *Crocodylus acutus*

(Crocodilia: Crocodylidae) on the Pacific coast of Costa Rica. Rev. Biol. Trop. 60(4): 1889-1901.

Abstract: The American crocodile, *Crocodylus acutus*, is widely distributed in the American neotropics. It is endangered throughout most of its range and is listed as vulnerable by the International Union for the Conservation of Natural Fauna and Flora (IUCN) and on Appendix I of the Convention for the International Trade in Endangered Species of Wild Flora and Fauna (CITES). Despite this listing, there are few published reports on population status throughout most of its range. We investigated the status of *C. acutus* at several locations along the Pacific coast of Costa Rica. We carried out spotlight and nesting surveys from 2007-2009 along the Costa Rican Pacific coast in four distinct areas, coastal areas of Las Baulas (N= 40) and Santa Rosa (N= 9) National Parks and the Osa Conservation Area (N= 13), and upriver in Palo Verde National Park (N= 11). We recorded crocodile locations and standard environmental data at each observation. Encounter rates, population structure, distribution within each area and data on successful nesting (presence of hatchlings, nests, etc.) were determined. We attempted to capture all crocodiles to record standard morphometrics. A total of 586 crocodiles were observed along 185.8 km of survey route. The majority of animals encountered (54.9%) were either hatchlings (<0.5 m) or juveniles (0.5-1.25 m). The average non-hatchling encounter rate per survey for the Pacific coast was 3.1 crocodiles/km, with individual encounter rates ranging from 1.2 crocodiles/km to 4.3 crocodiles/km in Las Baulas National Park and the Osa Conservation Area respectively. Distribution of size classes within the individual locations did not differ with the exception of Santa Rosa and Las Baulas National Parks, where hatchlings were found in water with lower salinities. These were the first systematic surveys in several of the areas studied and additional work is needed to further characterize the American crocodile population in Costa Rica.

Kommanee, J., Preecharram, S., Daduang, S., Temsiripong , Y., Dhiravisit, A., Yamada, Y. and Thammasirirak, S. (2012). Antibacterial activity of plasma from crocodile (*Crocodylus siamensis*) against pathogenic bacteria. Ann. Clin. Microbiol. Antimicrob. 11(22): (doi: 10.1186/1476-0711-11-22).

Abstract: The Siamese crocodile (*Crocodylus siamensis*) is a critically endangered species of freshwater crocodiles. Crocodilians live with opportunistic bacterial infection but normally suffer no adverse effects. They are not totally immune to microbial infection, but their resistance thereto is remarkably effective. In this study, crude and purified plasma extracted from the Siamese crocodile were examined for antibacterial activity against clinically isolated, human pathogenic bacterial strains and the related reference strains. Crude plasma was prepared from whole blood of the Siamese crocodile by differential sedimentation. The crude plasma was examined for antibacterial activity by the liquid growth inhibition assay. The scanning electron microscopy was performed to confirm the effect of crude crocodile plasma on the cells of *Salmonella typhi* ATCC 11778. Effect of crude crocodile plasma on cell viability was tested by MTT assay. In addition, the plasma was purified by anion exchange column chromatography with DEAE-Toyopearl 650 M and the purified plasma was tested for antibacterial activity. Crude plasma was prepared from whole blood of the Siamese crocodile and exhibited substantial antibacterial activities of more than 40% growth inhibition against the 6 reference strains of *Staphylococcus aureus*, *Salmonella typhi*, *Escherichia coli*, *Vibrio cholerae*, *Pseudomonas aeruginosa*, and *Staphylococcus epidermidis*, and the four clinical isolates of *Staphylococcus epidermidis*, *Pseudomonas aeruginosa*, *Salmonella typhi* and *Vibrio cholerae*. Especially, more than 80% growth inhibition was found in the reference strains of *Salmonella typhi*, *Vibrio cholerae* and *Staphylococcus epidermidis* and in the clinical isolates of *Salmonella typhi* and *Vibrio cholerae*. The effect of the crude plasma on bacterial cells of *Salmonella typhi,* a certain antibacterial material probably penetrates progressively into the cytoplasmic space, perturbing and damaging bacterial membranes. The effect of the crude plasma was not toxic by the yellow tetrazolium bromide (MTT) assay using a macrophage-like cell, RAW 264.7. The pooled four fractions, designated as fractions D1-D4, were obtained by column chromatography, and only fraction D1 showed growth inhibition in the reference strains and the clinical, human pathogenic isolates. The crude and purified plasma from the Siamese crocodile significantly showed antibacterial activity against pathogenic bacteria and reference strains by damage cell membrane of target bacterial cells. From the MTT assay, the Siamese crocodile plasma was not cytotoxic to the cells.

Buthelezi, S., Southway, C., Govinden, U., Bodenstein, J. and du Toit, K. (2012). An investigation of the antimicrobial and anti-inflammatory activities of crocodile oil. Journal of Ethnopharmacology 143(1): 325-330

Abstract: Crocodile oil has been used by traditional practitioners world-wide to treat microbial infections and inflammatory conditions. However, the scientific rationale behind its use is not completely understood. This study provides an updated fatty acid profile and novel scientific evidence of the antimicrobial and anti-inflammatory properties of crocodile oil, obtained from the Nile crocodile (*Crocodylus niloticus*), justifying its use by traditional healers. The fatty acid content of the oil was determined by gas chromatography and the major fatty acids were identified. A microplate method was used to assess activity of the oil against *Staphylococcus aureus*, *Klebsiella pneumoniae* and *Candida albicans*. The anti-inflammatory activity of the oil was assessed by oral administration and topical application, utilising a mouse model of acute croton oil-induced contact dermatitis. Sixteen fatty acids were identified with oleic, palmitic and linoleic acid being the major components of the oil. The optimal activity of the oil against the bacteria and fungus was obtained with 15% and 6% (w/v) oil respectively. No significant selectivity was observed against the bacterial species, but *Candida albicans* was more susceptible. The anti-inflammatory assays showed optimal activity at 3 h after the oral administration of oil (60.8±5.5%) and at 12 h

after topical application (57.5±5.9%). This suggested a short duration of action when the oil was orally administered, and a longer duration of action when it was topically applied. Subsequent studies may be directed towards the investigation of the mechanisms of action of the antimicrobial and anti-inflammatory activities of crocodile oil and its fatty acids.

Hermes-Lima, M., Carreiro, C., Moreira, D.C., Polcheira, C., Machado, D.P. and Campos, E.G. (2012). Glutathione status and antioxidant enzymes in a crocodilian species from the swamps of the Brazilian Pantanal. Comp. Biochem. Physiol. A Mol. Integr. Physiol. 163(2): 189-198.

Abstract: In a previous study oxidative damage markers - lipid peroxidation and protein oxidation - were determined in organs of wild *Caiman yacare* captured in winter-2001 and summer-2002 at various developmental stages. An increase in oxidative damage occurred in the hatchling-juvenile transition (but not in the juvenile-adult transition) and winter-summer transition (in juveniles), suggesting that oxidative stress is associated with development and season. Herein the effect of development and season on glutathione (GSH) metabolism and the effect of development on the activity of antioxidant enzymes (catalase, glutathione peroxidase, glutathione reductase and glutathione S-transferase) and glucose 6-phosphate dehydrogenase were analyzed. The ratio GSSG:GSH-eq increased in lung, liver, kidney and brain by 1.8- to 4-fold in the embryo/hatchling to juvenile transition. No changes occurred in juvenile-adult transition. GSSG:GSH-eq across seasons was significantly elevated in summer. Total-glutathione content was mostly stable in various organs; in liver it increased in the embryo-juvenile transition. Enzyme activities were only determined in summer-animals (embryos, hatchlings and juveniles). For most antioxidant enzymes, activities increased from embryo/hatchling to juvenile in liver and Kidney. In lung, there was an inverse trend for enzyme activities and total glutathione content. Thus, increased metabolic rates during early caiman growth - in embryo-juvenile transition - appears to be related to redox imbalance as suggested by increased GSSG:GSH-eq and activation of antioxidant defenses. Differences in oxidative stress across seasons were related with summer-winter nocturnal temperatures. These results, as a whole, were interpreted in the context of ecological biochemistry.

Stadler, A.M., Garvey, C.J., Bocahut, A., Sacquin-Mora, S., Digel, I., Schneider, G.J., Natali, F., Artmann, G.M. and Zaccai, G. (2012). Thermal fluctuations of haemoglobin from different species: adaptation to temperature via conformational dynamics. Journal of the Royal Society Interface 9(76): 2845-2855.

