CROCODILE SPECIALIST GROUP NEWSLETTER

VOLUME 33 No. 3 • JULY 2014 - SEPTEMBER 2014

IUCN • Species Survival Commission

CROCODILE

SPECIALIST

GROUP

NEWSLETTER

VOLUME 33 Number 3
JULY 2014 - SEPTEMBER 2014

IUCN - Species Survival Commission

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

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

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

COVER PHOTOGRAPH: Tomistoma habitat in Tanjung Puting National Park, Central Kalimantan Indonesia. Photograph: Bruce Shwedick.

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

CSG Newsletter Subscription

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

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

The CSG Newsletter is available as:

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

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

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

PATRONS

We thank all patrons who have donated to the CSG and its conservation program over many years, and especially to donors in 2013-2014 (listed below).

Big Bull Crocs! ($15,000 or more annually or in aggregate donations)
Japan, JLIA - Japan Leather & Leather Goods Industries Association, CITES Promotion Committee & Japan Reptile Leather Industries Association, Tokyo, Japan.
Heng Long Leather Co. Pte. Ltd., Singapore.
Hermes Cuirs Precieux, Paris, France.
Singapore Reptile Skin Trade Association, Singapore.
Species Management Specialists, Canberra, ACT, Australia.
United Leather Product Co. Ltd. and Nakorn Sawan Crocodile Farm, Thailand.

Friends ($3000 - $15,000)
Ashley and Associates, Florida, USA.
William Belo, Coral Agri-Venture Farm, Philippines.
CAICSA, Colombia.
Captain Morgan Rum, South Carolina, USA.
Conservation Force, Louisiana, USA.
Crocodile Conservation Institute, South Carolina, USA.
Dallas Safari Club, Texas, USA.
Ethiopian Rift Valley Safaris, Addis Ababa, Ethiopia.
International Reptile Leather Association (IRV), Germany.
Mainland Holdings, Lae, Papua New Guinea.
Phillip Cunliffe-Steel, New Zealand/Australia.
Enrico Chiesa, Italhide, Italy.
Yee Tai Leather Enterprise Ltd., Hong Kong.

Supporters ($1000 - $3000)
Shaun Foggett, Crocodiles of the World, Witngy, Oxon, UK.
J. Perran Ross, Gainesville, Florida, USA.
George Saputra, CV Alona Jaya, Jakarta, Indonesia.
Los Angeles Zoo, California, USA.
St. Augustine Alligator Farm, Florida, USA.
Porosus Pty. Ltd., NT, Australia.
Toronto Zoo, Ontario, Canada.
Yosapong Temsiripong, "Sriracha Moda" and "Crocodile & Ostrich Cooperative of Thailand", Thailand.
Virginia Aquarium and and Marine Science Center Foundation, Virginia Beach, Virginia, USA.
Zambia Crocodile Farmers Association, Lusaka, Zambia.
Zoo Leipzig, Leipzig, Germany.
Zoo Miami, Florida, USA.

Contributors ($250 - $1000)
East Coast Zoological Society (Brevard Zoo), FL, USA.
Simone Comparini, Pantera S.R.L., S. Croce s/Arno, Italy.
Crocodile Park, Malaga, Spain.
J.K. Mercado & Sons Agriculture Emterprises Inc., Philippines.
James Hennessey, The Reptile Village Zoo, UK.
The Ebey family, New Mexico, USA.
Marco Schultz, Germany.

Editorial

In June 2014, Dr. Paolo Martelli and Dr. Cathy Shilton (Co-Chairs of the CSG Veterinary Science group) participated in a joint meeting with fellow veterinarians on the possible establishment of a Centre for Crocodile Veterinary Work at Mahidol University, in Thailand (see page 6). Given the thousands of crocodile farms from village level upward in the Southeast Asia region, the sporadic impact of new diseases within crocodile farming generally, and the increasing focus on skin quality, having a dedicated centre would simply be wonderful.

In August 2014, I accompanied a CSG team comprising Lonnie McCaskill, Bruce Shwedick, Matthew Brien and Widodo Ramono, to Indonesia on a fact-finding mission to discuss crocodile conservation and management issues. We met with Central Government officers in Jakarta to discuss Indonesia's crocodile management program, and the extent to which the current Appendix-II listing for *Crocodylus porosus*, based on ranching, was still appropriate. Human-crocodile conflict is increasing in Indonesia, and pressure is being mounted to do something about it. Over and above attacks reported in the press, there are many attacks that are not reported. We also visited crocodile farms in the Medan area, Sumatra, which appear to be operating effectively. The team then continued to East Kalimantan, to meet with Provincial Government officers and representatives of the oil palm industry, to determine how to better protect the wetlands of Lake Mesangat, which contains both Siamese crocodiles (*Crocodylus siamensis*) and Tomistoma (*Tomistoma schlegelii*). Bruce Shwedick then continued on to Tanjung Puting and Danau Sentarum National Parks, where Tomistoma occurs and where the CSG-Tomistoma Task Force has been doing some work. I have subsequently written to the Indonesian authorities seeking their support to add the Siamese crocodile to the list of 'Priority' endangered species for conservation in Indonesia, which is currently under review. The full report on this mission is now being drafted, and a summary is on pages 4-5.

The Cambodian Prime Minister Samdech Hun Sen has now formally given approval for the Department of Fisheries Conservation to host a CSG regional meeting, on 25-29 May 2015, at Seam Reap. This will be a good opportunity for CSG members to familiarize themselves with the conservation and management challenges in this region, and the efforts being made by many people to overcome them. Details will soon be available on the CSG website and the meeting website.

The 3rd West and Central Africa CSG regional meeting scheduled to be held in Abidjan, Cote d'Ivoire, was once again a new opportunity to help and promote crocodile conservation work in this part of Africa. However,the meeting has had to be postponed due to the Ebola epidemic in the region and the uncertainty regarding its containment in the short-term. A tentative date for the meeting is in February or March 2015, but this has yet to be confirmed.

Matt Shirley has advanced his report on Ethiopia, which is extensive and very insightful. The Ethiopian ranching program has some quite unique management associated with it, that all helps insure sustainability. The previous trophy hunting component of its program, likewise, involves small numbers of animals taken and is also likely to be sustainable. But with it comes active management by those with the hunting concession, to add to what Government can devote. There is considerable room to upgrade the program, find ways of reducing conflict with fishermen, and increase the benefits extended to local people. It will be an important report.

South African National Parks has confirmed and committed to host the 24th CSG Working Meeting, from 23-26 May 2016, at the Nombolo Mdhluli Conference Centre, Skukuza Rest Camp, Kruger National Park, South Africa. This will be preceded by a CSG Standing Committee meeting on 22 May. Once again this represents a great opportunity for members to get an understanding of the challenges involved in crocodile conservation in South Africa. It has been 22 years since a CSG working meeting was held in Africa, and we hope that the meeting will also highlight the range of issues that face crocodilians in one of the CSG's largest and most diverse regions.

As many CSG members are aware, some animal rights organizations have been making political interventions aimed at preventing any crocodilian skin products being sold in the State of California, USA: the 9th largest economy in the world. It was a pleasure to learn that Governor Brown of California recently signed Bill AB2075, which extended the sunset clause for the legal sale of crocodilian products in California to 1 January 2019. Our many thanks go to Don Ashley for his tireless efforts on this issue.

