CROCODILE SPECIALIST GROUP NEWSLETTER

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COVER PHOTOGRAPH: First Philippine crocodile (*Crocodylus mindorensis*) hatched in Australia, at Melbourne Zoo. See pages 12-15. Photograph: Damien Goodall.

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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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Vic Mercado, Microlab, Philippines.
The Ebey family, New Mexico, USA.
Marco Schultz, Spende AG Krokodile PGHT, Germany.
Nao Thouk, Phnom Penh, Cambodia.

Editorial

It is with great regret that we have to advise of the recent passing of Keiran McNamara, a long-term CSG member from Australia (see page 4).

The 22nd Working Meeting of the Crocodile Specialist Group was held in Negombo, Sri Lanka, from 21-23 May 2013. As the first CSG working meeting in the South Asia and Iran region since 1978, the meeting had a strong regional content. It was great to see a good attendance from within and outside the region, and the increasing number of young, keen students working on crocodiles. The proceeds of the auction ($US3233) will be used to fund student projects in Sri Lanka. A summary of the working meeting is on pages 11-12.

A veterinary workshop held on 19 May attracted considerable interest, with some 100 participants (see page 11). The level of interest exemplifies the need for this type of training in the region.

The CSG Steering Committee met on 20 May, prior to the working meeting. A number of new appointments were made to the committee, and a wide range of issues was discussed. Of particular significance was a recent report from the Responsible Ecosystems Sourcing Platform (RESP) regarding the outcomes of a meeting of an International Working Group on Reptile Skins.

Following discussions, it was decided that the issues facing the snake skin trade are very specific to that industry, and do not relate to the situation with crocodilians where systems for verification, traceability and sustainability, although not perfect, have long been in place. It has been suggested that the CSG takes a more active role in clarifying what has been achieved with crocodiles, thereby distancing ourselves from forums concerning snakes, where one gets the impression that crocodiles are being dragged in for the wrong reasons. That they are "reptiles" does not necessarily create an umbrella for like treatment. Just as elephants and sheep are handled differently, despite both being "mammals". Crocodile experience has and may continue to provide some practical guidance for the snake trade, but the at this stage at least, I do not believe the crocodile trade has much to learn from the snake trade.

The Steering Committee agreed, subject to availability of external funding, that the CSG develop Best Management Practices (BMP's), to assist and guide the crocodile farming industry. Aspects of these BMP's may also be included within the web-based Crocodilian Capacity Building Manual (CCBM) currently being developed. A summary of the Steering Committee meeting is on pages 4-10.

The CSG bank account held at the University of Florida has now been closed, and US donors are advised to transfer their contributions directly to the account in Australia. The CSG Executive Officer can be contacted for details, or you can visit the CSG website (http://www.iucncsg.org/pages/Support-the-CSG.html) for a Donation Form.

A "CrocFest" fund-raising function was held on 29 June 2013 at the George Van Horn's Reptile World Serpentarium in St. Cloud, Florida, to raise funds in support of conservation of the American Crocodile in Jamaica. A full report of the success of the CrocFest will appear in the next CSG Newsletter.

Donations have begun to arrive in response to the annual letters of request, and I am personally very grateful to all who have made a contribution, past and present. The support of CSG donors, big and small, is critical to the CSG's ability to operate effectively and sustain itself.

Professor Grahame Webb, *CSG Chairman*.

CSG Student Research Assistance Scheme Update

The CSG Student Research Assistance Scheme (SRAS; http://www.iucncsg.org/pages/General-Information.html) provided funding to three students in the April-June quarter (see below). A further four applications are currently under review.

1. David Alonso Vargas Ortega (Colombia): Population and reproductive ecology of *Crocodylus acutus* (Curvier 1807) in the Tayrona National Park, Colombian Caribbean.

2. Roberto "Toby" Ramos Targarona (Cuba): Ecology and Conservation of the Cuban crocodile (*Crocodylus rhombifer*) in the Zapata Swamp, Cuba.

3. César Norberto Cedillo Leal (México): Nesting Ecology of *Crocodylus moreletii* in two villages in southern Tamaulipas, México.

Obituary

Keiran McNamara (27 June 1954 - 28 March 2013)

Sadly, on 28 March 2013, Keiran McNamara lost his battle with cancer after a short illness. After graduating in natural resources from the University of New England in Armidale, New South Wales, and a short stint in Saltwater crocodile research at the University of Sydney, he spent 7 years with the Australian National Parks and Wildlife Service in Canberra. While with ANPWS, Keiran contributed to the inquiry that ultimately led to Australia ceasing to be a commercial whaling nation, and the work of the International Whaling Commission and its Scientific Committee.

Being motivated to work in a more "hands on" role in wildlife conservation and management than was possible with the Commonwealth Government, in 1985 Keiran took up a position with the newly-established Department of Conservation and Land Management in Western Australia. In 1991 he was appointed the Director of Nature Conservation, going on to be appointed CALM Chief Executive in 2001. When the Government amalgamated CALM and the former Environment Department in 2006, Keiran was appointed as Director General of the new Department of Environment and Conservation.

There is little doubt that much of the achievements of the Western Australian Government in the areas of environment and conservation over the last 10 years can be attributed to Keiran's efforts. Keiran played a major role in expanding marine protection at Ningaloo Reef and steering its World Heritage nomination, as well as increasing the conservation estate in the Kimberley.

Keiran's passion for the environment was reflected throughout a distinguished career in the parks sector. His career and professional interests were in biodiversity conservation and establishing and managing protected areas systems. He had a long record of involvement in national intergovernmental conservation forums, as well as international treaties and the work of IUCN.

He is survived by his wife Anne, daughter Sarah, sons Peter and Ian, and extended family in Western Australia and New South Wales.

CSG Steering Committee Meeting
(Negombo, Sri Lanka, 20 May 2012)

1. Opening

Ruchira Somaweera, on behalf of the organising committee, welcomed everyone to Sri Lanka and to the CSG Steering Committee meeting.

In the absence of the CSG Chairman, who could not arrive in Sri Lanka until the nght of the 20th, Alejandro Larriera, Deputy Chairman, welcomed participants and thanked the organisers for their efforts in organising the meeting.

Steering Committee members present: Alejandro Larriera, Tom Dacey, Perran Ross, Charlie Manolis, Alvaro Velasco, Samuel Martin, John Caldwell, Paolo Martelli, Val Lance, Christine Lippai, Anslem de Silva, Ruchira Somaweera, Don Ashley, Kent Vliet, Yoichi Takehara, Enrico Chiesa, Bruce Shwedick, S.M.A. Rashid and Maheshwar Dhakal.

Observers present: Philip Cunliffe-Steel, Jeff Lang, Brian Wright, Ashley Pearcy, Robert Gandola, Mark Merchant, Sally Isberg, Benedict Solco, Brian Sibonga, Rainier Manalo, James Chan, Marisa Tellez, Brandon Sideleau, Matt Plummer, Vicente Mercado, Teri Aquino, Pedro Mendoza, Geoff McClure, Szu-Lung Chen, Alexander Meurer, Mushtaq Ahmed, Vyas Rajendrakumar Vajubhai, Cathy Shilton, Akira Matsuda, Agata Staniewicz, Jigar Upadhyay, Christoper Moran, Hasanta Lokugamage, Thilanka Samaraweera, Samantha Pushpakumara, Abusyem M. Arif, Colin Stevenson, Oswald Braken Tisen, Himanshu Rajeev Joshi, Chiranjibi Prasad Pokheral, Nazesh Subedi, Abhijit Das, Asghar Nawab, Csaba Geczy, John Brueggen, Jen Brueggen, Adam Britton, Erin Britton, Panduka de Silva, Ruttana Hassan, Bed Bahadur Khadka, Nilantha Kodithuwakkw, Sampath Gunasinghe, Chamara Amirsinghe, Chaminda Jayasekarra, Avinda Godahewa, Aviskka Godahewa, Rambli Bin Ahmad.

Apologies (Steering Committee members): Grahame Webb, Dietrich Jelden, Toshinori Tsubouchi, Choo Hoo Giam, Nao Thuok, Eric Langlet, Alfonso Llobet, Carlos Pina, Hesiquio Benitez Dias, Miryam Anaya, Luis Bassetti, Sergio Medrano-Bitar, Roberto Soberon, Bernado Ortiz, Jon Hutton, Ralf Sommerlad, Ruth Elsey, Allan Woodward, Noel Kinler, Frank Mazzotti, Tomme Young, Hank Jenkins, Yoshio Kaneko, James McGegor, Clara Lucia Sierra Diaz, Alison Leslie, Simone Comparini, Asghar Mobaraki, C.H. Koh.

Apologies (other CSG members): Patrick Aust, Manuel Muñiz, María de la Paz López Vázquez, Rafael Antelo, Rob Stuebing, Bienvenu ADJE Chabi, Laura Brandt, Gordon Grigg, Yosapong Temsiripong, Merlijn van Weerd, Antoine Cadi, Elham Abtin, Rene Hedegaard

Complete Steering Committee documents are available on the CSG website (http://www.iucncsg.org/pages/Publications.html).

Figure 1. Steering Committee, Negombo, May 2013.

1.1. Chairman's Report

The Deputy Chairman welcomed everyone and thanked the workshop organisers, including representatives of Government, academic institutions, industry and NGOs. He also drew attention to the activities of the CSG over the past year and the forthcoming years, highlighting:

- Three CSG members had passed away since the last working meeting: Saul Elias Gutierrez Eljuri (Venezuela), Keiran McNamara (Australia) and Alfonse Mava (Papua New Guinea), a long-time contributor to crocodile conservation and management programs in the Sepik River area. A minutes silence was held in remembrance.
- Changes to the Steering Committee.
- Various meetings in which the CSG had been involved over the past 12 months.
- The current status of trade in Madagascar, where CITES has maintained the trade suspension recommended by the CITES Standing Committee.
- The Order of the Silver Crescent award (South Carolina's highest award) to Phil Wilkinson.

1.2. Minutes and Actions from CSG SC Meeting, Manila, Philippines (May 2012)

Executive Officer Tom Dacey advised that all outstanding actions from the Manila meeting were either reported in the minutes of the meeting or addressed as separate agenda items in the papers for the working meeting. He also advised that the Proceedings from the Manila meeting had recently been printed and copies would be distributed to participants shortly. Completion of actions from the last CSG SC meeting was noted.

1.3. Executive Officer's Report

The Executive Officer highlighted:

- CSG membership of 488 (62 countries)
- Funding of a Regional Office (South Asia and Iran) in Sri Lanka.
- Reviews and meetings: Lao PDR; CoP16, Bangkok; and, 22nd CSG working meeting, Negombo.
- SRAS (Agenda item SC.7.1) - since 2009 there had been 61 applications, 58 of which were approved, and 3 are under consideration. To date, reports for 34 completed projects have been received. All details are available on the CSG website. Those applicants who have successfully completed their various projects have been offered membership of the CSG. Four SRAS students, Marisa Tellez, Ashley Pearcy, Agata Staniewicz and Ruchira Somaweera participated in the current CSG meeting.

1.4. Financial Report

The financial report highlighted the current balance of $US594,175 (at 31 March 2013), although this is declining with current exchange rates between $USD and $AUD. The account at the University of Florida is closed, and all funds are being transferred to the IACS account in Australia.

CSG-TTF funds currently total approximately $US46,500. Chinese Alligator Fund has $US7000 - the Executive Officer advised that there had not been any transactions for over 8 years and a decision needs to be taken on what to do with these funds. Discussions will be held with the Chinese delegates, CSG Executive and the original Chinese Alligator Fund organiser, Adam Britton.

1.5. International Association of Crocodile Specialists Inc.

The Executive Officer gave an outline of the establishment of IACS as a separate legal entity, specifically to manage the finances of the CSG. The Audited Financial Statement for 30 June 2012 was tabled. The Annual General Meeting was held on 7 November 2012.

2. Regional Reports

2.1. South and East Africa

As there is no Regional Chairman for South and East Africa at the moment. Christine Lippai and Alison Leslie provided the report highlighting recent activities:

- South Africa - Crocodile research activities including a workshop in the Kruger National Park (March 2012) and the depressed market for Nile crocodile skins.
- Namibia - status evaluation carried out in 2012 and need for crocodile management plan.
- Malawi - HCC is a major problem. Trophy hunting commenced in 2010 (quota of 15 for 2012).