Abstract: Thermodynamic stability, configurational motions and internal forces of haemoglobin (Hb) of three endotherms (platypus, *Ornithorhynchus anatinus*; domestic chicken, *Gallus gallus domesticus* and human, *Homo sapiens*) and an ectotherm (saltwater crocodile, *Crocodylus porosus*) were investigated using circular dichroism, incoherent elastic neutron scattering and coarse-grained Brownian dynamics simulations. The experimental results from Hb solutions revealed a direct correlation between protein resilience, melting temperature and average body temperature of the different species on the 0.1 ns time scale. Molecular forces appeared to be adapted to permit conformational fluctuations with a root mean square displacement close to 1.2 Å at the corresponding average body temperature of the endotherms. Strong forces within crocodile Hb maintain the amplitudes of motion within a narrow limit over the entire temperature range in which the animal lives. In fully hydrated powder samples of human and chicken, Hb mean square displacements and effective force constants on the 1 ns time scale showed no differences over the whole temperature range from 10 to 300 K, in contrast to the solution case. A complementary result of the study, therefore, is that one hydration layer is not sufficient to activate all conformational fluctuations of Hb in the pico- to nanosecond time scale which might be relevant for biological function. Coarse-grained Brownian dynamics simulations permitted to explore residue-specific effects. They indicated that temperature sensing of human and chicken Hb occurs mainly at residues lining internal cavities in the β-subunits.

Bhatt, H.P., Saund, T.B., Thapa, J.B. (2012). Status and Threats to Mugger Crocodile *Crocodylus palustris* Lesson, 1831 at Rani Tal, Shuklaphanta Wildlife Reserve, Nepal. Nepal Journal of Science and Technology 13(1): 125-131.

Abstract: A study was carried out for preparing baseline information on water quality, population status and threats to Mugger crocodile, *Crocodylus palustris* Lesson at Rani Tal, Shuklaphanta Wildlife Reserve. Water quality analysis was conducted for three seasons (summer, autumn and winter) in the year 2008-2009. The study has found the physico-chemical contamination in the lake. The water quality parameters (dissolved oxygen, total hardness, free carbon dioxide, biological oxygen demand and ammonia) exceeded the normal range to support the Muggers. A survey around the lake recorded four adult Mugger crocodiles (>180 cm body length) basking in sandy and muddy bank during the investigation period. The lake is under pressure from diverse anthropogenic factors. The principal threats to the Mugger crocodile include water pollution, habitat destruction, sedimentation, food shortage, egg collection and seasonal fluctuation of water level. The total area and depth of the lake is diminishing due to encroachment by *Phragmites karka* and flash flood during monsoon. Conservation and proper management of the lake are urgently required.

Walmsley, C.W., Smits, P.D., Quayle, M.R., McCurry, M.R., Richards, H.S., Oldfield, C.C., Wroe, S., Clausen, P.D. and McHenry, C.R. (2013). Why the long face? The mechanics of mandibular symphysis proportions in crocodiles. PLoS ONE 8(1): e53873.

Abstract: Crocodilians exhibit a spectrum of rostral shape from long snouted (longirostrine), through to short snouted (brevirostrine) morphologies. The proportional length of the mandibular symphysis correlates consistently with rostral shape, forming as much as 50% of the mandible's length in

longirostrine forms, but 10% in brevirostrine crocodilians. Here we analyse the structural consequences of an elongate mandibular symphysis in relation to feeding behaviours. Simple beam and high resolution Finite Element (FE) models of 7 species of crocodile were analysed under loads simulating biting, shaking and twisting. Using beam theory, we statistically compared multiple hypotheses of which morphological variables should control the biomechanical response. Brevi- and mesorostrine morphologies were found to consistently outperform longirostrine types when subject to equivalent biting, shaking and twisting loads. The best predictors of performance for biting and twisting loads in FE models were overall length and symphyseal length respectively; for shaking loads symphyseal length and a multivariate measurement of shape (PC1- which is strongly but not exclusively correlated with symphyseal length) were equally good predictors. Linear measurements were better predictors than multivariate measurements of shape in biting and twisting loads. For both biting and shaking loads but not for twisting, simple beam models agree with best performance predictors in FE models. Combining beam and FE modelling allows *a priori* hypotheses about the importance of morphological traits on biomechanics to be statistically tested. Short mandibular symphyses perform well under loads used for feeding upon large prey, but elongate symphyses incur high strains under equivalent loads, underlining the structural constraints to prey size in the longirostrine morphotype. The biomechanics of the crocodilian mandible are largely consistent with beam theory and can be predicted from simple morphological measurements, suggesting that crocodilians are a useful model for investigating the palaeobiomechanics of other aquatic tetrapods.

Martin, J.E. (2013). Surviving a potentially lethal injury? Bite mark and associated trauma in the vertebra of a dyrosaurid crocodilian. Palaios 28(1): 6-8.

Abstract: A vertebral centrum belonging to a dyrosaurid, a marine crocodilian recovered from the late Paleocene of Niger, bears a large ovoid and deep puncture on its lateral flank. This mark is identified as a wound inflicted by the bite of another crocodilian. Although the wound shows evidence of healing, the vertebral centrum has been severely damaged and deformed. It provides a rare direct evidence of the aggressive interactions taking place between these now extinct marine reptiles, the largest known marine predators of their time before the rise of the archeocetes.

Leitch, D.B. and Catania, K.C. (2012). Structure, innervation and response properties of integumentary sensory organs in crocodilians. Journal of Experimental Biology 215: 4217-4230.

Abstract: Integumentary sensory organs (ISOs) are densely distributed on the jaws of crocodilians and on body scales of members of the families Crocodilidae and Gavialidae. We examined the distribution, anatomy, innervation and response properties of ISOs on the face and body of crocodilians and documented related behaviors for an alligatorid (*Alligator mississippiensis*) and a crocodylid (*Crocodylus niloticus*). Each of the ISOs (roughly 4000 in *A. mississippiensis* and 9000 in *C. niloticus*) was innervated by networks of afferents supplying multiple different mechanoreceptors. Electrophysiological recordings from the trigeminal ganglion and peripheral nerves were made to isolate single-unit receptive fields and to test possible osmoreceptive and electroreceptive functions. Multiple small (<0.1 mm^2) receptive fields, often from a single ISO, were recorded from the premaxilla, the rostral dentary, the gingivae and the distal digits. These responded to a median threshold of 0.08 mN. The less densely innervated caudal margins of the jaws had larger receptive fields (>100 mm^2) and higher thresholds (13.725 mN). Rapidly adapting, slowly adapting type I and slowly adapting type II responses were identified based on neuronal responses. Several rapidly adapting units responded maximally to vibrations at 20-35 Hz, consistent with reports of the ISOs' role in detecting prey-generated water surface ripples. Despite crocodilians' armored bodies, the ISOs imparted a mechanical sensitivity exceeding that of primate fingertips. We conclude that crocodilian ISOs have diverse functions, including detection of water movements, indicating when to bite based on direct contact of pursued prey, and fine tactile discrimination of items held in the jaws.

Watanabe, Y.Y., Reyier, E.A., Lowers, R.H., Imhoff, J.L. and Papastamatiou, Y.P. (2013). Behavior of American alligators monitored by multi-sensor data loggers. Aquatic Biology 18: 1-8.

Abstract: Fine-scale behavior of crocodilians has rarely been recorded in the field despite the important ecological roles these reptiles play in wetland systems around the world. In this study, we attached multi-sensor data loggers to freeranging American alligators *Alligator mississippiensis* in the northern Banana River Lagoon, Florida, to record their diving and swimming behavior, diel activity patterns, and horizontal movements. The alligators repeatedly showed shallow, inactive dives (mean depth: 0.75 m, duration: 310 s), which may represent sit-and-wait foraging for prey. The alligators also showed periodic, submerged swimming events (mean duration: 59 s, swim speed: 0.31 m s^{-1}, tail-beat frequency: 0.47 Hz). Based on the occurrence of diving and swimming events, and the activity level inferred from acceleration records, the animals tended to be more active during the day than at night, suggesting behavioral thermoregulation. An individual with a global positioning system (GPS) logger attached swam northward along the shore, showing the utility of GPS tracking for this species. This study presents basic information for the natural behavior of crocodilians, an understudied group among aquatic vertebrates.

