CROCODILE SPECIALIST GROUP NEWSLETTER

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COVER PHOTOGRAPH: Hatchling Cuban crocodile (*Crocodylus rhombifer*) at Criadero de la Ciénaga de Zapata. Photograph: John Thorbjarnarson.

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

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Yee Tai Leather Enterprise Ltd., Hong Kong.

Editorial

The IUCN World Conservation Congress was held in Barcelona, Spain, on 5-14 October 2008. The CSG was represented by Christine Lippai, who was able to provide an update on the CSG mission to Madagascar. Simon Stuart was appointed as SSC Chair, replacing Holly Dublin. We take this opportunity to thank Holly for the ongoing support and encouragement she gave to the CSG. We of course look forward to working closely with Simon over the next triennium.

At the 19th CSG working meeting (Santa Cruz, Bolivia) the high levels of skin exports from Colombia, which matched reported imports into other countries, were a matter of significant concern to the CSG. As a consequence, the Colombian Government carried out a detailed analysis of trade levels and farm stocks, confirming the WCMC analyses. The origin of 1996 exports remains problematic, and the CSG continues to work with the Colombian Government to close avenues through which large, illegally taken wild skins can enter the legal trade. The CSG has advised that a morphometric study be used to determine the real size of the individuals in trade, rather than having physical size limits for say "tails", that can be met by trimming. Scute marking of hatchlings is one mechanism under trial to ensure the legal farm origin of skins.

The "CSG Review Report on Crocodile Conservation, Management and Farming in the Socialist Republic of Viet Nam" has been finalised and released (see page 6). The full report is now available on the CSG website (http://iucncsg.org/ph1/modules/Publications/reports.html). The main challenge for Viet Nam is to ensure imports of *C. siamensis* from Cambodia, and exports, particularly to China, are fully compliant with CITES. Efforts to register two additional captive breeding farms in Viet Nam with the CITES Secretariat are now underway. The reported production statistics for one farm (21-22 hatchlings produced per captive adult female maintained) should ideally be verified by the Vietnamese CITES Management Authority.

During November 2008, a CSG review team, under the leadership of CSG Deputy Chairman Alejandro Larriera, undertook a review of the conservation status, management and farming of crocodiles in Cuba. (see page 4). The full report with recommendations, in Spanish with English summary, is now available on the CSG website (http://iucncsg.org/ph1/modules/Publications/reports.html). Hybridisation between *C. acutus* and *C. rhombifer*, which appears to occur naturally in the wild, raises a series of novel problems for the conservation of *C. rhombifer*, which is endemic to Cuba and has a highly restricted distribution.

Over the past two years the CSG has once again been trying to assist Madagascar to improve the conservation, management and sustainable use of their *C. niloticus* population. Following a CSG review, field surveys of the wild populations were implemented in July-August. However, exports of large skins and products made from large skins, clearly derived from the wild and not from the ranching program, continues unabated. Commercial international trade in *C. niloticus* skins from Madagascar is not sustainable, is detrimental to the survival of the wild population, and is blatantly in breach of CITES, which will need to act decisively on this issue.

The CSG, through member, Phil Steel, has been attempting to review the "Crocodile Survey and Action Plan". Whilst a number of nominated reviewers have responded, the majority are still outstanding. It would be appreciated if the selected reviewers could finalise their components and get them back to Phil, or alternatively, advise Phil so he can find alternative reviewers.

Bergen Aquarium (Norway), in collaboration with Rene Hedegaard at Krokodille Zoo (Denmark), has been sponsoring a large, live crocodile exhibit, with 15 species and more than 35 individuals, emphasizing conservation and knowledge generation. The exhibit has been very successful, receiving over 257,000 visitors. The CSG has been pledged a modest contribution on a per visitor basis, which is earmarked to fund the CSG Student Research Assistance Scheme [see CSGN 27(2): 17]. We thank Bergen Zoo and Rene Hedegaard for the contribution of $US25,000 received in mid-January 2009.

There have been a number of changes to members of the CSG Steering Committee from the South Asia and Iran region (see page 32). I would like to take this opportunity to welcome Dr.

Toshinori Tsubouchi and Janaki Lenin as the new Regional Chairs for East and Southeast Asia and South Asia and Iran respectively. Activities proposed for these regions include: a CSG regional meeting in Madras, India, around October 2009; and, a workshop on crocodile conservation and management in Borneo [Sarawak, Sabah (Malaysia), Brunei, Kalimantan (Indoesia)] is to be held in Tuaran, Sabah, on 24-25 June 2009.

With the background of the Gharial crisis of December 2007, the "Veterinary Workshop - Necropsy Training" was hosted by the Madras Crocodile Bank Trust and the Gharial Conservation Alliance on 5-6 October 2008. Dr. Paolo Martelli, CSG Vice Chairman for Veterinary Science, played a leading role (see pages 12-13).

I wrote to REA Kaltim Plantations (Indonesia) about their proposal to develop large oil palm plantations in Mesangat Lake, East Kalimantan, which appears to be the main site where the Indonesian population of *C. siamensis* exists. There has been no formal response to the letter, and the world economy, with lower prices for palm oil, appears to be delaying the commencement of work. CSG members Hellen Kurniati and Jack Cox, with assistance from Rob Stuebing and Tarto Sugiarto, may be able to undertake a preliminary survey in February 2009.

Professor Grahame Webb, *CSG Chairman, <gwebb@wmi.com.au>*.

CSG Review with Recommendations on the Conservation, Management and Sustainable Use of Crocodilians in Cuba

Background

In December 2007 the CSG Chairman wrote to the Director of the Centre for Inspection and Environmental Control (CITMA), suggesting that a review (with recommendations) by the CSG could assist Cuba to: highlight achievements made, increase the CSG's knowledge on progress made; and, assist Cuban researchers and others involved with the management of crocodiles through direct on-site advice from the CSG. In April 2008, during the 23rd meeting of the CITES Animals Committee (AC23) in Geneva, the CSG Chairman met with José Alberto Álvarez (Cuban CITES Management Authority), who informed the CSG Chairman that there existed general support from Cuban authorities for a review.

On 8 May 2008, a letter from Jorge Álvarez Álvarez, Director of the CITES Management Authority (CCMA), informed the CSG that the CCMA and the National Department for the Conservation of Flora and Fauna (within the Ministry of Agriculture), had agreed to receive the CSG mission, and nominated José Alberto Álvarez and Roberto Rodríguez Soberón as national contacts for organising the visit.

The participation of the CSG Chairman in the review was cancelled at the last minute, and the final composition of the team was Alejandro Larriera (CSG Deputy Chairman), Carlos Piña (CSG Regional Chairman, Latin America and the Carribean) and Tom Dacey (CSG Executive Officer). Cuban contacts accompanying the team were Roberto Rodríguez Soberón (Flora and Fauna), Roberto (Toby) Ramos Targarona (Zapata Swamp Forestry Enterprise) and José Alberto Álvarez (CCMA). Dr. John Thorbjarnarson (Wildlife Conservation Society, USA) participated as an observer during the field trip. The review was undertaken on 6-15 November 2008.

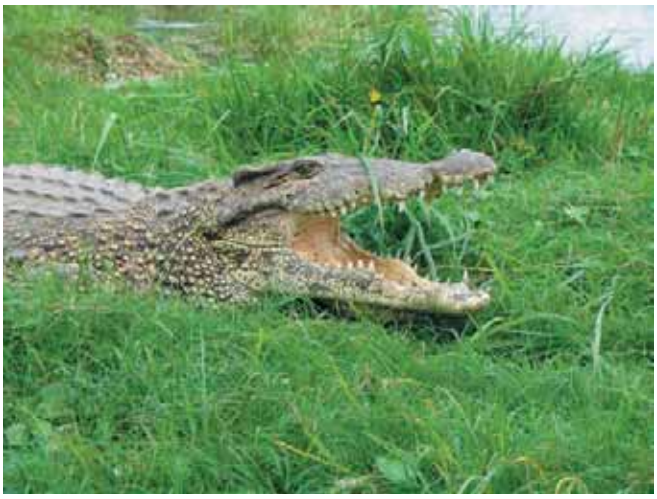

Figure 1. Adult Cuban crocodile at the Criadero de la Ciénaga de Zapata. Photograph: John Thorbjarnarson.

The endemic Cuban crocodile (*Crocodylus rhombifer*) is restricted to Zapata Swamp (mainland) and Lanier Swamp (Isle of Youth; re-introduced population), and a captive-breeding farm has been in operation since the late 1950s (Fig. 1). The American crocodile (*C. acutus*) has a more widespread distribution in Cuba, and was downlisted to CITES Appendix II at CITES CoP14 (2006), and is subject to an egg ranching program (Fig. 2). A feral population of *Caiman crocodilus* also exists on the Isle of Youth.

Figure 2. Adult American crocodiles at the Criadero de Manzanillo. Photograph: Tom Dacey.

Report with Recommendations

The full review report is available at "http://iucncsg.org/ph1/modules/Publications/reports.html". The report is written in Spanish, but includes "Conclusions and Final Recommendations" in English.

The review was undertaken within an environment of comraderie, friendship and open-ness, and the hospitality and assistance of the Cuban authorities throughout the visit is greatly appreciated.

The final 19 recommendations were:

By species:

Crocodylus acutus (Wild Populations)

1. To implement in the short-term, a wild egg ranching program in Monte Cabaniguán Refuge, based on the Cuban down-listing proposal accepted at CoP14.

2. To include other areas with good populations in the survey areas and evaluate their potential for nest/egg production, in order to increase the population subject to sustainable production, thereby generating incentives for *in situ* conservation of the species and its habitats.

Crocodylus acutus (Farming)

3. To undertake studies on egg quality and artificial incubation, in order to both explain and reduce the current high number of eggs that do not produce viable hatchlings.

4. To increase studies on the thermal management and housing of crocodiles under intensive farming conditions, in order to attain better growth rates and skin quality.

5. To increase studies on feeding (formulated, preferences and nutritional quality), and to provide food for farm raising.

Crocodylus rhombifer (Wild Populations)

6. To re-initiate and maintain a regular survey program in both remaining populations, in Zapata Swamp (natural) and Lanier Swamp (reintroduced).

7. To increase genetics studies in order to confirm or discard the hypothesis that hybridization between *C. acutus* and *C. rhombifer* occurs naturally in the wild.

8. If hybridization between *C. acutus* and *C. rhombifer* in Cuba occurs in the wild, as a natural event, to assess its past, present and future potential impact on *C. rhombifer*, with its reduced distribution.

9. To implement as soon as possible, and to sustain over time, the recommendations listed by the National working meeting on *C. rhombifer*, held at Zapata Swamp in May 2008 (Annex 2).

Crocodylus rhombifer (Farming)

10. To undertake studies on egg quality and artificial incubation, in order to both explain and reduce the current high number of eggs that do not produce viable hatchlings.

11. To increase studies on the thermal management and housing of crocodiles under intensive farming conditions, in order to attain better growth rates and skin quality.

12. To increase studies on feeding (formulated, preferences and nutritional quality), and to provide food for farm raising.

13. To determine, through genetic research, the degree of hybridization in the captive farm population.

14. Assess whether hybrids and pure *C. rhombifer* are discrete sub-populations that can be physically separated in the farm context.

Caiman crocodilus

15. To advance the development of population studies and surveys at the Isla de la Juventud, to quantify the status of the species in the wild, and the potential risks for the other crocodilian species if there is a high rate of population increase in *C. crocodilus* in the future.

16. To investigate the possible expansion of the management and harvest program for this species in the wild with a view to increasing the involvement of community rather than restricting the involvement to farm employees only.

General:

17. To facilitate access to different avenues of communication and international scientific contact, such as internet, in order for biologists, veterinarians and zoo technicians of the farms and monitoring programs, to be keep updated on the diverse and permanent improvements that are available on the web.

18. To facilitate the participation of Cuban specialists to both international scientific meetings and training courses in other similar projects overseas (Note: The ranching program in Argentina, has offered to receive and share with the Cuban colleagues experiences on ranching and caiman farming).

19. To advance market studies, and develop a sustainable commercial program for the different species, under different kinds of production, in order to implement short- and medium-term social and economic benefits to people from crocodiles. This can be achieved through wise management and creation of direct incentives for conserving crocodiles and their habitats.

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

CSG Review with Recommendations on Crocodile Conservation, Management and Farming in the Socialist Republic of Viet Nam

Background

On 4 October 2006 the CSG Chairman wrote to the Viet Nam Minister for Agriculture and Rural Development (MARD) concerning allegations of illegal trade in crocodiles between Cambodia and Viet Nam, and Viet Nam and China, which if found to be correct would have serious implications for the legal production and trade in crocodiles from Viet Nam in the future. Viet Nam responded that there had been no evidence found of illegal trade in crocodiles between Viet Nam and Cambodia, but that the control of cross border trade with Cambodia was difficult due to the length of the border and the numerous access points, both on land and water. These are understandable realities.

In order to strengthen the control of illegal trade, MARD directed the Vietnamese CITES Management Authority (MA) to develop a specific national action plan to 2010 and to collaborate with other law enforcement agencies to prevent and stop illegal trade of wildlife, including crocodiles.

On 14 February 2007, the CSG Chairman wrote to the Vice Minister for Agriculture and Rural Development, indicating that "The case for a thorough review of crocodile management and farming in Vietnam, with recommendations for improving controls, would seem to be strong". The CSG Chairman, met with Vietnam officials at CITES CoP14 (June 2007) and entered into subsequent discussions with Mr. Nguyen Huu Dzung, Vice-Director of Forest Protection Department, about the need to support legal trade and constrain illegal trade.

The CSG Executive Officer met with Vietnamese officials in Hanoi on 26 September 2007, who confirmed their support for a formal CSG review, and sought formal approval of the Minister for MARD. On 26 February 2008, Dr. Ha Cong Tuan, Director General, Forest Protection Department (CITES MA of Viet Nam), wrote to the CSG inviting them to participate in a mission to review the conservation, management and farming of crocodiles in Viet Nam. A CSG review team was formed in consultation with Vietnamese authorities, and draft Terms of Reference developed. The major aims of the review were to:

- Assemble available statistics on crocodile farms and farm stocks in Viet Nam and on the number of crocodiles and crocodile skins traded internationally;
- Visit a selection of large and small CITES-registered, non-registered and village level farms;
- Undertake consultations and interviews with major stakeholders;
- Formulate a review with recommendations; and,
- Present and discuss the findings and recommendations with all stakeholders (eg Government officials, crocodile industry, representatives of local people and NGOs).

Although the Siamese crocodile (*Crocodylus siamensis*) was the focus of the mission, information on the Saltwater crocodile (*C. porosus*) was also sought. The mission was carried out between 28 April and 5 May 2008, based on an itinerary mutually agreed upon before mission member's arrival. The CSG review team comprised Dr. Dietrich Jelden (CSG Deputy Chairman), Mr. Charlie Manolis (CSG Regional Chairman, Australia and Oceania), Dr. Toshinori Tsubouchi (CSG Regional Chairman, East and Southeast Asia) and Mrs. Nguyen Dao Ngoc Van (TRAFFIC Southeast Asia).

Report with Recommendations

The full review report is available at "http://iucncsg.org/ph1/modules/Publications/reports.html". Recommendations were divided into General and Specific classes.

General Recommendations (G1 to G5)

G1. The Government of Viet Nam needs to be fully aware that the status of wild populations of Siamese crocodiles (*Crocodylus siamensis*) in Viet Nam is a major concern for international wildlife conservation organisations, including the IUCN-SSC Crocodile Specialist Group (CSG). That this extinction is directly related to international trade in skins among other factors, is a serious issue given the aims and goals of CITES. Current conservation efforts in Viet Nam, which include identification of remnant populations and identification of sites where *C. siamensis* is extinct but where habitats may be suitable for the release of *C. siamensis*, needs to be maintained and where possible strengthened.