- Botswana - Okavango Crocodile Monitoring project continuing.

2.1.2. Lake Chamo, Ethiopia

Charlie Manolis reported briefly on the meeting with Ethiopian officials at CoP16 and the circumstances that resulted in the closure of trophy hunting in Lake Chamo. A CSG review is proposed to be undertaken subject to availability of funding.

A brief discussion was held on the issue of CSG members working in a private capacity being considered by outside parties as representing the CSG. There has always been a fine line between CSG members working privately or as CSG representatives, and members should consult the CSG policy on this issue.

2.2. West and Central Africa

Samuel Martin addressed the report, highlighting:

- Work is continuing in Benin on *Osteolaemus tetraspis* by the Credit ONG program and Nathalie Kpera.
- Lacoste/FDB and SOS Crocodiles of La Ferme aux Crocodiles (France), continue to be involved in several projects, particularly in Niger, where a number of issues have been identified.

A report was provided by Matt Shirley on the work he has been undertaking in:

- Gabon - Impact of the oil industry on crocodiles, particularly, Dwarf crocodile abundance and trade; proposed collaboration with Marisa Tellez; and, sustainable trade in crocodile bushmeat.
- Cote d'Ivoire - Rehabilitation at the Zoo National d'Abidjan, focusing on captive breeding of *M. cataphractus*.
- Two CSG SRAS students working in DR Congo and Uganda.
- Finalisation of Red List assessments for all African crocodile taxa.

A discussion was held on a proposed third regional meeting, however, no firm venue or dates have been identified.

2.3. East and Southeast Asia

The report collated by the CSG Executive Officer from various sources highlighted:

- Current WCS activities in Lao PDR, regarding their "Community Based Crocodile Recovery & Livelihood Improvement Project".
- Cambodian Crocodile Conservation Programme report by FFI and Cambodian Fisheries Department: ongoing protection of three breeding populations; monitoring of population trends and reproduction; National Siamese Crocodile Reintroduction and Reinforcement Strategy and Action Plan, including a pilot release in the Cardamom Mountains; and, Development of a National Crocodile Farmers Association.
- Sarawak update: "Holistic Crocodile Resource Inventory for Sarawak, 2013"; "Strategic Crocodile Management in Sarawak, November 2012"; HCC issues; and, various crocodile management activities.
- Sabah update - HCC attacks appear to be consistent.
- Philippines - reintroduction of *C. mindorensis* on Siargao Island and death of "Lolong". A progress report from the Mabuwaya Foundation arrived too late to be included in the agenda, but the full report is included with all SC documents on the CSG website.
- Japan - court case involving import of hybrids.
- China - sub-regional report on Chinese Alligator: captive breeding and release of captive breed Chinese Alligators in Anhui and Zhejiang Provinces; status of wild Alligator populations in Anhui Province; and, approval of future research projects.

2.4. North America

The report, provided by the Regional Chairs, Ruth Elsey and Allan Woodward, highlighted:

- Death of 140 American Crocodiles (*C. acutus*) in Southern Florida during the winter of 2010;
- Various State reports: Alabama hunting season; Arkansas increase in the annual maximum harvest; Florida alligator harvest programs and continued research efforts; Georgia - no recent changes to management programs; Louisiana - impact of the global financial crisis and it's effect on alligator industry in southern States; Mississippi - expansion of sport hunting opportunities on public waters; North Carolina undertaking a study to determine if State harvest of alligators is sustainable; Oklahoma - report on recent research efforts; South Carolina report on 2012 public hunting season and ongoing long term research; and, Texas - Nusiance Alligator Program.

Don Ashley and Perran Ross also provided additional information on activities, such as: animal welfare concerns; captive breeding operations; continued increases in the markets; and, Florida's proposal to open a hunting program.

2.5. South Asia and Iran

The report was provided by Anslem de Silva, with input from the various Vice Chairs, who introduced their individual country reports:

- Iran (no representative present) - report on recent surveys and current status;
- Pakistan (no representative present) - increase in the number of captive breeding farms, work with village communities and general distribution and status of crocodilians;
- Sri Lanka (Ruchira Somaweera) - population studies, HCC surveys and issues and public awareness programs;
- Nepal (Maheshwar Dahakal) - *ex-situ* conservation and restocking program continues, however, maintaining a healthy wild Gharial population remains a major challenge;
- India (Raju Vyas) - status reports on all three species (Gharials, Saltwater crocodiles and Muggers) and future research incentives; and,
- Bangladesh (S.M.A. Rashid) - reports on Gharials, Mugger and Saltwater crocodiles, commercial activities and HCC issues.

Anslem de Silva provided an overall summary for the SA&I region.

2.6. Australia and Oceania

The report provided by Regional Chairman Charlie Manolis, highlighted:

- Northern Territory: Review of Saltwater crocodile management completed; HCC attacks; no response from Federal Government on trial trophy hunting; and, NT Parks and Wildlife work in relation to the decrease in the Freshwater Crocodile population due to cane toads.
- Queensland - Edward River Crocodile Farm has gone into receivership. Adam Britton gave a brief overview of the pilot wild egg harvest program currently being undertaken at Edward River.
- Papua New Guinea - crocodile farming industry continues to focus on *C. porosus*, although wild harvesting involves both *C. porosus* and *C. novaeguineae*. Population monitoring shows increasing populations of both species.
- East Timor - the East Timorese Government recently formed a Crocodile Task Force to improve knowledge and experience in managing crocodile populations. HCC continues to be an issue.
- Solomon Islands - HCC continues to be a major issue and creating negative attitudes towards crocodiles.

2.7. Europe

Regional Chairman Jon Hutton was unable to attend the meeting, but had advised that the African Survey Database (www.crocsurveys.net) had been updated and improved.

2.8. Latin America and Caribbean

The report was presented by Deputy Chairman Alejandro Larriera, who thanked all representatives from LA&C region for their inputs into the regional report and offered an apology for all those who were unable to attend the meeting. Issues highlighted:

- Colombia and Venezuela visits.
- Argentina - proposed downlisting of the Broad-snouted caiman under the US ESA has been further delayed by the USFWS.
- Paraguay - skin stockpiles still not sold.
- Uruguay - *C. latirostris* farm at Cerros Azules to be closed.
- Bolivia - Reports on: *C. yacare* wild harvest, ranching and captive breeding programs; *M. niger* and *C. latirostris* Action Plans; and, confiscation of caimans in Bolivia.
- Peru - report on *C. acutus* captive breeding and conservation status, situation with *M. niger* and other activities and issues.
- Brazil - concern about the closed-cycle *C. latirostris* farm in the State of Alagoas exporting Appendix-I skins to Europe; and, 7th Field Training Course conducted in October 2012 (9 participants from 5 countries).
- Colombia - discussions between farmers and Government regarding the scar button (scute marking) and verification process. New protocols have been developed.

Marisa Tellez reported briefly on the following:

- Belize - *C. moreletii* is semi-stable, in areas of Hennonite farm communities they are extirpated; *C. acutus* is declining as a result of habitat loss and senseless killing; with both species, crocodile education is helping with public acceptance of crocodiles, but it is a slow process.
- Guatemala - a group known as ARCAS is working with the government to increase crocodile research and education. I worked with them in March 2013 and will return in September to train people in parasitological techniques and assist a wild population survey; they are interested in expanding crocodile research.

2.8.1. Crocodile conservation in Jamaica

Perran Ross presented the paper and the issues discussed at the *C. acutus* meeting held in Miami on 15 February 2013. Reasonable

progress has been made to date and approval of the Jamaican agency heads obtained. Currently developing the outline of a proposed action plan. A fund-raising program has been proposed to enable a further meeting of the working group to be held in Jamaica.

3.1. Vietnam Review

There was no specific report from Vietnam and no representative from Vietnam present at the meeting. However, Agenda SC.2.3 mentions "*Crocodylus siamensis* Exports vs. Domestic consumption, 2002-2012".

3.2. Cambodia: Implementation of Recommendations

The detailed report from Fisheries Administration of Cambodia on implementation of the recommendations of the 2005 CSG review was included in the agenda papers.

Recommendations 1, 2, 3, 4, 5, 6, 7, 9, 12, 21, 22, 3, 25, 26, 27 were considered to have been completed. Recommendations 13, 18, 19, 24, 29 and 31 were considered to have been partly completed and ongoing. Recommendations 8, 10, 11, 15, 16, 17, 20, 28, 30 were considered to be ongoing. Charlie Manolis gave a brief overview of achievements and ongoing activities, including the recently approved re-introduction program (SC.2.3 also refers).

3.3. Madagascar Review

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

3.4. Cuba Review

As Roberto Soberon has now moved to Spain, and the CSG Executive appointed Manuel Tabet as a LA&C Vice Chair. The Deputy Chairman, Alejandro Larriera, had recently spoken with Manuel Tabet by telephone, which will the main means of communication in the future. At this stage there is no further report on the Cuba review recommendations.

3.5. First Species (*C. siamensis*) Meeting, Bangkok - Progress Report

The Executive Officer reported that the major subsequent outcome from the Bangkok meeting has been the establishment of the Siamese Crocodile Task Force, to discuss what might be possible in respect of the common recommendations on compliance, capacity building, etc. A report from the Task Force is at SC.6.3. The report was noted.

3.6. Lao PDR Review

The Executive Officer report on the visit to Lao PDR was included in the documents and also reported in the CSG Newsletter. Highlights included meetings with representatives from DFRM and WCS officials, and visits to Lao Zoo (privately owned) and Tansoum and Ban Nao Nua Villages. The WCS report at SC.2.3 also refers.

4. Thematic Vice Chair Reports

4.1. CITES

The report was briefly introduced by Charlie Manolis, highlighting:

- Madagascar - the trade ban continues (see SC3.3).
- Colombian proposal to transfer the Cispata Bay population of *C. acutus* from Appendix I to Appendix II was not adopted at CoP16.
- Thailand's proposals for the transfer of *C. siamensis* and *C. porosus* from Appendix I to Appendix II were unsuccessful at CoP16.
- CoP16 adopted revisions to paragraph A.2 of the Precautionary Measures in Annex 4 to Resolution Conf. 9.24 (Rev. CoP15), which reinstates Resolution Conf. 11.16 (Rev. CoP15) as a "stand alone" alternative mechanism [to Resolution Conf. 9.24 (Rev CoP15)] for downlisting proposals based on ranching.

The opportunity was also taken to discuss various conservation and management issues with: Ethiopia, Thailand, Costa Rica, Israel, Uganda and Rwanda.

4.2. Industry Report

Vice Chair Don Ashley addressed the report highlighting:

- The continuing trend of Animal Rights campaigns for exotic leather product bans remain a central concern;
- Traceability and Sustainability Study co-commissioned by the United Nations Conference on Trade and Development (UNCTAD) and CITES Secretariat;
- The study conducted by the "Expert Panel on Humane Killing of Reptiles" has been proposed for consideration by the World Organisation for Animal Health, as a worldwide standard on slaughtering methods; and,
- Suggested strategy for overcoming concerns: capacity building; institutional framework; compliance audits; non-detriment findings; traceability; and, trade monitoring.

4.3. Trade Monitoring

Vice Chair John Caldwell presented the report, highlighting: the source of the trade data; outstanding CITES reports (eg Australia); and, preparation of IACTS reports.

4.4. Veterinary Science

Paolo Martelli presented the report, highlighting:

- Membership is now 14 CSG members.
- Progress with the CSG website update on Veterinary Science.
- The Workshop on Crocodile Clinical Techniques, held prior to the Steering Committee meeting was very well attended.
- PhD on electro-stunning (South Africa).

4.5. Zoos

Vice Chair Kent Vliet presented the report highlighting:

- Good relationships with Zoos and Zoo participants in North America and Europe;
- Activities of AZA Crocodilian Advisory Group (USA);
- St. Augustine Alligator Farm Zoological Park;
- San Diego Zoo and Busck Gardens Tampa involvement with Ivory Coast project on *M. cataphractus*;
- Development of Crocodilian Conservation Centre of Florida;
- Steve Platt (WCS) visit to China;
- "Croc Fest" fund raising activities; and,
- Various reports by European Zoos - Cologne Zoo; ARTIS Royal Zoo, Amsterdam; Dortmund Zoo; Protivin Crocodile Zoo; Dvur Kralove Zoo; and, Krokodille Zoo.