Tosun, D.D. (2013). Crocodile farming and its present state in global aquaculture. Journal of Fisheries Sciences 7(1): 43-57.

Abstract: Crocodiles are hunted for their skins, meat, oil and

claws. Over catching of this animal has led to the decline of this species in wild populations. Although it is not a new idea, breeding this animal under captivity is a developing industry in some parts of the world. Crocodiles have been bred in farms since early 20th century. The majority of these farms were tourist attractions with wild caught alligators or crocodiles under captivity. Decline of the wild populations led to the prohibitions around the word. In crocodile farming operations, the idea is to obtain skins, meat and other products without stressing wild populations. This animal has its own characteristics and they should be learned well before any economic investment. In this review, our aim is to identify these characteristics and inform farmers about the challenges, downsides and advantages of crocodile farming with emphasis on their biology and present farming operations.

Ludovisi, A., La Grange, L.J., Morales, M.A.G. and Pozio, E. (2013). Development of an ELISA to detect the humoral immune response to *Trichinella zimbabwensis* in Nile crocodiles (*Crocodylus niloticus*). Veterinary Parasitology (dx.doi.org/10.1016/j.vetpar.2013.01.053).

Abstract: Crocodiles are known reservoir hosts of *Trichinella papuae* and *Trichinella zimbabwensis*, two zoonotic parasites that also infect mammals. Since commercial crocodile farming represents a key source of income in several countries, it is important to monitor this nematode infection in both farmed crocodiles and in breeding stocks which are frequently introduced from the wild. For this purpose, an indirect ELISA was developed to detect the anti-*Trichinella* immune response in crocodile sera. New Zealand rabbits were immunized with pooled sera from non-infected farmed crocodiles in the presence of Freund's complete adjuvant. The anti-crocodile serum was then conjugated with horseradish peroxidase. Serum samples from four Nile crocodiles (*Crocodylus niloticus*) experimentally-infected with *T. zimbabwensis* and from four uninfected crocodiles were used to set up the ELISA. The larval burden per gram of muscle tissue was determined by muscle biopsy. The test was performed on serum samples from an additional 15 experimentally-infected crocodiles as well as 8 wild Nile crocodiles. Among the 19 experimentally-infected crocodiles, seroconversion was observed in 11 animals. The highest antibody response was observed 6 weeks post infection (p.i.), but in most of these animals, antibodies were not detectable after 6 weeks p.i. even though live larvae were present in the muscles up to 6 months p.i.

Chaipayang, S., Heamatorn, N., Keha, L., Daduang, S., Songsiriritthigul, C., Swatsitang, P., Dhiravisit, A. and Thammasirirak, S. (2013). Purification and characterization of ovotransferrin from *Crocodylus siamensis*. Protein J.

Abstract: Ovotransferrin (OTf) is the major glycoprotein in reptile egg whites. However, knowledge concerning its functional and biological properties remains limited. In this study, OTf from *Crocodylus siamensis* was purified and characterized. The proteins were precipitated with 80% ammonium sulfate and then purified by anion exchange chromatography followed by hydrophobic interaction chromatography. The purified crocodile ovotransferrin (cOTf) had a molecular weight of 79 kDa. Analysis by two-dimensional polyacrylamide gel electrophoresis (2D-PAGE) indicated multiple isoforms of cOTf, which had isoelectric points ranging from 6.0 to 6.8. cOTf was N-linked glycosylated protein identified by using PNGase F deglycosylation technique. Optimal autoproteolysis of cOTf occurred under acidic conditions and pH values more than 5, which differs from that of OTf.

Prajanban, B.O., Shawsuan, L., Daduang, S., Kommanee, J., Roytrakul, S., Dhiravisit, A. and Thammasirirak, S. (2012). Identification of five reptile egg whites protein using MALDI-TOF mass spectrometry and LC/MS-MS analysis. J. Proteomics 75(6): 1940-1959.

Abstract: Proteomics of egg white proteins of five reptile species, namely Siamese crocodile (*Crocodylus siamensis*), soft-shelled turtle (*Trionyx sinensis taiwanese*), red-eared slider turtle (*Trachemys scripta elegans*), hawksbill turtle (*Eretmochelys imbricata*) and green turtle (*Chelonia mydas*) were studied by 2D-PAGE using IPG strip pH 4-7 size 7 cm and IPG strip pH 3-10 size 24 cm. The protein spots in the egg white of the five reptile species were identified by MALDI-TOF mass spectrometry and LC/MS-MS analysis. Sequence comparison with the database revealed that reptile egg white contained at least 7 protein groups, such as serpine, transferrin precursor/iron binding protein, lysozyme C, teneurin-2 (fragment), interferon-induced GTP-binding protein Mx, succinate dehydrogenase iron-sulfur subunit and olfactory receptor 46. This report confirms that transferrin precursor/iron binding protein is the major component in reptile egg white. In egg white of Siamese crocodile, 20 isoforms of transferrin precursor were found. Iron binding protein was found in 4 species of turtle. In egg white of soft-shelled turtle, 10 isoforms of lysozyme were found. Apart from well-known reptile egg white constituents, this study identified some reptile egg white proteins, such as the teneurin-2 (fragment), the interferon-induced GTP-binding protein Mx, the olfactory receptor 46 and the succinate dehydrogenase iron-sulfur subunit.

Laverty, T.M. and Dobson, A.P. (2013). Dietary overlap between Black Caimans and Spectacled Caimans in the Peruvian Amazon. Herpetologica 69(1): 91-101.

Abstract: The Black Caiman (*Melanosuchus niger*) experienced a dramatic population decline in the mid-20th century, becoming extinct or locally rare over most of its range due to habitat destruction and the commercial value of its hide. As the success and re-establishment of the species is now dependent on conservation efforts throughout the Amazon basin, Black Caimans require continuous monitoring despite extensive current legal protection. Although such efforts have mitigated the threat of human harvesting, a key issue facing the species today is ecological competition from sympatric

Spectacled Caimans (*Caiman crocodilus*). In this study, we investigated this inferred competition by detailing the dietary overlap between Black Caimans and Spectacled Caimans in the Pacaya Samiria National Reserve in 2009. Using an adaptation of the hose-Heimlich technique, we collected and then compared the stomach contents of several individuals of each species. We found that although the proportions of prey items in their stomach contents varied seasonally, the dietary overlap between the two species remained high, suggesting intense competition for food resources. In addition to seasonal changes, the diet composition of Black Caimans also shifted ontogenetically. Young Black Caimans primarily ate insects and crustaceans, whereas larger individuals mostly preyed on fish, reducing intraspecific competition between crocodilian adults and young. Our findings suggest that Spectacled Caimans will continue to hinder the recovery of the Black Caiman population.

Kaur, T., Japning, J.R., Sabki, M.S., Sidik, I., Chong, L.K, and Ong, A.H. (2013). Genetic diversity of *Tomistoma schlegelii* inferred from mtDNA markers. Biochem. Genet. (doi: 10.1007/s10528-012-9562-9).

Abstract: The genetic diversity of the endangered crocodile *Tomistoma schlegelii* was characterized using the protein coding ND 6-tRNA^{glu}-cyt b and the cytochrome b-control region (cyt b-CR) markers. Concatenate data revealed 6 haplotypes with an overall haplotype diversity of 0.769 ± 0.039; nucleotide diversity was 0.00535 ± 0.00172. A nearest-neighbor analysis showed that all individuals clustered with four geographic regions (Sumatra, Peninsular Malaysia, Sarawak, and East Kalimantan) and were genetically differentiated. With the exception of the individuals from haplotype H2, which occurred in both Peninsular Malaysia and Sarawak, all other haplotypes were geographically distinct. The H4 lineage, which was found to be the most divergent, clustered exclusively in the basal clade in all phylogenetic trees, and the haplotype network was unconnected at the 95% reconnection limit, suggesting further investigation to establish its possible status as a distinct evolutionary significant unit or a cryptic species.

Que, T., Xie, Y., Zheng, J., Hu, Q., Hu, Y. and Luo, Z. (2013). Analysis of nutritional and odor components in muscle of Siam alligator (*Crocodylus siamensis*). Journal of Zhejiang University (Agriculture and Life Sciences) 39(2): 122-132.