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G2. The historical and/or present status of the saltwater crocodile (*C. porosus*) within Viet Nam needs to be investigated. The species may now be extinct in Viet Nam, and international trade may have been involved. Captive stocks of *C. porosus* on some farms need to be identified, as they may contain the last genetic stock of *C. porosus* from Viet Nam. The Forest Protection Department (FPD) needs to consider the reintroduction of the species into some wild areas within Viet Nam.

G3. Improving the management of crocodile farming and trade in crocodile products from Viet Nam, and improving compliance with CITES, are considered essential prerequisites to improving crocodile management action in Viet Nam. Mandatory reporting for all farms, verification of data reported by all farms and implementation of a registration system for all establishments holding crocodiles are considered a priority. The development and implementation of a training programme on how to operate farming facilities in compliance with CITES provisions by making use of the international NGO expertise available in Viet Nam should be considered as another priority.

G4. Communication and information exchange between all stakeholders in Viet Nam with an interest in the conservation, management or sustainable use of crocodiles, needs to be improved. The current lack of open communication is a serious impediment to improved management in Viet Nam, and constrains public education about the link between crocodile conservation and

crocodile trade.

G5. Cross-border co-operation between neighbouring countries of the Mekong River basin is essential to improving the management and conservation of crocodile populations in the wild and in captivity, within and outside Viet Nam, particularly with Cambodia. A regional, international stakeholders workshop should be implemented as soon as possible to improve trans-boundary conservation efforts.

Specific Recommendations (S1 to S19)

Specific recommendations are listed and numbered in the order in which they appear in the report. The main general subject to which each specific recommendation refers is indicated in square brackets (CITES= CITES compliance and National Legislation; Captive= management and trade in captive populations; Wild= all matters concerning wild population; Illegal Trade= trade undertaken in contravention of National and International laws).

Specific recommendations are summarised as:

S1. Ensure appropriate legal actions are taken (eg confiscation, penalties, publicity) if the farm monitoring program identifies illegal stocks [CITES].

S2. Assess all breeding farms, including CITES-registered operations, to ensure compliance with CITES and National legislation [CITES].

S3. Continue close monitoring through FPD during the CITES registration process and beyond for MHCF and YCF to ensure that both operations are in full compliance with the resolutions on captive breeding and registration for operations that breed CITES Appendix-I animal species for commercial purposes [CITES].

S4. Continue close monitoring through FPD of HCF in particular with regard to the farm's remaining potential of producing hatchlings on its own [CITES].

S5. As satellite farms would be considered the easiest avenue for undetected illegal trade in hatchling crocodiles across borders with neighbouring countries, a significant increase of regular monitoring efforts of satellite farms on behalf of Government authorities is recommended [Captive, CITES].

S6. Establish under the FPD a Vietnamese Captive Breeding Monitoring Unit to monitor farms and wild populations. [Wild, Captive].

S7. Review and improve reporting system of farm data to the FPD. Any reporting review should also consider reviewing all transport permits issued over the past 10 years in Vietnam to determine which crocodile farms, including all satellite operations, comply with National and international regulations [Captive, CITES].

S8. At it earliest convenience, the centralisation, ongoing computerisation and analysis of farm records should be undertaken by FPD [Captive].

S9. Review the licensing system to ensure coverage of all farming operations (ie anyone with crocodiles), tanneries, traders and exporters [Captive].

S10. Strengthen enforcement capability of relevant agencies (eg customs, police, fisheries, market control, communities, forest protection and judiciary system) through training, capacity-building, information sharing and co-operation on CITES issues [Captive, Wild, CITES].

S11. Consider seeking CITES registration of all established crocodile farms that are producing *C. siamensis* through captive breeding and exporting. Exporting through other registered farms creates difficulties with control, reporting and compliance with CITES [Captive, CITES].

S12. Consider reviewing Government policy with regard to implementation of CITES Resolution Conf. 12.10 (Rev. CoP 14) registration of captive breeding operations for *C. siamensis* [CITES].

S13. Continue and intensify dialogue process with neighbouring States, through a regional working group under an appropriate body (e.g. ASEAN wildlife trade initiative and/or Mekong River Sub-regional CITES Working Group), to address regional issues and problems with *C. siamensis* [CITES].

S14. Establish a Crocodile Farming Association of Viet Nam, through which Government and industry can communicate more effectively [Wild, Captive].

S15. Develop and implement a National Crocodile Management Plan with clear targets and objectives for the management of the wild and the captive crocodile population of Viet Nam [Captive, Wild, CITES].

S16. Derive clear criteria for recognizing hybrids and assess and quantify the extent of hybridisation between *C. siamensis* x *C. rhombifer* on farms in Viet Nam [Captive, Wild].

S17. Implement actions to contain, reduce or eliminate hybridization in order to minimise or eliminate the possibility of *C. siamensis* x *C. rhombifer* genetic material entering the wild Siamese crocodile population [Wild, Captive].

S18. Identify new protected areas and/or sanctuaries for future reintroduction or recovery programs for *C. siamensis*, and possibly *C. porosus* [Wild].

S19. Continue regular systematic monitoring of reintroduced populations of *C. siamensis* so that the success of this conservation initiative can be assessed objectively, and used to underpin other reintroduction programs [Wild].

Figure 1. Large numbers of crocodile products are manufactured for the local tourist market, as well as for export. Photograph: Charlie Manolis.

Figure 2. Some of the larger crocodile farms are also involved in tourism. Photograph: Charlie Manolis.

Figure 3. Juvenile *C. siamensis* at a satellite farm, where efforts were being made to improve raising facilities (eg smooth surfaces) to reduce skin defects. Photograph: Charlie Manolis.

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

"Global Re-Introduction Perspectives"

The IUCN-SSC Reintroduction Specialist Group (RSG), in conjunction with the Environment Agency-Abu Dhabi (UAE) and the Denver Zoological Foundation (USA), has published "Global Re-Introduction Perspectives - Re-introduction Case -Studies from around the Globe". Edited by Pritpal S. Soorae, the book presents a range of re-introduction case studies, with examples from invertebrates (corals, clams, 2 insects), fish (7 species), amphibians (3 species), reptiles (tuatara, 1 lizard, 1 snake, 1 turtle, 4 crocodilians), birds (16 species), mammals (10 species) and plants (10 species).

All case-studies have been prepared in a standardised format: Introduction, Goals, Success Indicators, Project Summary, Major Difficulties Faced, Major Lessons Learned and Success of Project (with reasons for success or failure). The projects selected varied with regard to success: 21% Highly Successful, 33% Successful, 43% Partially Successful and 3% were Failures. With regard to crocodilians, the following four projects were included:

Xiaobing Wu and Hongxing Jiang. Re-introduction of Chinese alligators into the Gaojingmiao forestry farm, Anhui Province, China.

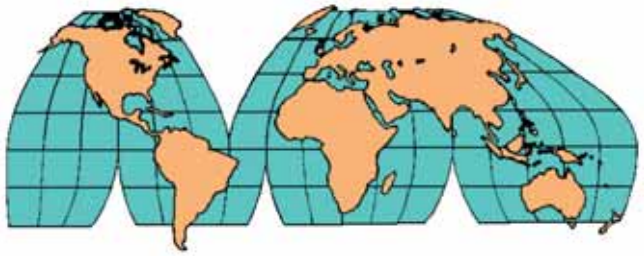
Merlijn van Weerd and Jan van der Ploeg. Philippine Crocodile hatchling head-start and re-enforcement program in San Mariano, Isabela Province, Luzon, the Philippines.

Alvaro Velasco B., Rafael Antelo and Omar Hernandez. Conservation plan and re-introduction program of Orinoco Crocodile in Venezuela.

R.J. Rao. Supplementation of Indian Gharial in protected areas of Madya Pradesh, India.

The book, which also includes two IUCN Policy Guidelines on translocations and re-introductions, can be downloaded from <http://www.iucnsscrsg.org> (downloads section).

Regional Reports



Latin America & the Caribbean

Mexico

MORELETII RBPC PROJECT: TABASCO, MEXICO. In Mexico, crocodilians are represented by three species, that are

distributed over a large part of the national territory: *Caiman crocodilus fuscus* (caiman or pululo), *Crocodylus acutus* (royal or river crocodile) and *C. moreletii* (swamp crocodile or swamp lizard). These species were extensively exploited in the past, and in 1970 a total ban on the hunting of wild populations was established; some poaching continues. In the same decade, research papers on the status of crocodilians as a natural resource began to be published, but none examined the status of wild populations, particularly *C. moreletii*.

Knowledge on the current status of wild *C. moreletii* populations in Mexico is limited, although there has been an overall assessment of the species. In the State of Tabasco, population studies have included characterisation by longitudal range of *C. moreletii* in Illusions Lake (Pacheco-De la Cruz 1997) and monitoring of wild populations in the municipalities of Jonuta, Nacajuca and Balancan (Figueroa-Ocaña 2000). As Tabasco has 30% of the water resources of Mexico, which form wetlands of great importance such as the Biosphere Preserve of Centla Swamps (BPCS), in 2003 a multidisciplinary group of researchers received a support research grant from the National Council of Science and Technology (CONACYT) for a project entitled "Evaluation and Diagnosis of the Population of Swamp Crocodile (*Crocodylus moreletii*) in the Biosphere Preserve of Centla Swamps, Tabasco Mexico" - the title of which was shortened to "Moreletii RBPC Project".

The main objective of the Moreletii RBPC Project was to develop assessment, protection and management strategies for *C. moreletii* populations through the characterisation and evaluation of geographical, biological and environmental conditions of the species in the BPCS. Fieldwork was divided into three research stages: a) remote sensing of study sites; b) population studies; and, c) verification of population studies.

Figure 1. Members of the Moreletii RBPC Project team; (from left) Marco Palacios, Juan Valencia, José Gallegos, Fernando Rodríguez-Quevedo, Eunice Pérez-Sánchez, Ranferi Antonio and Natalia Ovando-Hidalgo. Photograph: Moreletii RBPC Project.

The team was made up of: Eunice Perez-Sánchez (project head), specialist in water-based resources management; Fernando Rodriguez-Quevedo (head of crocodile program), specialist in management and conservation of *C. moreletii*; Carolina Zequeira-Larios, specialist in database design and sustainable development; and, Jorge Cruz-Vera, specialist in molecular biology (see Fig. 1).

Fifteen undergraduate students of the Division Academica de Ciencias Biologicas, undergoing BSc programs on biology, ecology and environmental engineering, collaborated in different aspects of fieldwork and database analysis within the program. Students and researchers of the Universidad Juarez Autonoma de Tabasco, as well as others outside this institution, were also involved in training courses organized by the project on different topics (eg Qualitative Research Techniques in Biological Sciences; Community Environmental Assessment; First Aid (rescue practices); GIS Modelling for the Evaluation and Management of Natural Resources; Applications of GIS in the Management of Wildlife; Aerial Photography; Watershed Management in the Rural-Urban Interface and Use and Management of GPS Equipment).

Any actions taken to address and manage conservation plans for crocodilians in protected natural areas will depend on knowledge of wild populations. Taking into account the main objective of the project, as well as the current patterns of social development, the integration of communities located in and around the BPCS was a key strategy to develop the project, as these communities interact daily with the species and its habitat. The building of a database detailing the state of the crocodile population provides the basis for devising short-, medium- and long-term protection and monitoring programs for the species, particularly for population control and structure conservation to support its survival. In addition, the project will provide information about the toxicological exposure of *C. moreletii* to pesticides, identifying locations of high, medium and low risk groups and actions to reduce impacts on wild populations. Based on these data, two undergraduate dissertations have been produced and one postgraduate dissertation is in progress.

Collaboration with different research groups and specialists have been developed and supported through the Moreletii RBPC Project. Two academic events, with international and national impact, were organized with the objective of exchanging experiences and scientific knowledge/technology for conservation of habitat and species: II Workshop/ Symposium on Coastal Ecosystems of the Gulf of Mexico and Caribbean Sea: Towards the Integration of Research Groups; and, 2nd Week Crocodile: Management of Populations of Wild Crocodiles.

Scientific papers and notes have been produced (eg Rodríguez-Quevedo *et al*. 2007; Pérez-Sánchez *et al*. 2006). Academic visits have allowed exchange of management approaches with other specialists and researchers working with other species. Two academic visits for research and outreach were made in 2007 (Crocodile Farm COCOMEX S.A. of C.V., Culiacán Sinaloa; UMA Reptilario CIPACTLI, Universidad de Guadalajara, Puerto Vallarta, Jalisco). Academic exchange

programs have also been supported through the project. For example, Helios Hernández Hurtado (UMA Reptilario CIPACTLI, Universidad de Guadalajara) conducted an academic visit as part of his PhD program, collaborating on wild population management approaches and issues of the Moreletii RBPC Project.

We have obtained valuable data for a greater understanding of wild populations of *C. moreletii*, that will promote and support conservation and restoration, where needed, to ensure the presence of the species as an essential part of mangrove and swamps ecosystems, so important for the conservation of biodiversity in the State of Tabasco.

Acknowledgements

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ASSESSMENT OF HUMAN-CROCODILE INTERACTION IN THE STATE OF TABASCO, MEXICO. The State of Tabasco represents significant biodiversity status. Over its territory flows a third of Mexico's hydrological resources, forming diverse wetlands of great importance such as the Biosphere Preserve of Centla Swamps (BPCS). This wetland is one of the largest in Mesoamerica, and is classified by the Ramsar Convention as a high-priority wetland due to its large area (302,706 ha) and high biodiversity (Barba *et al*. 2006). Around 569 species of vascular plants and 523 species of vertebrates have been listed for BPCS (Romero *et al*. 2000), many of which are classified as "threatened" or "in danger of extinction" according to the Mexican Official Norm NOM-059-SEMARNAT-2001. Hunting of wildlife is prohibited within the area (SEMARNAP 2000). Morelet's crocodile (*Crocodylus moreletii*) is protected by Mexico Wildlife General Law approved in July 2000 and is considered a Species Subject to Special Protection by the NOM-059-SEMARNAT-2001. Wild *C. moreletii* populations cannot be used for commercial purposes, but commercial use of the species is possible through closed-cycle farms (Domínguez-Laso 2006).

A study to quantify interactions between *C. moreletii* and the human population in the BPCS was carried out within the "Moreletii RBPC Project" funded by the National Council for Research and Technology of Mexico (see preceding article). The study took place from 2005 to 2007. Data were collected through a questionnaire applied randomly in 30 rural communities. Questions were designed to identify the existing conflicts between people and *C. moreletii*, either for the use of natural resources or for physical space, as well as to determine the perception of BPCS residents of *C. moreletii* as a commercial resource.

The results of the study indicated that *C. moreletii* habitat is well known by BPCS residents. Interaction with the species is significant, with most of interviewees knowing where to find the species. Residents were careful when they were questioned about hunting practices - 11% reported occasional hunting for live animals for sale as pets [price around $MX100 ($USD9.40)]. The reactions of residents when

seeing a crocodile were diverse, varying from ignoring their presence (perceived as another organism that is part of the local environment) to just going away. It was widely accepted that the "crocodile is an animal that if you don't bother it he doesn't harm you", similarly to observations in Central America (Escobedo 2004).

The residents of BPCS possess a remarkable knowledge of the flora and fauna of the swamps; only 8% of residents reported to have a crocodile in their "backyard" or allow them to come ashore on their land. The acceptance and respect that the residents showed for the species were also demonstrated by the proximity of crocodile nests to houses, and the transfer of hatchlings by female crocodiles or by local residents to nearby natural or man-made ponds (*jagüey*) to protect them while they grow. These *jagüeyes* are designed in a way that allows them to fill with water during natural flooding periods. During this time the crocodiles can return to larger waterbodies to find food or refuge. Crocodiles maintained under these conditions are treated as part of the family, and are fed, protected and even given a name.