4.5. Community Education

Vice Chair Clara Lucia Sierra Diaz was unable to attend the meeting so Charlie Manolis addressed the report highlighting: mission; new name of group (Public Education and Community Participation); and, proposed activities and actions.

4.7. General Research

Vice Chair Val Lance gave a verbal report highlighting the high number of recent papers dealing with crocodilians and listing a number of specific relevant papers (eg genomes, chromosome painting, fossil crocodilians and feral pig predation of alligator eggs).

5. IUCN Red List Authority

Perran Ross advised that Red List Assessments had been completed for *C. siamensis* (Critically Endangered A2c.) and *Tomistoma schlegelii* (Vulnerable A2cd) and submitted to SSC/IUCN for review (previously Endangered). The assessment of *C. mindorensis* is in the process of revision by the assessors (proposed Critically Endangered A2cd). A draft assessment of *C. niloticus* is being prepared by Matt Shirley. A request has been submitted to SSC/IUCN Red List staff to include an additional taxon *C.* "*suchus*", representing those "nile crocodiles' found in Central and West Africa. During the CSG Working Meeting a Red List assessment for *C. palustrus* is to be conducted.

6. Task Force/Working Group Reports

6.1. Tomistoma Task Force

The report was presented by TTF Chair Bruce Shwedick, highlighting:

- Funding support received from various contributors and activities;
- Activities and reports; and,
- CSG-TTF Mission to Singapore Zoo (29 May 2012).

6.2. Human-Crocodile Conflict

HCC Chairman Allan Woodward was unable to attend the meeting but provided a written report. Charlie Manolis addressed the report, highlighting:

- The outcomes of the Working Group meeting in Manila (May 2012);
- Proposed development of an online database by Brandon Sideleau and Adam Britton; and,

- A special HCC session will be held in Louisiana (May 2014), including presentations of HCC case studies.

6.3. Siamese Crocodile Task Force

SCTF Chairman Parntep Ratanakorn was unable to attend the meeting but provided a written report outlining progress to date, including:

- Informal meetings held during CITES CoP16;
- Surveillance of *C. siamensis* diseases in captive breeding operations in Thailand;
- Development of a *C. siamensis* database for captive and wild populations;
- Organisation of a Regional Workshop on *C. siamensis* reintroduction; and,
- Survey of wild *C. siamensis* in Bueng Borapet and planning for reintroduction in Pang Sida National Park.

6.4. Capacity Building Manual Working Group

Verbal report presented by Charlie Manolis, highlighting the outcomes from the previous CSG Working Group meeting in Manila:

- "Wikipedia" summary approach to be undertaken;
- Charlie Manolis had drafted a number of examples to indicate style/format of contributions;
- Ashley Pearcy had approached selected people for contributions. To date, 50% of the items have been completed, but are still subject to further review; and,
- There was a need for further contributions and the first sections should be available on the CSG website by the end of June 2013.

6.5. Space and Husbandry Standards for Captive Crocodilians

Report was provided by Kent Vliet, outlining:

- Background to the issue;
- The scope of the task only relates to captive crocodilians in zoos;
- Space requirements have been addressed in some countries (eg Germany and Australia);
- Recommendation that the CSG avoid a highly prescriptive approach;
- Husbandry standards; and,
- Welfare is a paramount issue.

The matter was referred back to the working group to meet, with other interested participants, during the current working meeting. The out of session discussions agreed that the CSG would avoid a highly prescriptive approach and adopt the guidelines proposed by Queensland, Australia: "the space required to hold captive crocodilians in zoos must meet the behavioural and physical needs of the crocodilian".

7. General Business

7.1. Student Research Assistance Scheme

The report presented by Executive Officer Tom Dacey highlighted:

- 61 applications received since 2009, 58 approved, 3 applications under consideration and 34 reports received;
- Details of successful applications are now on the CSG website, including final reports as they are received; and,
- Upon receipt of an acceptable report, the successful SRAS Students are offered CSG membership if they intend to continue working on crocodilians.

7.2. International Working Group on Reptile Skins

The Chairman, Alejandro Larriera, introduced this paper and outlined the background of the issue, including the recent e-mail from Eduardo Escobedo (Responsible Ecosystems Sourcing Platform) and the initial reply from CSG Chairman. A general discussion ensued and Don Ashley also provided further background on the issue.

The matter was deferred for further discussion by key members during the working meeting.Following the out of session discussions it was agreed and reported to the final plenary that, subject to availability of external funding, the CSG would undertake the development of Best Management Practices (BMPs), to assist and guide the crocodile industry and to counter attacks by anti-use organisations. These BMPs will also form part of the web-based Crocodilian Capacity Building Manual (CCBM), which is currently being undertaken (see 6.4).

8. Next CSG Working Meeting

The 23rd CSG Working Meeting will be held at McNeese University, Louisiana, USA, on 26-30 May 2014. It will be preceded by a meeting of the Steering Committee on 25 May. Mark Merchant gave an overview of progress to date.

The meeting closed at 1600 h.

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

Veterinary Workshop (19 May 2012)

The Working Meeting was preceded by a Veterinary Workshop at the Department of National Zoological Gardens, Dehiwala. This involved hands-on training session in veterinary aspects of crocodilians by Paolo Martelli, Gowri Mallapur and Colin Stevenson (Figs. 1-2). This was then followed by a postmortem session conducted by Cathy Shilton at the University of Sri Jayewardena Pura (Fig. 3).

Around 100 delegates participated in the workshop, and the feedback was overwhelmingly positive, with most people finding it useful and wanting more. The interest generated reflects the need for this type of training in the region.

Figure 1. Paolo Martelli addresses participants at the workshop. Photograph: Anslem de Silva.

Figure 2. Paolo Martelli and Colin Stevenson demonstrate how to collect blood. Photograph: Anslem de Silva.

Figure 3. Cathy Shilton carries out post-mortem. Photograph: Anslem de Silva.

CSG Meeting (21-23 May 2012)

The 22nd Working Meeting of the IUCN-SSC Crocodile Specialist Group (CSG), titled "World Crocodile Conference", was held at the Goldi Sands Hotel in Negombo, Sri Lanka, from 20-23 May 2013. "Living with Crocodilians" was the theme of the meeting. Anslem de Silva, CSG Regional Chairman for South Asia and Iran, and his team of local CSG members organised the meeting, and Sri Lanka's leading conference and exhibition organizing firm, Lanka Exhibition and Conference Services, were contracted to undertake the organizational/logistical aspects. Financial support was provided by a number of organizations, including Lacoste.

The working meeting attracted around 164 participants from 27 countries (Argentina, Australia, Austria, Bangladesh, Canada, China, Czech Republic, Denmark, France, Germany, India, Ireland, Italy, Japan, Malaysia, Nepal, New Zealand, Pakistan, Philippines, South Africa, Sri Lanka, Taiwan, Thailand, United Arab Emirates, United Kingdom, USA, Venezuela). This was considered a good turnout considering that the last CSG working meeting was held in May 2013, just 12 months earlier.

Following a traditional Sri Lankan welcome and lighting of the lamp (Figs. 1-3), the meeting was formally opened by Mr. HD Ratnayake, Director General, Sri Lanka Department of Wildlife Conservation, and the Governor of Central Province, Hon. TB Kobbekaduwa. Professor Grahame Webb, CSG Chairman, presented the keynote address and Anslem de Silva launched his book 'Crocodiles of Sri Lanka' (Fig. 4).

Figure 1. VIPs are led into meeting by traditional drummers and dancers. Photograph: Anslem De Silva.

Figure 2. Alejandro Larriera lights the traditional lamp. Photograph: Alvaro Velasco.

Figure 3. VIP table, with traditional lamp in foreground. Photograph: Alvaro Velasco.

Figure 4. Anslem de Silva presents copies of his book "Crocodiles of Sri Lanka" to Chairman Grahame Webb (left) and Governor Kobbekaduwa (right). Photograph: Alvaro Velasco.

CSG working meetings are a major forum for presenting new findings and new directions in research and management, and the 22nd meeting was no exception. Sessions covered research in Sri Lanka, Gharials, Human-Crocodile Conflict, Veterinary/Husbandry, general research, and status reports from the Philippines, Lake Mesangat (Indonesia), India, Iran and Sri Lanka.

Perran Ross conducted a special session on the IUCN Red List process and the meeting then undertook a Red List assessment of *Crocodylus palustris*. A poster session also saw a diverse range of topics being covered. A photograph and painting exhibition of the region's three crocodilian species by the leading Sri Lankan animal artist J. Jinasena were also on display.

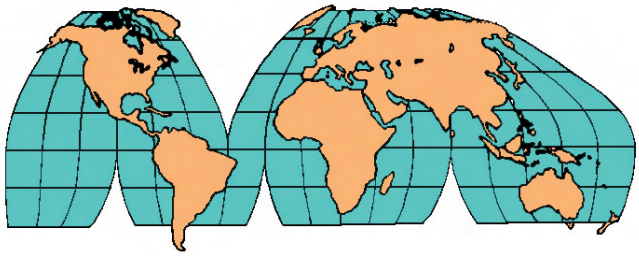
Working groups were established for the CSG's Veterinary Science, Tomistoma Task Force, Zoos and Human-Crocodile Conflict thematic groups, and their deliberations will be summarised in the Proceedings.

The welcome function on Tuesday night and the Wednesday night function featuring entertainment by the Sunil's Dance Academy group of dancers, was a great success. The closing ceremony banquet on Friday night, with the CSG Auction, provided a fitting end to a great meeting. The auction once again proved popular, with auctioneer Mark Merchant working at a furious pace (Fig. 5). A total of $US3233 was raised, which will be used to fund student research projects in Sri Lanka. Thanks are extended to all those people who contributed items to the auction, and of course to those who dug deep into their pockets to buy them. Following the meeting, participants had the opportunity to go on tours to the many tourist venues around Sri Lanka.

Figure 5. Auctioneer Mark Merchant and assistant Soleil Martin coax some money out of Tom Dacey.

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

Regional Reports



Australia and Oceania

Australia

MELBOURNE ZOO BREEDS THE PHILIPPINE CROCODILE . Zoos Victoria (ZV), in Melbourne, Australia, has a long association with the Philippine crocodile, *Crocodylus mindorensis*. This commenced in 1992 with a partnership with Silliman University and the Department of Environment & Natural Resources (DENR) (Banks 1996). In 1999, our focus moved to northern Luzon Island, when the presence of the species was confirmed on the western slopes of the Northern Sierra Madre Range. That resulted in close engagement with the Cagayan Valley Program on Environment & Development and its CROC program - Crocodile Rehabilitation, Observance and Conservation. CROC was institutionalised in 2003 as the Mabuwaya Foundation, which is now ZV's primary *in-situ* conservation partner. The history and achievements of this program are excellently presented in the recent book, "The Philippine Crocodile: Ecology, Culture and Conservation" (van Weerd and van der Ploeg 2012).

Having Philippine Crocodiles on display at ZV's Melbourne Zoo property is critical to telling the species' conservation story and engaging zoo visitors in our conservation partnership. Our pair of crocodiles are members of a group of 6 animals that were imported from the Palawan Wildlife Rescue & Conservation Centre in late 2002 and are among the most popular animals on exhibit in the Zoos' reptile house.

Introductions and Courtship

Efforts to establish compatibility between the zoo's pair of crocodiles began to increase in 2010 as the crocodiles approached a sexually mature size and age. At that time the male was 12-years-old and the female 11 years. However, observations and initial interactions during 2010 and until early 2012 indicated a lack of maturity, with the male being highly aggressive over territory and unwilling to accept another crocodile in his presence.

Prior to 2010, the two crocodiles were in a single large exhibit, but separated from each other by a sliding mesh divide. Exhibit dimensions, landscaping and management features are as outlined by Dunn (1981) in a publication on breeding the Estuarine crocodile (*C. porosus*) at Melbourne Zoo.