Abstract: Crocodile is covered in treasure. Its leather has a high reputation in the world, and its armour contains a lot of bone collagen, protein, calcium, phosphorus and so on, and its gallbladder contains more than 20 kinds of bile acids and bilichols, which has a great medicine value. Its blood with antibacterial and antitumor activity is getting the attention of researchers both at home and abroad. There has been growing interest in commercial marketing of the crocodiles meat for human consumption in China, Thailand, America and Australia, which are all artificially breeding Siam alligator, Estuarine crocodile and Nile crocodile etc. Siam alligator is also called Siam freshwater crocodile, Singapore small crocodile, and is commonly known as Thai crocodile. It is getting more and more attention in China. With the increased amount of breeding, the deep processing for the meat of Siam alligator will be the focus of future research. Hence, our objectives were to identify the volatile components of Siam alligator muscle and evaluate its nutritional value. Odors in the muscle of Siam alligator were collected and determined by solid phase microextraction (SPME) and gas chromatography-mass spectrometry (GCMS) before and after deodorization, and the nutritional components in the muscle of Siam alligator were analyzed by common methods. The result showed that there were 72 kinds of volatile compounds detected, in which hexaldehyde was the main component of the odors, along with others constituted the peculiar smell of Siam alligator meat. The contents of moisture, protein, fat and ash in Siam alligator meat were 76.8%, 19.8%, 2.0% and 1.0% respectively. Sixteen types of amino acids in muscle were contained with accounting for 70.44% of the muscle dry matter content and including seven essential ones for human being. The constitutional rate of the essential amino acids was in accordance with the FAO (Food and Agriculture Organization) standard. According to the nutrition evaluation in amino acid score (AAS) and chemical score (CS),the essential amino acid index (EAAI) was 60.63%. The muscle also contained a variety amount of unsaturated fatty acids, in which the contents of eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) were 1.44% and 2.96%, respectively. The Siam alligator meat also contained rich minerals and trace elements, especially the most calcium content. Consequently, the meat of Siam alligator is a kind of high quality one with high protein and low fat, rich in a variety of unsaturated fatty acids and minerals.

Siroski, P.A., Merchant. M.E., Poletta, G.L., Larriera, A. and Ortega, H.H. (2013). Detection and characterization of phospholipase A2 (PLA2) in *Caiman latirostris* and *Caiman yacare* plasma. Zoological Science 30(1): 35-41.

Abstract: Reptiles have proven to have a versatile and efficient nonspecific immune system adapted to the environments in which they commonly live. Phospholipase A2 (PLA2) is important hydrolytic enzyme involved in the regulation of specific types of messengers, with significant roles in the innate immune response. A number of agents that exert effects on cellular receptors emit a series of signals leading to the increased activity of PLA2. Phospholipase A2 has been identified and characterized in temperature, plasma concentration, and kinetic dependence in two species of caiman. The results of these studies suggest that the high PLA2 activities observed in caiman plasma may be an important component of a well-developed innate immunity. Based on the knowledge of their properties, this powerful immunologic component should be evaluated as a possible application in the veterinary or even human therapeutic industry. Additionally, this is another reason to consider these animals excellent models for the study of immune phylogenetic mechanisms.

Groffen, J., Parmentier, H.K., Van de Ven, W.A.C. and Van Weerd, M. (2013). Effects of different rearing strategies and ages on levels of natural antibodies in saliva of the Philippine crocodile. Asian Herpetological Research 4(1): 22-27.

Abstract: The endemic Philippine crocodile (*Crocodylus mindorensis*) is a relatively small, critically endangered freshwater crocodile. In a head start program, crocodile hatchlings are caught in the wild, reared in captivity, and released back into the wild after two years. The current study aimed to determine optimal rearing strategies of Philippine crocodile hatchlings, including identification of possible diseases during rearing, and studying the effect of ages on natural antibody (NAb) levels. Thirty Philippine crocodiles were divided into two groups, half were reared with a hiding board, and half without the hiding board. Both groups received three different kinds of diets: meat, shrimp, or a combination of both. Saliva samples of the crocodiles were taken three times over a period of three months to test for NAb levels. Saliva samples were also taken from older crocodiles and crocodiles from different locations. NAb titres were compared to sheep red blood cells. Each time saliva samples were taken, a health check was done. The results showed that crocodiles would prefer the hiding board, and neither housing nor diet could affect the level of NAb titres in saliva. A positive correlation was found between NAb titres and body size, weight and age. Wild hatchlings had higher NAb titres than the hatchlings born in captivity, but the difference diminished with ageing. Five different diseases were found.

Wang, Y., Feng, D., Xue, H., Nie, C., Li, E. and Wu, X. (2013). Universal DNA primers for amplification of complete mitochondrial protein-coding genes and ribosomal RNA genes from Crocodilia. Conservation Genetics Resources (doi: 10.1007/s12686-013-9899-3).

Abstract: PCR amplification and direct sequencing of mitochondrial genes of target taxa with universal primers designed according to a public DNA database can provide valuable information for phylogenetic inferences. This study describes the design of universal primer sets for an amplified partial 12S rRNA gene and fourteen other complete genes (16S rRNA gene plus 13 protein-coding genes) from the mitochondrial genome of 21 crocodilian species. This provides useful tools for the study of genetic variability in Crocodilia at or below the species level.

Alibardi, L. (2013). Cornification in reptilian epidermis occurs through the deposition of keratin-associated beta-proteins (beta-keratins) onto a scaffold of intermediate filament keratins. Journal of Morphology 274(2): 175-193.

Abstract: The isolation of genes for alpha-keratins and keratin-associated beta-proteins (formerly beta-keratins) has allowed the production of epitope-specific antibodies for localizing these proteins during the process of cornification epidermis of reptilian sauropsids. The antibodies are directed toward proteins in the alpha-keratin range (40-70 kDa) or beta-protein range (10-30 kDa) of most reptilian sauropsids. The ultrastructural immunogold study shows the localization of acidic alpha-proteins in suprabasal and precorneous epidermal layers in lizard, snake, tuatara, crocodile, and turtle while keratin-associated beta-proteins are localized in precorneous and corneous layers. This late activation of the synthesis of keratin-associated beta-proteins is typical for keratin-associated and corneous proteins in mammalian epidermis (involucrin, filaggrin, loricrin) or hair (tyrosine-rich or sulfur-rich proteins). In turtles and crocodilians epidermis, keratin-associated beta-proteins are synthesized in upper spinosus and precorneous layers and accumulate in the corneous layer. The complex stratification of lepidosaurian epidermis derives from the deposition of specific glycine-rich versus cysteine-glycine-rich keratin-associated beta-proteins in cells sequentially produced from the basal layer and not from the alternation of beta- with alpha-keratins. The process gives rise to Oberhäutchen, beta-, mesos-, and alpha-layers during the shedding cycle of lizards and snakes. Differently from fish, amphibian, and mammalian keratin-associated proteins (KAPs) of the epidermis, the keratin-associated beta-proteins of sauropsids are capable to form filaments of 3-4 nm which give rise to an X-ray beta-pattern as a consequence of the presence of a beta-pleated central region of high homology, which seems to be absent in KAPs of the other vertebrates.

Tanaka, K. and Zelenitsky, D.K. (2013). Relationships between nest humidity and nest types in living archosaurs. Historical Biology: An International Journal of Paleobiology (doi: 10.1080/08912963.2013.772169).

Abstract: Nest humidity (P_{nest}) is important for archosaur incubation because it has a direct effect on the water vapour conductance (G_{H2O}) of the eggs. Estimates of G_{H2O} are commonly used to infer nest type in extinct archosaurs, although it is unknown whether a relationship exists between nest type and nest humidity or between nest type and . In this study, the nests of 54 living archosaur species (ie birds and crocodilians) were classified into three generalised nest types, including covered, non-covered cup and non-covered scrape nests, based on their nest architectures. P_{nest} and ambient humidity of the nesting habitat (P_a) of these species were compared among these three nest types. Statistical analyses show that P_{nest} is significantly higher in covered nests than in the non-covered nests, including both cup and scrape types, indicating that the covered nests are significantly more humid than the non-covered nests. Although P_a is lower than P_{nest} in all species, P_a is not significantly different among the three nest types. These results suggest that although P_a has a fundamental effect on P_{nest} (ie $P_{nest} \geq P_a$), the nest humidity is affected by the architecture of the nesting materials, that is the covered nests are shown to retain more humidity than the non-covered nests.