Despite CSG membership being large (500+), we are always interested in learning about awards that our members receive for their conservation efforts. I take this opportunity to congratulate:

- Marites (Tess) Gatan-Balbas, who received a Whitley Award for Nature from HRH the Princess Royal in the Royal Geographical Society in London, for the community-based Philippine crocodile (*Crocodylus mindorensis*) conservation work of the Mabuwaya Foundation.
- Dr. Angel Alcala, who was conferred the Order of National Scientist by President Aquino of the Philippines for his achievements in science and technology over many years.
- Rene E. Honegger, one of the CSG's oldest serving members, was awarded the title of Honorary Doctor by the University of Zurich's Veterinary Faculty (Switzerland) in recognition of his achievements in the propagation and presentation of reptiles and amphibians in zoos.

Professor Grahame Webb, *CSG Chairman*.

CSG Student Research Assistance Scheme

The CSG Student Research Assistance Scheme (SRAS; http://www.iucncsg.org/pages/General-Information.html) provided funding to 3 students in the July-September 2014 quarter. **Three** further applications are under review.

1. William Versfeld (South Africa): Nile crocodile genetic diversity and population structure within the Kunene and Kavango Rivers, northern Namibia.

2. Luke Evans (United Kingdom): Assessing impacts of habitat fragmentation and anthropogenic expansion on the Estuarine crocodile (*Crocodylus porosus*).

3. Ehit Bekele (Ethiopia): Hatching success and growth rate of hatchlings ar Arba Minch Crocodile Ranch, Ethiopia.

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

CSG Review Mission to Indonesia

From 25 August to 17 September 2014, a CSG fact-finding mission consisting of CSG Chairman Grahame Webb and CSG members Lonnie McCaskill, Bruce Shwedick, Widodo Ramono and Matthew Brien was conducted in Indonesia for the purpose of reviewing the current situation regarding crocodile conservation, management and farming. The team was accompanied on various aspects of the mission by Ministry of Forestry representatives Badiah Achmad Said, Sri Ratnaningsih, Amir Hamidy and Fajria Novaril, LIPI representative Helen Kurniati, Tarto and Adrian Sugiarto (Surya Raya Crocodile Farm), Erick Wiradinata (Indonesian Crocodile Farmers Association; ICFA), Imanul Huda (PRCF-Indonesia) and Kamil Insan (Department of National Parks).

On 25 August a meeting was held at the Ministry of Forestry in Jakarta, with representatives from the KK-PHKA, LIPI, the ICFA and the CSG review team, to outline the purpose and aims of the review mission (Fig. 1). Attendees included Ministry Director Bambang Dahono Adji, the Deputy Director of Biodiversity Consevation Agus Priambudi, and Rosichon Ubaidillah, Head of Zoology Division at LIPI.

The priority issues of the mission were:

1. Appropriateness of Indonesia's current CITES Appendix-II listing (under the ranching resolution) for *Crocodylus porosus*.
2. Crocodile farming.
3. Human-crocodile conflict and management.
4. Conservation of Siamese crocodile (*C. siamensis*) and options for the long-term protection of the Lake Mesangat wetlands.

Figure 1. From left, Bruce Shwedick, Matt Brien, Widodo Ramono, Grahame Webb, Rachmat Wiradinata, George Saputra, Lonnie McCaskill and Erick Wiradinata.

Four crocodile farms were visited in the week following this initial meeting [Ekandinya Karsa (Jakarta, Java), Alian Ruswan (Medan, Sumatra), Yakita Malia (Medan, Sumatra), Surya Raya (Balikpapan, Kalimantan)].

On 29 August the team met with BKSDA (Forestry Department) in Samarinda (Kalimantan) to discuss options for protecting the Lake Mesangat wetlands due to the importance of the *C. siamensis* population.

The following day, the team left Samarinda for a field trip to the Lake Mesangat wetlands. Widodo Ramono remained in Samarinda to meet with the Bureau of Environment of Kalimantan Province. After arriving at the Yayasan Ulin office in Muara Ancalong and then traveling by boat to the floating raft at Long Toh, the team conducted a 7-hour spotlight survey with the assistance of Yayasan Ulin staff and local fishermen. Five *C. siamensis* were sighted, one of which was caught, photographed, measured and released (Fig. 2). A Tomistoma mandible measuring 76.25 cm (Fig. 3) was also recovered during the night survey by one of the guides from submerged mud and detritus in the flooded forest near Long Toh. Over the next two days the team traveled by longboat and car observing conditions surrounding the wetlands and interviewing fishermen and other local villagers.

Figure 2. Matt Brien with *C. siamensis* captured during spotlight survey at Mesangat.

With the exception of Bruce Shwedick, team members departed Indonesia around 3 September. Bruce remained in Indonesia to focus on projects that have been funded by the CSG-Tomistoma Task Force. He traveled to Danau Sentarum National Park along with CSG member and PRCF-Indonesia Director, Imanul Huda. During their 4-day visit they conducted two spotlight surveys for Tomistoma in the Leboyan River, two daytime surveys in nesting areas and one daytime survey in the Tengkidap River. They met with the Park's Director, Hasdin Siregar, and Head of Administration, Lidia Lilly, as well as other staff members.

This visit was followed by a meeting on 8 September with Sustyo Iriyono, Director of BKSDA in Pontianak, to discuss human-crocodile conflict issues in West Kalimantan.

On 9-11 September Bruce traveled to Pangkalan Bun and made a site visit to Tanjung Puting National Park. He was accompanied during this visit by national park staff, including the Park's Director Kamil Insan and Tomistoma researcher Budi Surinsyah. Two spotlight surveys were conducted in the Sekonyer River and one daytime search for nests. After returning to Pangkalan Bun, word was received that a 5-m Tomistoma had been captured in Lamandau earlier that week. Unfortunately by this time the animal had died (Fig. 3). A necropsy was performed at the BKSDA office in Pangkalan Bun and arrangements were made for the skull of this specimen, along with the jawbone recovered in Mesangat, to be transferred to the Bogor Zoological Museum.

On 17 September a follow-up meeting was held at the Ministry of Forestry (Jakarta) with Bambang Dahono Adji, Agus Priambudi, Agung Nugroho, Widodo Ramono, Erick Wiradinata, Bruce Shwedick, Adrian Sugiarto and Fajria Novaril. Following discussions on our shared experiences during the proceeding month, Bambang Adji presented a letter to Widodo Ramono (as a representative of the CSG), indicating that *C. siamensis* would become a priority species for conservation in Indonesia. This letter is also being sent to the other relevant ministries and Government agencies in Indonesia. He also informed the meeting that Agung Nugroho, Species Coordinator for the Ministry of Forestry, is now the key person for conservation action related to *C. siamensis* in Indonesia. Agung is now responsible for organizing a workshop focusing on this species and its remaining habitat in East Kalimantan to be held later this year (presumably in Samarinda).

Figure 3. Top, Tomistoma mandible recovered from flooded forest near Long Toh (Mesangat); bottom, Bruce Shwedick recovers and measures skull of dead Tomistoma at Lamandau, Central Kalimantan.

Bambang Dahono Adji expressed his appreciation to the CSG and those CSG members present thanked the Ministry of Forestry, LIPI, ICFA, and the Sugiarto and Wiradinata families for their assistance and hospitality during the review mission.

A detailed report including discussions, interviews, survey results and recommendations is being prepared, and will be soon be available on the CSG website.