Introduction of the two Philippine crocodiles was staged to coincide with "dry season" conditions replicated in their enclosure to stimulate mating behaviour. Many hours were spent by keepers during the introductions monitoring behaviour, including after hours and at night via infrared CCTV recordings. It was initially thought that the crocodiles were concentrating on the presence of keepers observing the animals. This was later found not to be the case and reluctance of each crocodile to enter the others enclosure via the open gate was probably due to habituation of respective enclosures and the short period when the access gate was open. After almost 38 hours of non-continuous access to each other over 8 days, the male became more inquisitive of the female's enclosure. All interactions during this period resulted in aggressive behaviour and fighting instigated by the male, with most encounters needing to be manually separated by keeping staff due to risk of serious injury to one or both animals. At no stage did the crocodiles exhibit courtship behaviour.

During May 2012 the female began showing signs of nest preparation by what appeared to be test digging, although no mating or positive introductions had occurred. At this time both animals began showing positive behaviours towards each other by sitting in close proximity to one another on either side of the dividing gate. This was witnessed on an almost daily occurrence, as well as posturing and occasional vocalization, usually in the form of dull bellows. Again, introductions resulted in aggressive fighting, although slightly less intense than previously witnessed. As the male seemed to be exhibiting territorial aggression we swapped their enclosures and did not give them access to each other until mid August 2012 in an attempt to break his behaviour. Throughout this period they continued to exhibit the above mentioned behaviour towards each other.

On the morning of 16 August 2012 the dividing gate was opened after both animals were seen displaying to each other. Almost immediately the male swam down towards the female, both animals approached each other and began circling with no aggression. Long periods of courting (predominantly chin rubbing and circling) followed, with the female continually mounting and dominating the male (Fig. 1). This behaviour lasted for close to one hour before the male mounted the female. Several attempts later their cloacas joined and both animals sat in a trance for approximately 10 seconds before separating (Fig. 2). Following separation the male instantly became aggressive and started attacking the female, whereupon she immediately retreated to the land area. The male was called back to his enclosure and the divider closed. Subsequent to this initial mating the pair was given access to each other almost daily, depending on available trained staff present to observe the animals. The above-mentioned courting and female dominant mating behaviour was witnessed each time. However, time spent courting reduced with each interaction, down to as little as 10 minutes.

Figure 1. Female (top) dominating male during courtship. This dominating behaviour was initiated by the female each time before the male would mount her. Photograph: Deon Gilbert.

Figure 2. Male (top) and female aligning cloacas prior to copulation. Photograph: Deon Gilbert.

On 25 August, immediately after opening the gate, the female retreated to the land portion of the exhibit into a plant pocket away from the reach of the male; no courting or copulation was recorded. Two more successful copulations were recorded after this initial retreat behaviour was witnessed. On occasions the male would seek out the female and become aggressive towards her until he was called back to his enclosure. The interactions of both animals at this stage were far more relaxed and they were able to tolerate being in the same pond for up to seven hours with no aggression. Both animals were still separated overnight.

Three successful copulations were recorded between 0805 h and 0930 h on 13 October and the pair was given full access to each other all day with no aggression. This was the only observation of repeated mating.

The following day the female was seen making attempts to get into her original enclosure, which contained the only area suitable for nest building in the exhibit. Consequently, she was given access and the male moved back to his original enclosure. That afternoon she began nest building and by the next morning a typical crocodile mound nest had been constructed using all available substrate in the exhibit comprising of coarse river sand, potting soil, and pea straw. Additional pea straw, leaf litter and coconut peat was added to the enclosure and quickly utilised by the female, creating a nest mound approximately 1.3 m in diameter and 0.6 m deep.

Nesting and Egg-laying

Introductions ceased as their courting behaviour was subsiding and the male's behaviour towards the female had become unpredictable. It was also clear that the female was gravid as her abdomen had begun to distend and swell.

The female tended to her nest daily and spent her time on the nest or in the pond at its base. Her feeding was intermittent and she showed very little aggression during the daily husbandry routine of opening the enclosure and watering plants. However, she was aggressive when keepers took nest temperatures.

Ten eggs, all with opaque bands, were discovered on 14 December 2012. They were thought to have been laid a couple of days earlier as the nest was checked 4 days previously and no eggs had been found. The eggs were deposited in the middle of the nest under a large log that was part of the enclosure. The egg chamber began approximately 24 cm below the top of the nest substrate - 3 eggs were deposited at the top, 5 in the middle and 2 at the bottom. The temperature gradient within the nest ranged from 30.8°C at the top to 33°C at the bottom.

The eggs were removed, numbered, measured (mean length= 74.91 mm long, mean width= 41.18 mm) and weighed (mean= 75.53 g). They were divided into two groups and incubated at two temperature regimes: the 5 eggs toward the bottom of the nest at 33°C and the 5 eggs closer to the top incubated at 29-31°C, with the aims of producing females and males respectively. The eggs were placed in 1:1 vermiculite to water mix.

Despite extensive efforts to obtain commitments from other zoos to receive any potential hatchlings, it was only possible to secure placement for 6 hatchlings - one at Melbourne Zoo and 5 in US institutions. Some zoos in Australia that were interested in obtaining specimens were prevented from doing so by State legislation. Consequently 4 of the eggs were euthanased before the mid-point of incubation. Six eggs were retained - four low temperature regime and two at the higher regime. Of the 4 eggs destroyed, two of those incubated as female-producing tempeartures shows signs of early embryonic development. That was not apparent in the two eggs.

At 95 days incubation one of the higher temperature eggs was manually pipped to check the health of the animal. Blood supply looked good and the hatchling responded to touch and could be heard calling. The following day none of the eggs showed progression so they were opened. Both of the eggs incubated as females were fertile, however one had died 24-48 hours prior to being opened - the animal was fully developed and the reason for not hatching is unknown. The other female was healthy, but had used the majority of its yolk supply and was quite weak.

Of the 4 eggs incubated at male-producing temperatures only one showed early signs of development. We are confident that without intervention the sole hatchling survivor would have also perished inside the egg. It was encoraging to achieve 100% egg fertility for this firt-time breeder.

Hatchling Growth

Although still early in development, the one surviving hatchling is growing well (see front cover of Newsletter). When assisted from the egg, it weighed 54.13 g, 115 mm snout-vent length and 242 mm total length. The animal was kept in the incubator for 8 days post-hatching to allow its umbilicus to fully close and for it to gain strength. After removal from the incubator, it was placed in a 160-litre glass tank with 20 cm of water at 28°C and some strands of floating vegetation. A concrete brick with astro-turf on top provides the hatchling with a dry basking site and underwater shelter. A suspended heat lamp maintains the basking site at 31°C.

The young crocodile is relaxed and not bothered by the close presence of people. It also feeds readily from fingers or forceps.

Wider Partnership Context

Although a first breeding success and a single surviving hatchling, the entire process has significantly increased staff understanding of successfully managing this species in captivity. In particular, dealing with the well-known aggression that can occur between individuals (eg Sibal *et al*. 1994; C. Adams, pers. comm.). Communication with colleagues in Europe and the USA about placing the potential

hatchlings also led to revisiting earlier discussions about improved coordination between zoos holding *C. mindorensis*, and in particular the need to identify recipient institutions well in advance of a breeding cycle. Indeed, this aligns with Objective 5.3.2 in the most recent edition of the National Recovery Plan for the Philippine Crocodile, ie. "Establish a coordinated global captive management program for *C. mindorensis*" (Banks 2005). This will be pursued in coming months.

The arrival of the little crocodile, which has been named "Tess" in recognition of Marites Gatan-Balbas, the Deputy Director of the Mabuwaya Foundation in Luzon, comes at a perfect time for Zoos Victoria, as we have just committed to an expanded 3-year partnership with the Foundation. This will include increased engagement with our visitors and the broader Melbourne community, in which the crocodiles themselves have critical roles.

Acknowledgements

The transfer of the Philippine Crocodiles to Melbourne Zoo was undertaken under Memoranda of Agreement, initiated in 1992 and renewed in 2000 (and again in 2009), with the Protected Areas & Wildlife Bureau of the Philippine Department of Natural Resources and Environment.

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West and Central Africa

Niger

NEW CONSERVATION PROJECT LAUNCHED IN NIGER. On 6 March 2013 representatives of the Ministry of Environment and the Ministry of Tourism of the Republic of Niger attended the launch of a new conservation project on the Niger River. The project will benefit the conservation of crocodiles in the project area. Biodiversité et Appui aux Inititiatives Locales (BAIL) and the Association Internationale Conservation et Ecotourisme (COECO), which had initiated the project 'Développement des communautés rurales et valorisation et conservation de la zone humide du fleuve Niger' (Development of Rural Communities through valorisation and conservation of wetland zones of the Niger River), will benefit through funding of around €80,000 over two years from two French conservation organizations, Fonds de Dotation pour la Biodiversité (FDB) and 'SOS Crocodiles' of La Ferme aux Crocodiles.

Among other objectives such as overall improvement of the livelihoods of the communities on the 150-ha Karey-Kopto Island in the Niger River (Fig. 1), the project will also focus on the conservation of Nile crocodiles by building a research and education centre within the project area. The center will also co-ordinate any activities of the project.

Figure 1. Location of Karey-Kopto project area, Niger.

Among the 6 principle components of the project, environmental education and restoration of habitat and associated fauna shall impact positively on three flagship species - crocodiles, hippopotamus and manatees. Further objectives will be to reinforce and strengthen existing control posts within the 5 villages (Kirtachi, Guième, Korogoungou, Karey-Koptp and Boumbawhich) that are in close proximity to the 'National Park W' (Fig. 2), in order to create more efficient disincentives for poachers that usually cross the river near these villages into the national park. Finally, for crocodiles an artifical lake on Karey-Kopto shall be re-built to allow Nile crocodiles to be introduced there. The project will also establish some infrastructure for eco-tourists to visit the area, which would provide additional income to the poor local communities.

Figure 2. Crocodile program team.

Overall, this new laudable conservation project is entirely in line with the goals embedded in the 'Framework Strategy for the Conservation and Management of Crocodilians in West Africa', which was discussed and adopted at the second CSG West African regional meeting held at Nazinga, Burkina Faso, in 2010.

Ali Bouzou, *President BAIL, Niamey, Niger (bouzou_ali2000@yahoo.fr),* Samuel Martin, *Director, La Ferme aux Crocodiles, Pierrelatte, France (S.Martin@lafermeauxcrocodiles.com)* and Dietrich Jelden, *FANC, Bonn, Germany (dietrich.jelden@bfn.de).*

South Asia and Iran

Nepal

STATUS AND CONSERVATION OF THE MUGGER CROCODILE IN NEPAL. The Mugger Crocodile (*Crocodylus palustris*) is distributed in Iran, Pakistan, India, Nepal, Sri Lanka and Bhutan. It is perhaps extirpated from Bangladesh and may occur in few Indo-Chinese countries (De Silva and Lenin 2010). In Nepal, it is found throughout lowlands where suitable habitat remains and illegal hunting is minimal (Shah and Tiwari 2004). The species is listed as "Vulnerable" on the IUCN Red List (IUCN 2012).

Here, we aim to update the population status of the Mugger Crocodile in Nepal, based on systematic surveys, casual observations and consultations with local experts and local people. This paper is intended to instigate further research into this threatened species with proper survey methodology and robust data set.

Survey Methods and Materials

Various protected wetlands of lowland Nepal, mainly Shuklaphanta, Parsa and Koshi Tappu Wildlife Reserves, Bardia, Banke and Chitwan National Parks, were visited between 2008 and 2012. Outside protected areas, wetlands of national and international importance such as Ghodaghodi Lake Area, Badhaiya Tal, Jagadishpur Reservoir, Gaidahawa Tal, Bees Hazari Tal, Chimdi Tal, Betana Tal and other wetlands were also visited.

Numbers of Muggers counted on sunny days in winter months (November-March) were considered to give the best estimate of the population, and the maximum number counted on one of the survey days was regarded as an index of the population in a particular wetland.