"Conflicts" with crocodiles are mainly due to people's fear of potential attack on children, livestock or poultry. However, the incidence of these events is low, and it was generally recognized that attacks have been either accidental or due to people "annoying" or provoking adult crocodiles. Accidental deaths of crocodile were reported as a result of entanglement in fishing nets, being run over on the highway, or when caught in fires associated with agriculture activities.

It is known in the BPCS that hunting of crocodiles is illegal. However, fishermen in the area are always prepared to capture crocodiles, but only if they have the proper tools. It is not a very common activity, since the market for crocodile skin in the area has diminished significantly; it forces poachers to commercialize crocodile skins outside of the BPCS.

The residents interviewed expressed great interest in protecting *C. moreletii*, but pointed out that they do not have enough information and ignore the legal possibilities that allow appropriate handling of the species, and lack the economic resources to carry out any protection plan. There is a management scheme promoted by the Environment and Natural Resources Secretariat for conservation in natural protected areas (Wildlife Management Units), which could allow maintenance of the species and at the same time support commercial advantages. Use for human consumption or commercialization should not be considered negative. *Crocodylus moreletii* has been locally appreciated for generations for the flavor and nutritional value of its meat, and is included in the traditional way of life of the residents of the BPCS.

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Argentina

MANAGEMENT AND CONSERVATION OF ARGENTINEAN CROCODYLIA WORKING MEETING. A working meeting on Management and Conservation of Argentinean Crocodylia, hosted by Proyecto Yacaré, was held in Granja la Esmeralda (Santa Fe City), on 25 November 2008.

Thirty-two participants from Argentina, involved with management and/or research on caimans, participated in the one-day meeting. This included: representatives of all the ranching programs in the country; representatives of the National authority (Dirección de Fauna Silvestre de la Nación); authorities of the different Provinces (Dirección de Recursos Naturales de Corrientes, Dirección de Fauna y Parques de Formosa, Secretaría de Recursos Naturales of

Santa Fe Province, Subsecretaría de Producción Agrícola, Recursos Naturales y Desarrollo Rural de la Secretaría de la Producción of Entre Ríos Province); and, researchers from universities and institutes (CICyTTP-CONICET, UNL).

The meeting began with a welcome by Alejandro Larriera (CSG Deputy Chairman), where he outlined the origin, objectives and actions of the CSG regional office. He also detailed the history of the CSG and the changes in the structure in different regions, the increase in Latin American representation in the last four CSG working meetings, the re-organization of the CSG, and the creation of a new structure in the Latin America and the Caribbean Region. The Regional Office can now respond directly to the CSG Executive Committee, through replacement of a single Regional Chairman by Regional Thematic Chairmen and Regional Vice Chairmen.

Alejandro also detailed and explained the criteria for CSG membership, and the new questionnaire that is circulating among members, ex-members and potential members. Finally, he asked for the participation of all the audience to share part of their time and knowledge to contribute to crocodiles conservation - the major objective of the CSG.

Lic. Walter Prado gave a presentation on control and law enforcement of ranching programs in the country, where he detailed most of the legislation relevant to caiman management. He expressed the need for carrying out proper marking of the hatchlings to ensure that they are easily recognized. Walter also mentioned that the Dirección de Fauna Silvestre de la Nación, and other organizations, are working on modifications to Resolución 03/2004, such that only caiman species are included on the resolution. All the participants agree that this was a very important action.

We also discussed whether monitoring was an efficient tool to asses the impact of ranching in *Caiman latirostris* populations (Larriera *et al*. presented a paper on this issue at the 19th CSG meeting). It was agreed that monitoring should be improved and some other indicators be included, such as environmental variables and harvesting information to evaluate potential impact in the mid- and long-term.

Some participants expressed different opinions about the utility (or efficiency) of ranching for the conservation of wild species. Most participants mentioned that ranching does help populations because it saves wild animals in cases of severe drought or drastic environmental change (eg marsh canalization), but more importantly, it is an incentive for species conservation by local inhabitants. It was also noted that ranching helps habitat conservation where caimans live, and that public education, as an element of ranching programs, plays an important role in conservation.

Pablo Siroski gave a presentation on production, with the main objective the creation of an association that includes all producers and people involved in the caiman market, to promote and protect common interests. The basis for an association are:

- It has to represent all the members, in order to facilitate contact and protect their interests.
- To discuss and propose projects of general benefit.
- To share services.
- To be a link for research funding.

At a previous meeting in September 2007, some people have expressed the necessity for all producers to be in an association; now producers and some other people interested have decided to develop such an association.

The ranching programs [Yacaré Porá (Corrientes), Caimanes de Formosa, Proyecto Caimán (Formosa), Yacarés Santafesinos (Santa Fe)], agreed to participate in the association, and Sergio Trachter has offered himself to develop and prepare the paper work and to contact by e-mail other possible interested people.

Finally there was a session on research, where we listed all the research projects that are being implemented (or planned for the near future) in Argentina, in order to integrate and have an idea on what different groups are doing. The importance of having fluid interaction among research groups in order to optimize human resources, facilitate sampling, fieldwork costs, etc., was highlighted.

Dr. Carlos Piña, *CSG Regional Chairman for Latin America and the Caribbean, <cidcarlos@infoaire.com.ar>* and Josefina Boned, *CSG Regional Office for Latin America and the Carribean <oficinaregionalcsg@gmail.com>*.

Europe

DGHT STUDBOOK FOR CHINESE ALLIGATOR. The Chinese alligator (*Alligator sinensis*) is a critically endangered species that has been legally and illegally exported to Europe. The Crocodilian Working Group of the German Herpetological Society (DGHT) recently created a studbook for captive *A. sinensis* in Europe, which is available to zoos, aquaria and the private sector. The studbook currently lists 39 individuals (10 M, 15 F, 14 U) from Germany (31), Denmark (5), Netherlands (2) and France (1). Thirteen of these individuals are held in zoos, and 26 are in private holdings. In order to increase the gene pool, all European breeders/owners of *A. sinensis* are encouraged to list their animals in the DGHT studbook. To date, no captive breeding of the species is known to have occurred in Europe.

Dr. Bernd Jensch, *Studbook Keeper, Chinese Alligator, AG Krokodile of DGHT, <info@crocworld.de>*.

South Asia and Iran

India

The Gharial crisis that occurred in the Chambal River in December 2007 demonstrated a general lack of training and experience in the region when it comes to conducting reptile

post-mortems, collecting samples and recording findings. To improve this situation, a Veterinary Workshop - Necropsy Training was organized at the Madras Crocodile Bank Trust (MCBT) on 5-6 October 2008, designed to teach participants how to perform technically sound necropsies and to accurately record and report data. The workshop was hosted by the MCBT and the Gharial Conservation Alliance (GCA).

The first day involved detailed training in post-mortem procedure. Physical examination and sample collection methods were demonstrated, including the location of blood collection sites. This was followed by a detailed demonstration of post-mortem procedure. Participants were divided into two groups of three and each person was trained in actual procedure, appropriate sample collection, management and data recording. Participants were then shown how to convert data to an electronic format following the Necropsy Guide designed by Dr. Paolo Martelli and Dr. Fritz Huchzermeyer (CSG). As a standard reporting procedure is essential when consulting with experts from different regions and backgrounds (pharmacology, toxicology, etc.), the importance of appropriate terminology and descriptive methods were emphasized.

The second day continued with participants working independently and with different working groups on post-mortem procedures. Post-mortems were performed on a Gharial (*Gavialis gangeticus*) and a Mugger crocodile (*Crocodylus palustris*) with a history of disease. The gross pathology of all organs was discussed and samples collected. The post-lunch session involved hands-on training in crocodile capture and restraint led by Nikhil Whitaker (Curator, MCBT) and MCBT keepers. Blood collection at different injection sites was practised on live animals under the supervision of Dr. Martelli. Samples were taken to the laboratory and the participants briefed on simple laboratory techniques that could be carried out in the field with only modest equipment.

Dr. Martelli discussed and presented reports on various aspects of the Gharial Crisis of 2007. He then presented global cases of pathological conditions in crocodilians to familiarise participants with crocodilian organ pathology and common diseases. A presentation was also given on correct crocodile capture and restraint procedures.

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We appreciate the attendance of all participants: Dr. J.K. Jatav, Dr. A. Sha Arun, Dr. Yaduraj Khadpekar, Dr. Prabhat Basumatary, Dr. Phulmoni Gogoi, Dr. Priyadarshini Govind, Dr. Gowri Mallapur. We would also like to thank the Zoological Society of San Diego and Cleveland Zoo (USA) for generous donations; Dr. Paolo Martelli, Oceanpark (Hong Kong) for time and expertise; Central Zoo Authority (India) for providing a laboratory development grant; Romulus Whitaker (Gharial Conservation Alliance); Ravi Singh (WWF); Suhas Kumar (MPFD); Kartick Satynarayanan (WLSOS); Vivek Menon (WTI); Dr. N.V.K. Ashraf, (WTI); and, MCBT staff.

Figure 1. Workshop attendants (L-R). Dr. Y. Khadpekar, Dr. P. Gogoi, Dr. G. Mallapur, Dr. A. Sha Arun, R. Whitaker, Dr. P. Martelli, Dr. P. Basumatary, N. Whitaker, S. Mukherjee, Dr. J.K. Jatav, K. Mumnnuswamy. Photograph: P. Molur.

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Iran

FIRST STEPS TOWARDS ESTABLISHMENT OF A CROCODILE REHABILITATION CENTRE. The Iranian population of Mugger crocodile (*Crocodylus palustris*) is small and scattered in the southeastern part of the country, near the border with Pakistan. The main habitats can be classified in two main natural and artificial habitats. The main natural habitats are the small and large ponds along the main rivers: Kaju, Sarbaz and Bahukalat (Mobaraki 2002). The artificial water bodies also play an essential role for the crocodile population, with small and large ponds near villages constructed for rainwater storage for daily use by local people.

Movement of crocodiles between habitats has been reported in the area (Mobaraki and Abtin 2007). In most areas crocodiles have close contact with local people, creating some problems. The main part of the crocodiles' range, designated by importance of habitat, is a "protected area". The small ponds dry out some months after the rainy season, and crocodiles leave these drying ponds to find new ones.

In ponds near villages some aggressive crocodiles provide problems to local people by attacking livestock. In these cases the crocodiles should be removed and/or kept in other places. The establishment of rehabilitation centres are considered necessary to control this situation, as well as achieving other objectives.

In this regard, "Dargas Station" has the best characteristics as a rehabilitation centre, due to its location in the central part of the area, and facilities. One pond is inside the station area to house crocodiles (Fig. 1), and one burrow beside the pond is also used by the crocodiles there (Fig. 2). At the moment the pond maintains 7 small and large crocodiles. The intention is to expand the facilities to facilitate captive breeding and rearing for conservation goals.

Figure 1. Pond at Dargas Station.

Figure 2. Crocodile using artificial burrow.

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Bangladesh

SECOND COMMERCIAL FARM APPROVED. On 22 December 2008, the Wildlife Advisory Board of the Government of the People's Republic of Bangladesh approved a second commercial crocodile farm (Akij Wildlife Farm Ltd). The company plans to import Saltwater crocodiles (*Crocodylus porosus*) from CITES-registered commercial farms soon. The proposed farm site is in Gazipur, near Dhaka.

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Australia and Oceania

Australia

QUEENSLAND CROCODILE RESEARCH AND MANAGEMENT PROGRAM UNDER FIRE. In early November 2008, reports of a 3.5 m long Saltwater crocodile (*Crocodylus porosus*) at Magnetic Island, off the coast of Townsville, Queensland, began a chain of events that have rocked the State wildlife authority and Government. The crocodile, nick-named "Wighty", had been relocated some 1000 km from a sparsely populated area of Cape York to Magnetic Island, a highly populated tourist area. "Wighty", which had been fitted with a satellite transmitter prior to its relocation, had disrupted residents and holiday makers on the island, leading to its recapture by Queensland Parks and Wildlife Service (QPWS)/Environmental Protection Agency (EPA) staff.

A media release later claimed "Wighty" had died soon after capture, as a result of having ingested a number of plastic bags. Amidst the media delving into the veracity of the cause of death, on 12 November 2008 an anonymous letter was tabled in the Queensland Parliament by Mr. Lawrence Springborg MP. The letter, believed to have been written by a QPW officer, alleged gross mismanagement and negligence by the QPWS crocodile research and management division, and that a "culture of secrecy, deceit and intimidation exists in the QPW northern region". The letter claimed:

- The crocodile that attacked and killed Mr. Barry Jefferies at Lakefield National Park in August 2005 had been previously captured and relocated to this section of the river by QPW. Despite a QPW media release at the time advising the crocodile responsible for the attack had been shot, it was actually captured a week later, several kilometres downstream. It was then taken to a QPW facility in Townsville, where it was held for two months before being transported to Steve Irwin's "Australia Zoo", where it disgorged Mr. Jefferies' dental plate while in the enclosure.

- The crocodile that killed Mr. Arthur Booker in Cooktown (30 September 2008) was known by QPWS as a potentially dangerous "problem" animal.

- That a large crocodile ("Wighty") had been relocated from a sparsely inhabited area to Magnetic Island (see above).

- Any staff that opposed relocation/release of dangerous crocodiles in the name of science and research were subject to harassment and threats by management. QPW officers have been gagged and threatened with dismissal if they speak out against circumstances surrounding the two recent deaths (2005 and 2008) resulting from crocodile attacks.

- Hard copy files have been destroyed, personal diaries confiscated and lost, and electronic data (server back up tapes and discs) have been erased in the event of a potentially damaging Freedom of Information request.

It appears that Saltwater crocodiles were relocated, despite current QPW-EPA crocodile management policy which states "that problem crocodiles will not be relocated due to the risk of such crocodiles returning to their capture location" and that "All crocodiles two meters or greater in length will be automatically targeted for removal from defined urban zones unless the crocodiles are clearly only passing through the zone or are in well known crocodile habitat areas within that zone" [Nature Conservation (Estuarine Crocodile) Conservation Plan 2007 and Management Program 2007-2017; www.epa.qld.gov.au/publications/?id=2259).

On 27 November 2008, QPW revealed that in May 2006 another crocodile had been relocated from Alligator Creek to the Bohle River, near Townsville (Sydney Morning Herald 13/12/2008).

Many of the claims were denied by the EPA, and Director General Terry Wall responded (Sydney Morning Herald 13/12/2008):

- Denying the two deaths had anything to do with relocated crocodiles. "The crocodile that killed Arthur Booker this year had never previously been caught or trapped by the EPA".

- The EPA had relocated the crocodile that killed Mr. Jefferies but only back to its original home after it was trapped some distance away at the end of the wet season. "The crocodile was in its original and long-term home when it killed Mr. Jefferies".

- "Neither the Bohle crocodile nor Wighty were targeted by the EPA for removal as problem crocodiles. Wighty was captured incidentally during a trapping operation for another animal."

The allegations raised in the anonymous letter have resulted in an investigation by Queensland's Crime and Misconduct Commission, an internal review of EPA management and scientific processes, and an independent audit of EPA crocodile research and management (Sydney Morning Herald 13/12/2008).

Over the last few years EPA has been under public pressure to deal with increasing numbers of crocodiles in urban areas. Crocodiles have been sighted in areas where they have not been known in living memory, and anecdotal evidence suggests an increasing crocodile population. However, EPA reports (unpublished, unsighted) deny that this is the case. Although the Queensland Crocodile Management Program advocates sustainable use, long-term efforts to establish a limited wild egg harvest (as operate in the Northern Territory, Western Australia and many other countries around the world) have been met with bureaucratic and "scientific" hurdles. Hopefully the internal review now underway will allow crocodile management to proceed in a sound, realistic manner, ensuring the long-term conservation of the species.