Matt Brien *(crocmatt@hotmail.com)* and Bruce Shwedick *(Chair CSG-Tomistoma Task Force, Bshwedick@aol.com).*

Veterinary Science Group

CSG VETERINARIANS VISIT THAILAND. CSG Veterinary Science Group Co-Chairs Dr. Paolo Martelli and Dr. Cathy Shilton attended a productive, interesting and enjoyable meeting with crocodile veterinarians and researchers at Mahidol University, Thailand, on 20-21 June 2014. The "Meeting on Comparative Crocodile Health Management: The Experience of Thailand and Australia" was hosted by Dr. Parntep Ratanakorn, Dean of the Faculty of Veterinary Science (Fig. 1), and came about following a recent visit by CSG Chair Grahame Webb to Thailand. Professor Webb noted opportunities to share crocodile disease information and develop research collaborations among the CSG, Thailand and Australia. This opportunity was also recognised by the Crocodile Farmers Association of the Northern Territory, which subsequently covered Dr. Shilton's costs to attend the meeting.

Figure 1. Dr. Parntep Ratanakorn addresses the meeting.

On the first day of the meeting, participants headed out to the countryside surrounding Bangkok to visit several related crocodile farms that encompassed all stages of farming, from egg incubation to breeding (Fig. 2). The farmers were very welcoming and knowledgeable and were keen to show their farms and answer questions about their farming practices.

Figure 2. Dr. Cathy Shilton (far right) with Thai researchers on farm visit.

The second day of the visit was based at Mahidol University. It started with a tour of the impressive laboratory facilities at the Veterinary Science division, and was followed by several presentations, including Mahidol University veterinarians summarising their investigations over the past few years into diseases of farmed Siamese crocodiles (*Crocodylus siamensis*) in Thailand. Dr. Shilton made a presentation on common diseases and new emerging diseases in farmed Saltwater crocodiles (*C. porosus*) in the Northern Territory of Australia, and Dr. Martelli's presentation was on various important or emerging diseases that he has come across in various crocodile species.

The meeting closed with discussions on how to continue to develop relationships, including prospects for obtaining grant funding for crocodile research, sharing PhD students between Thailand and Australia, and the value of all parties obtaining CITES registration for scientific institutions, to more easily facilitate the exchange of specimens (eg formalin or ethanol-fixed samples, or histology blocks, for diagnostics and research).

Throughout the visit, Dr. Shilton and Dr. Martelli enjoyed fantastic hospitality, including Thai food (and beer) with their hosts, for which they extend their deep appreciation.

Cathy Shilton *(Cathy.Shilton@nt.gov.au)* and Paolo Martelli *(paolo.martelli@oceanpark.com.hk), CSG Co-Chairs Veterinary Science Group.*

FRITZ HUCHZERMEYER VETERINARY SCIENCE STUDENT RESEARCH GRANT. The Fritz Huchzermeyer Veterinary Science Student Research Assistance Scheme (FHVSRAS) has been developed with the specific goal of encouraging and assisting undergraduate and post-graduate students to undertake formal research to advance crocodilian veterinary science. The CSG recognizes that crocodilian research often involves a greater commitment of resources and time by students, relative to many other subjects, and believes that this justifies efforts to assist. Research gives students the skills needed to assist crocodilian veterinary science and to become active CSG members in the future.

The FHVSRAS will provide up to $US1000 per year to a project, or divided among multiple projects, that meet the criteria for assistance. The grant is not designed to fully fund projects, nor to sustain them over years, but rather to provide some direct financial assistance to students during their study. Students are encouraged to use CSG funds, and the "CSG Approved Project" status, to try and lever more project funds from other sources.

Details on the FHVSRAS are on CSG website (www.iucncsg.org/pages/Veterinary-Science-Grants-English.html) (also available in Spanish and French), including eligibility, project criteria and how to apply. Donations may be specified for the FHVSRAS through the links to support the CSG (www.iucncsg.org/pages/Veterinary-Science-Grants-English.html).

Paolo Martelli, *CSG Co-Chair Veterinary Science Group (paolo.martelli@oceanpark.com.hk).*

CSG VETERINARY SCIENCE GROUP EXPERTISE REGISTER - PLEASE SIGN UP. At the CSG Veterinary Science Group meeting held at the 23rd CSG Working Meeting (May 2014), attendees were asked to add their name, contact details and area of crocodilian expertise to a list for posting on the CSG website. This can serve as a resource for CSG members and non-members requiring veterinary advice or looking for research collaborators.

Many CSG members not at the Louisiana Working Meeting, and who may have expertise to offer, are encouraged to provide their details by e-mail to Dr. Paolo Martelli (paolo.martelli@oceanpark.com.hk) or Dr. Cathy Shilton (Cathy.Shilton@nt.gov.au), and have their name added to the list. Please provide your: full name; e-mail; interest/expertise; and, country.

Dr. Shilton and Dr. Martelli will maintain an updated list (including e-mail addresses) that can be provided on request.

Cathy Shilton, *CSG Co-Chair Veterinary Science Group (Cathy.Shilton@nt.gov.au).*

HUMANE EUTHANASIA/KILLING METHODS FOR CROCODILIANS. In 2011, largely in response to concerns raised after the screening of a documentary depicting the slaughter of snakes in Southeast Asia as cruel, the Swiss Government established an Expert Panel to assess humane methods of killing reptiles (Expert Panel 2013). The methods outlined in this document were essentially extracted from the few Codes of Practice that specifically deal with the killing/slaughter of crocodilians [eg Australia (NRMMC 2009), Zimbabwe (CFAZ 2012), Louisiana, USA (LDWF and LSU 2011) and South Africa (SABS Standards Division 2014) have Codes of Practice or guidelines that include methods of killing/euthanasia/slaughter]. In addition, the CSG is currently developing a Best Management Practices Manual for crocodilian farming that will provide guidance to crocodilian farms around the world.

In the interim, the CSG Veterinary Science Group has extracted and adapted the humane methods for crocodilians that were outlined in Expert Panel (2013). It is hoped that this summary document ("Humane Euthanasia/Killing Methods for Crocodilians") will assist farming operations when dealing with this particular issue. It is available from the CSG website [www.iucncsg.org/pages/Publications.html (search CSG reports)] or from Dr. Paolo Martelli (paolo.martelli@oceanpark.com.hk) or Dr. Cathy Shilton (Cathy.Shilton@nt.gov.au).

Literature Cited

CFAZ (Crocodile Farmers Association of Zimbabwe) (2012). Codes of Practice. CFAZ: Harare.

Expert Panel (2013). Analysis of Humane Killing Methods for Reptiles in the Skin Trade, ed. by Swiss Federal Veterinary Office. Swiss Federal Veterinary Office: Berne,.

LDWF and LSU (Louisiana Department of Wuldlife and Fisheries and Louisiana State University) (2011). Best Management Practices for Louisiana Alligator Farming. LDWF and LSU: Louisiana, USA.

NRMMC (National Resource Management Ministerial Council) (2009). Code of Practice for the Humane Treatment of Wild and Captive Australian Crocodiles. NRMMC: Canberra.

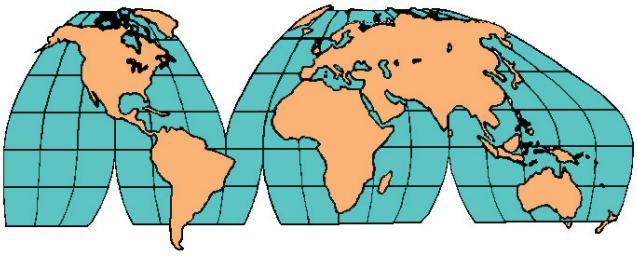
SABS Standards Division (2014). South African National Standard: Crocodiles in Captivity. SABS Standards Division: Pretoria. (http://law.resource.org/pub/za/ibr/za.sans.631.2009.html).

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

Other Veterinary Science News? Please Contribute!