Drumheller-Horton, S.K. (2012). An Actualistic and Phylogenetic Approach to Identifying and Interpreting Crocodylian Bite Marks. PhD Thesis, The University of

Iowa. Available at Iowa Research Online: http://ir.uiowa.edu/etd/3446.

Abstract: Bite marks provide direct evidence of trophic interactions, feeding behavior, and inter- or intraspecific conflict in the fossil record. However, their utility as a source of taphonomic and paleoecologic data requires differentiation from traces left by other processes. Since the 19th century, taphonomists have often relied on actualistic observations of modern bite marks and feeding behaviors in order to identify diagnostic traces and patterns. A recent increase in interest in taphonomic research has resulted in a large body of work describing patterns of bite marks from many different clades. Most research has been focused on mammalian taxa, but a smaller number of non-mammalian groups, including crocodylians, have also drawn interest. Crocodylians are taphonomic agents who consume and modify bones, often depositing them in the active depositional systems in which they live. However, actualistic observations of crocodylian bite marks have been limited to forensic case studies and surveys of two taxa: *Crocodylus niloticus* and *Crocodylus porosus*. Both surveys utilized captive animals, which often exhibit atypical morphologies that may bias ensuing bite mark datasets. In order to address this issue, a 2D morphometric analysis of *Alligator mississippiensis* crania from captive and wild specimens was performed. A principal component analysis and a canonical variates analysis revealed some statistically significant differences between the two groups, while crossvalidation had mixed resuts. An ANCOVA test of the covariance of centroid size and origin against shape (principal component scores) revealed that the effects of ontogeny introduced a stronger signal than captivity. This implies that while using captive crocodylians in fine scale analyses should be avoided, they are suitable for gross scale research, such as bite mark analyses. To explore crocodylian bite mark patterns in greater depth, a large scale survey of 2 traces left by *A. mississippiensis* was performed. Bite mark types on samples taken from individual feedings were discussed in light of vital statistics and collection protocols. Bite mark types on samples taken from group feedings were classified by location and orientation on bone and type. The results were compared to pre-existing crocodylian datasets with regards to potentially diagnostic traits: bisected marks, hook scores, and a lack of furrows. Bisected marks were found in rates similar to those seen in *C. niloticus*, and rates of hook scoring and bone breakage were higher. These traces were present in higher rates than those reported in *C. porosus*. Furrows were identified, but rare. Finally, a survey of bite marks from 21 of the 23 generally recognized species of extant crocodylians was performed to better characterize marks found across Crocodylia and to test methods for synthesizing taphonomic datasets. Bite marks were identified, and specimens were then coded for presence or absence of mark subscores. Attempts to find statistical correlation between mark types, animal vital statistics, and sample collection protocol were unsuccessful. Mapping bite mark character states on a eusuchian phylogeny successfully predicted the presence of bisected marks in previously published, extinct taxa. Predictions for clades that may have created multiple subscores, striated marks, and extensive crushing were also generated. Inclusion of fossil bite marks which have been positively associated with extinct species allow this method to be projected beyond the crown group. The results of this study indicate that phylogenies can and should be explored further for use as predictive tools in a taphonomic framework.

Green, T.W., Slone, D.H., Swain, E.D., Cherkiss, M.S., Lohmann, M., Mazzotti, F.J. and Rice, K.G. (2013). Evaluating effects of Everglades restoration on American crocodile populations in South Florida using a spatially-explicit, stage-based population model. Wetlands (doi: 10.1007/s13157-012-0370-0).

Abstract: The distribution and abundance of the American crocodile (*Crocodylus acutus*) in the Florida Everglades is dependent on the timing, amount, and location of freshwater flow. One of the goals of the Comprehensive Everglades Restoration Plan (CERP) is to restore historic freshwater flows to American crocodile habitat throughout the Everglades. To predict the impacts on the crocodile population from planned restoration activities, we created a stage-based spatially explicit crocodile population model that incorporated regional hydrology models and American crocodile research and monitoring data. Growth and survival were influenced by salinity, water depth, and density-dependent interactions. A stage-structured spatial model was used with discrete spatial convolution to direct crocodiles toward attractive sources where conditions were favorable. The model predicted that CERP would have both positive and negative impacts on American crocodile growth, survival, and distribution. Overall, crocodile populations across south Florida were predicted to decrease approximately 3% with the implementation of CERP compared to future conditions without restoration, but local increases up to 30% occurred in the Joe Bay area near Taylor Slough, and local decreases up to 30% occurred in the vicinity of Buttonwood Canal due to changes in salinity and freshwater flows.

Alibardi, L. (2013). Granulocytes of reptilian sauropsids contain beta-defensin-like peptides: A comparative ultrastructural survey. J. Morphol. (doi: 10.1002/jmor.20143).

Abstract: The ability of lizards to withstand infections after wounding or amputation of the tail or limbs has suggested the presence of antimicrobial peptides in their tissues. Previous studies on the lizard Anolis carolinensis have identified several beta-defensin-like peptides that may potentially be involved in protection from infections. The present ultrastructural immunocytochemical study has analyzed tissues in different reptilian species in order to localize the cellular source of one of the more expressed beta-defensins previously sequenced in lizard indicated as AcBD15. Beta-defensin-like immunoreactivity is present in some of the larger, nonspecific granules of granulocytes in two lizard species, a snake, the tuatara, and a turtle. The ultrastructural study indicates that only heterophilic and basophilic granulocytes contain this defensin while other cell types from the epidermis, mesenchyme, and dermis, muscles, nerves, cartilage or bone

are immunonegative. The study further indicates that not all granules in reptilian granulocytes contain the beta-defensin peptide, suggesting the presence of granules with different content as previously indicated for mammalian neutrophilic leucocytes. No immunolabeling was instead observed in granulocytes of the alligator and chick using this antibody. The present immunocytochemical observations suggest a broad cross-reactivity and conservation of beta-defensin-like sequence or steric motif across lepidosaurians and likely in turtles while archosaurian granulocytes may contain different beta-defensin-like or other peptides.

Bezuijen, M.R., Cox, J.H., Jr., Thorbjarnarson, J.B., Phothitay, C., Hedemark, M. and Rasphone, A. (2013). Status of Siamese Crocodile (*Crocodylus siamensis*) Schneider, 1801 (Reptilia: Crocodylia) in Laos. Journal of Herpetology 47(1): 41-65.

Abstract: The Siamese Crocodile (*Crocodylus siamensis*) is critically endangered and, until a decade ago, few remaining wild populations were known to exist. Described here are the first in-depth surveys for C. siamensis in Laos with new field data on ecology and conservation. Small breeding populations of *C. siamensis* are confirmed to persist in Laos. During surveys between 2003 and 2008, *C. siamensis* was recorded in 13 sites of 6 river systems, where at least 36 individuals (1-11 per site) were documented. In all sites, crocodile densities and recruitment rates were extremely low. Eight nests were recorded - among the first wild nests of *C. siamensis* to be reported. Perennial, thickly vegetated floodplain lakes are critical dry-season refugia and breeding habitats for *C. siamensis* in Laos. Opportunistic collection of crocodiles by local communities was observed, and at all sites there is increasing degradation of floodplain lakes for agriculture or economic development. National crocodile records were compiled and indicate that, historically, *C. siamensis* was widespread in lowland riverine and palustrine habitats of Laos, with most records from Central and South Laos in the Mekong Plain. These records also suggest that a severe range decline has occurred over the past century, although most wetlands remain unsurveyed for crocodiles. *Crocodylus siamensis* is probably now extirpated from the Lao Mekong and many other wetlands. Remnant *C. siamensis* populations in Laos are of global importance. All documented breeding sites, and most confirmed national records, are in rural lands outside the national protected area system, and conservation efforts will require community-based approaches.

Submitted Publications

SEBA'S PLATE 106 MAKES MUCH BETTER SENSE NOW. This paper details what are apparently the oldest two European graphics that are really good and accurate pictures of a northern African crocodile. We compare these crocodile depictions with each other, and also compare them with a later and more stylized and unidentifiable picture that is wrong for the Crocodylia, but is important in crocodilian nomenclature. Our discovery does not destabilize *Crocodylus niloticus*, and it supports the modern usage of *Crocodylus acutus* for the American crocodile, as opposed to the older name *Crocodylus americanus*.