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North America

USA

INITIAL IMPACT OF HURRICANES GUSTAV AND IKE ON ALLIGATORS IN LOUISIANA. Hurricane Gustav was a powerful hurricane that made landfall at Cocodrie, Louisiana on 1 September 2008. Although the worst of the flooding from storm surge affected southeast Louisiana, nearly the entire state was affected by widespread power outages. The state's capital, Baton Rouge, was particularly hard hit and numerous regions were without electricity for over two weeks. Fortunately storm surge effects were less than anticipated; although long-term effects on marsh degradation and habitat loss due to saltwater intrusion and wave action remain to be quantified.

Hurricane Ike was a tremendously large Category 2 hurricane that made landfall on Saturday morning, 13 September 2008, near Galveston, Texas. Essentially the entire coast of Louisiana was affected by this storm with massive areas of flooding due to hide tides and storm surges; southwest Louisiana was severely impacted. These two storms were ominously reminiscent of the same scenario that occurred just three years ago when Hurricanes Katrina and Rita devastated southeast and southwest Louisiana respectively.

Similar to Katrina/Rita in 2005, the storms in 2008 occurred during the wild alligator harvest in Louisiana. The harvest season began 27 August in the east zone and 3 September in the west zone. Coastal marshes had recovered fairly well from the 2005 hurricanes, and the nest count in 2008 was the second best year (over 43,000 nests) on record (Fig. 1). This nest count/population index led to a record alligator harvest quota (CITES tag allocation) of 40,725 alligators.

The timing of Hurricanes Gustav and Ike was just after the completion of wild alligator egg ranching activities (eggs are deposited in June, and hatch from mid-August to early September). As we experienced with Hurricanes Katrina and Rita, the wise use of an egg ranching program likely saved thousands of alligator eggs/new hatchlings from natural mortality. Uncollected eggs may have flooded and some wild

hatchlings may have been displaced by storm surge or killed by high salinity storm waters had they not been previously collected by participating landowners/egg ranchers.

Figure 1. Alligator nest in recovered marsh at Rockefeller.

Due to numerous factors (displacement of alligator trappers from their homes, lack of electricity to power walk-in freezers/coolers for hide/meat processors, shortages of ice and fuel, etc.) the alligator season was extended until 19 October to allow trappers additional time to harvest their alligators and allow for proper processing of the meat and hides. Some 35,000 (about 86%) of tags issued were used; we believe the alligator season was quite successful despite the obstacles of implementing the harvest due to the hurricanes.

We have been pleased that our first year using bar-coded CITES tags was successful. Minimal problems were encountered in the field and mandatory hide inspections prior to shipping have been streamlined with incorporation of this technology.

Rockefeller Refuge is located in southwest Louisiana in Cameron and Vermilion Parishes. Its coastal location and low elevation make it prone to inundation and many protection levees remain damaged from Hurricane Rita in September 2005. Cameron Parish roads located several miles inland from the coast were already overtopped by high tidewater by mid-day Friday, hours before Hurricane Ike made landfall.

The storm surge from Hurricane Ike was estimated to be approximately 2.4 m (8') at Rockefeller's Headquarters and office facilities. The four newly rebuilt metal buildings (shop, lumber shed, boat shed, and tractor shed) sustained some damage, most extensively to the shop (Fig. 2).

The portable buildings (temporary lab and two equipment buildings - one for fisheries research equipment and one for alligator research equipment) were completely washed away, as were three alligator egg incubators fabricated by staff. The older alligator holding tanks/facilities were damaged with loss of lids and hinges; the awning/cover appeared to have weathered the storm with little if any damage (Fig. 3).

Figure 2. Flooded shop.

Figure 3. Flooded alligator tanks.

Habitat loss continues to be a problem on the area, as many protection levees were already in substandard condition due to extensive damage from Hurricane Rita in 2005. Continued wave action with high tides and subsidence has reduced the effectiveness of some levees; in some areas they are eroded nearly to marsh level.

Limited if any loss of wildlife was noted in preliminary surveys. Numerous alligators and turtles were seen and alligators appeared in good condition; some were undoubtedly pushed north by high water. No major fish kills were noted; minor losses were observed. Vegetative damage to plant communities may be evident over time but preliminary salinity measurements were not excessively high. LDWF employees stationed at Rockefeller were all displaced, but fortunately only for several weeks.

Thus far it has been a relatively dry fall; we are hopeful normal winter rains will help dilute residual waters of higher than desired salinities and restore healthier conditions to the marsh and enhance conditions for alligator nesting next summer.

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SUCCESSFUL HATCHING OF TOMISTOMA. The San Antonio Zoo's (SAZ) Department of Herpetology proudly announces the successful hatching of two *Tomistoma schlegelii*. This has been an ongoing challenge for our department since acquiring a compatible adult pair of Tomistoma in 1995 (male is on loan from St. Augustine Alligator Farm and female belongs to SAZ). The male is approximately 4.0-4.3 m (13-14') long, and the female is around 3 m (10') in length. Both animals are wild-caught of unknown age, but are believed to be close to 40 years old.

The female has routinely nested and laid eggs over the last 10 years. However, all eggs proved to be infertile until this year. Hopefully fertility will increase with future clutches.

The clutch (45 eggs) was laid on 8 June 2008, and eggs were collected on 10 June. The nest mound measured 216 cm (length), 132 (width) and 60 cm (height). Temperature at the top of the nest was 30°C and in the egg chamber it was 32.7°C. Water temperature nearest the nest was 26°C - water flowing into the exhibit is 25.5°C. Details on the two hatchlings (Fig. 1) are summarised below.

Hatchling:	No. 1	No. 2
Hatch date:	16 Sep	19 Sep
Incubation temperature (°C):	31.0-32.7	31.0
Incubation period (d):	100	103
Initial egg weight (g):	205.4	204.4
Bodyweight (g):	111	118.5
Total length (cm):	34	32
Snout-vent length (cm):	15.8	14.5
Head length (cm):	5.5	5.5
Head width (cm):	21	21

Figure 1. Hatchling *Tomistoma schlegelii*.

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Science

Recent Publications

Matthew L. Brien, Michael S. Cherkiss and Frank J. Mazzotti. (2008). American crocodile, *Crocodylus acutus*, mortalities in southern Florida. Florida Field Naturalist 36(3): 55-59.

Abstract: Deaths of 143 American crocodiles (*Crocodylus acutus*) were recorded in southern Florida between 1967 and November 2007. The majority of deceased crocodiles (67.8%) were located adjacent to a road, with vehicle collision the likely cause of death. Mortalities have increased over time with 51% of deaths occurring over the past nine years. Recommendations to reduce vehicle collisions include underpasses, fenced roadways, warning signs and seasonal speed restrictions in areas where crocodiles are known to cross the road or where deaths have occurred.

McVay, J.D., Rodriguez, D., Rainwater, T.R., Dever, J.A., Platt, S.G., McMurry, S.T., Forstner, M.R.J. and Densmore, L.D. (2008). Evidence of multiple paternity in Morelet's crocodile (*Crocodylus moreletii*) in Belize, CA, inferred from microsatellite markers. J. Exp. Zool. 309A: 643-648.

Abstract: Microsatellite data were generated from hatchlings collected from ten nests of Morelet's Crocodile (*Crocodylus moreletii*) from New River Lagoon and Gold Button Lagoon in Belize to test for evidence of multiple paternity. Nine microsatellite loci were genotyped for 188 individuals from the 10 nests, alongside 42 nonhatchlings from Gold Button Lagoon. Then mitochondrial control region sequences were generated for the nonhatchlings and for one individual from each nest to test for presence of *C. acutus*-like haplotypes. Analyses of five of the nine microsatellite loci revealed evidence that progeny from five of the ten nests were sired by at least two males. These data suggest the presence of multiple paternity as a mating strategy in the true crocodiles. This information may be useful in the application of conservation and management techniques to the 12 species in this genus, most of which are threatened or endangered.

Platt, S.G., Rainwater, T.R., Thorbjarnarson, J.B. and McMurry, S.T. (2008). Scalation of Morelet's crocodile (*Crocodylus moreletii*) from northern Belize. Herpetological Review 39(3): 293-296.

Abstract: We describe scalation in a large sample (n = 102) of Morelet's crocodile (*Crocodylus moreletii*) collected in freshwater wetlands of northern Belize from 1994 through 1997. We found little variation in the number of post-occipital scales (mean = 4.0 ± 0.4; range = 3 to 6), and the nuchal scale group generally consisted of two tandem pairs of enlarged scales flanked by a smaller scale on each side. The mean

number of transverse dorsal scale rows was 15.9 ± 0.3 (range = 15 to 17), while the mean number of dorsal scales in each transverse row was 4.3 ± 0.9 (n = 1624 dorsal scale rows). The mean number of transverse ventral scale rows was 31.5 ± 1.5 (range = 28 to 37). The mean number of double- and single-crested caudal whorls was 17.3 ± 0.6 (range = 16 to 19) and 20.0 ± 1.0 (range = 16 to 22), respectively. Our study constitutes the first quantitative description of scalation among *C. moreletii* from a specific, well-defined geographic region. Differences between our data and published descriptions were noted among post occipital, dorsal, and ventral scale groups, suggesting that interpopulational differences in scalation may exist among *C. moreletii*. Whether populations can be identified on the basis of scalation remains to be determined, and a complete analysis of geographic variation in scalation among *C. moreletii* must await the publication of comparable data from other range countries.

Weaver, J.P., Rodriguez, D., Venegas-Anaya, M., Cedeño-Vázquez, J.R., Forstner, M.R.J., Densmore III, L.D. (2008). Genetic characterization of captive Cuban crocodiles (*Crocodylus rhombifer*) and evidence of hybridization with the American crocodile (*Crocodylus acutus*). J. Exp. Zool. 309A: 649-660.

Abstract: There is a surprising lack of genetic data for the Cuban crocodile (*Crocodylus rhombifer*), especially given its status as a critically endangered species. Samples from captive individuals were used to genetically characterize this species in comparison with other New World crocodilians. Partial mitochondrial sequence data were generated from cyt-*b* (843 bp) and the $tRNA^{Pro}$- $tRNA^{Phe}$-D-loop region (442 bp). Phylogenetic analyses were performed by generating maximum parsimony, maximum likelihood, and Bayesian-based topologies. In addition, in an effort to identify species-specific alleles, ten polymorphic microsatellite loci were genotyped. Distance and model-based clustering analyses were performed on microsatellite data, in addition to a model-based assignment of hybrid types. Both mitochondrial and nuclear markers identified two distinct *C. rhombifer* genetic sub-clades (α and β); and microsatellite analyses revealed that most admixed individuals were F_2 hybrids between *C. rhombifer*-α and the American crocodile (*C. acutus*). All individuals in the *C. rhombifer*-β group were morphologically identified as *C. acutus* and formed a distinct genetic assemblage.

Cedeño-Vázquez, J.R., Rodriguez, D., Calme, S., Ross, J.P., Densmore III, L.D. and Thorbjarnarson, J.B. (2008). Hybridization between *Crocodylus acutus* and *Crocodylus moreletii* in the Yucatan Peninsula: I. Evidence from mitochondrial DNA and morphology. J. Exp. Zool. 309A: 661-673.

Abstract: The American crocodile (*Crocodylus acutus*) and the Morelet's crocodile (*C. moreletii*) are broadly sympatric in Belize and Mexico. The presence of morphologically anomalous individuals in the overlapping range area suggests possible hybridization between these species. Analysis of 477 base pairs of the mitochondrial tRNAPro-tRNAPhe-Dloop region revealed the presence of pure *C. acutus* (N543) and *C. moreletii* (N556), as well as a high proportion of interspecific hybrids (N517, 14.6%) in the Yucatan Peninsula, Mexico. Although all individuals could be assigned to one species or other based on phenotypic characters, some had been characterized as potential hybrids in the field by anomalous scale counts. The hybridization zone lies along the area of sympatry between *C. acutus* and *C. moreletii* investigated in this study, but extends further inland if hybrid localities from Belize are included. Hybridization in the Yucatan Peninsula is bidirectional, which indicates considerably more genetic contact between these species than previously recognized, and is probably more detrimental to the genetic integrity of smaller *C. acutus* populations. A more intensive study of the pattern of hybridization is warranted and supports continued classification of *C. acutus* as a critically threatened species in the Yucatan Peninsula.

Rodriguez, D., Cedeño-Vázquez, J.R., Forstner, M.R.J. and Densmore, L.D. (2008). Hybridization between *Crocodylus acutus* and *Crocodylus moreletii* in the Yucatan Peninsula: II. Evidence from microsatellites. J. Exp. Zool. 309A: 674-686.

Abstract: Detecting and quantifying hybridization between endangered or threatened taxa can provide valuable information with regards to conservation and management strategies. Hybridization between members of the genus *Crocodylus* has been known to occur in captivity and in some wild populations. We tested for hybridization among wild populations of American crocodile (*C. acutus*) and Morelet's crocodile (*C. moreletii*) in the Yucatan Peninsula by comparing Bayesian assignment tests, based on microsatellite data, to mitochondrial and morphological assignments. Skin clips from 83 individuals were taken for genetic identification, and a total of 32 individuals (38.6%) exhibited some evidence of hybridization by combined morphological, mitochondrial and microsatellite analyses. The majority of hybrids were classified as F_2 hybrids and backcrosses to *C. moreletii*. Most of the introgression occurs in two national biosphere reserves located on the northern and eastern coasts of the Yucatan Peninsula. Preliminary tests did not find a significant decrease in hybridity across three life stages, thus far indicating a low level of selection against hybrids. Model-based analyses on multilocus genotypes of pure individuals returned little geographic partitioning in both *C. acutus* and *C. moreletii*.

Kundrát M. (2008). HNK-1 immunoreactivity during early morphogenesis of the head region in a nonmodel vertebrate, crocodile embryo. Naturwissenschaften 95(11): 1063-1072.

Abstract: The present study examines HNK-1 immunoidentification of a population of the neural crest (NC) during early head morphogenesis in the nonmodel vertebrate, the crocodile (*Crocodylus niloticus*) embryos. Although HNK-1 is not an exclusive NC marker among vertebrates, temporospatial immunoreactive patterns found in the crocodile are almost consistent with NC patterns derived from gene expression studies known in birds (the closest living relatives

of crocodiles) and mammals. In contrast to birds, the HNK-1 epitope is immunoreactive in NC cells at the neural fold level in crocodile embryos and therefore provides sufficient base to assess early migratory events of the cephalic NC. I found that crocodile NC forms three classic migratory pathways in the head: mandibular, hyoid, and branchial. Further, I demonstrate that, besides this classic phenotype, there is also a forebrain-derived migratory population, which consolidates into a premandibular stream in the crocodile. In contrast to the closely related chick model, crocodilian premandibular and mandibular NC cells arise from the open neural tube suggesting that species-specific heterochronic behavior of NC may be involved in the formation of different vertebrate facial phenotypes.

Martin Kundrát (2009). Primary chondrification foci in the wing basipodium of *Struthio camelus* with comments on interpretation of autopodial elements in Crocodilia and Aves. J. Exp. Zool. 312B: 30-41.