It would be great to see more veterinary news or brief summaries of interesting veterinary clinical or pathology cases in the CSG Newsletter. If you would like to submit an article for the Newsletter, please send it via e-mail to Paolo Martelli (paolo.martelli@oceanpark.com.hk) or Cathy Shilton (Cathy.Shilton@nt.gov.au), who will collate submissions and forward them to the CSG Newsletter Editor.

Regional Reports



North America

USA and Canada

CANADIANS JOIN SUMMER CROCFEST 2014, AND NEW FUNDRAISING RECORD SET. Summer CrocFest 2014 took place on 28 June 2014 at Carl Barden's Reptile Discovery Center in DeLand, Florida, USA, attracting 175 attendees and raising $US18,000. Event organizers were: Colette Adams (General Curator, Gladys Porter Zoo); Curt Harbsmeier (Executive Board Member, Tampa's Lowry Park Zoo); Shawn Heflick (General Curator, Central Florida Zoo; Director, Crocodile Manor); and, Flavio Morrissiey (Director, Gator Adventure Productions).

On 21 June 2014, a week prior to the Summer CrocFest, a satellite CrocFest fundraiser took place in Hamilton, Ontario, Canada. It was sponsored by the team of Reptile Camp (Steve Featherstone), Little Ray's Reptile Zoo (Paul Goulet) and Reptilia (Lee Parker), and raised an additional $US4850! Attendees enjoyed face painting, outdoor games, live reptile

exhibits and a live auction.

The total of $US22,850 is a fundraising record for CrocFests. CrocFests are family-friendly events geared to increase awareness of and raise money for international crocodile conservation. Since 2010 over $US87,000 has been generated for crocodilian projects worldwide.

Attendees in the USA were able to meet Carl Barden, world-famous venomous snake expert, and visit his live reptile exhibits and view a venom extraction show (Fig. 1). Live animal presentations (courtesy of Gator Adventure Productions), barbeque (prepared by Sonny's BBQ), an open bar, and a rousing live auction conducted by Shawn Heflick and Joe Wasilewski (Fig. 2), kept event-goers entertained well into the night.

Figure 1. Carl Barden extracts venom.

Figure 2. Auctioneers Shawn Heflick (left) and Joe Wasilewski (right) plying their "trade".

Proceeds from Summer CrocFest 2014 will benefit two Critically Endangered species of crocodilian - the Gharial (*Gavialis gangeticus*) and the Philippine crocodile (*Crocodylus mindorensis*).

Gharial: The Gharial project will be carried out by the Turtle Survival Alliance (TSA) India Turtle Conservation team, which has initiated a project on the Ghaghra River that aims to evaluate the effectiveness of headstarting through staging and incorporating soft release and post-release monitoring. This work is needed because previous governmental efforts to recover the Gharial in India have included primarily rear and release initiatives to supplement key populations. However, despite such prior and ongoing efforts, this magnificent animal continues to face unacceptably high risks of extinction. Further, little information is available on survival, dispersal and habitat use in such headstarted cohorts. The project employs VHS radio telemetry to compare survival and dispersal among Gharial headstarted via hard and soft release strategies, looking for differences that could benefit future releases and establishing populations where the species has been extirpated.

The TSA is currently working in the area of the Tarai Arc Landscape (TAL), a biodiversity hotspot in the foothills of the Himalayas. Other severely threatened freshwater vertebrates in the area include the Indian Narrow-headed Softshell turtle (*Chitra indica*), the Three Striped Roofed turtle (*Batagur dhongoka*) and the Crowned River turtle (*Hardella thurjii*). Funds generated at CrocFest will be used to construct soft release ponds, provide security for the ponds once the Gharial have been introduced, purchase transmitters and conduct monitoring. Monitoring will be initiated three months prior to release on the soft-release animals and up to a year following the liberation of both soft and hard release Gharial. In addition, some funds will be used to construct a small on-site education center.

Why the TSA? The TSA became involved in this project after TSA member Lonnie McCaskill invited fellow biologists from the TSA India project to accompany him to Cambodia to conduct similar studies on released Siamese crocodiles (*C. siamensis*) that had been headstarted. Accordingly, the TSA has been asked to assist in establishing a similar program for Gharial in India, under the oversight of Dr. Shailendra Singh. Dr. Singh will liaise with governmental departments, coordinate the team and remain responsible for quality control and reporting.

Philippine Crocodile: Funds raised will also be used to further develop the Philippine crocodile rearing station in San Mariano, northern Luzon, into an environmental information and crocodile breeding center. For more information on this project, see www.mabuwaya.org. Also see http://whitleyaward.org/winners/taking-local-action-to-save-the-worlds-rarest-crocodile/.

We would like to express our appreciation to our corporate sponsors, without whose support we could not easily sustain the growth this event has enjoyed over the past several years: Canadian Reptile Breeders Expo, ZooMed, Central Florida Zoo, DeLand Animal Hospital, Animals in the Attic, Gator Adventure Productions and Crocodile Manor.

We also need to thank all of the individuals, businesses and

zoos that supported this fundraising event, including but not limited to: Carl Barden, Flavio Morrissiey, Curt Harbsmeier, Colette Adams, Shawn Heflick, Jen and Thorne Heflick, Kelly Silvano and Collective ConSERVation, Megan Terry, Meghan Padgett, Central Florida Zoo Keeper Staff, Ty Park, Paul Schulz, Norm Benoit, Ron Sandler, Mark Merchant, Lonnie McCaskill, Jenn Andringa, John and Jen Brueggen, Bruce Shwedick, Alvaro Velasco, Jeff Chiyka, Wayne Hill, Joe Wasilewski, Florida Fossil Hunters, Gator Adventure Productions, John Than, Rob Adams, Rob Sprackland, Dave and Tracy Barker, Gary Johnson, Ralf Sommerlad, Boggy Creek Airboat Tours, Randal Berry, David Kledzick, Indigenous Arts, Emily Hutchinson, Michelle Wallenstein, Tom Crutchfield, Ali Donovan, Temptation Boas, Wild Things, USARK, Phil Goss, Woody Woodward, Patrick Delaney (FWC), City Walks Tours, Greg Lepera, Candace Donato, Kevin Earley, Gold Coast Reptiles (Craig Tillem), Angelique Adams, Alexis Harbsmeier, Jim Murphy, San Antonio Zoo (Craig Pelke and Becki Muscher), St. Augustine Alligator Farm (John Brueggen), Wildlife Conservation Society (Don Boyer), Wildlife Discovery Center (Rob Carmichael), The Florida Aquarium (John Than), Zoos Victoria/Melbourne Zoo (Chris Banks), Lion Country Safari (Terry Wolfe), Zoo Miami (Steve Conners), Virginia Aquarium (Mark Swingle /Chip Harshaw), Tampa's Lowry Park Zoo (Larry Kilmar), Busch Gardens (Mike Malden and Rob Yordi), Oklahoma City Zoo (Dwight Lawson), Palm Beach Zoo at Dreher Park (Emily Maple), Ft. Worth Zoo (Mike Fouraker), Memphis Zoo (Steve Reichling), Brevard Zoo (Keith Winston), Jacksonville Zoo & Gardens (John Lucas).

South Asia and Iran

Nepal

POPULATION STATUS OF THE MUGGER IN CHITWAN NATIONAL PARK, NEPAL. Two species of crocodilian occur in Nepal, the Mugger (*Crocodylus palustris*) and the Gharial (*Gavialis gangeticus*). The last extensive survey of the Mugger population, in 1993, indicated 200 individuals restricted to isolated populations, primarily in protected habitats of Chitwan and Bardiya National Parks and KoshiTappu and Shuklaphanta Wildlife Reserves (Andrews and McEachern 1994). Since that time there has been no extensive survey, and so population status of this species is poorly understood. Here, we assess the population status and threats to the Mugger population in Chitwan National Park (CNP) and its associated Buffer Zone area (BZ) through surveys carried out in March 2014. Understanding population status and identifying threats is a key step to determine conservation activities for the species. Similarly, assessment of physico-chemical parameters and biodiversity of wetlands used by Muggers is crucial to maintaining a functional aquatic ecosystem and understanding composition, abundance and distribution of aquatic flora and fauna.