Titled "Die Nilpferd Jagd" or "die Nilpferdjagd" and dated 1615-1616, the Peter Paul Rubens hippopotamus hunt painting includes a *C. niloticus* in it, and is historically older than Albert Seba's (1734) famous and controversial plate 106 crocodilian. Newly we believe that Seba's artist got the concept of his plate 106 animal from the Rubens painting, but in an indirect way, because he actually worked from an engraving done slightly later than 1616 by Pieter Claesz Soutman, a Dutch contemporary and associate of Rubens. This Soutman engraving is left-right obverse of the Rubens oil painting, but is otherwise remarkably true to the original. Both Rubens and Soutman included three men on horseback, three dogs, a hippopotamus, and in the foreground there are two men and a crocodile, but Seba's plate 106 was later significantly edited to isolate and show only the crocodile.

Directly behind the crocodile's head, the postoccipital scales in the Rubens oil painting are very slightly different from those in its subsequent Soutman engraving, and similarly the nuchal scales are essentially the same, but not exactly identical, in both pictures. However, the neck scales in both of these two really old graphics, and the spaces of bare skin between the groups of cervical scales and between the nuchal shield and the start of the thoracic dorsal armor, are all within acceptable variation for the Nile crocodile. In contrast, the dorsal neck and thoracic region in Seba's newer plate 106 crocodilian became entirely stylized and inventively resembles no known species. The absence of clear scales on the Seba plate 106 neck has been hypothesized by some to reflect the sometimes remarkably reduced cervical armor in the American crocodile, today *Crocodylus acutus* (Cuvier, 1807). For example, the type-description of *Crocodylus americanus* (Laurenti, 1768), characterized the species as naked necked ("nucha nuda"), and individually Seba's plate 106 was cited as the specimen basis.

With 6 to 8 longitudinal rows of keels in the midbody dorsal armor, both the Rubens oil-painting and the Soutman engraving are correct for northern African *C. niloticus*, and both are wrong for the *C. acutus*. In the original hippopotamus hunt painting, and also in the later hippopotamus hunt engraving, there are parts of the body and pelvic dorsal armor that are obscured by a dead-man's leg and separately one front paw of the hippopotamus. In contrast, the Seba plate 106 version has had the human leg, the hippo's paw, and everything else except the crocodile removed, and then a new landscape was invented.

The bending of the head and neck, and of the body and the anterior third of the tail, are all remarkably similar in these three pictures. Further, the animal is depicted from approximately the same viewing angle in all three graphics, and this convinces us that Seba's plate 106 crocodilian was based either on the Rubens oil painting, or on the Soutman engraving, or theoretically possibly both. The transverse rows of dorsal scales on the crocodile's body in the Rubens and Soutman graphics are recognizable as being crocodilian

(though artistically edited). In contrast, the same dorsal armor became stylized beyond recognition in Seba (1734).

Seba's plate 106 newly shows the crocodile's tail making a vertical loop posterior to the basicaudal region, but the distal two-thirds of the tail did not make this loop in the two earlier versions. Both Rubens and Soutman had showed the tail gently curving to the left and right, and much closer to being straight. Clearly Seba's artist devised the caudal loop to make it fit inside plate 106 better. Nonetheless, the number of double and single crested caudal whorls is similar in all three of these graphics, and more importantly the positioning and bending of three of the crocodile's limbs is identical. The fourth limb, a back leg and foot, was shown by neither Rubens nor Soutman, and was later invented by Seba's artist.

The one hindlimb illustrated in the Rubens painting is the animal's right leg, and in the Soutman obverse it is the animal's left leg, but this is not a biological difference. However, there are 4 toes on this foot in the Rubens original, while in contrast there are 5 in Soutman's engraving, and this is a very significant biological difference. No true crocodilian exhibits 5 functional and externally visible toes per hindfoot. The Soutman graphic is wrong about this detail, and clearly the fifth toe was an artistic invention. This mistake was made more obvious in Seba (1734), because his artist showed both hindlimbs, and spread the toes apart to make it easier to count them, and further added interdigital hindfoot webbing that had not been evident in the earlier two graphics.

As shown in Figure 1, it is not possible to count the fingers on either of the Rubens crocodile's front paws, because both hands are in strong shadow and the hand on the animal's right arm is entirely obscured by the cranial part of its head. In contrast, the same biological hand got moved by Soutman to become partly visible through the crocodile's open jaws, as shown in Figure 2. Also, the front paw on the other side, the animal's complete left arm in Soutman's engraving, somewhat clearly shows 4 fingers, each of which bears a terminal claw.

Figure 1. The crocodile part of the "Die Nilpferd Jugd" oil-painting by Rubens is identifiable as *Crocodylus niloticus* with 4 toes on the hindfoot shown.

Figure 2. The crocodile part of the "Die Nilpferd Jugd" engraving by Soutman is wrong for the Nile crocodile because it has 5 toes on the hindfoot shown.

It is remotely possible that the Rubens original could be interpreted as having 5 toes on the one hindfoot that is shown, because of an ambiguous shadow on its outside edge. Similarly remotely, the Soutman engraving could possibly be interpreted as having 5 fingers on the one hand completely shown. However, and in contrast, the Seba (1734) version of the crocodile clearly has 5 toes (each with a terminal claw), and clearly has 5 clawed fingers. At least some of these digits and claws were added by Seba's artist.

For a picture of what the Rubens and Soutman crocodile looks like without the 5 humans, 3 large dogs, and one raging hippopotamus in the picture and partly obscuring the crocodile, see the cover of this CSG Newsletter issue. It was explicitly posed after the Soutman engraving, but is printed in left-right obverse of the engraving, and thus the cover graphic has the original Rubens orientation with the relatively straight tail aiming to the upper right of the composition. Dated 1798, this cover illustration is significantly more recent than Seba's plate 106.

Plate 26 in Blumenbach (1798) and reprinted unchanged in Blumenbach (1810), the Newsletter cover picture has had the man's leg and the hippo's front paw removed, and the dorsal armor in these two places has been added with reference to a stuffed specimen in Germany. However, Blumenbach's (1798, 1810) illustration is not a picture of a German specimen, but rather is merely a partly augmented picture of the Soutman engraving, which itself was incomplete.

There are many additional looped tailed and unidentifiable crocodile pictures that have the dorsal neck and body and pelvic armor stylized the same way as Seba's (1734) picture, and most of them are known to be more recent than Seba's plate 106. One is figure 1 on plate 3 in Bonnaterre (1789) which was explicitly said to be based on exclusively Seba (1734). Another is the bottom picture on page 256 in Campbell and Winterbotham (1985), which appears to

be based on Bonnaterre (1789). There is also a loop-tailed version in Shaw's (1802) plate 59, and yet another in plate 24 (figure 39) in Wilhelm (1794) and reprinted unchanged in Wilhelm (1818, 1834). It is likely that Shaw (1802) based his crocodile on Seba exclusively, because the 1802 hindfoot toes are connected by webs, while in the Bonnaterre (1798) version the interdigital webbing on both back feet were deleted by Bonnaterre's artist. Similarly, the hindfoot webbing in Wilhelm (1794, 1818, 1834) resembles that in Seba, but newly and inventively the front paws are clearly webbed between each of the 5 fingers per hand in Wilhelm, and further the extra toe on the partly obscured hindlimb in Wilhelm (1794, 1818, 1834) has changed position.

The problematical fifth externally visible and functional (and clawed) hindfoot toe was not clearly present in Rubens. Rather, it appears to have originated in the Soutman engraving, where it fictitiously occupied the position of digit #5 (the little toe in humans). Oddly, the extra toe moved to the position of digit #1 (the big toe in humans) in Seba (1734), in Bonnaterre (1789), in Shaw (1802), and also on one foot in Wilhelm, but uniquely (and violating biological bilateral symmetry) the other back paw in Wilhelm (1794, 1818, 1834) has the extra toe inventively moved to the digit #5 position for artistic reasons, and thus it accidentally reverted to the earlier Soutman condition. However, the toes in Wilhelm's picture are spread apart the Seba way on this hindlimb that was not shown by Rubens and Soutman.

The hindleg that Seba (1734) invented, the one with its knee sticking up from behind the animal's back, had the toe that looks wrong located proximal to what looks like the real digit #1 in Seba's plate 106, and the foot on the completely shown leg is its mirror opposite. This is different from the single hindpaw shown in the Soutman graphic, which is the biological whole leg shown in Seba. However, in the engraving by Soutman the extra toe is distal to the real digit #4, but it looks wrong and is positioned peculiarly. Cumulatively, including both arrangements in Wilhelm (1794, 1818, 1834), the presence of 5 digits per hindpaw is fiction, and it was fiction in Soutman as well.