The most systematic count of Muggers was carried out in Ghodaghodi Lake. Here, a fixed route was followed to check suitable basking sites both on the land and in water and to identify sites that had been used by crocodiles. The route was marked on a map and the whole wetland was covered at the same time by three experienced groups of observers to avoid double counting. A UNDP-GEF Nepal Government funded project has carried out systematic surveys two times per year (winter and summer) in this lake since 2009. The figure obtained from the last count, in January 2013 (CSUWN 2013), was used in this paper. Other data presented, if not referenced, are based on opportunistic surveys and consultation with various local experts and people knowledgeable to the particular area. Wetlands were covered on foot, boat or a slow moving jeep (10 km/h). A pair of binoculars, spotting scope, GPS, and a notebook were used for the survey.

Counts and other estimates were adjusted for suitable Mugger habitat that was not covered (40-80%). Estimation of suitable habitat areas was based on our field experiences and careful interpretation of consultations with local experts and knowledgeable people. No corrections were made for adjusting relative counts to absolute counts.

Results

Muggers were observed in five protected areas and two sites outside the protected area network of lowland Nepal (Fig. 1). These sites spanned to 9 different districts of Nepal, namely Kanchanpur, Kailali, Bardia, Banke, Dang, Nawalparasi, Chitwan, Saptari and Sunsari Districts. Presence of 196 crocodiles in these districts was verified mostly with a direct count (Table 1) except at Banke National Park where the population of crocodiles was based on information provided by local people and knowledgeable persons in the area (Tulasi Sharma, pers. comm. 2012; Dinesh Giri, pers. comm. 2012). In Rupandehi and Kapilvastu Districts it was believed that crocodiles persisted as recently as 20 years ago, but their presence now could not be confirmed through these surveys.

The largest populations of the species were confined to protected areas. Wetlands in Chitwan valley held nearly half of all the known Mugger populations in Nepal, followed by wetlands in Bardia National Park, and Shuklaphanta and KoshiTappu Wildlife Reserves. The only viable and significant population outside of protected areas was in Ghodaghodi Lake Area. Crocodile numbers in Dang and Banke Districts were very low.

The largest crocodiles were observed in the Koshi area, with one individual estimated to be around 15 feet long. Hatchlings

and similar sized crocodiles were noted in all the protected areas mentioned as well as in Ghodaghodi Lake Area.

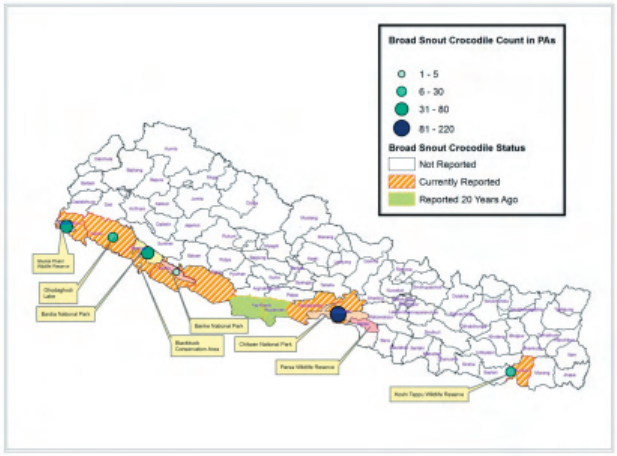

Figure 1. Distribution and population size of Muggers in lowland Nepal.

Table 1. Numbers of Muggers sighted during surveys, and adjusted totals for percentage of habitat surveyed (see text). Estimate for Banke NP based on local informants.

Area	Year	Maximum Sighted	% Area Surveyed	Adjusted Totals
Shuklaphanta WR and surrounding areas	2009	36	55	65
Ghodaghodi Lake Area	2013	15	60	25
Bardia National Park and surrounding areas	2008	30	38	80
Banke National Park and surrounding areas	2012	1	20	5
Dang District	2010	3	60	5
Chitwan National Park and surrounding areas	2012	95	53	220
Parsa WR	2012	0	60	0
Koshi Tappu WR and surrounding areas	2012	16	45	30
Total	**-**	**196**	**-**	**430**

Discussion

Available data were adjusted for the proportion of habitat that was not surveyed, but no attempt was made to adjust counts for rates of increase or decrease in years since surveys were undertaken (eg since 2008/2009 in some areas), for sightability of Muggers, or for any observer biases during surveys. Nonetheless the Mugger population in Nepal is estimated to be between 400 and 500 individuals. This estimate is higher than earlier estimates of 107-148 (Maskey and Schleich 1992) and 200 (McEachern 1994) individuals, partly because of a greater coverage of the current survey. However, increased level of protection for various sites is considered to have contributed to an increase in the Mugger population.

There are published accounts on numbers of Mugger in Koshi and Chitwan prior to this survey. Previous counts of crocodiles at Koshi (21 crocodiles) (Goit and Basnet 2011) and Chitwan (55 crocodiles) (Khadka 2012) are similar to our own counts (16 for Koshi and 50 crocodiles for Chitwan for 2012). Data on crocodiles have been taken using different methods, different observers and under different weather conditions. For example, Khadka (2013) reported only 41 Muggers during surveys in the same area in Chitwan, perhaps reflecting local weather conditions. Therefore, it is difficult for a direct comparison of the data between years and surveys.

The current global wild population of *C. palustris* was estimated to be 5400 to 7100 non-hatchlings (De Silva and Lenin 2010). However an assessment of the species for the IUCN Red List in CSG Working Meeting in Sri Lanka (May 2013) suggests that the population is much higher than this, as the number of adult Muggers alone is estimated to exceed 6000 individuals (Charlie Manolis, pers. comm. 2013).

It can be assumed that Muggers once had a contiguous presence in suitable lakes and rivers along the entire length of lowland Nepal. Because of rapid loss of wetlands and persecution of the animals for an uncontrolled urbanisation and settlement, these were exterminated from their former haunts. Most populations now lie west of Chitwan National Park, the Koshi Tappu population being the only one in east Nepal. Current Mugger populations in Nepal can be divided into five major subpopulations: Sukla Phanta, Ghodaghodi, Bardia, Chitwan and Koshi. Distance between these is so great and habitat fragmented, it is unlikely that these subpopulations have any chance of exchanging their genetic make-up. All the protected areas except Banke National Park seem to have viable populations. Ghodaghodi is the only area outside protected area where Muggers are known to breed on a regular basis, and there is a significant population (Khatri and Baral 2012). As found in other areas the Banke and Dang populations may increase if provided further protection and species management programs are strengthened as well.

Although stated to occur historically in Gaidahawa Tal (Rupandehi District) and Jagadishpur Reservoir (Kapilvastu District), crocodiles have been extirpated from these two districts. Local extinction of this species may also continue in other areas, especially those with small populations and high levels of threats.

Muggers in Nepal prefer a combination of relatively undisturbed ponds, lakes and marshes, as well as slow moving streams and rivers. In some areas of northern India and Nepal, Muggers occupy habitats that are marginal for Gharial *Gavialis gangeticus*, and will sometimes compete for basking and nesting banks where the two species are sympatric (De

Silva and Lenin 2010). The have been found breeding in most protected areas in which they occur. However, the first breeding record for Mugger in Ghodaghodi Lake (outside protected area network) was in June 2009, when 13 hatchlings were observed close to a nest (Khatri and Baral 2012).

Threats

Groombridge (1982) described the threats to the Muggers as habitat destruction and fragmentation, drowning in fishing nets, egg collection and hunting by people for use in traditional medicinal remedies. Many of these threats are still there.

Some people believe that crocodilian eggs have aphrodisiac properties. Crocodiles have a significant role in ecoystems, and have religious and cultural importance in Nepali society. However, the growth of human populations in more recent years has overshadowed religious attachments, and as a result survival of the species is somewhat tenuous.

Currently the major threats to the survival of crocodiles in Nepal are considered to be:

1. Habitat degradation and loss, due to anthropogenic activities like diversion of water, change in water quality due to industrial effluents and indiscriminate use of agricultural pesticides, construction of dams, and removal of water from lakes and ponds for collecting fish. The construction of reservoirs and dams in and around suitable habitats is an unavoidable problem that exists till now. These conditions strongly affect their natural movement and in many cases allow only one way (ie downwards movement).

2. There is confirmed evidence of captive-reared Muggers and Gharials released by the Nepalese authorities in the rivers either immigrating or being swept by monsoon floodwaters to Indian territories.

3. Nest flooding, caused by man-induced hydrological changes, is now thought to be the principal factor limiting the population in the Narayani River of Nepal (Maskey 1989). Torrential floods often destroy many nests and this problem may even be aggravated in future due to climate change.

4. Disturbances due to human activities like rafting, fishing, travelling and irrigation are also major concern. Significant mortality still occurs due to entrapment in nylon gill nets introduced for fishing. These accidental trappings in fish nets force fisherman to take prompt action through killing them, as they think crocodiles will damage their nets. Once crocodiles are trapped, it is not possible for fishermen to free them manually as they do with fish, and they use sticks, khukuri (a traditional large Gurkha knife), stones or any available weapons to kill them.

5. There is little predation on adult crocodiles, however high predation on eggs and young ones by natural predators occurs. Predation is largely in the egg and hatchling stages due to predators such as large wading birds and birds of prey, rats, pigs, jackals, monitor lizards, mongoose and other animals including humans. Hatchlings are taken by birds of prey and large wading birds and in water by large turtles and fish. It has been reported that less than 1% of young hatched in the wild survive to reach a length of about 2 m at which time they become immune to predation (Singh 1986).

6. Information gaps on its ecology, status and distribution in Nepal and general lack of conservation awareness and species' portrayal as harmful animal among the local people are also responsible for Mugger population decline.

7. There is existing legislation to protect species such as the Mugger, but lack of enforcement has hindered conservation efforts.

8. Deliberate killing of animals due to presumed medicinal values, and eating of their eggs and meat by some ethnic groups (Shah 1997).

9. Shortage of food items especially depletion of fish population by excessive fishing and poisoning of the habitats have been additional causes that might have constrained the population growth of these reptiles.

10. Bhatt *et al*. (2012) have studied Marsh Mugger in Rani Tal, Sukla Phanta Wildlife Reserve, and discussed threats to crocodiles due to water quality. Water quality parameters (dissolved oxygen, total hardness, free carbon dioxide, orthophosphate, biological oxygen demand and ammonia) of Rani Tal exceeded the normal range to support the Mugger crocodile. Water qualilty therefore is an important consideration where captive rearing is involved for reintroduction to the wild.

Conservation Initiatives

There are already some activities within protected areas for the conservation of Muggers. These include habitat management and artificial incubation of eggs in a hatchery farm established in Chitwan National Park (Maskey 1989). Outside protected areas, Ghodaghodi Lake has been the focus of crocodile conservation where habitat restoration and participatory monitoring activities have been successfully launched (CSUWN 2012a; Top Bahadur Khatri, pers. comm. 2013). In Dang District, the local community has provided special protection to a 3-km stretch of river and especially one part where some ponds are created by the flooded waters of the Satbariya stream. The District Forest Office at that time and Terai Arc Landscape Program provided some support to appreciate such solely community led conservation initiatives (Kishore Chandra Gautam, pers. comm. 2013). Such community crocodile conservation efforts can be linked to different tourist categories if the destination in the area has diversified attractions (Rafsanjani and Karami 2011). The following activities are recommended for the conservation of Marsh Mugger crocodiles in Nepal:

1. Conduct a nationwide survey with competent researchers

following the monitoring protocol developed by Conservation and Sustainable Use of Wetlands in Nepal (CSUWN 2012b);

2. Prepare a Species Management Plan/Action Plan that is achievable;

3. Restore degraded wetlands as habitats for crocodiles and conduct activities to minimise threats;

4. Re-populate suitable lakes and rivers in Kailali District, Badhaiya Lake, Bardia, Jagadishpur Reservoir, Gaidahawa Lake, lakes in the east Nepal after discussion with local people and conservationists in the area;

5. Link crocodile conservation with income generating activities (eg tourism and recreation); and,

6. Conduct education and awareness activities in the vicinity of the wetlands that contain crocodiles.

Acknowledgements

We would like to thank Tika Ram Adhikari (Chief Warden, Bardia National Park), Jhamak Karki (Chief Warden, Chitwan National Park), Uba Raj Regmi (Chief Warden, Sukla Phanta Wildlife Reserve), Ashok Kumar Ram (Conservation Officer, Koshi Tappu Wildlife Reserve), Bed Bahadur Khadka (Assistant Conservation Officer, Chitwan National Park), Daya Ram Chaudhary (Ghodaghodi Lake Area), Kishor Chandra Gautam (District Forest Office, Dang), Tulasi Sharma (Chief Warden, Banke National Park), Krishna Pokharel (District Forest Office, Kapilvastu), Ram Bahadur Shahi (Bardia Nature Club), Jagannath Singh (Chief Warden, Parsa Wildlife Reserve), Kapil Pokharel (National Trust for Nature Conservation-Parsa sector), and Anish Timsina (Koshi Bird Society) for providing additional information. We also wish to thank Top Bahadur Khatri, Dr. Shalu Adhikari and Dr. Bibekananda Jha (Conservation and Sustainable Use of Wetlands in Nepal; CSUWN) for sharing information about their project activities. We thank Rajiv Paudel, GIS expert, for producing the crocodile distribution map. Last but not least to Charlie Manolis (CSG) for his comments to improve this paper.