Historically, the Mugger was relatively common throughout the Terai of Nepal, inhabiting marshy lakes, ponds and small rivers (Groombridge 1982), and so it received little attention for conservation action. However, reduction of wetland areas, deposition of silt and sediments, eutrophication, deterioration of water quality, mortality in fisheries operations, construction of dams and other anthropogenic factors have been implicated in the decline in the Mugger's range and population in Nepal (McEachern 1994; Shrestha 2001).

The Mugger is a semi-aquatic, keystone and top carnivore of slow flowing freshwater ecosystems, and is considered to perform a vital service in the aquatic ecosystem by distributing the nutrients throughout the water body resulting an increase in primary production and fish populations (Mulozoki 2000). Like other crocodilians, Muggers at smaller sizes often eat aquatic insects, small fish and crustaceans, and as they grow they tend to eat more vertebrates, including fish, turtles, birds and mammals (Wagle 2010). Muggers reach maturity at 6-10 years of age, when between 1.7 and 2.6 m long. Females (1.8-2.0 m) lay 25-30 eggs in a hole-nest during the annual dry season (Whitaker and Whitaker 1989); in CNP nesting occurs in late March to early April.

Study area

The study was carried out in CNP and BZ area, including Bishazar and its associate lakes which was listed as Ramsar site in 2003. CNP is one of the natural world heritage sites (UNESCO), situated in south central Nepal, covering 932 km^2 core and 750 km^2 BZ in the sub-tropical lowlands of the inner Terai (27°30'N 84°20'E). It has a subtropical monsoonal climate with relatively high rainfall (around 2100 mm annually). The park has a wide diversity of species and habitats within the elevation range from 110 to 850 m asl. More than 70% of the park is covered by Sal (Shorea robusta) forest, about 20% is covered by floodplain grasslands, 7% by riverine forest and 3% includes other forests, riverbeds, etc. (DNPWC 2006). It is habitat for about 70 species of mammals, >550 species of birds, 49 species of reptiles and amphibians, and 120 species of fish. The park is drained by the Narayani, Rapti and Reu Rivers systems, which together with more than 58 other wetland sites, including Bishazar Lake complex in and around Chitwan, provide good habitats for many reptiles and amphibians.

Methodology

Informal interviews and discussions with the key informants having long experience in CNP were conducted to design the field survey program, and to understand the past and present issues associated with Muggers and wetland habitats. Visits and observations were carried out in each wetland site based on the information from the key informants, literature review and also from the personal knowledge and experience. A standard survey format was developed to record sightings of Muggers and some habitat characteristics following consultation with researchers and academics.

Daytime surveys were conducted in March 2014. Muggers bask during the day in post-winter and pre-summer month of March for longer periods due to mild temperatures, providing

the opportunity for sighting them. The survey was conducted at 0830-1100 h and 1545-1700, avoiding the midday hot sun when Muggers are likely to be in the water. The survey took place around the time of nesting, so Muggers sighted were allocated to the following "total length" size classes (hatchlings <30 cm, yearlings 30<50 cm, juveniles 50<125 cm, sub-adult 125<180 cm, adult >180 cm). Muggers were sighted and habitat parameters recorded by an experienced observer (using 10 x 50 DPS1 Olympus DPSR binoculars and Canon Powershot 5x40 HS camera). Dugout canoes were used to conduct surveys on rivers, while observations were done from vantage or elephant back for ponds, lakes and marshes. Trained local youths or the Citizen Scientists were also used for field survey in addition to the experienced and trained staff of CNP.

Result and Discussion

A 1993 survey (Andrews and McEachern 1994) indicated that Muggers in Nepal were in isolated populations restricted to protected habitats in Mahakali, Karnali, Babai, Rapti/ Narayani and Koshi. Presently, Muggers are confined to Chitwan and Bardia National Parks and Koshi Tappu and Sukla Wildlife Reserves.

Muggers were recorded from 37 (17 in CNP, 20 in BZ area) of the 58 wetland sites and two of the three river systems (Rapti and Narayani) (Fig. 1). They have also been recorded from many private fish ponds, based on information provided by pond owners seeking authorities to remove the Muggers from ponds. None were sighted in the Reu River, but interestingly there are records of Muggers entering fish ponds in the Madi Valley, the catchment of the Reu River.

The species has a wide but patchy distribution in CNP, which is correlated with the number and quality of the wetland sites. They are not limited only to natural wetlands, even found in the artificial pound in between rainy to winter season and eventually they get back to natural wetlands in dry season due to low availability of water, fish and nesting sites.

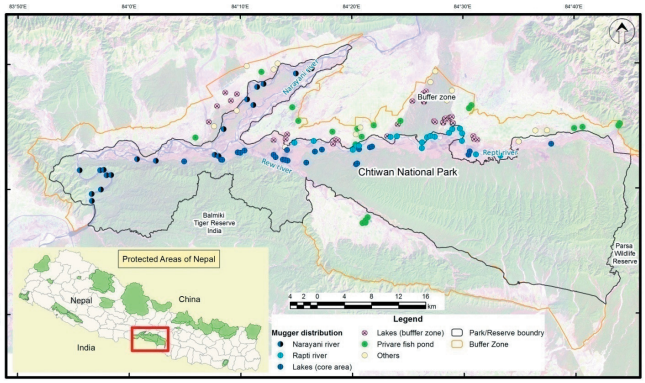


Figure 1. Distribution of Mugger crocodiles in Chitwan National Park and Buffer Zone area.

A total of 245 Muggers, comprising 2 hatchlings, 19 juveniles, 53 sub-adults and 171 adults, were sighted in CNP and its BZ area. Some 35% (N= 86) of sightings were in the BZ area, 34% (N= 82) were in the Rapti and Narayani Rivers systems, and 31% (N= 77) in CNP lakes (Table 1). The high proportion (66.5%) of Muggers recorded in lakes, marshes and ponds suggests a preference for these habitats compared to rivers/ streams. Competition with Gharial, which are restricted to the lotic environment, might suppress the population in the Rapti and Narayani Rivers.

Table 1. Results of daytime surveys in Chitwan National Park and Buffer Zone area. Y= yearlings, J= juveniles, SA= sub-adults, A= adults; Dens.= Relative Non-Hatchling Density (per km for rivers, and per ha for lakes); * including feeder streams.

Site	km/ha	Y	J	SA	A	Total	Dens.
Narayani *	100	-	-	8	30	38	0.38
Rapti *	50	-	7	8	29	44	0.88
Sub-total	**150**	**-**	**7**	**16**	**59**	**82**	**0.55**
CNP lakes	70.54	2	3	23	49	77	1.09
BZ lakes	68.14	-	9	14	63	86	1.26
Sub-total	**138.68**	**2**	**12**	**37**	**112**	**163**	**1.18**
Totals	**-**	**2**	**19**	**53**	**171**	**245**	**-**

Khadka (2011) carried out surveys of the Rapti and Narayani Rivers (feeder streams excluded) in the rainy season (November 2010 and November 2012), and sighted 53 and 41 Muggers respectively. Dry season surveys in March 2011 and March 2014 (this study) recorded 82 and 70 Muggers respectively. These wet and dry season indices of abundance suggest that there may have been a reduction in the Mugger population over time. Some Muggers are known to have been killed by local fishermen (see later), and this may explain in some part for the decreased numbers of sightings.