Two additional pictures of looped-tailed and five-toed creatures resemble Seba (1734), Bonnaterre (1789), Shaw (1802), Wilhelm (1794, 1818, 1834) and Campbell and Winterbotham (1985), but their dates of origin are unknown to us. We are sure that the page 233 graphic in Ross (1989), which was also the logo of the 21st CSG Working Meeting (Manila, 2012), and was reprinted in Ross (2011), is after neither Rubens nor Soutman nor Blumenbach (1798, 1810), because the tail and the dorsal armor and the spread-apart toes and fingers, and the presence of all 4 limbs, are all of the Seba (1734) kind. Similarly, the 1989 CSG Newsletter picture of a loop-tailed crocodilian discussed and reproduced in Ross and King (1990) is without known real provenance, and from its primitive and generalized nature we suspect that it is a copy of Seba, as opposed to Seba (1734) being a copy of it. The same probably applies to the more elegant Ross (1989) and reprinted in Ross (2011) graphic. Thus, Seba appears to be the original loop-tailed graphic, and secondarily plate 59 in Shaw (1802) is unique among the copies of the old Seba, because its loop newly fails to contact the dorsal profile of the animal.

With reference to our front cover graphic, we stress that because the text for Blumenbach's (1798, 1810) plate 26 said that the crocodile was posed directly after the Soutman engraving ("Die Abbildung ist nach einem ausgestopfen Exemplar im academischen Museum, und nur die Stellung von dem herrlichen Blatte mit der Jagd des Crocodils und Nilpferdes entlehnt, das Soutman nach Rubens gestochen hat."), its provenance and date make it clearly independent of Seba (1734).

Titled "Die Nilpferd Jagt" (The Hippopotamus Hunt), the 1615-1616 finished painting was done in Antwerp, Belgium, and was thereafter hung in a palace in Bavaria, Germany, until being stolen by the French during the Napoleonic Wars, and then later returned (internet sources). Thus, Seba's (1734) artist never saw the Rubens original. In contrast, however, the Soutman engraving was surely and easily available to Seba's artist. It is possible, and even probable, that Rubens had neither the crocodile nor the hippopotamus in Antwerp, but rather based these two exotic animals on his own oil-sketches done earlier in Italy. If so, then Soutman never saw the physical crocodile, and there is nothing in the Soutman engraving that contradicts this hypothesis. However, as shown in Figure 3, the 5 toes per foot and 5 fingers per hand in Seba's (1734) new plate 106 are in some respects an improvement on the earlier Soutman engraving.

Figure 3. The plate 106 crocodile in Seba (1734) was modified after Soutman (as opposed to Rubens), but is newly so stylized that it is wrong for *C. niloticus* and *C. acutus*.

In comparison with the Soutman engraving, we observe that the falsely shown digits #2, #3, #4 and #5 (sic) on the hindfoot in Seba (1734), which are really toes #1 to #4, look more authentically crocodilian, as also do the 5 fingers. However, the Crocodylia is today characterized as having only 3 toes (the real #1, #2 and #3) clawed, and having only 3 fingers (again #s 1-3) with a terminal claw. The functional and externally visible real crocodilian toe #4 lacks the claw, and fingers

#4 and #5 are clawless. Clearly Seba's artist was somewhat corrective about the front paws especially, and we wonder if the specimen known to Rubens was stuffed (and thus stood still for him), but the details of its hands and feet had been damaged. Alternatively, he may possibly have worked from a living captive in Italy, or at least for the animal's posture, which is convincingly lifelike.

The species-group name *C. americanus* is not based on a Nile crocodile specimen, but rather upon the misleading and embellished fiction picture in Seba (1734), which poorly and inventively depicts the five-toed and thus partly fiction engraving by Soutman, which in turn was a slightly inventive copy of a finished P.P. Rubens oil-painting of a Nile crocodile that may have been painted from sketches made earlier in Italy by Peter Paul Rubens himself. Our assertions that there was no hippopotamus specimen in Antwerp in 1615-1616, and that Rubens included information about animals seen in Italy in some of his paintings done in Belgium, are based on the internet.

The complete Nile-horse Hunt (the hippopotamus and crocodile hunt) color painting by Rubens can be seen in hard copy in Graham and Beard (1973). The complete Soutman engraving titled "the Hippopotamus Hunt" can be seen at the Harvard University art museum's website. We thank Sven Sachs for help with Blumenbach's (1798, 1810) old German sentence, which translates as "the figure is after a stuffed specimen in the academic museum, just the posture is inspired by the beautiful plate with the hunt of crocodile and hippopotamus, which Soutman engraved after Rubens". We also thank Konstantin Milto of the Zoological Institute of the Russian Academy of Sciences in St. Petersburg for sending a series of photographs of potentially germane specimens to Mark Van Tomme, from which we concluded that, despite any rumors and speculation, the specimen depicted in plate 106 was probably not ever in Seba's collection, and definitely is not among the Seba specimens that went to Saint Petersburg. Credit is also due to George R. Zug (U.S. National Museum) who in answer to an e-mail question from Andy Ross, concerning the citation for the 2012 Manila meeting's logo, said that the looped-tailed creature is Seba's plate 106 in obverse, but for reasons explained above and in Ross (2011), he too was fooled by an art-fake that is technically "after" Seba.

Lastly, we correct a mistake in the second paragraph in Ross (2011), where the limb that sticks up from behind the dorsal edge of the body was accidentally called an arm with an elbow, when it is actually a leg with a knee. The count of complete keel bumps silhouetted and connecting this partly shown and partly obscured hindlimb to the place where the loop of the tail similarly obscures the keel bumps is 12-13 complete bumps in a series in Seba (1734), and is 20 bumps in Bonnaterre (1789), and 10 keels silhouetted in Wilhelm (1794, 1818, 1834), but because the loop fails to contact the animal's body's dorsal edge, the defined bump count is not applicable in Shaw (1802). Most recently, the Campbell and Winterbotham (1985) graphic has 19 keel bumps in the defined dorsal edge series, and in the Ross (1989) graphic reproduced in Ross (2011) the result is 17, which is very high compared with the low result of 7 on the Ross and King (1990) picture.

Literature Cited

Blumenbach, J.F. (1798). Abbildungen naturhistorischer Gegenstande. Part 3 (numbers 21-30). J.C. Dieterich: Göttingen, Germany.

Blumenbach, J.F. (1810). Addildungen naturhistorischer Gegenstande. Numbers 1-100. H. Dieterich: Göttingen, Germany.

Bonnaterre, P.J. (1789). Tableau encyclopédique et méthodique des trois règnes de la nature. Erpétologie. Panckouke: Paris.

Campbell, G.R. and Winterbotham, A.L. (1985). Jaws, Too! Southerland Publishing: Ft. Myers, Florida.

Graham, A. and Beard, P. (1973). Eyelids of Morning. New York Graphic Society: New York. (Reprinted in 1990 by Chronicle Books, San Francisco, California).

Ross, C.A. (1989). Editor's addenda. Pp. 230-236 *in* Crocodiles and Alligators, ed. by C.A. Ross. Weldon Owen: Sydney.

Ross, F.D. (2011). Ross brothers fooled by art-fakes. Crocodile Specialist Group Newsletter 30(3): 27.

Ross, F.D. and King, F.W. (1990). It is not an alligator, caiman, crocodile or gharial. Crocodile Specialist Group Newsletter 9(1): 22-23.

Seba, A. (1734). Locupletissimi rerum naturalium thesauri. Volume 1. Amsterdam. Plates only reprinted as "Albertus Seba, Cabinet of Natural Curiosities" in 2001 by Taschen: Cologne, Germany.

Shaw, G. (1802). General Zoology, or Systematic Natural History. Volume 3, Part 1: Amphibia. G. Kearsley: London.

Wilhelm, G.T. (1794). Unterhaltungen aus der Naturgeschichte. Die Amphibien. Engelbrechisschen: Augsburg, Germany.

Wilhelm, G.T. (1818). Unterhaltungen aus der Naturgeschichte. Die Amphibien. Self-published: Vienna, Austria.

Wilhelm, G.T. (1834). Unterhaltungen aus der Naturgeschichte. Die Amphibien. Schlossers: Augsburg, Germany.