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India

TRAIL CAMERAS SHOW PROMISING RESULTS IN CORBETT TIGER RESERVE. For the first time, trail cameras have been incorporated in Gharial monitoring work in the Dhikala Range of Corbett Tiger Reserve. Combining the use of trail cameras, boat surveys and stationary counts, this new methodology has already shown promising results, with 32 adult Gharial (including 7 adult males) being identified. In the same area in 2008, 18 adults (including 2 adult males) were recorded.

Ongoing crocodile surveys indicate an increase in mature Gharials in Corbett Tiger Reserve, which contains at least 20% to the global wild population of adult Gharial. The species is estimated to comprise around 200-250 mature individuals (IUCN 2012).

The work in Corbett, with a focus on crocodiles and freshwater turtles, is being implemented by Subir Mario Chowfin in partnership with Dr. Alison Leslie. Collaborators are the Corbett Tiger Reserve, Uttarakhand Forest Department, The Gadoli and Manda Khal Wildlife Conservation Trust and The University of Stellenbosch.

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Science

Recent Publications

Kusumi, K., May, C.M. and Eckalbar, W.L. (2013). A large-scale view of the evolution of amniote development: insights from somitogenesis in reptiles. Current Opinion in Genetics & Development (dx.doi.org/10.1016/j.gde.2013.02.011).

Abstract: Uncovering the genetic and developmental changes that generate morphological diversity is one of the longstanding challenges in biology. The developmental process generating the spine, one of the defining features of vertebrates, constitutes one of these core questions. The vertebral column is patterned in early development through the formation of segments, called somites, regulated by gene networks collectively called the segmentation clock. While previous studies of somite development in amniotes have focused almost exclusively on the mouse and chick model systems, the growing availability of genomic sequences in other taxa has opened up the possibility of comparative developmental studies in nontraditional reptilian models, such as the anole lizard, alligator, and snake. These studies have identified conserved features of the segmentation clock, but they have also challenged previous assumptions and identified divergence in the genetic networks. Ongoing work will help to elucidate which of these morphological changes may be explained by divergences in development in amniote evolution.

Schachner, E.R., Hutchinson, J.R. and Farmer, C.G. (2013). Pulmonary anatomy in the Nile crocodile and the evolution of unidirectional airflow in Archosauria. Peer J. 1:e60 http://dx.doi.org/10.7717/peerj.60.

Abstract: The lungs of birds have long been known to move air in only one direction during both inspiration and expiration through most of the tubular gas-exchanging bronchi (parabronchi). Recently a similar pattern of airflow has been observed in American alligators, a sister taxon to birds. The pattern of flow appears to be due to the arrangement of the primary and secondary bronchi, which, via their branching angles, generate inspiratory and expiratory aerodynamic valves. Both the anatomical similarity of the avian and alligator lung and the similarity in the patterns of airflow raise the possibility that these features are plesiomorphic for Archosauria and therefore did not evolve in response to selection for flapping flight or an endothermic metabolism, as has been generally assumed. To further test the hypothesis that unidirectional airflow is ancestral for Archosauria, we measured airflow in the lungs of the Nile crocodile (*Crocodylus niloticus*). As in birds and alligators, air flows cranially to caudally in the cervical ventral bronchus, and caudally to cranially in the dorsobronchi in the lungs of Nile crocodiles. We also visualized the gross anatomy of the primary, secondary and tertiary pulmonary bronchi of *C. niloticus* using computed tomography (CT) and microCT. The cervical ventral bronchus, cranial dorsobronchi and cranial medial bronchi display similar characteristics to their proposed homologues in the alligator, while there is considerable variation in the tertiary and caudal group bronchi. Our data indicate that the aspects of the crocodilian bronchial tree that maintain the aerodynamic valves and thus generate unidirectional airflow, are ancestral for Archosauria.

Campbell, H.A., Sissa, O., Dwyer, R.G. and Franklin, C.E. (2013). Hatchling crocodiles maintain a plateau of thermal independence for activity, but at what cost? Journal of Herpetology 47(1): 11-14.

Abstract: Crocodilians show a broad plateau of thermal independence for sustained activity. It has been hypothesized that this reflects a performance breadth necessary for carrying out ecologically important behaviors across a range of ambient temperatures. Here, we swam Saltwater Crocodiles (*Crocodylus porosus*) in a thermally controlled flume at 23, 28 and 33°C and recorded oxygen consumption (VO_2) before and after swimming activity. Ambient temperature altered spontaneous VO_2 in a positively linear manner, but there was no significant difference in the distance the crocodiles would swim voluntarily. Excess postexercise oxygen consumption (EPOC) increased 10-fold between swimming trials at 28 and 33°C, and the anaerobic debt took 3 times longer to clear at the higher temperature. The results show that, although *C. porosus* demonstrated a broad thermal breadth for swimming performance, a higher degree of anaerobic metabolism was required to sustain activity at the upper limits of the thermal plateau. Why crocodiles should choose to sustain an anerobic debt rather than reduce their swimming activity when exposed to high experimental temperatures is perplexing, but the study findings provide a physiological rationale for some of the diel and seasonal activity patterns observed in wild crocodilians.

Murray, C.M., Piller, K.R., Merchant, M., Cooper, A. and Easter, M.E. (2013). Salinity and egg shape variation: a geometric morphometric analysis. Journal of Herpetology 47(1): 15-23.

Abstract: The harvest and incubation of American Alligator (*Alligator mississippiensis*) eggs is an important component to the commercial alligator harvest industry in the southeastern United States. As a result, various methodologies have been used to monitor alligator populations including abundance counts, stress quantification, and nesting surveys. Past studies have dismissed the importance of egg shape in crocodilians, Squamates, and turtles and deemed egg shape in birds and other amniotes as similar, in relation to functionality. The complexity of crocodilian eggs has been examined, and both turtle and Squamate eggs have been regarded recently as physiologically more intricate than bird eggs. This study introduces a physiological approach to monitor alligator populations in freshwater and low salinity environments by quantifying egg shape in correlation with varying salinity. We introduce a fractional semilandmark-shape template method to quantify egg shape within a geometric morphometric framework. This approach is beneficial because it allows for the quantification of shape for curved structures, such as eggs, which lack homologous landmarks. The results from this study suggest that alligator egg shape is correlated with varying salinity levels, such that variation in alligator egg shape at low salinities changes in gradient-like fashion, whereas salinities high enough to be deemed stressful result in reversion back to a low salinity egg shape or desiccation. This study elucidates a correlation that can be implemented in management and breeding techniques and opens the door to in-depth physiological examination of the system.

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

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

Meganathan, P.R., Dubey, B., Jogayya, K.N. and Haque, I. (2013). Identification of Indian crocodile species through DNA barcodes.

Abstract: The biodiversity of India includes three crocodile species, *Crocodylus palustris*, *C. porosus* and *Gavialis gangeticus*, whose status is threatened due to bushmeat crisis and illegal hunting. The crocodilian conservation management requires novel techniques to help forensic analysts to reveal species identity. DNA barcoding is a species identification technique, where a partial cytochrome c oxidase subunit 1 gene is used as a marker for species identification. Herein, the DNA barcoding technique is evaluated for three Indian crocodiles by analyzing an approximately 750-bp barcode region. The alignment result shows interspecific variations between sequences for discrimination of the three Indian crocodiles leading to species identification. The phylogenetic analyses also substantiate the established crocodilian relationships, which add further advantage to use this DNA barcoding approach for Indian crocodiles. This study provides preliminary evidences for the use of DNA barcoding technique in the identification of Indian crocodile species.

Cuff, A.R. and Rayfield, E.J. (2013). Feeding mechanics in spinosaurid theropods and extant crocodilians. PLoS ONE 8(5): e65295. doi:10.1371/journal.pone.0065295

Abstract: A number of extant and extinct archosaurs evolved an elongate, narrow rostrum. This longirostrine condition has been associated with a diet comprising a higher proportion of fish and smaller prey items compared to taxa with broader, more robust snouts. The evolution of longirostrine morphology and a bulbous anterior rosette of premaxillary teeth also occurs in the spinosaurid theropod dinosaurs, leading to suggestions that at least some members of this clade

also had a diet comprising a notable proportion of fish or other small vertebrates. Here we compare the rostral biomechanics of the spinosaurs *Baryonyx walkeri* and *Spinosaurus* c.f. *S. aegyptiacus* to three extant crocodilians: two longistrine taxa, the African slender-snouted crocodile *Mecistops cataphractus* and the Indian gharial *Gavialis gangeticus*; and the American alligator *Alligator mississippiensis*. Using computed tomography (CT) data, the second moments of area and moments of inertia at successive transverse slices along the rostrum were calculated for each of the species. Size-independent results tested the biomechanical benefits of material distribution within the rostra. The two spinosaur rostra were both digitally reconstructed from CT data and compared against all three crocodilians. Results show that African slender-snouted crocodile skulls are more resistant to bending than an equivalent sized gharial. The alligator has the highest resistances to bending and torsion of the crocodiles for its size and greater than that of the spinosaurs. The spinosaur rostra possess similar resistance to bending and torsion despite their different morphologies. When size is accounted for, B. walkeri performs mechanically differently from the gharial, contradicting previous studies whereas *Spinosaurus* does not. Biomechanical data support known feeding ecology for both African slender-snouted crocodile and alligator, and suggest that the spinosaurs were not obligate piscivores with diet being determined by individual animal size.

Magadán-Mompó, S., Sánchez-Espinel, C. and Gambón-Deza, F. (2013). IgH loci of American alligator and saltwater crocodile shed light on IgA evolution. Immunogenetics (doi: 10.1007/s00251-013-0692-y).

Abstract: Immunoglobulin loci of two representatives of the order Crocodylia were studied from full genome sequences. Both *Alligator mississippiensis* and *Crocodylus porosus* have 13 genes for the heavy chain constant regions of immunoglobulins. The IGHC locus contains genes encoding four immunoglobulins M (IgM), one immunoglobulin D (IgD), three immunoglobulins A (IgA), three immunoglobulins Y (IgY), and two immunoglobulins D2 (IgD2). IgA and IgD2 genes were found in reverse transcriptional orientation compared to the other Ig genes. The IGHD gene contains 11 exons, four of which containing stop codons or sequence alterations. As described in other reptiles, the IgD2 is a chimeric Ig with IgA- and IgD-related domains. This work clarifies the origin of bird IgA and its evolutionary relationship with amphibian immunoglobulin X (IgX) as well as their links with mammalian IgA.

Schneider, L., Maher, W., Green, A. and Vogt, R.C. (2013). Mercury Contamination in Reptiles: An Emerging Problem with Consequences for Wild Life And Human Health. Nova Publishers.