Abstract: The present analysis consists of (1) description of the primary chondrification patterns and their transformation into ossified elements in the basipodium of *Struthio camelus*; (2) comparison of these with the conditions found in *Alligator* and *Gallus*; and (3) interpretation of the autopodial elements of *Archaeopteryx*. Conclusions: (1) The existence of five discrete metacarpal condensations in the 16-day embryo of Struthio argues for unique linear patterning process for each, and these are interpreted as digits 2,3,4 originating from metacarpal condensations 2,3,4. Nine chondrogenic foci appear in the *Struthio* carpus: radiale, centrale, intermedium, ulnare, pseudoulnare, pisiform, distal carpal 2+3, distal carpal 4, and distal carpal 5. It is evident that: (a) the avian radiale represents fused chondrogenic foci of the intermedium plus the radiale; (b) a neomorph carpal element, the pseudoulnare (probably avian autapomorphy), replaces the ulnare cartilage in Struthio; (c) the pseudoulnare in *Struthio* and Hinchliffe's element X are not identical to each other. (2) Spatio-temporal conditions of the autopodium are less constrained in the development of *Struthio* than they are in *Gallus*. This favors the ostrich model as the more appropriate for interpretation of the autopodial skeleton in the oldest birds and their ancestors. (3) An interpretation of the elements of the hand skeleton of *Archaeopteryx* is as follows: (a) digits 2,3,4; (b) distal carpal 2+3 (the semilunate); (c) distal carpal 4 (a missing element filling the gap between the semilunate and metacarpal IV); (d) the radiale+intermedium complex (the proximal carpal bone); (e) the pseudoulnare (the proximal carpal bone).

Vargas, A.O., Kohlsdorf, T., Fallon, J.F., Vandenbrooks, J. and Wagner, G,P. (2008). The evolution of HoxD-11 expression in the bird wing: insights from *Alligator mississippiensis*. PLoS ONE 3(10): e3325.

Abstract: Comparative morphology identifies the digits of the wing of birds as 1,2 and 3, but they develop at embryological positions that become digits 2, 3 and 4 in other amniotes. A hypothesis to explain this is that a homeotic frame shift of digital identity occurred in the evolution of the bird wing, such that digits 1,2 and 3 are developing from embryological positions 2, 3 and 4. Digit 1 of the mouse is the only digit that shows no late expression of HoxD-11. This is also true for the anterior digit of the bird wing, suggesting this digit is actually a digit 1. If this is the case, we can expect closer relatives of birds to show no HoxD-11 expression only in digit 1. To test this prediction we investigate HoxD-11 expression in crocodilians, the closest living relatives of birds. Using degenerate primers we cloned a 606 nucleotide fragment of exon 1 of the alligator HoxD-11 gene and used it for whole-mount in-situ detection in alligator embryos. We found that in the pentadactyl forelimbs of alligator, as in the mouse, late expression of HoxD-11 is absent only in digit 1. The ancestral condition for amniotes is that late-phase HoxD-11 expression is absent only in digit 1. The biphalangeal morphology and lack of HoxD-11 expression of the anterior digit of the wing is like digit 1 of alligator and mouse, but its embryological position as digit 2 is derived. HoxD-11 expression in alligator is consistent with the hypothesis that both digit morphology as well as HoxD-11 expression are shifted towards posterior in the bird wing.

Sadleir, R.W. and Makovicky, P.J. (2008). Cranial shape and correlated characters in crocodilian evolution. J. Evol. Biol. 21(6): 1578-1596.

Abstract: Crocodilians show a high degree of cranial variation and convergence throughout their 80 million-year fossil record that complicates their phylogenetic reconstruction. Conflicting phylogenetic results from different data partitions and character homoplasies typify crocodilian phylogeny, and differences between molecular and morphological phylogenetic hypotheses are believed to be associated with the slender-snout skull shape of *Gavialis gangeticus* and *Tomistoma schlegelii*. Slender-snout skulls are one of five identified eusuchian cranial ecomorph shape categories (ESCs) thought to reflect functional or ecological specialization. This paper tested the effect of transitions among general, blunt and slender ESCs on cranial character-state distributions in phylogeny using the concentrated changes test. In addition, 'tree-free' character compatibility analysis of character independence was conducted on the morphological character matrix to determine if character correlations are observed independent of specific tree topologies. Results suggest cranial ESCs do affect cranial character-state gains in phylogeny. Concentrated changes identify a broad suite of character-state changes that significantly correlate with transitions to slender, general and blunt ESCs on morphological, molecular and combined-data tree topologies, but numbers of correlated characters for each category differ according to topology. Character compatibility analysis results do not mirror the concentrated changes test results and reflect hierarchically distributed support throughout the data. As cranial ESCs affect character-state transitions, it is possible that nonphylogenetic variables could affect inferences of crocodilian phylogeny by affecting cranial morphology.

Valle, L.D., Nardi, A., Gelmi, C., Toni, M., Emera, D. and Alibardi, L. (2009). β-keratins of the crocodilian epidermis:

composition, structure, and phylogenetic relationships. J. Exp. Zool. 312B: 42-57.

Abstract: Nucleotide and deduced amino acid sequences of three β-keratins of Nile crocodile scales are presented. Using 5'- and 3'-RACE analysis, two cDNA sequences of 1 kb (Cr-gptrp-1) and 1.5 kb (Cr-gptrp-2) were determined, corresponding to 17.4 and 19.3 kDa proteins, respectively, and a pI of 8.0. In genomic DNA amplifications, we determined that the 5'-UTR of Cr-gptrp-2 contains an intron of 621 nucleotides. In addition, we isolated a third gene (Cr-gptrp-3) in genomic DNA amplifications that exhibits seven amino acid differences with Cr-gptrp-2. Genomic organization of the sequenced crocodilian -keratin genes is similar to avian β-keratin genes. Deduced proteins are rich in glycine, proline, serine, and tyrosine, and contain cysteines toward the N- and C-terminal regions, likely for the formation of disulfide bonds. Prediction of the secondary structure suggests that the central core box of 20 amino acids contains two β-strands and has 75-90% identity with chick β-keratins. Toward the C-terminus, numerous glycine-glycine-tyrosine and glycine-glycine-leucine repeats are present, which may contribute to making crocodile scales hard. *In situ* hybridization shows expression of β-keratin genes in differentiating β-cells of epidermal transitional layers. Phylogenetic analysis of the available archosaurian and lepidosaurian β-keratins suggests that feather keratins diversified early from nonfeather keratins, deep in archosaur evolution. However, only the complete knowledge of all crocodilian β-keratins will confirm whether feather keratins have an origin independent of those in bird scales, which preceded the split between birds and crocodiles.

Eaton M.J., Martin, A., Thorbjarnarson, J. and Amato, G. (2008). Species-level diversification of African dwarf crocodiles (Genus *Osteolaemus*): A geographic and phylogenetic perspective. Mol. Phylogenet. Evol.

Abstract: The taxonomy of the African dwarf crocodile (genus *Osteolaemus*) has been disputed since a novel morphotype was discovered in the early 20th Century. Because this poorly-known reptile is widely hunted throughout the forests of Central and West Africa, resolving the existence and extent of taxonomic units has important management and conservation implications. Lack of molecular data from individuals of known origin and historical disagreement on diagnostic morphological characters have hindered attempts to settle one of the most important taxonomic questions in the Crocodylia. In an effort to clarify the evolutionary relationships among dwarf crocodiles, we sequenced three mitochondrial and two nuclear genes using a large sample of dwarf crocodiles from known localities across major drainage basins of forested Africa. Concordant results from Bayesian, maximum likelihood, maximum parsimony and population aggregation analytical methods support a previously recognized division of the dwarf crocodile into a Congo Basin form (*O. osborni*) and a West African form (*Osteolaemus tetraspis*), but also reveal a third diagnosable lineage from West Africa warranting recognition as an separate taxonomic unit. Corrected genetic distances between geographic regions ranged from 0.2% to 0.6% in nuclear fragments and 10.0 to 16.2% in mitochondrial COI. Population aggregation, using fixed and alternate character (nucleotide) states to cluster or divide populations, recovered 232 such molecular characters in 4286bp of sequence data and unambiguously aggregated populations into their respective geographic clade. Several previously recognized morphological differences coincide with our molecular analysis to distinguish Congo Basin crocodiles from the Ogooué Basin and West Africa. Discrete morphological characters have not yet been documented between the latter two regions, suggesting further work is needed or molecular data may be required to recognize taxonomic divisions in cases where putative species are morphologically cryptic. This study highlights the importance of using widespread taxon sampling and a multiple evidence approach to diagnose species boundaries and reveal cryptic diversity.

Kawagoshi, T., Nishida, C., Ota, H., Kumazawa, Y., Endo, H. and Matsuda, Y. (2008). Molecular structures of centromeric heterochromatin and karyotypic evolution in the Siamese crocodile (*Crocodylus siamensis*) (Crocodylidae, Crocodylia). Chromosome Res. 16(8): 1119-1132.

Abstract: Crocodilians have several unique karyotypic features, such as small diploid chromosome numbers (30-42) and the absence of dot-shaped microchromosomes. Of the extant crocodilian species, the Siamese crocodile (*Crocodylus siamensis*) has no more than 2n = 30, comprising mostly bi-armed chromosomes with large centromeric heterochromatin blocks. To investigate the molecular structures of C-heterochromatin and genomic compartmentalization in the karyotype, characterized by the disappearance of tiny microchromosomes and reduced chromosome number, we performed molecular cloning of centromeric repetitive sequences and chromosome mapping of the 18S-28S rDNA and telomeric (TTAGGG)(n) sequences. The centromeric heterochromatin was composed mainly of two repetitive sequence families whose characteristics were quite different. Two types of GC-rich CSI-HindIII family sequences, the 305 bp CSI-HindIII-S (G+C content, 61.3%) and 424 bp CSI-HindIII-M (63.1%), were localized to the intensely PI-stained centric regions of all chromosomes, except for chromosome 2 with PI-negative heterochromatin. The 94 bp CSI-DraI (G+C content, 48.9%) was tandem-arrayed satellite DNA and localized to chromosome 2 and four pairs of small-sized chromosomes. The chromosomal size-dependent genomic compartmentalization that is supposedly unique to the Archosauromorpha was probably lost in the crocodilian lineage with the disappearance of microchromosomes followed by the homogenization of centromeric repetitive sequences between chromosomes, except for chromosome 2.

Owerkowicz, T. and Baudinette, R.V. (2008). Exercise training enhances aerobic capacity in juvenile estuarine crocodiles (*Crocodylus porosus*). Comp. Biochem. Physiol. A 150(2): 211-216.

Abstract: Aerobic capacity (VO_2max) of endothermic

vertebrates is known to increase with exercise training, but this effect has not been found to-date in non-avian reptiles. We exercised juvenile estuarine crocodiles (*Crocodylus porosus*) to walk at 0.75-0.88 km/h on a treadmill for up to 20 min a day over 16 weeks, and compared their aerobic performance with that of unexercised crocodiles. In the exercised group, VO_2max increased from 6.9 to 8.5 mLO_2/kg/min (+28%), and locomotor endurance increased from 3.8 to 6.9 min (+82%). Neither VO_2max nor endurance changed significantly in the sedentary group. This finding extends the exercise training effect onto another vertebrate clade, and demonstrates that ectothermic amniotes are capable of elevating their aerobic capacity in response to exercise training. We propose that differences in cardiopulmonary structure and function in non-avian reptiles may be responsible for the absence (in squamates) or presence (in crocodilians) of a strong training effect on aerobic capacity.

Honeyfield, D.C., Ross, J.P., Carbonneau, D.A., Terrell, S.P., Woodward, A.R., Schoeb, T.R., Perceval, H.F. and Hinterkopf, J.P. (2008). Pathology, physiologic parameters, tissue contaminants, and tissue thiamine in morbid and healthy central Florida adult American alligators (*Alligator mississippiensis*). J. Wildl. Dis. 44(2): 280-294.

Abstract: An investigation of adult alligator (*Alligator mississippiensis*) mortalities in Lake Griffin, central Florida, was conducted from 1998-2004. Alligator mortality was highest in the months of April and May and annual death count peaked in 2000. Bacterial pathogens, heavy metals, and pesticides were not linked with the mortalities. Blood chemistry did not point to any clinical diagnosis, although differences between impaired and normal animals were noted. Captured alligators with signs of neurologic impairment displayed unresponsive and uncoordinated behavior. Three of 21 impaired Lake Griffin alligators were found to have neural lesions characteristic of thiamine deficiency in the telencephalon, particularly the dorsal ventricular ridge. In some cases, lesions were found in the thalamus, and parts of the midbrain. Liver and muscle tissue concentrations of thiamine (vitamin B(1)) were lowest in impaired Lake Griffin alligators when compared to unimpaired alligators or to alligators from Lake Woodruff. The consumption of thiaminase-positive gizzard shad (*Dorosoma cepedianum*) is thought to have been the cause of the low tissue thiamine and resulting mortalities.

Wood, A., Ogawa, M., Portier, R.J., Schexnayder, M., Shirley, M. and Losso, J.N. (2008). Biochemical properties of alligator (*Alligator mississippiensis*) bone collagen. Comp. Biochem. Physiol. B 151(3): 246-249.

Abstract: Acid-soluble collagen (ASC) and pepsin solubilized collagen (PSC) isolated and purified from alligator (*Alligator mississippiensis*) bone were studied for molecular size, amino acid profile, secondary structure, and denaturation temperature by SDS-PAGE, HPLC, circular dichroism, and viscometry. Two collagen subunits, alpha1 and alpha2 were identified by SDS-PAGE. The molecular masses for alpha1 and alpha2 chains of ASC were 124 kDa and 111 kDa, respectively. The molecular masses were 123 kDa for alpha1 and 110 kDa for alpha2 chains of the PSC preparation. The molecular masses for ([alpha1](2) alpha2) of ASC and PSC were 359 kDa and 356 kDa, respectively. The major composition of alligator bone ASC and PSC was found to be typical type I collagen. The amino acid profiles of alligator ASC and PSC were similar to amino acid profile of subtropical fish black drum (*Pogonias cromis*, Sciaenidae) bone. Comparison of amino acid profiles with shark cartilage PSC, showed differences in alanine, hydroxylysine, lysine, and histidine contents. The denaturation temperatures (T(d)) of alligator ASC and PSC collagen measured by viscometry were 38.1 and 38.2°C, respectively. Thermal denaturation temperatures, measured by melting point using circular dichroism, were 37.6 and 37.9°C, respectively. Taken together, these results suggest that alligator bone collagen may find a wide range of applications in biological research, functional foods and nutraceuticals, and biomedical and pharmaceutical research.

Kohno, S., Bermudez, D.S., Katsu, Y., Iguchi, T. and Guillette, L.J. Jr. (2008). Gene expression patterns in juvenile American alligators (*Alligator mississippiensis*) exposed to environmental contaminants. Aquat. Toxicol. 88(2): 95-101.

Abstract: Reproductive and developmental abnormalities have been reported in the American alligator (*Alligator mississippiensis*) population from Lake Apopka, FL, that is chronically exposed to a complex mixture of environmental contaminants. To begin to understand the molecular mechanisms that could lead to the observed abnormalities of the reproductive and endocrine system, we quantified concentrations of the steroid hormones testosterone (T) and estradiol-17beta (E(2)) and expression of steroid hormone receptors and genes relating to steroidogenesis in gonadal tissue from juvenile alligators from three lakes in Florida using enzyme immunoassay and quantitative real-time polymerase chain reaction. Alterations of ESR2 (estrogen receptor beta) and SF1 (steroidogenic factor 1) mRNA expression in male gonadal tissue, without an observed difference in plasma concentrations of T, from the different lakes, begin to provide insight into potential mechanisms underlying the alterations of the reproductive system previously observed. Likewise, alterations in P450 aromatase and DAX1 (dosage-sensitive sex reversal, adrenal hypoplasia congenita critical region on the X chromosome, gene 1) mRNA expression, with elevated plasma E(2) concentrations in females, provide leads to the potential mechanisms modifying folliculogenesis and ovarian development. The investigation of these genes also helps clarify normal endocrine and reproductive system function in the American alligator.