Franklin D. Ross[1], Edio-Ernst Kischlat[2], Mark P.A. Van Tomme[3]† and Charles A. Ross[4]†; *[1]Naturalis Biodiversity Center, box 9517, Leiden 2300RA, the Netherlands; [2]Rua Afonso Taunay 180/802, Porto Alegre 90520-540, Rio Grande do Sul, Brazil; [3]Belem, Brazil and Brussels, Belgium, deceased; [4]US National Museum, and Manila, Philippines, deceased.*

Steering Committee of the Crocodile Specialist Group

Chairman: Professor Grahame Webb, P.O. Box 530, Karama, NT 0813, Australia
For further information on the CSG and its programs, on crocodile conservation, biology, management, farming, ranching, or trade, contact the Executive Office (csg@wmi.com.au) or Regional Chairmen

Deputy Chairmen: Dr. Dietrich Jelden, Bundesamt für Naturschutz, Konstantin Str. 110, Bonn D-53179, Germany, Tel: (49) 228 849 11310, Fax: (49) 228 84911319, <Dietrich.Jelden@BfN.de>. Alejandro Larriera, Pje. Pvdo. 4455, Centeno 950, Santa Fe, Argentina, Tel: (543) 42 4531539, Fax: (543) 42 558955, <alelarriera@hotmail.com>.

Executive Officer: Tom Dacey, P.O. Box 72, Smithfield, QLD 4878, Australia, Tel/Cell: (61) 419704073 <csg@wmi.com.au>.

Regional Chairman, South and East Africa: to be confirmed. **Regional Vice Chairmen**: Christine Lippai <lippainomad@gmail.com>, Dr. Alison Leslie <aleslie@sun.ac.za>.

Regional Chairman, West and Central Africa (including Madagascar): Dr. Samuel Martin, La Ferme aux Crocodiles, Pierrelatte, France <s.martin@lafermeauxcrocodiles.com>. **Regional Vice Chairmen**: Prof. Guy Apollinaire Mensah <mensahga@gmail.com>; Christine Lippai <lippainomad@gmail.com>.

Regional Chairmen, East and Southeast Asia: Dr. Toshinori Tsubouchi <t_tsubouchi@seisa.ac.jp>, Dr. Jiang Hongxing <hongxingjiang@yahoo.com>. **Regional Vice Chairmen**: Dr. Choo Hoo Giam <giamc@singnet.com.sg>; Dr. Nao Thuok <naothuok.fia@maff.gov.kh>; Uthen Youngprapakorn <thutcroc@ksc.th.com>; Yosapong Temsiripong <yosapong@srirachamoda.com>.

Regional Chairman, Australia and Oceania: Charlie Manolis <cmanolis@wmi.com.au>. **Regional Vice Chairmen**: Eric Langelet <croctech@mainland.com.pg>; Steve Peucker <speucker@barneveld.com.au>.

Regional Chairman, South Asia and Iran: Anslem de Silva <kalds@sltnet.lk>. **Regional Vice Chairmen**: Dr. Ruchira Somaweera <ruchira.somaweera@gmail.com>; Maheshwar Dhakal <maheshwar.dhakal@gmail.com>; Raju Vyas <razoovyas@gmail.com>; Abdul Aleem Choudhury <aleemc1@gmail.com>; Asghar Mobaraki <amobaraki@hotmail.com>; Dr. S.M.A. Rashid <rashidsma@yahoo.co.uk>.

Regional Chairmen, Latin America and the Caribbean: Alfonso Llobet (Management Programs) <allobet@cotas.com.bo>; Dr. Carlos Piña (Human Resources Development) <cidcarlos@infoaire.com.ar>; Alvaro Velasco (Incentives for Conservation) <velascocaiman@gmail.com>; **Regional Vice Chairmen**: Hesiquio Benítez Diaz <hbenitez@conabio.gob.mx>; Dr. Miryam Anaya <dracocodrilo@hotmail.com>; Dr. Luis Bassetti <luisbassetti@terra.com.br>; Sergio Medrano-Bitar <faunasilvestre@gmail.com>; Dr. Roberto Soberón <rsoberon@enet.cu>; Bernardo Ortiz (Regional Trade) <bernardo.ortiz@traffic.sur.iucn.org>.

Regional Chairmen, Europe: Dr. Jon Hutton, UNEP World Conservation Monitoring Centre, United Nations Environment Program, 219 Huntingdon Road, Cambridge CB3 0DL, UK, Tel: (44) 1223 277314, Fax: (44) 1223 277136 <Jon.Hutton@unep-wcmc.org>; Dr. Samuel Martin, La Ferme aux Crocodiles, Pierrelatte, France <s.martin@lafermeauxcrocodiles.com>. **Regional Vice Chairman**: Ralf Sommerlad <crocodilians@web.de>.

Regional Chairmen, North America: Dr. Ruth Elsey, Louisiana Wildlife and Fisheries Department, 5476 Grand Chenier Highway, Grand Chenier, LA 70643, USA, Tel: (1) 337 5382165, Fax: (1) 337 4912595, <relsey@wlf.louisiana.gov>; Allan Woodward, Florida Fish and Wildlife Conservation Commission, 1105 SW Williston Road, Gainesville, FL 32601, USA, Tel: (1) 352 9552081, Fax: (1) 352 9552183, <allan.woodward@myfwc.com>. **Regional Vice Chairmen**: Noel Kinler <nkinler@wlf.louisiana.gov>; Dr. Frank Mazzotti <fjma@ufl.edu>; Dr. Thomas Rainwater <trrainwater@gmail.com>.

Vice Chairman for CITES: Hank Jenkins, P.O. Box 390, Belconnen, ACT 2616, Australia, Tel: (61) 2 62583428, Fax: (61) 2 62598757, <hank.jenkins@consol.net.au>; **Deputy Vice Chairman**: Dr. Yoshio Kaneko <gtrust@wa2.so-net.ne.jp>.

Vice Chairman, Industry: Don Ashley, Belfast Dr., Tallahassee, FL 32317, USA, Tel: (1) 850 893 6869, <Jdalligator@aol.com>. **Deputy Vice Chairmen**: Yoichi Takehara <official@horimicals.com>; C.H. Koh <henglong@starhub.net.sg>; Kevin Van Jaarsveldt <kvj@mweb.co.za>; Enrico Chiesa <enricochiesa@italhide.it>; Jorge Saieh <jsaieh99@yahoo.com>; Thomas Kralle <Thomas@Kralle.com>; Chris Plott <cjp@amtan.com>; Jerome Caraguel <jerome.caraguel@hcp-rtl.com>; Simone Comparini <renzocomparini@liberi.it>.

Vice Chairman, Trade Monitoring: John Caldwell <john.caldwell@mad.scientist.com>. **Deputy Vice Chairman**: James MacGregor <James.MacGregor@WorleyParsons.com>; Steve Broad, TRAFFIC International <steven.broad@traffic.org>.

Vice Chairman, Veterinary Science: Dr. Paolo Martelli <paolo.martelli@oceanpark.com.hk>.

Vice Chairman, Zoos: Dr. Kent Vliet, University of Florida, Gainesville, FL 32611, USA, Tel: (1) 352 3928130, Fax: (1) 352 3924738, <kvliet@ufl.edu>.

Vice Chairman, Community Education: Clara Lucia Sierra Diaz (clsierra@hotmail.com).

Vice Chairman, General Research: Dr. Valentine Lance, Graduate School of Public Health, San Diego State University, San Diego, CA, USA, <lvalenti@sunstroke.sdsu.edu>.

Vice Chairman, Legal Affairs: Tomme Young <tomme.young@googlemail.com>.

CSG IUCN Red List Authority: Dr. Perran Ross, Department of Wildlife Ecology and Conservation, P.O. Box 110430, University of Florida, Gainesville, FL 32611, USA, Tel: (1) 352 392 7137 <pross@ufl.edu>.

Honorary Steering Committee Members: Prof. Harry Messel (Australia), Ted Joanen (USA), Romulus Whitaker (India), Phil Wilkinson (USA), Prof. F. Wayne King (USA), Dr. Fritz Huchzermeyer (South Africa).

Task Force/Working Group Chairmen: Siamese Crocodile, Dr. Parntep Ratanakorn <parntep.rat@mahidol.ac.th>; Chinese Alligator, Dr. Jiang Hongxing <hxjiang@forestry.ac.cn>; Tomistoma, Bruce Shwedick <Bshwedick@aol.com>; Human-Crocodile Conflict, Allan Woodward <allan.woodward@myfwc.com>.