There are no historical data on the overall Mugger population in CNP. The proportion of Muggers present that were not sighted during this survey is unknown, but the total population is considered to be around 300-350 non-hatchlings.

The majority (N= 163; 66.5%) of Muggers sighted were basking on wet muddy areas next to lakes and rivers, and sandy areas (N= 67; 27.4%). The few (N= 9; 3.7%) basking on rocks were adults, and some sub-adults and juveniles were basking on logs (N= 3; 1.2%) and gravel (N= 3; 1.2%).

Field observations in Chitwan suggest seasonal movement of Mugger from rivers during times of flooding and high water volumes towards upstream areas and sometimes streams (tributaries). They move back into the downstream sections of rivers during the breeding season when water levels in wetlands and streams begin to drop. In 2012, surveys were undertaken in the Rapti, and Naryani Rivers in February (dry season) and November (wet season). Results indicated a 7.7% decrease in sightings in the Rapti River between dry and wet seasons, and a 41.4% decrease in sightings for the Narayani River.

The principal threats to the Mugger include water pollution, habitat destruction, sedimentation, food shortage and seasonal fluctuation of water level. The Narayani and Rapti Rivers and some BZ wetlands face comparatively higher anthropogenic pressure than wetlands of core area of CNP.

Unlike Gharials, which avoid human disturbance, Muggers appear to be more tolerant to anthropogenic pressure. Fishing and other human disturbance activities were also recorded from most of the areas where Muggers were sighted. More than two-thirds of the Muggers sighted were in areas where fishing activities occur. Highly destructive disturbances such as mining and poisoning were found at only a few sites (eg Bhutai Ghol).

Table 2. Levels of disturbance and invasive plant species at 118 locations where Muggers were sighted within the 37 wetland sites in CNP and BZ area (ie rivers excluded).

Category	% of Locations
Disturbance	
Fishing	74.6
Washing/swimming	17.8
Cattle grazing	12.7
Sand mining/stone quarrying	5.1
Poisoning	2.5
Invasive species	
Pistia stratiotes	54.2
Eichernia crassipes	50.9
Leersia hexandra	10.2

Similarly water hyacinth (Kumbika; *Pistia stratiotes*) and water cabbage (Jalkumbhi; *Eichernia crassipes*) were recorded as major invasive species, and to a lesser extent Karauti grass (*Leersia hexandra*), in areas where Muggers were recorded. Narayani River habitat has not been affected by any of these three species, whereas habitats in core lakes have been severely affected by all of them.

Almost all wetlands are shrinking due to sediment deposition and encroachment of invasive species such as *E. crassipes*, *P. stratiotes*, *Leersia hexandra*, *Ipomoea carnea* (Besharm; Morning Glory Bush), etc. Some sites, such as Devital, Sheratal, Sitamaighol and Singe Tal, are severely affected. It is unclear whether the encroachment of invasive plant species influences the movement of Muggers out of CNP and into village fish ponds, or whether Muggers are simply attracted to the fish within the ponds - the latter is more likely. More than 500 private fish ponds (300 ha) are in the buffer zone/vicinity of park.

The local extinction of Muggers from the Reu River is an alarming result for conservation of the species. The high number of records of Muggers entering fish ponds in the BZ area makes them more vulnerable to retaliatory killing by fish farmers. Generally, few Muggers are killed (<5 annually), as communities are aware of biodiversity conservation efforts, and 50% of park revenue goes back through BZ area communities. Authorities are alerted and asked to rescue Muggers from fish ponds [eg 9 juvenile Muggers were rescued between July 2012 and December 2012 (Khadka 2013) and 10 juveniles were rescued between June 2013 and December 2013 (Khadka, unpublished data)].

Detailed and continuous study of the physio-chemical analysis of water and wetland diversity is required to ensure the functionality of these wetlands and the effective management actions. Effective campaigns of conservation awareness program within the vicinity of CNP, private fish farm communities and also the establishment of a Mugger rescue team for the reduction of human attacks should be initiated in CNP. Official records indicate that 4 local people were injured by Muggers between 2008 and 2011.

Under this situation, conservation and proper management of the wetlands are urgent necessity for better habitat of crocodile. Mugger crocodile is a predatory apex species in the wetland ecosystem but it has been overshadowed by other terrestrial flagship species for conservation action.

Acknowledgements

We would like to thank Kamal Jung Kunwar (Chief Warden, CNP), Dr. Chiranjibi Prasad Pokheral (Program Coordinator/Senior Conservation Officer, NTNC Biodiversity Conservation Center, Sauraha, Chitwan), Ashish Adhikari, and my assistants who helped me directly or indirectly during the survey.

Literature Cited

Andrews, H.V. and McEachern, P. (1994).Crocodile Conservation in Nepal. IUCN Nepal & USAID: Kathmandu.

Groombridge, B. (1982). The IUCN Amphibia-Reptilia Red Data Book. Part 1. Testudines Crocodylia and Rhyncocephalia. IUCN: Gland, Switzerland.

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

Khadka, B.B. (2013). Population Trend for Gharial and Mugger in the Narayani and Rapti Rivers of Chitwan National Park, Nepal, January to March 2013. Crocodile Specialist Group Newsletter 32(1): 23-25.

McEachern, P. (1994). Interim results of the IUCN Nepal crocodile survey. Pp. 199-217 in Crocodiles. Proceedings of the 12th Working Meeting of the IUCN-SSC Crocodile Specialist Group. IUCN: Gland, Switzerland.

Mulozoki, C.J. (2000). Opportunities and constraints of the crocodile ranching in Tanzania. M.Sc. Thesis, Agricultural University of Norway, Norway.

Patralekh, L.N. (1994). Comparative account of physico-chemical properties of three freshwater ecosystems. J. Freshwater Biol. 6: 115-119.

Shrestha, T.K. (2001). Herpetology of Nepal: A Field Guide to the Amphibians and Reptiles of the Trans Himalayan Region of Asia. Mrs. Bimala Shrestha: Kathmandu.

Wagle, B.H. (2010). Institutional strengthening and awareness raising project for sustainable crocodile conservation in Nepal. Final report submitted to Rufford Small Grants Foundation, UK.

Whitaker, R. (1987). The management of crocodilians in India. Pp. 63-72 in Wildlife Management: Crocodiles and Alligators, ed. by G.J.W. Webb, S.C. Manolis and P.J. Whitehead. Surrey Beatty and Sons: Sydney.

Whitaker, R. and Whitaker, Z. (1989). Ecology of the mugger crocodile. Pp. 276-297 *in* Crocodiles. Their Ecology Management and Conservation. A Special Publication of the Crocodile Specialist Group. IUCN: Gland.

Bed Bahadur Khadka *(Assistant Conservation Officer, CNP, Kasara, Nepal, bed.khadka@gmail.com)*, Amir Maharjan *(Assistant Conservation Officer, CNP, Kasara, Nepal, maharjanamir23@yahoo.com)*, Bishnu Prasad Thapalia *(Assistant Conservation Officer, CNP, Kasara, Nepal, bpthapaliya2001@yahoo.com)* and Babu Ram Lamichhane *(Research Officer (Wildlife) NTNC Biodiversity Conservation Center, Bachhauli - 2, Sauraha, Chitwan, Nepal, baburaml@gmail.com).*

Science

Recent Publications

Aggarwal, R.K., Lalremruata, A. and Dubey, B (2014). Development of fourteen novel microsatellite markers of *Crocodylus palustris*, the Indian mugger, and their cross-species transferability in ten other crocodilians. Conservation Genetics Resources (doi: 10.1007/s12686-014-0331-4).