Skovgaard, N., Zibrandtsen, H., Laursen, B.E., Simonsen, U. and Wang, T. (2008). Hypoxia-induced vasoconstriction in alligator (*Alligator mississippiensis*) intrapulmonary arteries: a role for endothelin-1? J. Exp. Biol. 211(9): 1482-1489.

Abstract: Hypoxic pulmonary vasoconstriction (HPV) is an adaptive response that diverts pulmonary blood flow from

poorly ventilated and hypoxic areas of the lung to better ventilated parts, matching blood perfusion to ventilation. HPV is an ancient and highly conserved response expressed in the respiratory organs of all vertebrates. However, the underlying mechanism and the role of the endothelium remain elusive. Isolated intrapulmonary arteries (internal diameter <346 microm) from the American alligator Alligator mississippiensis were mounted in microvascular myographs for isometric tension recording. Resting vessels and vessels contracted with either serotonin (5-HT) or endothelin-1 (ET-1) were exposed to sustained (45 min) hypoxia (PO2<5 mmHg). In ET-1-contracted vessels, hypoxia induced a monophasic, sustained and fully reversible constriction, which was independent of the endothelium. In relaxed or in 5-HT-contracted vessels, hypoxia did not cause constriction. The effects of ET-1, ET(A) and ET(B) as well as the general ET-receptor antagonist were studied. ET-1 caused a contraction of the pulmonary arteries through stimulation of ET(A)-receptors. ET(A) and ET(B) immunoreactive staining revealed the location of both receptors in the smooth muscle layer and of ET(B) receptors in the endothelium. In conclusion, because precontraction with serotonin did not facilitate HPV, the required precontraction in alligators seems specific to ET-1, which implies that ET-1 plays an important permissive role for the HPV response in alligators.

Davis, L.M. and Spackman, E. (2008). Do crocodilians get the flu? Looking for influenza A in captive crocodilians. J. Exp. Zool. 309A: 571-580.

Abstract: It is well established that several wild aquatic bird species serve as reservoirs for the influenza A virus. It has also been shown that the influenza A virus can be transmitted to mammalian species such as tigers and domestic cats and dogs through ingestion of infected birds. Another group of animals that should also be considered as potential hosts for the influenza A virus are the crocodilians. Many crocodilian species share aquatic environments with wild birds that are known to harbor influenza viruses. In addition, many large crocodilians utilize birds as a significant food source. Given these factors in addition to the close taxonomic proximity of aves to the crocodilians, it is feasible to ask whether crocodilian species may also harbor the influenza A virus. Here we analyzed 37 captive crocodilians from two locations in Florida (plus 5 wild bird fecal-samples from their habitat) to detect the presence of influenza A virus. Several sample types were examined. Real-time RT-PCR tests targeting the influenza A matrix gene were positive for four individual crocodilians - *Alligator sinensis*, *Paleosuchus trigonatus*, *Caiman latirostris* and *Crocodylus niloticus*. Of the seven serum samples tested with the avian influenza virus agar gel immunodiffusion assay, three showed a nonspecific reaction to the avian influenza virus antigen - A. sinensis, P. trigonatus and C. niloticus (C. latirostris was not tested). Viable virus could not be recovered from RT-PCR-positive samples, although this is consistent with previous attempts at viral isolation in embryonated chicken eggs with crocodilian viruses.

Gist, D.H., Bagwill, A., Lance, V., Sever, D.M. and Elsey, R.M. (2008). Sperm storage in the oviduct of the American alligator. J. Exp. Zool. 309A:581-587.

Abstract: Oviducts of the American alligator (*Alligator mississippiensis*) were examined histologically for the presence of stored sperm. Two regions containing sperm were identified, one at the junction of the posterior uterus and the vagina (UVJ) and the other at the junction of the tube and isthmus (TIJ). In these areas, sperm were found in the lumina of oviductal glands. The glands in these areas of the oviduct are diffuse and shallow and appear to allow better access to sperm than glands located elsewhere. Histochemically, the glands of the UVJ reacted weakly for carbohydrates and proteins, whereas those of the TIJ reacted strongly for these same two components, secretions of which are associated with sperm storage structures in other reptiles. Sperm were not in contact with the glandular epithelium, and glands at the UVJ contained more sperm than those at the TIJ. Oviductal sperm storage was observed not only in recently mated females but in all females possessing uterine eggs as well as all females known to be associated with a nest. We conclude that female alligators are capable of storing sperm in their oviductal glands, but not from one year to the next.

Hrbek, T., Vasconcelos, W.R., Rebelo, G. and Farias, I.P. (2008). Phylogenetic relationships of South American Alligatorids and the Caiman of Madeira River. J. Exp. Zool. 309A: 588-599.

Abstract: We analyzed DNA sequences of the mitochondrial cytochrome b gene (cyt b), the nuclear Recombination Activating Gene 1 (RAG1) and the myelocytomatosis oncogene (MYC) to infer the phylogenetic relationship of *Caiman crocodilus* and *Caiman yacare*, and other South American alligatorid crocodilian species. Phylogenetic relationships were robustly supported with *Paleosuchus* sister to *Melanosuchus* and *Caiman*. Phylogenetic relationships of *C. crocodilus* and *C. yacare* were unclear as these two species share mitochondrial and nuclear haplotypes. Specifically this sharing occurs among specimens of *C. yacare* and *C. crocodilus* from the Madeira River drainage. Two potential explanations stand out: secondary contact followed by hybridization, and differentiation along a cline. Current data cannot resolve between these two competing hypotheses. In comparison with *C. yacare* and *C. crocodilus*, *Paleosuchus trigonatus* and *Paleosuchus palpebrosus* are very well differentiated and also show surprising haplotypic diversity in spite of their phenotypic similarity..

Vasconcelos, W.R., Hrbek, T., Da Silveira, R., De Thoisy, B., Dos Santos Ruffeil, L.A.A. and Farias, I.P. (2008). Phylogeographic and conservation genetic analysis of the black caiman (*Melanosuchus niger*). J. Exp. Zool. 309A: 600-613.

Abstract: We assessed the spatial distribution of the genetic variability of *Melanosuchus niger* from 11 localities in

South America using 1,027 base pairs of the mitochondrial cytochrome b gene. Screening 132 animals, we found 41 haplotypes, high values of genetic diversity, low values of nucleotide diversity and significant deviations from neutral expectation of allelic frequencies in some localities. Mantel test and nested-clade analysis indicated that isolation-by-distance was an important population dynamic for the species as a whole. Wright's fixation indexes analyses showed that hydrogeographically separated populations from French Guiana together with Amapá state population in Brazil are genetically differentiated from all other populations that are found in the Amazon drainage basin. These indexes also disclosed that the population from Ecuador is genetically differentiated in relation to the populations from Brazil, Peru and French Guiana. Within the Amazon Basin little differentiation exists, and genetic and geographic distances are not correlated. Demographic data as well as population genetic data suggest that *M. niger* is recovering in some protected regions. However, part of this apparent recovery may be owing to the movement of animals into protected regions.

Venegas-Anaya, M., Crawford, A.J., Escobedo Galván, A.H., Sanjur, O.I., Densmore III, L.D. and Bermingham, E. (2008). Mitochondrial DNA phylogeography of *Caiman crocodilus* in Mesoamerica and South America. J. Exp. Zool. 309A: 614-627.

Abstract: The Neotropical crocodylian species, *Caiman crocodilus*, is widely distributed through Mesoamerica, northern South America, and the Amazon basin. Four subspecies are recognized within *C. crocodilus*, suggesting some geographic variation in morphology. In this study, we utilized mitochondrial DNA (mtDNA) sequence data from 45 individuals of *C. crocodilus* throughout its range to infer its evolutionary history and population structure, as well as to evaluate genealogical support for subspecies and their geographic distributions. Our molecular phylogenetic results identified five mtDNA haplotype clades with a mean sequence divergence of 3.4%, indicating considerable evolutionary independence among phylogeographic lineages. Our results were also broadly consistent with current subspecific taxonomy, with some important additional findings. First, we found substantial genetic structuring within *C. c. fuscus* from southern Mesoamerica. Second, though we confirmed the existence of a widespread Amazonian clade, we also discovered a cryptic and divergent mtDNA lineage that was indistinguishable from *C. c. crocodilus* based on external morphology. Third, we confirm the status of *C. c. chiapasius* as a distinct evolutionary lineage, and provide evidence that *C. c. fuscus* may be moving northward and hybridizing with *C. c. chiapasius* in northern Mesoamerica. Finally, our results parallel previous phylogeographic studies of other organisms that have demonstrated significant genetic structure over shorter geographic distances in Mesoamerica compared with Amazonia. We support conservation efforts for all five independent lineages within *C. crocodilus*, and highlight the subspecies C. c. chiapasius as a unit of particular conservation concern. .

Villela, P.M.S., Coutinho, L.L., Piña, C.I. and Verdade, L.M. (2008). Macrogeographic genetic variation in broad-snouted caiman (*Caiman latirostris*). J. Exp. Zool. 309A: 628-636.

Abstract: Broad-snouted caiman's (*Caiman latirostris*) geographic distribution comprises one of the widest latitudinal ranges among all crocodilians. In this study we analyzed the relationship between geographic distance (along the species latitudinal range) and genetic differentiation using DNA microsatellite loci developed for *C. latirostris* and *Alligator mississippiensis*. The results suggest that there is a consistent relationship between geographic distance and genetic differentiation; however, other biogeographical factors seem to be relevant. The Atlantic Chain (Serra do Mar) seems to be an effective geographic barrier, as well as the relatively narrow (1.5 km) sea channel between Cardoso Island and the continent. In addition, coastal populations seem to have been well connected in recent geological time (Pleistocene 16,000 years ago) all along the eastern Brazilian coast. Further studies should focus on the São Francisco River drainage, which is still poorly known for this species.

Amavet, P., Rosso, E., Markariani, R. and Piña, C.I. (2008). Microsatellite DNA markers applied to detection of multiple paternity in *Caiman latirostris* in Santa Fe, Argentina. J. Exp. Zool. 309A: 637-642.

Abstract: Detecting multiple paternity in wild populations of the broad-snouted caiman (*Caiman latirostris*) has important implications for conservation efforts. We have applied microsatellite markers to examine genetic variation in *C. latirostris* and also have provided the first data concerning detection of multiple paternity in wild populations of this species. Blood samples from four nest-guarding *C. latirostris* females and their hatchlings were obtained from Santa Fe Province, Argentina. Amplified products were analyzed by electrophoresis on 10% polyacrylamide gels and visualized with silver staining. Four out of the eight markers tested reliably amplified and yielded useful data. Using polyacrylamide gels with silver staining provides high enough resolution to obtain individual genotypes. In order to assess the presence or absence of more than two parents in each nest, we used the single locus Minimum Method, and applied Cervus 3.0 and Gerud 2.0 software in parentage analyses. Our results indicate more than one father in at least two families. This behavior could be the consequence of high habitat variability in the area where our population was sampled. The ability to understand mating systems is important for maintaining viable populations of exploited taxa like *C. latirostris*.

Perez, A.T. (2008). Growth of the Orinoco Caiman (*Crocodylus intermedius*, Crocodylia: Crocodylidae) under two captivity conditions. Rev. Biol. Trop. 56(1): 349-354. [Article in Spanish]

Abstract: Growth of the Orinoco Caiman (*Crocodylus intermedius*, Crocodylia: Crocodylidae) under two captivity conditions. In order to determine the growth of Caiman of the

Orinoco (*Crocodylus intermedius*) under two conditions of captivity, 40 specimens were raised during 11 months and 15 days in two circular tanks, with 28.3 m^2 of surface area and a volume of 62.2 m^3 in each tank. The tanks were built with concrete walls and guarded blocks covered internally with sheets of myrrhlike resin, and a roof of galvanized sheets. One tank was covered partially with the galvanized sheets (tank I), the other was totally covered (tank II). Twenty caimans were placed in each tank, and both groups were fed with 85% beef, 10% fresh fish, 5% hen eggs and a mixture of minerals and vitamins. The length and weight differed significantly between the groups ($p < 0.001$). Mean growth (103.0 +/- 6.81 cm) and weight (3 987 +/- 0.98 g) were higher in tank II, (tank I: 88.9 +/- 7.58 cm; 2 705 +/- 0.69 g). The greater growth in tank II reflects higher air and water temperatures. The survival rate was 97.5%. These results can be used for rearing caimans in captivity for conservation and commercial purposes.

Huchzermeyer, F.W., Langelet, E. and Putterill, J.F. (2008). An outbreak of chlamydiosis in farmed Indopacific crocodiles (*Crocodylus porosus*). J. S. Afr. Vet. Assoc. 79(2): 99-100.

Abstract: An outbreak of chlamydiosis was diagnosed in hatchling and juvenile Indopacific crocodiles (*Crocodylus porosus*) on a crocodile farm in Papua New Guinea. The outbreak was characterised by high mortality with hepatitis and exudative conjunctivitis. The agent appears to have been introduced with live wild-caught crocodiles, which are purchased routinely by the farm. Improved quarantine procedures and treatment with tetracycline led to a rapid reduction of losses on the farm.

Lovely, C.J. and Leslie, A.J. (2008). Normal intestinal flora of wild Nile crocodiles (*Crocodylus niloticus*) in the Okavango Delta, Botswana. J. S. Afr. Vet. Assoc. 79(2): 67-70.

Abstract: Bacterial and fungal cultures were performed from cloacal swabs collected from 29 wild Nile crocodiles, captured in the Okavango Delta, Botswana. Sixteen species of bacteria and 6 fungal species were cultured. Individual crocodiles yielded 1-4 bacterial species, and 0-2 fungal species. The most commonly isolated bacteria were *Microbacterium*, *Enterococcus faecalis*, *Aeromonas hydrophila*, and *Escherichia coli*. No salmonellae were cultured. The most commonly occurring fungus was *Cladosporium*. Several of the bacterial and fungal species isolated have been implicated in cases of septicaemia in crocodilians. Knowledge of the normal intestinal flora will contribute towards the development of a crocodile-specific probiotic for use in farmed crocodiles.

Merchant, M., Williams, S, and Hardy, R. (2009). Production of superoxide ions by leukocytes of the American alligator (*Alligator mississippiensis*). Comp. Biochem. Physiol. B 152(1): 67-71.

Abstract: This study was conducted to characterize the production of superoxide ions by leukocytes in whole blood of the American alligator (*Alligator mississippiensis*). We used WST-1, a tetrazolium salt which can be reduced to a water-soluble formazan compound with high molar absorptivity at 438 nm, to probe the production of superoxide by alligator leukocytes. Incubation of alligator whole blood with WST-1 resulted in a time- and concentration-dependent increase in absorbance of the plasma at 438 nm. The reduction of WST-1 was inhibited in a concentration-dependent manner by superoxide dismutase, an enzyme that catalyzes the reduction of superoxide to peroxide, confirming that the reduction of WST-1 was due to the presence of superoxide. Treatment of whole blood with nitrotetrazolium blue (NBT) resulted in the staining of heterophils and monocytes, enforcing the idea that that the production of superoxide is due to the presence of leukocytes, and not other blood cell components. It is interesting to note that the production of superoxide by the alligator leukocytes required no external stimulation while human leukocytes must be stimulated with an immunological challenge before producing superoxide. This is the first report of the production of superoxide as an innate immune mechanism in crocodilians.

Barbosa, J.A., Kellner, A.W. and Viana, M.S. (2008). New dyrosaurid crocodylomorph and evidences for faunal turnover at the K-P transition in Brazil. Proc. Biol. Sci. 275(1641): 1385-1391.