Abstract: Methyl mercury is a persistent environmental contaminant that threatens the health of organisms in ecosystems throughout the world. Since methylmercury bioaccumulates over time and biomagnifies at each trophic level, long-lived, carnivorous species such as reptiles are at greatest risk. Reptiles have often been used as bioindicators of local mercury contamination, and many species have been shown to accumulate large concentrations of mercury in affected habitats. Annually worldwide, millions of reptiles, both wild and farm-raised, are sold for human consumption. Consuming wildlife contaminated with mercury poses a serious threat to human health, particularly for pregnant women and children. In this chapter, we review data of mercury concentrations in reptile species harvested for food. Mercury concentrations in reptile species are compared considering their trophic status and origin (wild-caught or farm-raised) to assess how different groups of organisms respond to mercury contamination. Also, the different origins of Hg are considered in order to understand the effects of different bioaccumulation routes. The issue of legal and illegal trade of reptiles for food in both developed and developing countries is described here to demonstrate the potential health risks to humans. In order to assess the contamination risk per species, we compared Hg concentrations in reptiles with consumption limits developed by the U.S. Environmental Protection Agency and Food and Drug Administration to evaluate mercury consumption through ingestion of fish. Few studies have examined health risks associated with reptile consumption. Although reptiles are not consumed in high numbers in most developed countries, they are a major source of protein in many developing countries where consumers may be at high risk from mercury-related health problems. To conserve endangered species, non-invasive techniques to measure mercury concentrations, by use of skin, shell and blood of reptiles, are described. Shell samples from turtles are especially important because they are composed of layers of keratin deposited throughout an individual‘s life span, thus providing a history of mercury contamination in turtles.

Leitch, D.B. (2013). Comparative Topics in Vertebrate Mechanoreception with a Special Focus on the Crocodilians. PhD thesis, Vanderbilt University, Nashville, Tennessee, USA.

Abstract: Insights into the organization of vertebrate nervous systems have often arisen through systematic examinations of specific behaviors and their possible neural substrates. This approach is even more effective when diverse groups can be assessed in order to identify commonalities in innervation, anatomy, or nervous system representation. Throughout this collection of investigations, we have examined a wide-ranging group of semi-aquatic vertebrates possessing peripheral nervous system specializations related to mechanotransduction. These included a range of insectivores such the American water shrew (*Sorex palustris*), the smallest homeothermic diver with an elaborate array of whiskers. We also analyzed the behavior and central nervous system representations of the tentacled snake (*Erpeton tentaculatus*) in the process of identifying the sensory function of the unique paired facial appendage. More extensive observations were collected from two members of the order Crocodylia - the Nile crocodile (*Crocodylus niloticus*) and the American alligator (A*lligator mississippiensis*) - with particular attention

devoted to their integumentary sensory organs (ISOs). These ubiquitous dome-shaped protuberances speckle the jaws of all crocodilians and are also found on the bodies scalation of members of the families Crocodilidae and Gavialidae, yet their precise function and the behaviors they mediate have remained ambiguous. We suggest that the ISOs impart an exquisite level of tactile sensitivity, even exceeding that of the primate fingertip, thereby providing a sophisticated sense of touch to an otherwise armored body surface and draw comparisons between the sensory system organization of mammalian and reptilian taxa.

Fukuda, Y., Saalfeld, K., Lindner, G. and Nichols, T. (2013). Estimation of total length from head length of Saltwater Crocodiles (*Crocodylus porosus*) in the Northern Territory, Australia. Journal of Herpetology 47(1): 34-40.

Abstract: Populations of Saltwater Crocodiles (*Crocodylus porosus*) have been monitored in the Northern Territory since the species' protection. This monitoring relies on standardized spotlight surveys in which crocodiles are counted and classified by estimated total length (TL). Although the accurate estimation of TL is important for analyses, often crocodiles are submerged and their TL is estimated from their heads, which may be visible above the water surface. With some variation, it is generally thought that TL of a crocodile is seven times the length of the animal's head. This study examined the ratio of TL to head length (HL) from morphological measurements of 2,755 Saltwater Crocodiles caught in various locations in the Northern Territory. The results showed that the generic ratio for crocodiles ranging from 38 to 503 cm was 7.01. The ratio increased logistically from 6.7 to 7.1 for crocodiles in the 120-420-cm size range in TL in 30-cm intervals. We suggest that TL can be reliably estimated from HL at least for crocodiles in 120-420 cm in the wild, with the use of the generic and size-specific ratios calculated for the various size classes at every 30 cm. The size-specific estimation for animals <120 cm or >420 cm was not possible because of limited sample sizes in these crocodile size ranges, although a few reliable records suggest that a ratio increasingly becomes larger and 1:8 should be used for crocodiles >510 cm in TL.

Hauswaldt, J.S., Vences, M., Louis, E., Brennemann, R. and Zuegler, T. (2013). Genetic screening of captive Philippine crocodiles (*Crocodylus mindorensis*) as prerequisite for starting a conservation breeding program in Europe. Herpetological Conservation and Biology 8(1): 75-87.

Abstract: Philippine Crocodiles (*Crocodylus mindorensis*) are among the rarest crocodilians worldwide. Captive propagation for building up a conservation breeding and reserve population in Europe has recently been undertaken as a management action. For this purpose, 15 presumed *C. mindorensis* all originating from a captive source in the Philippines were brought to different facilities in Europe in 2006. Identification of hybrid individuals, deriving from crosses of the Philippine Crocodile with the Saltwater Crocodile (*C. porosus*) at a captive breeding facility in the Philippines prompted us to undertake a genetic screening of the European individuals to determine whether evidence for hybridization could be detected. We sequenced the 14 remaining *C. mindorensis* individuals, five additional *C. mindorensis* from other sources, and two *C. porosus* for two mitochondrial and three nuclear gene fragments. No evidence of *C. porosus* introgression was detected in 18 of the presumed pure *C. mindorensis*; however, we found one presumed pure *C. mindorensis* to be a Western Nile Crocodile (western lineage of *C. niloticus sensu lato*, proposed to be named *C. suchus* by Schmitz *et al.* 2003). Both *C. porosus* individuals were in genetic agreement with known *C. porosus* gene sequences. Of the three nuclear markers, LDH-A was most informative to discriminate between *C. mindorensis* and *C. porosus*. With this first genetic screening, an important step towards a proper European conservation breeding program has been made.

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

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

Wu, P., Wu, X., Jiang, T-X., Elsey, R.M., Temple, B.L., Divers, S.J., Glenn, T.C., Yuan, K., Cheng, M-H., Widelitz, R.B. and Chuong, C-M. (2013). Specialized stem cell niche enables repetitive renewal of alligator teeth. Proceedings of the National Academy of Sciences of the United States of America (doi: 10.1073/pnas.1213202110).

Abstract: Reptiles and fish have robust regenerative powers for tooth renewal. However, extant mammals can either

renew their teeth one time (diphyodont dentition) or not at all (monophyodont dentition). Humans replace their milk teeth with permanent teeth and then lose their ability for tooth renewal. Here, we study tooth renewal in a crocodilian model, the American alligator, which has well-organized teeth similar to mammals but can still undergo life-long renewal. Each alligator tooth is a complex family unit composed of the functional tooth, successional tooth, and dental lamina. Using multiple mitotic labeling, we map putative stem cells to the distal enlarged bulge of the dental lamina that contains quiescent odontogenic progenitors that can be activated during physiological exfoliation or artificial extraction. Tooth cycle initiation correlates with β-catenin activation and soluble frizzled-related protein 1 disappearance in the bulge. The dermal niche adjacent to the dermal lamina dynamically expresses neural cell adhesion molecule, tenascin-C, and other molecules. Furthermore, in development, asymmetric β-catenin localization leads to the formation of a heterochronous and complex tooth family unit configuration. Understanding how these signaling molecules interact in tooth development in this model may help us to learn how to stimulate growth of adult teeth in mammals.

Caut, S. (2013). Isotope incorporation in broad-snouted caimans (crocodilians). Biology Open (doi: 10.1242/bio.20134945).

Abstract: The trophic ecology and migration of vertebrate species have been increasingly studied using stable isotope analysis. However, this approach requires knowledge on how dietary isotopic values are reflected in consumers' tissues. To date, this information has only been obtained for a handful of ectotherms; in particular, little is known about crocodilians. In this study, diet-tissue discrimination factors (DTDFs) and carbon and nitrogen stable isotope turnover rates were estimated for plasma, red blood cells (RBCs), and muscle obtained from broad-snouted caimans (*Caiman latirostris*). Individuals were fed two different control diets for 189 days. DTDFs for δ15N (Δ15N) and δ13C (Δ13C) ranged from -2.24‰ to 0.39‰ and from -0.52‰ to 1.06‰, respectively. Isotope turnover rates in tissues, expressed as half-lives, ranged from 11 to 71 days, with plasma<muscle<RBCs. Δ15N was found to be particularly small, even when compared to values found for other ectotherms, a result that may be linked to the unique excretion physiology of crocodilians. These stable isotope incorporation data should help inform future interpretations of isotopic values obtained in the field for this taxon.

Snively, E., Cotton, J.R., Ridgely, R. and Witmer, L.M. (2013). Multibody dynamics model of head and neck function in *Allosaurus* (Dinosauria, Theropoda). Palaeontologia Electronica 16.2.11A.

Abstract: We present a multibody dynamics model of the feeding apparatus of the large Jurassic theropod dinosaur *Allosaurus* that enables testing of hypotheses about the animal's feeding behavior and about how anatomical parameters influence function. We created CT- and anatomical-inference-based models of bone, soft tissue, and air spaces which we use to provide inertial properties for musculoskeletal dynamics. Estimates of bone density have a surprisingly large effect on head inertial properties, and trachea diameter strongly affects moments of inertia of neck segments for dorsoventral movements. The ventrally-placed insertion of m. longissimus capitis superficialis in *Allosaurus* imparted over twice the ventroflexive accelerations of a proxy control insertion lateral to the occipital condyle, the latter being its position in nearly all other theropods. A feeding style that involved defleshing a carcass by avian-raptor-like retraction of the head in *Allosaurus* is more probable than is lateroflexive shake-feeding, such as that seen in crocodilians and inferred for tyrannosaurids.

Scheyer, T.M., Aguilera, O.A., Delfino, M., Fortier, D.C., Carlini, A.A., Sánchez, R., Carrillo-Briceño, J.D., Quiroz, L. and Sánchez-Villagra, M.R. (2013). Crocodylian diversity peak and extinction in the late Cenozoic of the northern Neotropics. Nature Communications 4(1907) (doi: 10.1038/ncomms2940).

Abstract: Northern South America and South East Asia are today's hotspots of crocodylian diversity with up to six (mainly alligatorid) and four (mainly crocodylid) living species respectively, of which usually no more than two or three occur sympatrically. In contrast, during the late Miocene, 14 species existed in South America. Here we show a diversity peak in sympatric occurrence of at least 7 species, based on detailed stratigraphic sequence sampling and correlation, involving four geological formations from the middle Miocene to the Pliocene, and on the discovery of two new species and a new occurrence. This degree of crocodylian sympatry is unique in the world and shows that at least several members of Alligatoroidea and Gavialoidea coexisted. By the Pliocene, all these species became extinct, and their extinction was probably related to hydrographic changes linked to the Andean uplift. The extant fauna is first recorded with the oldest *Crocodylus* species from South America.

Hastings, A.K., Bloch, J.I., Jaramillo, C.A., Rincon, A.F. and MacFadden, B.J. (2013). Systematics and biogeography of crocodylians from the Miocene of Panama. Journal of Vertebrate Paleontology 33(2): 239-263.

Abstract: Despite the fact that fossil crocodylians have been recovered from the Panama Canal Zone starting with initial excavations in 1912, detailed studies have been lacking. Recent excavations of the canal have resulted in new discoveries of many vertebrate fossils, including the first known Miocene crocodylian skulls from Central America. These fossil skulls from the early-middle Miocene represent two new taxa with distinct morphology that is shared with extinct and extant caimans (Caimaninae). A cladistic analysis of 32 alligatorid and three outgroup taxa, scored for 75 characters, resulted in 1210 equally most parsimonious cladograms, all of which

suggest that *Culebrasuchus mesoamericanus*, gen. et sp. nov., is the sister taxon to all previously known Caimaninae. Additionally, the analysis suggests that *Centenariosuchus gilmorei*, gen. et sp. nov., is the sister taxon to a caimanine clade that includes *Purussaurus* from the Miocene of South America. In fact, teeth very similar to those of *Purussaurus* have also been recovered from the Panama Canal. Given these South American affinities, we suggest that these early caimanines dispersed across saltwater. This is a potentially surprising result, because all extant alligatorids lack the salt glands that would have been necessary for the marine dispersal required to reach Central America during the Miocene. Unlike Miocene mammals that all have North American affinities, the Miocene crocodylians of Panama represent a 'melting pot' with taxa of disparate origins living together at the southern extreme of Central America.