Abstract: *Crocodylus palustris* (Indian Mugger) is an endangered species with declining populations due to illegal hunting and habitat destruction. The situation warrants conservation efforts for which understanding the genetic structure of the extant populations becomes important. Here, we describe 14 new mugger-specific microsatellite markers (Simple Sequence Repeats, SSRs), developed from SSR-enriched partial genomic DNA library and ESTs. All markers were validated using 48 population samples. In general, markers were highly polymorphic; amplified 2-12 alleles/marker with H e and H o ranging from 0.23-0.91 and 0.25-1.0, respectively. Notably, all markers except CpSSR10, also exhibited near 100% cross-species transferability when tested on ~30 samples belonging to 10 related crocodilians. These microsatellite markers are thus expected to be highly useful for the population genetics and other conservation studies on Indian mugger and other crocodilians.

Adams, T.L. (2014). Small crocodyliform from the Lower Cretaceous (late Aptian) of central Texas and its systematic relationship to the evolution of Eusuchia. Journal of Paleontology: 88(5): 1031-1049.

Abstract: A new Early Cretaceous neosuchian crocodyliform is recognized on the basis of two skulls and postcranial material collected from the late Aptian Twin Mountains Formation at Proctor Lake, central Texas. The new species, *Wannchampsus kirpachi*, is distinguished by a unique combination of characters including an enlarged third maxillary tooth, internal choanae bordered anteriorly by the palatines and by the pterygoids posteriorly and laterally, anterior margin of the choanae situated at the posterior edge of the suborbital fenestrae, a median crest along the midline of the parietal and frontal, and procoelous vertebrae. A phylogenetic analysis recovered the new taxon as the sister to the 'Glen Rose form,' an undescribed taxon of neosuchian. Together, with *Shamosuchus*, *Batrachomimus*, and *Rugosuchus*, they form a monophyletic group, Paralligatoridae, that is the sister clade to Eusuchia within Neosuchia. The Proctor Lake taxon and the undescribed yet widely discussed 'Glen Rose form' are referable to the same genus.

Brochu, C.A. and Jiminez-Vazquez, O. (2014). Enigmatic crocodyliforms from the early Miocene of Cuba. Journal of Vertebrate Paleontology 34(5): 1094-1101.

Abstract: Early Miocene deposits from the Domo de Zaza locality, in the south-central Cuban province of Sancti Spiritus, preserve crocodyliform remains, including compressed serrated teeth closely resembling those of South American sebecids. Fragmentary cranial and mandibular material is more difficult to assess. Referral to any other post-Paleogene crocodyliform known from the Western Hemisphere can be ruled out, and phylogenetic analyses are unable to pinpoint its relationships. Similarities can be found with planocraniids, including ventrally oriented and mediolaterally expanded orbital surfaces, but the morphology of the quadrate is inconsistent with a planocraniid affinity. A sebecid in the Miocene of Cuba would be congruent with evidence from other vertebrates suggesting extensive dispersal between the Greater Antilles and South America during the Neogene, and it would be the first Neogene record of the group outside South America. The other crocodyliform may indicate the presence of an endemic West Indian lineage not closely related to any contemporaneous group. It is also consistent with extant *Crocodylus* arriving in the Neotropics within the past 5-10 million years.

Passos, L.F., Coutinho, M.E. and Young, R.J. (2014). Demographic and growth analysis of broad snouted caiman (*Caiman latirostris*) in a disturbed environment in southeastern Brazil. The Herpetological Journal 24(4): 223-228.

Abstract: Crocodilian life history traits exhibit strong size and age dependence, which is determined, ultimately, by how fast individuals grow. Crocodilian population dynamics are dependent on environmental conditions such as local temperatures and hydrology. From February 2010 to October 2011 we conducted monthly spotlight surveys to study a broad-snouted caiman population at the Três Marias Hydroelectric Reservoir, southeast Brazil. A total of 12 spotlight surveys were conducted (17.3 to 48.0 km in length), and animals were captured, measured and marked whenever possible. Data were obtained on population size, sex structure, survival, distribution and growth. The number of caimans counted, including hatchlings, varied from 6 to 78 per survey. Marked

individuals showed a growth rate that varied between 0.0 and 0.3 cm d^{-1} SVL, and between -6.0 and 8.0 g d^{-1} body mass. Polyphasic growth was associated with rainfall and water level, which in turn were associated with changes in temperature and diet. The species seems to be resistant to the ecological impacts of damming, an important conservation conclusion considering the large number of hydroelectric dams within the species' range in Brazil.

Nuñez Otaño, N.B., Piña, C.I., Bucsinsky, A. and Arambarri, A.M.M. (2014). Fungal diversity on broad-snouted caiman (*Caiman latirostris*) eggs, and their effects on hatchlings, The Herpetological Journal 24(4): 217-223.

Abstract: Studies describing and identifying mycobiota affecting the eggs of wild reptiles are rare, despite the potential importance of mycoses for the survival and performance of individuals and populations. The aim of this study was to identify the fungal species on eggshell and eggshell membranes of *C. latirostris* and to discover potential compositional changes between these two substrates. Twenty-four species of fungi were isolated from eggshells and 17 species were isolated from membranes; 10 species were shared between both substrates. Saprophytic fungi comprised 64.1% of eggshell and 59.4% of eggshell membranes mycobiota, respectively. Potentially pathogenic fungi occurred more frequently on the eggshell membrane (71.4%). From pathogenic assays we cannot conclude that fungi like *Aspergillus fumigatus* and *Fusarium oxysporum* have a negative effect on hatching success, weight and snout-vent length of *C. latirostris* hatchlings.

Kabbua, T., Anwised, P., Boonmee, A., Subedi, B.P., Pierce, B.S. and Thammasirirak, S. (2014). Autoinduction, purification, and characterization of soluble a-globin chains of crocodile (*Crocodylus siamensis*) hemoglobin in *Escherichia coli*. Protein Expr. Purif. S1046-5928(14)00188-0 (doi: 10.1016/j.pep.2014.08.013).

Abstract: We have established a method to achieve pure, soluble, and heme-bound recombinant crocodile (*Crocodylus siamensis*) α-globin chains in bacteria (*Escherichia coli*) using an autoinduction system without exogenous heme. This is the first time that heme-bound crocodile α-globin chains have been expressed in bacteria without *in vitro* heme reconstitution. The molecular mass of purified α-globin is consistent with the primary amino acid sequence of native crocodile (*C. siamensis*) α-globin. Both the monomeric and the dimeric protein configuration formed by intermolecular disulfide bond could be purified as soluble protein. Spectroscopic characterization [UV-visible, circular dichrosim (CD), and electron paramagnetic resonance (EPR)] of purified α-globin demonstrates nearly identical properties as reported for hemoglobin and myoglobin isolated from other organisms. For comparison, cyanide and nitric oxide binding of purified α-globin was also investigated. These results suggested that *C. siamensis* α-globin expressed in *E. coli* were correctly folded with the proper incorporation of the heme cofactor. The expression method we now describe can facilitate production and isolation of individual globin chains in order to further study the mechanism and assembly of crocodile hemoglobin.

Woodward, H.N., Horner, J.R. and Farlow, J.O. (2014). Quantification of intraskeletal histovariability in *Alligator mississippiensis* and implications for vertebrate osteohistology. PeerJ. 3;2:e422 (doi: 10.7717/peerj.422).