Abstract: The discovery of a new dyrosaurid crocodylomorph from the well-dated Palaeocene deposits of northeastern Brazil sheds new light on the evolutionary history of this extinct group of marine crocodylomorphs that have survived the Cretaceous-Palaeogene (K-P) extinction crisis. *Guarinisuchus munizi*, the most complete member of this group collected in South America so far, is closely related to the African forms, and this fact suggests that dyrosaurids had crossed the Atlantic Ocean before the K-P boundary and dispersed from there to North America and other parts of South America. This discovery also suggests that on the coast of northeastern Brazil, dyrosaurids replaced the pre-existing Late Cretaceous fauna of diversified mosasaurs, a group of marine lizards, after the K-P extinction event, becoming the main predators, together with sharks, in shallow marine Palaeocene environments. More detailed stratigraphic records and detailed dating of the deposits with dyrosaurids are necessary to correlate this particular pattern found in the ancient northeastern Brazilian coast within the evolution of the group, especially in Africa.

Submitted Articles

USE OF CAPTIVE BOLT PISTOL FOR HUMANE SLAUGHTER OF CROCODILIANS. The "GIL-Techno Abates" captive bolt pistol (model "Zilka"), developed for the humane slaughter of crocodilians (Campos 2000), has now been in use for over 4 years in Brazil. It has been shown to be very efficient for the slaughter of Pantanal caimans, and can be used for all sizes of crocodilian.

The Cooperativa de Criadores de Jacaré do Pantanal, located in Cáceres, Mato Grosso, in the northern Pantanal, is the only facility that currently uses the "Zilka" (Fig. 1). The facility operates through the ranching of caiman, and has been in operation since 1991. In 2003 a refrigerated slaughterhouse was established, through which 180-200 caimans are processed daily (bodyweight 5-6 kg). To date, about 20,000 caimans have been slaughtered.

Figure 1. The "Zilka" weighs approximately 5 kg and costs around $US6250.

After fasting for 24 h, caimans are killed using the "Zilka", after which they are washed, processed, etc. The "shot" consists of the short stroke of a piston activated by an air compressor with capacity of 15 ft^3/minute (0.4 m^3/min.) (Campos *et al*. 2005). It is directed at the cranial platform of the animal, between the eyes, and results in a cerebral lesion and consequent stunning, after which the spine is cut as well as blood vessels allowing better handling, complete bleeding, and consequently clearer meat with better appearance, less acid, and with a longer time of preservation (Bressan 1998; Prândal *et al*. 1994).

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Campos, Z., Coutinho, M.E. and Oliveira, T.M. (2005). Abate humanitário de crocodilianos. Circular Técnica 59, Embrapa Pantanal, 2 pp.

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Prandal, O., Fischer, Schimidhofer, T. and Sinel, H.J. (1994). Tecnologia y Hygiene de la Carne. Zaragoza: Acribia.

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ANOTHER SPECIES DOUBLE-CLUTCHES AT CROC BANK? Double-clutching, the laying of two clutches per year, has been a common occurrence for some Mugger crocodiles (*Crocodylus palustris*) at the Madras Crocodile Bank since the 1970s (Whitaker and Whitaker 1884). However, to our knowledge it has not been reported for other species of crocodilian. This year we were able to consider adding another species to the "double-clutching club".

On 14 April 2008 our pair of Siamese crocodiles (*C. siamensis*) laid 24 eggs, of which 20 were assessed as being viable by candling. A thorough inspection of the nest mound was made to make ensure that all eggs had been collected, much to the chagrin of the male and female. Going on our experience from previous years, we thought "no more eggs until next April". How wrong we were!

On 13 September, we found the nest had been excavated, and eggshells were strewn around the nest and in the water. We drained the pond and captured 8 hatchlings. Closer inspection of the nest revealed 4 dead eggs with embryos within them, putting this second clutch size at 12 eggs.

Assuming that incubation could have taken as little as 65 days (high incubation temperature) or as long as 90 days (low incubation temperature), the date of laying of the second clutch is considered to have occurred within the last week of June or first week of July. The period between laying of the two clutches is thus estimated to be 10-13 weeks.

Crocodilians have been reported to lay eggs at one time, followed by more eggs a few days later. For example, Blake and Loveridge (1987) reported a captive female Nile crocodile (*C. niloticus*) laying eggs in two distinct nests, 38-39 days apart. This has also been recorded with captive Saltwater crocodiles (*C. porosus*) (C. Manolis, pers. comm.), but because of the relatively short time between laying events it has been interpreted as the production of a single clutch, but with laying occurring in two episodes.

In American alligators (*Alligator mississippiensis*), the time between follicular development (enlargement of follicles from resting stage) and egg-laying is around 8 weeks (Lance 1987). Based on the time between laying events for our *C. siamensis*, the following could apply:

1. A totally separate, second clutch was produced from "scratch" after the first clutch (double clutching).
2. Enlarged follicles produced that season were "ovulated" on two separate occasions.
3. Eggs (12) were retained in the oviduct/s after the first laying, and laid at a later date. If so, the fact that eggs could be retained for so long before laying, and still produce hatchlings, is of interst. Typically crocodilians are unable to hold eggs for long periods of time once they are "ready" to be laid.

Clutch size for our female *C. siamensis* has previously ranged from 12 to 43 eggs. We would be very interested to receive other documented information on double-clutching in crocodilians?

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WHO'S GOT THE BIGGEST? The fascination for 'finding the biggest' is deeply engrained, and when film producer Harry Marshall at Icon Films (UK) offered a chance to search for the world's largest crocodilian - who could refuse?

Claims of giant crocodiles are as wild as those for outsize fish and snakes. "It was longer than the boat", has been earnestly related in a dozen languages, from the Rift Valley lakes of Ethiopia to the mighty Fly River in Papua New Guinea. And the Fly River is where this 'skull quest' (for that's what it's become) began.

Largest Crocodile with Photographic Documentation

In 1980 I (RW) was working for the United Nations crocodile program in Papua New Guinea as 'Production Manager'; the second author (NW) was also there, see illustration. Along with UN volunteer Jerome Montague, also a biologist, we went off on patrol down the Fly River, checking on the success of village crocodile farms, and providing water pumps and advice on husbandry. When we arrived at Obo Village one sultry afternoon the villagers gathered on the riverbank to greet us and to excitedly show what they had caught the previous morning in a net set for the famous local fish, the barramundi. A huge male Saltwater crocodile had gotten his teeth tangled in the hand-made rope net and drowned. It took 50 men to haul the giant out onto the bank (it could have weighed a ton), and when they cut it open there was a whole Rusa deer in its stomach. The skin had been salted and rolled up, so we flattened it out on the ground and measured it. The total length was 6.20 m long (a little over 20'). Since it was already a bit dry, it may have been a little longer.

The note that Jerome published on this find (Montague 1983) didn't exactly shake the world. People were (and still are) quite convinced that *C. porosus* well over 20' long are on record. But when the quest for the biggest started to get serious, it was soon obvious that these 'records' are mostly anecdotes with no solid evidence. Some colleagues are ready to accept anecdotal total lengths - we are much more skeptical.

The 1:7 Hypothesis

Wouldn't it be just great if you could get the head (skull) length of a crocodile, multiply it by a simple number and get the total length? Well, Banks (1931), Schmidt (1944), Wermuth (1964), Bellairs (1970), Greer (1974) and Woodward *et al* (1995) are some of the authors who concurred that an average ratio for head length (HL) to total length (TL) comes close to 1:7, using several samples of *C. porosus*, *C. niloticus* and *Alligator mississippiensis*. In this formula, the simple measurement of the skull/head length is from nose tip to the back of the cranial platform (see Fig. 1), preferably using a big tree caliper or at least a perpendicular steel ruler front and back while laying the tape. (Professional 'skullers' will warn that a crocodile skull will shrink up to 4% in passing years).

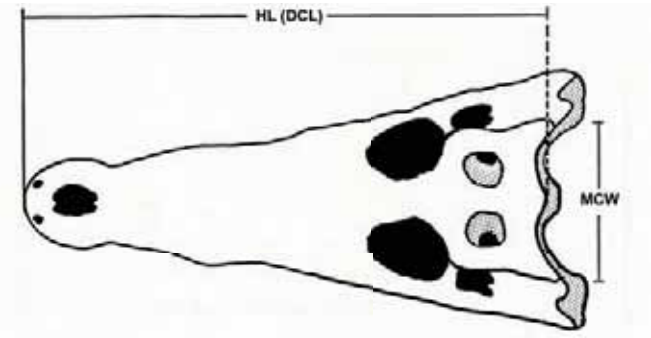

Figure 1. Standard measurement of head length (HL) [= dorsal cranial length (DCL)] and maximum craniun width (MCW).

Unfortunately some crocodile workers have taken head length to mean from nose tip to the back of the mandible (lower jaw bone, which sticks way out behind the skull), adding 25% or more in length. Other workers routinely measure from nose tip to the back of the occipital condyle which articulates with the spinal column, which adds a few extra centimetres to the length of a large skull.

However, the 1:7 ratio is based mainly on smaller individuals, with few samples of crocodilians over 4 m in length. While alligators and broad-snouted crocodiles like the mugger (*C. palustris*) are relatively 'stumpy' animals, and the Indian gharial (*Gavialis gangeticus*) are at the other linear extreme, salties and American crocodiles (*C. acutus*) fall in the intermediate range. Wermuth (1964) notes that *C. porosus* have a proportionately longer tail (relative to trunk length) than other crocodiles and that in individuals over 1.5 m, the head width increases at a proportionately greater rate than trunk length. The other problem is of course that crocodiles are like us, they grow long when young, then slow down and start growing outward, again complicating the simple ratio.

So there are bound to be serious difficulties when trying to apply the 1:7 ratio to all crocodiles of all ages. Predictably, though there are some big skulls in collections, there are very few whole skeletons or reliable total lengths to go with these

skulls. A single illustration will serve as an example of the unreliability of historical references (Barbour 1924): the *C. porosus* skull from Luzon, Philippines (killed in the 1880s), measures 71 cm (dorsal cranial length, not the mandible), a big one indeed. Using the 1:7 ratio that would make it 4.7 m long, yet the data card for the skull, repeated ad nauseum in the literature, assures us that it was an amazing 33' or 10 m in length (plus 4% for shrinkage)! Even with a 1:9 HL:TL ratio (which we can confirm some salties indeed have) this animal couldn't have been more than 6.5 m long (21.5').

Australia

Although the Aussies claim the biggest crocodiles, there is little solid evidence. The often quoted 28 footer killed back in July 1957 by the Pawlowskis in the Norman River estuary of the Gulf of Carpentaria remains just an unverified anecdote, no matter how many publications the story appears in.

Adam Britton and I (RW) measured two of the largest *C. porosus* skulls in Australia, one called 'Charley' at the Darwin Crocodile Farm (a 'mere' 64.4 cm) and one shot by Terry Hulse on display at the Corroboree Tavern near Darwin (Manolis 2006). This one measures 68.8 cm and is possibly the largest skull in Australia. Driving down the road we stopped in for yet another cold one at the Bark Hut Inn, Annaburroo, where we found and measured a *C. porosus* mandible - at 89.9 cm it was longer than the Corroboree mandible. Adam has heard of another skull in the Northern Territory with a mandible of 96 cm (close to the size of the Paris Museum monster crocodile). The search continues for the largest Aussie skull.

News of an estimated 6.7 m (22') animal on the Bullo River was also noted. We saw some 4.9 m (16') crocodiles, and one massive slide, but the Bullo giant is still out there.

India

In India there are current stories of 7 m (23') long crocodiles in Bhitarkanika National Park in the State of Orissa. In fact, someone is such a convincing story teller that the Guinness Book of Records proclaims that this is where the largest crocodile in the world lives. It could be true, we hope it is, but we need evidence and not another tale of 'it was bigger than the boat'. Hopefully Guinness does more rigorous verification with their other stories.

There is, however, some solid evidence of giant crocodiles in the form of a couple of skulls, one of them owned by Prince Shivendra, the Raja of the erstwhile Principality of Kanika (part of it now included in the National Park, famous for its amazingly successful crocodile recovery program) (Kar 2006b). A big crocodile, killed in 1926 on the Dhamra River was said to have been 7 m long. The huge skull is the only remaining evidence, and at 73.3 cm from nose tip to back of occiput, appears to be the largest *C. porosus* skull in India (one in the Indian Museum, Calcutta, measures 73 cm) and one of the top three in the world. [Note: Daniel and Hussain (1973) reported this skull to be 1 m, and in 1978 I (RW) reported it as 78 cm! Obviously meticulous measurements using tree calipers is the way to go].

Figure 2. Prince Shivendra, Raja of Bhitarkanika, with Rom Whitaker and 'Kalia', India's biggest Saltwater crocodile skull. Photograph: Janaki Lenin.

But if 'Kalia' (the name of this giant crocodile which reportedly ate 13 women - their bangles were recovered from his stomach; Fig. 2) was indeed 7 m long, then the skull length to total length ratio is 1:9.4, far away from the 'standard' ratio of 1:7. Another crocodile, found dead in the same river by the Wildlife Department in 2005, had a head length of 66 cm and a total length of about 5.2 m (17') (ratio= 1:7.9), though the authorities reported that the carcass measured over 5.7 m (19') and the skull 68 cm (ratio= 1:8.38) (Kar 2006a). Luckily the entire skeleton was preserved and can be carefully re-measured.

To confirm the inapplicability of the 1:7 ratio for big crocodiles, we measured 'Jaws III', the 4.8 m (16'), 38-year-old *C. porosus* at the Madras Crocodile Bank. The HL:TL ratio was 1:9. If we just had a larger sample size we would be closer to a more realistic ratio. It is very evident that big crocodiles (alligators too) slow down on linear growth and start getting bulkier at a certain point. Webb and Messel (1978) make the point that it would not be valid to apply the same formulae used in smaller individuals to those over 4 m. This of course tosses the 1:7 ratio for a loop, though it's still helpful and somewhat accurate for animals below 4 m, especially when doing size estimates during night counts when all you see is the head.

Biggest Saltie Skull in the World

At the CSG meeting in Montelimar in June 2006, Peter Taylor promised to blow our minds with details of a spectacular skull at the Paris Museum, which he was privileged to measure in great detail in July 2003. And sure enough, with a dorsal head length of 76 cm, maximum skull width of 48 cm and a massive mandible of 98.3 cm, this specimen gets the prize of biggest known *C. porosus* skull; these three measurements exceed anything else on record for broad-snouted crocodiles. It was apparently killed in Cambodia in the early 1800s, but no other details are available.

Giant Nile Crocodiles

The last lap of the "skullology tour" had to be Africa. Everyone has seen the spectacular footage of wildebeest and gazelles being snapped up like rats by huge Nile crocodiles, but just how big are they? Local intelligence was that the largest C. niloticus were at Lake Chamo, a Rift Valley lake in southern Ethiopia. We used some fancy military issue range-finding binoculars to get very accurate distances between us (and camera) and the crocodiles. Then, combined with an ordinary digital camera and a bit of Photoshop magic we got some accurate remote measurements of Nile crocodiles, some over 5.5 m (18') - saltie size. This is how it's done: do the range-finding and picture simultaneously, put the picture onto Photoshop where the pixel length of the croc is easily converted to millimeters, multiply the pixel length by the recorded distance of camera-to-crocodile in millimetres (ie how big it actually was on the camera sensor) and then divide by the focal length of the lens. This gives you a reasonably accurate length of the critter. Other researchers have proposed similar photographic techniques for estimating size (Gorzula 1984; Choquenot and Webb 1987)

We discovered a dusty little cubbyhole at the Arba Minch Crocodile Ranch near Chamo where skulls of crocodiles drowned in fishing nets (Nile perch) were given their final rest. It was a bonanza of giant skulls and our excitement grew as we measured a dozen of the biggest. All we could think was "bloody hell, these are the biggest Nile crocodile skulls on record". Our enthusiasm was obviously infectious, the farm manager, Assegid Gebre, got all the skulls cleaned up and the next time we visited he had them carefully mounted in glass cases. These are truly invaluable specimens, one measuring over 68 cm, the size of the Corrorboree Tavern *C. porosus* skull, the biggest we found in Australia. This Lake Chamo skull is the largest on record for *C. niloticus*!