Campos, Z., Sanaiotti , T., Muniz, F., Farias, I. and Magnusson, W.E. (2012). Parental care in the dwarf caiman, *Paleosuchus palpebrosus* Cuvier, 1807 (Reptilia: Crocodilia: Alligatoridae), Journal of Natural History 46(47-48): 2979-2984.

Post-hatching parental care is common in crocodilians, but the little information available for Cuvier's dwarf caiman (*Paleosuchus palpebrosus*) indicates that they show little post-hatching parental care. During surveys undertaken between 2005 and 2011, we counted and captured groups of hatchlings and observed the presence or absence of attending adults in streams around the Pantanal, along the Guaporé-Madeira River and flooded forest in central Amazonia, Brazil. We found 37 groups of hatchlings, of which 29 were accompanied by adults. We captured 13 of these adults and all were females. The groups of hatchlings remained with adults for up to 21 months.We monitored females and hatchlings in streams around the Pantanal using captures and with radiotelemetry and showed that females and hatchlings frequently remained together in burrows, especially during the dry season.

Moreno-Azanza, M., Bauluz, B., Canudo, J.I., Puértolas-Pascual, E. and Sellés, A.G. (2013). A re-evaluation of aff. Megaloolithidae eggshell fragments from the uppermost Cretaceous of the Pyrenees and implications for crocodylomorph eggshell structure. Historical Biology: An International Journal of Paleobiology (doi: 10.1080/089129 63.2013.786067).

Abstract: The Upper Cretaceous outcrops of the Pyrenees yield one of the most extensive and continuous records of paleoological remains anywhere in the world. Most of eggs and eggshells have been referred to the oofamily Megaloolithidae. In this study, we present a revision of eggshell fragments from the Blasi 2 locality, lattermost Maastrichtian in age, previously assigned to aff. Megaloolithidae. The presence of a blocky extinction pattern and basal knobs supports a crocodilian affinity of these materials. We classify them as Krokolithidae indet. Three structural layers can be recognised in the Blasi 2 eggshells, a feature that is shared with other recent eggshells (eg *Crocodylus porosus* and *Crocodylus niloticus*) and fossil crocodylomorph eggshells (Krokolithes wilsoni), which were previously described as single layered. The new proposed affinity of the Blasi 2 eggshells reduces the Megaloolithidae oodiversity of the last few million years of the Cretaceous in the Pyrenees to only two valid ootaxa, *Megaloolithus mamillare* and *Megaloolithus baghensis*. The lack of more complete material precludes the erection of new ootaxa based on the Blasi 2 material.

Platt, S.G., Thorbjarnarson, J.B., Rainwater, T.R. and Martin, D.R. (2013). Diet of the American Crocodile (*Crocodylus acutus*) in marine environments of coastal Belize. Journal of Herpetology 47(1): 1-10.

Abstract: We studied diet and size-related dietary patterns among American Crocodiles (*Crocodylus acutus*) in marine habitats of coastal Belize (1996-1997). Prey items recovered from crocodile (N= 97) stomach contents included insects, mollusks, crustaceans, fish, amphibians, reptiles, birds, and mammals. Based on an overlapping group analysis of percent occurrence, we concluded that hatchlings and small juveniles feed largely on insects and crustaceans, larger juveniles broaden their diet to include fish and nonfish vertebrates, subadults consume increasing amounts of crustaceans with lesser amounts of insects and nonfish vertebrates, and adults subsist primarily on marine crustaceans. Dietary diversity was uniformly low across all size classes but greatest among small and large juveniles. Conversely, hatchlings, subadults, and adults had the most specialized (least diverse) diet owing to reliance upon a limited selection of prey, largely insects (hatchlings) or crustaceans (subadults and adults). Dietary overlap was greatest between adjacent size classes and lowest between the largest and smallest size classes. The high prevalence of freshly ingested prey among all size classes indicates frequent, regular feeding by *C. acutus* in coastal habitats, perhaps driven by the relatively small size of frequently consumed prey such as crabs. Because crabs have a blood salt content equivalent to the external medium and comprise a large portion of the diet, these prey likely impose a high osmoregulatory burden on *C. acutus* inhabiting hyperosmotic coastal environments. Contrary to earlier assertions that salt glands in *C. acutus* lack the excretory capacity to balance salt and water, we suggest populations in coastal Belize rely on these glands in addition to behavioral strategies to maintain osmotic homeostasis.

Alibardi, L. (2013). Ultrastructural immunocytochemistry for the central region of keratin associated-beta-proteins (beta-keratins) shows the epitope is constantly expressed in reptilian epidermis. Tissue and Cell (dx.doi.org/10.1016/j.tice.2013.01.003).

Abstract: The presence of beta-proteins containing a core-box region in specific regions of reptilian epidermis has been studied by immunological methods. Alpha-keratins are detected by the antibody AK2 that recognizes a sequence

toward the C-terminal of acidic alpha-keratins of 48-52 kDa. Beta-proteins are recognized by an antibody directed to the core-box region specific for these proteins of 18-37 kDa. The AK2 antibody labels with variable intensity alpha-keratin bundles in basal and suprabasal keratinocytes in the epidermis of representative species of reptiles but immunolabeling decreases or disappears in pre-corneous and corneous cells. As opposite, the core-box antibody only labels with variable intensity the dense beta-corneous material formed in pre-corneous and corneous layers of crocodilian and turtle epidermis. In lepidosaurian epidermis the core-box antibody labels the beta-layer while the mesos and alpha-layers are poorly or not labeled. The immunological evidence indicates that beta-proteins are synthesized in the upper spinosus and pre-corneous layers of the epidermis and replace or mask the initial alpha-keratin framework present in keratinocytes as they differentiate into cells of the beta-layer. In the specialized pad lamellae of gecko and anoline lizards charged beta-proteins accumulate in the adhesive setae and may affect the mechanism of adhesion that allows these lizards to walk vertical surfaces. The addition of beta-proteins to the alpha-keratins in upper cell layers of the epidermis recalls the process of cornification of mammalian epidermis where specific keratin-associated proteins (involucrin, loricrin and filaggrin) associate with the keratin framework in terminally differentiating keratinocytes of the stratum corneum.

Iungman, J.L. and C.I. Piña, C.I. (2013). Hypoxia and temperature: does hypoxia affect caiman embryo differentiation rate or rate of growth only? J. Thermal Biology (http://dx.doi.org/10.1016/j.jtherbio.2013.05.003).

Abstract: In Crocodilians, the rate of embryonic development and consequently many posthatch attributes are affected by temperature. Since temperature exhibits strong influences on fitness (embryo survivorship and phenotype) by shaping development, we manipulated oxygen concentration in order to uncouple the effects of developmental rate from the direct effects of temperature. Here we consider whether oxygen constrains either differentiation rate (progression from one stage to the next) or embryonic growth (size). Thus, we incubated *Caiman latirostris* eggs at various oxygen concentrations, and at two temperatures (31°C, 100% female-producing temperature, and 33°C, 100% male-producing temperature). We monitored the developmental stages of these embryos within the thermosensitive period (stages 20-24), and assessed several physiological and morphological hatchling traits. While embryonic size was strongly influenced by oxygen, differentiation rate did not seem to be affected. Very low oxygen concentrations and high temperatures inhibited embryo survival. In addition, oxygen availability affected incubation period and hatchling size, whereas temperature did not cause a significant variation in hatchling size. By investing energy in differentiation hypoxic embryos decreased their size.

Submitted Publications

RECORDS OF NILE CROCODILE PREDATION ON BLACK RHINOCEROS. Field observations of foraging, predation, and prey handling by crocodilians are fundamental to understanding the ecology of these large aquatic predators (Rosenberg and Cooper 1990; Platt *et al*. 2007), and yet notable for their paucity in the literature (Lang 1987; Gans 1989). However, the lack of observational reports is not unexpected because much foraging activity is nocturnal, crocodilians are often wary, and turbidity may obscure underwater behavior (Magnusson *et al*. 1987; Thorbjarnarson 1993). Given these potential limitations, even anecdotal observations of predation events are noteworthy and can provide valuable insights into crocodilian foraging strategies. Moreover, foraging observations of large adult crocodiles are of special interest as this size class is generally under-represented in traditional dietary studies owing to logistic difficulties in capturing and recovering stomach contents from these animals (Platt *et al*. 2007). Here we present two records gleaned from the popular literature and over-looked by contemporary biologists (but see Cott 1961), describing predation by large Nile crocodiles (*Crocodylus niloticus*) on Black rhinoceros (*Diceros bicornis*).

The first record is provided by Frederick Courteney Selous (1908), the noted British big-game hunter, explorer, naturalist and soldier (Millais 1919). Selous (1851-1917) travelled and hunted widely in what is now Transvaal and Zimbabwe, assembled a large collection of big-game trophies, and despite his advanced age, served in the British army during the East African campaigns of World War I where he was killed by a German sniper (Millais 1919; Farwell 1986). According to Selous (1908), Max Fleischmann photographed a large crocodile attacking and killing a Black rhinoceros, and later described the attack in correspondence to Theodore Roosevelt, then serving as President of the United States of America. Not much is known about Fleischmann, although Roosevelt stated he was a "man of good standing, entirely truthful, and had little [understanding of the] importance of what he was telling me" (Selous 1908). Roosevelt subsequently passed Fleischmann's letter and photographs to Selous, thinking the information might be incorporated into his forthcoming book on African wildlife. Selous (1908) in turn reproduced the correspondence between Roosevelt and Fleischmann, and added further commentary regarding the incident.

According to Fleischmann's letter, his observations were made in the Thika River about 100 yards (91 m) above its confluence with the Tana River in what was then British East Africa. A large crocodile (estimate of body size not provided) seized the left hind leg of a female Black rhinoceros as it ventured into the river to drink. Initially the rhinoceros appeared "panic stricken", and was "straining and heaving" to break free from the grip of the crocodile while standing in shallow water. The quantity of blood in the water led Fleischmann to conclude (probably erroneously) that other crocodiles, submerged and unseen, had joined the attack. The rhinoceros remained standing, and moved slowly downstream until "apparently maddened by pain", it attempted to swim

across the river channel to the opposite shore. Upon entering deeper water the rhinoceros lost its foothold and the crocodile quickly pulled it beneath the surface. Fleischmann speculated the crocodile was only able to pull the rhinoceros below the surface because it had wrapped its tail around a submerged object, although both Roosevelt and Selous discount this assertion. The three enlarged photographs reproduced by Selous (1908) show the attack sequence from its beginning until the point when the rhinoceros is being pulled under while attempting to swim across the river channel.

A second reported instance of crocodile predation on a rhinoceros is presented in Capstick (1977). This attack was witnessed by a group of vehicle-bound tourists photographing wildlife at a waterhole "in a Tanzanian game park during the late 1950s". As described by Capstick (1977), a Nile crocodile estimated to be 14' long (4.2 m) "exploded from the water" and seized the rostrum of a 4000 lb (1814 kg) female Black rhinoceros as it lowered its head to drink. The initial phase of the struggle is described as a "test of strength" between the two animals; the rhinoceros strained to back away from the waterhole while the crocodile attempted to draw the rhinoceros into deeper water. Neither animal was able to move for almost an hour, but eventually the rhinoceros began "inching into the water". Thirty minutes later when its head was pulled beneath the water, the rhinoceros "rolled over in a final flurry" and drowned. Presumably the crocodile then began feeding on the carcass, although no further detail is provided.

Predation by Nile crocodiles on Black rhinoceros was no doubt rare and is probably even more so today given the near-extirpation of the latter throughout much of its historic distribution in Sub-Saharan Africa (Emslie and Brooks 1999). Nonetheless, these accounts and others (eg Cott 1961) indicate that Nile crocodiles are capable of killing large mammals that otherwise have few natural predators. Finally, these reports highlight the value of historic accounts, which can provide information on species interactions that may no longer (or rarely) occur due to the rarity of one or more of the interacting partners.

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Saltwater crocodile. Photograph: Jakub Vágner.

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