Other Giants

After years of being convinced that salties are the biggest crocodilian, colleagues who knew of our interest started sending in intriguing bits of information, including the statistics of a *C. acutus* skull at the American Museum of Natural History (AMNH) in New York. At 73.5 cm it is a shade bigger than 'Kalia' the giant Orissa *C. porosus* skull.

But what really zapped us were sizes of Malayan false gharial (*Tomistoma schlegelii*) skulls: one at the British Museum measures 84 cm (this is presently the longest known crocodilian skull in existence; Fig. 3); one at Munich Museum at 81.5 cm; and, another at the AMNH at 76.5 cm - overshadowing the other species. What the HL:TL ratio is for this species is only now coming to light. Our friend Uthen Youngprapakorn has a gang of living giant 'Tommies' at Samut Prakarn Crocodile Farm in Bangkok, and in early November our colleague Ralf Sommerlad was able to put a tape to one of 4.76 m TL (close to 16'). With a dorsal cranial length of 74.2 cm we get a ratio of 1:6.4; using this ratio, the world's biggest skull came from a 5.38 m (18') *Tomistoma* (so the 'broadsnouts' still rule!).

Figure 3. Colin McCarthy (Natural History Museum, London) with world's largest crocodile skull, *Tomistoma schlegelii*. Photograph: George Craig.

The third longest skull in the world is an Indian gharial at Munich, which measures 77.3 cm, but again we don't know how long the animal was or what the HL:TL ratio might be (ratio for 4 *Gavialis* of 1.5 to 3.7 m TL measured on the Chambal last February was 1:5 to 1:6.5). Skull lengths are proportionally longer for these species compared with other crocodilians, and don't necessarily translate to longest body length.

Discussion

While we can now say with certainty that *C. porosus* can reach lengths of 6 m (20') and above, it is also quite certain that *G. gangeticus*, *T. schlegelii*, *C. acutus* and *C. niloticus* can reach over 6 m. And we shouldn't totally discount the Orinoco crocodile (*C. intermedius*) measured by A. von Humboldt's assistant in 1800, which was purportedly 6.78 m (22' 3") (Schmidt 1944).

An interesting aside gleaned while spending an afternoon with paleo-croc master, Dr. Wann Langston Jr. at the University of Texas in Austin: while modern crocodilians seem to peak out at around 6 m (20'), the big extinct mesoeucrocodilians like *Deinosuchus*, *Sarcosuchus* and *Terminonaris* seemed to have peaked at about 12 m (40') and weighed up to 3000 kg! We wonder what their HL:TL ratio is?

Table 1. Data on 40 "record" crocodile skulls. Species (Sp.): Cc = *Crocodylus cataphractus*; Ci = *Crocodylus intermedius*; Cn = *Crocodylus niloticus*; Cp = *Crocodylus porosus*; Gg = *Gavialis gangeticus*; Ts = *Tomistoma schlegelii*; Am = *Alligator mississippiensis*. AMNH= American Museum of Natural History, MCZ= Museum of Comparative Zoology. [1] not including occipital condyle; [2] there are several more 64-69 cm (HL) *T. schlegelii* skulls at Munich; [3] there are several more 64-67 cm (HL) *C. niloticus* skulls at Arba Minch. MHW= maximum head width; HL= head length; TL= total length.

Sp.	Origin	Current Location	HL[1] (cm)	MHW (cm)	TL (m)	TL (ft)	HL:TL Ratio	Mandible (cm)	Source
Ts		British Museum	84.0	-	-	-	-	104.0	G. Craig, C. McCarthy (pers. comm.)
Ts	Central Borneo	Munich Museum	81.5	-	-	-	-	-	Muller (1927)
Gg	India	Munich Museum	77.3	-	-	-	-	-	Muller (1927)
Ts	Central Borneo	Munich Museum	77.0	-	-	-	-	-	Muller (1927)
Ts	Borneo	Munich Museum	76.5 [2]	-	-	-	-	-	Muller (1927)
Ts		AMNH, New York	76.3	-	-	-	-	-	Paolo Piras (pers. comm.)
Cp	Cambodia	Paris Museum	76.0	48.0	-	-	-	98.3	Peter Taylor (pers. comm.)
Ts		Brussells Museum	75.9	-	-	-	-	-	Paolo Piras (pers. comm.)
Gg	India	Paris Museum	75.3	-	-	-	-	-	Paolo Piras (pers. comm.)
Gg	India	Munich Museum	75.0	-	-	-	-	-	Muller (1927)
Cp		Leningrad?	74.0 ?	-	-	-	-	-	Sudhakar Kar (2006a)
Ca	S. America	AMNH, New York	73.5	-	-	-	-	-	Paolo Piras (pers. comm.)
Cp	Bhitarkanika, India	Raja of Kanika	73.3	45.8	-	23'?	1:9.0 ?	-	RW (pers. obs.)
Cp	India	Indian Mus., Calcutta	73.0	39.0	-	-	-	92.0	Kaushik Deuti (pers. comm.)
Cp	Obo, Fly R., PNG	Wildlife Department?	72.0	-	6.20	20.7'	1:8.6	-	RW (pers. obs.)
Cp	Bengal	British Museum	71.1	-	-	33'myth	-	91.4	George Craig (pers. comm.)
Cp	Sarawak	Sarawak Museum	71.1	-	-	-	-	-	Banks (1931)
Cp	India	Indian Museum	71.0	35.0	-	-	-	86.0	Kaushik Deuti (pers. comm.)
Ts		MMNB, Berlin	70.4	-	-	-	-	-	Paolo Piras (pers. comm.)
Gg	India	Tubingenrept	70.3	-	-	-	-	-	Paolo Piras (pers. comm.)
Gg	India	AMNH, New York	69.7	-	-	-	-	-	Paolo Piras (pers. comm.)
Cp	Fly R., PNG	St. Aug. Gator Farm	69.0	-	5.34	17.8'	-	-	"Gomek"; J. Brueggen (pers. comm.)
Cp	Mary R., Australia	Corroboree, Darwin	68.8	43.9	5.64	18.5'	1:8.1	86.0	AB, RW (pers. obs.)
Cn	L. Chamo, Ethiopia	Arba Minch, Ethiopia	68.6	40.4	5.40?	18' ?	1:7.8 ?	87.0	RW (pers. obs.)
Cn	L. Chamo, Ethiopia	Arba Minch, Ethiopia	67.9	41.4	5.40?	18' ?	1:7.8 ?	-	RW (pers. obs.)
Ts		MCZ, Harvard	67.8	-	-	-	-	-	Paolo Piras (pers. comm.)
Cn	L. Chamo, Ethiopia	Arba Minch, Ethiopia	67.3 [3]	42.1	5.40?	18' ?	1:7.8 ?	85.8	RW (pers. obs.)
Cp		Paris Museum	66.4	39.2	-	-	-	84.0	Ivan Ineich (pers. comm.)
Cp	Bhitarkanika, India	Wildlife Department	66.0	40.2	5.10?	17' ?	1:7.7	-	RW (pers. obs.)
Cp	Luzon, Philippines	MCZ, Harvard	66.0	-	-	29'myth	-	84.4	Greer (1974)
Ci	S. America	Senckenberg	65.1	-	-	-	-	-	Paolo Piras (pers. comm.)
Gg	India	MMNB Berlin	65.5	-	-	-	-	-	Paolo Piras (pers. comm.)
Cp	Mary R., Australia	Darwin Croc Farm	64.4	46.3	6.00?	20' ?	1:9.3 ?	-	"Charley"; Webb and Messel (1978)
Am	Sebastian R. Florida	MCZ, Harvard	64.0	-	4.54	14.8'	1:7	-	Barbour (1933)
Cp	Bhitarkanika, India	Wildlife Department	62.8	42	5.40?	18' ?	1:8.5 ?	-	Orissa Wildlife Dept. (pers. obs.)
Cc	Africa	Paris Museum	61.7	-	-	-	-	-	Paolo Piras (pers. comm.)
Am	Apilachicola R., Fl.		60.0	-	4.27	14.3'	1:7.1	-	Woodward *et al*. (1995)
Am	Orange Lake, Florida		58.4	-	4.23	14.1'	1:7.2	-	Woodward *et al*. (1995)
Cp	Singapore?	Madras Croc Bank	56.3		5.13	16.8'	1:9.1		"Jaws"; RW (pers. obs.)
Cp	Australia	St. August. Gator Farm	55.0		4.65	15.5'	1:8.5	-	"Maximo"; J. Brueggen (pers. comm.)

This is an intriguing subject and hopefully this note will encourage colleagues out there to come up with bigger skulls (or other solid evidence) than we've been able to find. It might also encourage some re-measuring, using a standard caliper, some creative mathematics to account for shrinkage and a more comprehensive table of crocodilian maximum sizes for all crocodilian species. We also need to take a cue from Webb and Messel (1978) where they suggest that it might make more sense to derive a relationship between volume of bone in the skull and TL rather than linear ratios which just don't seem to work for the real big ones. And not to be ignored is the formula derived by John Thorbjarnarson and colleagues working with a large sample of Orinoco and American crocodiles [TL = hindfoot (longest toe with nail) length x 11.85 - 12.97; Thorbjarnarson and Hernandez 1993]. The days of listening to the same old 'bigger than the boat' stories are over.

Table 1 lists the 30 or so biggest crocodiles/skulls we were able to locate, and includes the very few examples of both HL and TL that we have been able to find for big crocodiles and also some of the wide ranging ratios that are driving us 'skullduggers' nuts. The unfortunate thing is that perhaps the genes favouring gigantism have been lost from the gene pool as a result of the selective killing of big crocodiles around the world. This is a good argument against the continued 'safari' harvests of the world's remaining giant crocodiles.

A number of colleagues generously contributed to this compilation of big crocodile information and we'd like

to profusely thank: Wayne King, the late Phil Hall, Ivan Ineich, Wann Langston, Peter Taylor, Paolo Piras, Gunther Koehler, Fred Glaw, Adam Britton, Charlie Manolis, Jack Cox, Mike Klemens, George Craig, Sudhakar Kar, Jerome Montague, Assegid Gebre, Allan Woodward, Ruth Elsey, John Thorbjarnarson, Ralf Sommerlad, Rich Fergusson, John Brueggen, Jeff Lang, Kent Vliet, Uthen Youngprapakorn, Kaushik Deuti and others we may have omitted. Thanks also to the Icon Films crew for facilitating the crocodile measuring trip around the world and to African Parks colleagues who hosted Nik and I in Ethiopia. Janaki Lenin, John Thorbjarnarson and Adam Britton kindly reviewed the manuscript.

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[Note: This article, together with additional photographs that could not be included here, is available at www.iucncsg.org/ph1/modules/Publications/reports.html].

CROC FAT FUEL! Experiments in bio-fuels at Rhodes University (Grahamestown, South Africa) turned up a surprising result. Biotechnology students took on the lawns at Rhodes Great Field on lawnmowers powered by fuels produced from pure crocodile fat, beef fat, a mixture of the two, or sunflower oil.

The mower powered by pure crocodile fat triumphed over competitors using lower proportions of crocodile fat mixed with cow fat and/or sunflower oil. The results astounded both researchers as well as students.

The unusual experiment was the brainchild of Grahamstown alternative-energy guru Dr. Garth Cambray, who began investigating the benefits of using crocodile fat as bio-diesel earlier this year. Dr. Cambray was the winner of "The Herald Citizen of the Year" award last year.

It takes about two hours to turn crocodile fat into fuel by heating it up and separating the oil from the water. The potential to produce large amounts of bio-fuel is evident, considering the numbers of crocodiles that are utilised each year around the world..

Source: Weekend Post <*www.weekendpost.co.za/main/2008/12/06/news/nl11_06122008.htm*>.

6th World Congress on Herpetology

The 6th World Congress of Herpetology was held in Manaus, Brazil, on 17- 22 August 2008. Dick Vogt, who organized the Congress, had asked CSG members John Thorbjarnarson and Kent Vliet to organize a symposium on crocodiles. The crocodile symposium was well attended, presentations were generally very good, albeit they were mostly limited to Brazilian fauna.

It was unfortunate that the day and time for the crocodile symposium was changed (from Thursday to Friday) without any of the speakers being contacted. As a result, Lew Densmore was unable to attend as he was on a flight leaving Friday morning. Also disappointing was the acceptance of speakers by the organisers without consultation with JT or KV, and the rigid time allowance for each speaker, even though there was sufficient time for much longer presentations.

The speaker program comprised:

Lew Densmore: Genetic Variation and interspecific hybridization in New World crocodiles: implications for conservation and management.

Chris Brochu: The role of paleontological information in the conservation of crocodiles.

Val Lance: The reproductive cycle of the American alligator: physiology and endocrinology.

Kent Vliet: Management implications of training captive crocodilians.

Marcos Coutinho: Recent advances in management and conservation of Brazilian crocodiles.

Robinson Botero-Arias, Boris Marioni and John Thorbjarnarson: Management of caiman in the Brazilian Amazon: a case study.

Francisco Villamarin-Jurado : Black caiman (*Melanosuchus niger*) nesting ecology in a protected varzea forest from Central Amazon, Brazil.

Boris Marioni, Ronis Dasilveira, Robinson Btero-Arias and John Thorbjarnarson: Hunt, management and productive values of caimans in the Amazon.

Juan F. Duenas-Serrano, Santiago R. Ron, Francisco Villamarin-Jurado and Andres Vallejo: Population trends of *Melanosuchus niger* and *Caiman crocodilus* (Crocodilia: Alligatoridae) in four black lakes in Reserva de Produccion Faunistica Cuyabeno, Ecuador.

John Thorbjarnarson, Roberto Ramos Targarona, Roberto Soberón and Manuel Alonzo Tabet: Conservation of the enigmatic Cuban Crocodile.

Shelley Burgin: Crocodiles and "grey-headed nomads": a deadly combination?

William Rangel Vasconcelos: Diversity and distribution of *Caiman* sp. from Amazon to Pantanal.

Two posters on crocodilians were also presented:

Zilca Campos, Tania Sanaiotti and William Magnusson: Maximum size of the dwarf caiman, *Paleosuchus palpebrosus* (Cuvier, 1807) in Central Amazonia.

Jaydione Luiz Marcon, Herlane do Nascimento Medes, Adriana Teizeira de Oliveira, *et al*. Hematology and plasma biocheical profile of *Paleosuchus trigonatus*.

In terms of general organisation and amenities, the registration fee ($US540) was considered excessive, and the purported 5-Star rating of the Tropicana Hotel was not reflected in the condition of the rooms, but was certainly reflected in the cost. Even more upsetting was the fact that room rates were increased for Congress attendees - had we showed up without any reservation it would have been cheaper!

Dr. Val Lance, *CSG Vice Chairman for General Research,* <*lvalenti@sunstroke.sdsu.edu*>.

A near miss for a Whistling kite that flew a little too close for comfort to a Saltwater crocodile (*Crocodylus porosus*) at Corroboree Billabong, Northern Territory, Australia.

Top: Kite makes first pass looking for small fish at the waters' surface. Bottom: 20 seconds later, the kite passes close to the crocodile - which lunges but misses its feathered prey. Photographs: Chris O'Brien <chris@dreamedia.com.au>.

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