Abstract: Bone microanalyses of extant vertebrates provide a necessary framework from which to form hypotheses regarding the growth and skeletochronology of extinct taxa. Here, we describe the bone microstructure and quantify the histovariability of appendicular elements and osteoderms from three juvenile American alligators (*Alligator mississippiensis*) to assess growth mark and tissue organization within and amongst individuals, with the intention of validating paleohistological interpretations. Results confirm previous observations that lamellar and parallel fibered tissue organization are typical of crocodylians, and also that crocodylians are capable of forming woven tissue for brief periods. Tissue organization and growth mark count varies across individual skeletal elements and reveal that the femur, tibia, and humerus had the highest annual apposition rates in each individual. Cyclical growth mark count also varies intraskeletally, but data suggest these inconsistencies are due to differing medullary cavity expansion rates. There was no appreciable difference in either diaphyseal circumference or cyclical growth mark circumferences between left and right element pairs from an individual if diaphyses were sampled from roughly the same location. The considerable intraskeletal data obtained here provide validation for long-held paleohistology assumptions, but because medullary expansion, cyclical growth mark formation, and variable intraskeletal growth rates are skeletal features found in tetrapod taxa living or extinct, the validations presented herein should be considered during any tetrapod bone microanalysis.

Wu, T., Hong, B., Wu, X., Wu, J., Wang, X., Yi, Z., Zhao, J., Zhan, M. and Mai, B. (2014). Persistent halogenated compounds in captive Chinese alligators (*Alligator sinensis*) from China. Chemosphere 110: 23-30.

Abstract: While a number of studies have reported residual levels of persistent halogenated compounds (PHCs) in crocodilia, there is still a dearth of information on the Chinese alligator, a critically endangered crocodilian species. In the present study, several PHCs, including polybrominated diphenyl ethers (PBDEs), polychlorinated biphenyls (PCBs), and dichlorodiphenyltrichloroethane and its metabolites (DDTs), were detected in the adult tissues, neonates, and eggs of captive Chinese alligators from China. The concentrations of ΣPBDEs, ΣPCBs, and ΣDDTs in Chinese alligators ranged from 0.11 to 16.1, 1.12 to 22.2, and 6.03 to 1020 ng g^{-1} wet weight, respectively, with higher levels of ΣPCBs and ΣDDTs in the neonates and eggs than in muscle tissues. The ΣDDT residues in the studied Chinese alligators were at the high end of reported ranges from crocodilia around the world, and some results exceeded levels known to cause a female-biased sex ratio in crocodilians.

Marschand, R.E., Wilson, J.L., Burleson, M.L., Crossley, D.A. and Hendrick, M.S. (2014). Effects of prolonged lung inflation or deflation on pulmonary stretch receptor discharge in the alligator (*Alligator mississippiensis*). Respir. Physiol. Neurobiol. 200: 25-32.

Abstract: The American alligator (*Alligator mississippiensis*) is a semi-aquatic diving reptile that has a periodic breathing pattern. Previous work identified pulmonary stretch receptors, that are rapidly and slowly adapting, as well as intrapulmonary chemoreceptors (IPC), sensitive to CO_2, that modulate breathing patterns in alligators. The purpose of the present study was to quantify the effects of prolonged lung inflation and deflation (simulated dives) on pulmonary stretch receptors (PSR) and/or IPC discharge characteristics. The effects of airway pressure (0-20 cm H_2O), hypercapnia (7% CO_2), and hypoxia (5% O_2) on dynamic and static responses of PSR were studied in juvenile alligators (mean mass= 246g) at 24°C. Alligators were initially anesthetized with isoflurane, cranially pithed, tracheotomized and artificially ventilated. Vagal afferent tonic and phasic activity was recorded with platinum hook electrodes. Receptor activity was a mixture of slowly adapting PSR (SAR) and

rapidly adapting PSR (RAR) with varying thresholds and degrees of adaptation, without CO_2 sensitivity. Receptor activity before, during and after 1min periods of lung inflation and deflation was quantified to examine the effect of simulated breath-hold dives. Some PSR showed a change in dynamic response, exhibiting inhibition for several breaths after prolonged lung inflation. Following 1min deflation, RAR, but not SAR, exhibited a significant potentiation of burst frequency relative to control. For SAR, the post-inflation receptor inhibition was blocked by CO_2 and hypoxia; for RAR, the post-inflation inhibition was potentiated by CO_2 and blocked by hypoxia. These results suggest that changes in PSR firing following prolonged inflation and deflation may promote post-dive ventilation in alligators. We hypothesize that PSR in alligators may be involved in recovery of breathing patterns and lung volume during pre- and post-diving behavior and apneic periods in diving reptiles.

Nevarez, J.G., Strain, G.M., da Cunha, A.F. and Beaufrère, H. (2-14). Evaluation of four methods for inducing death during slaughter of American alligators (*Alligator mississippiensis*). Am. J. Vet. Res. 75(6): 536-543.

Abstract: Objective: To evaluate physical methods for inducing death during the slaughter of American alligators (*Alligator mississippiensis*). Animals: 24 captive hatched-and-reared American alligators. Procedures: Baseline electroencephalograms (EEGs) were obtained for awake and anesthetized alligators. Corneal reflex, spontaneous blinking, and EEGs were evaluated after severance of the spinal cord, severance of the spinal cord followed by pithing of the brain, application of a penetrating captive bolt, or application of a non-penetrating captive bolt (6 alligators/group). Results: Overall, alligators subjected to spinal cord severance alone differed from those subjected to the other techniques. Spinal cord severance alone resulted in postprocedure EEG power values greater than those in anesthetized alligators, whereas the postprocedure EEG power values were isoelectric for the other 3 techniques. Corneal reflex and spontaneous blinking were absent in all alligators immediately after application of a penetrating or nonpenetrating captive bolt. One of 6 alligators had a corneal reflex up to 1 minute after pithing, but all others within that group had immediate cessation of reflexes after pithing. Mean time to loss of spontaneous blinking and corneal reflex for alligators subjected to spinal cord severance alone was 18 minutes (range, 2 to 37 mins) and 54 minutes (range, 34 to 99 mins), respectively. Conclusions and Clinical Relevance: Spinal cord severance followed by pithing of the brain and application of a penetrating or nonpenetrating captive bolt appeared to be humane and effective techniques for inducing death in American alligators, whereas spinal cord severance alone was not found to be an appropriate method.

Ferraro, J.V. and Binetti, K.M. (2014). American alligator proximal pedal phalanges resemble human finger bones: Diagnostic criteria for forensic investigators. Forensic Sci. Int. 240: 151.e1-7.

Abstract: A scientific approach to bone and tooth identification requires analysts to pursue the goal of empirical falsification. That is, they may attribute a questioned specimen to element and taxon only after having ruled out all other possible attributions. This requires analysts to possess a thorough understanding of both human and non-human osteology, particularly so for remains that may be morphologically similar across taxa. To date, forensic anthropologists have identified several potential 'mimics' for human skeletal remains, including pig teeth and bear paws. Here we document another possible mimic for isolated human skeletal elements - the proximal pedal phalanges of American alligators (*Alligator mississippiensis*) closely resemble the proximal and intermediate hand phalanges of adult humans. We detail morphological similarities and differences between these elements, with the goal of providing sufficient information for investigators to confidently falsify the hypothesis that a questioned phalanx is derived from an American alligator.

Owen, I.L., Awui, C., Langelet, E., Soctine, W and Reid, S. (2014). The probable role of cannibalism in spreading *Trichinella papuae* infection in a crocodile farm in Papua New Guinea. Vet. Parasitol. 203(3-4): 335-338.

Abstract: Between 2003 and 2007, 83 (50%) of 167 crocodiles (*Crocodylus porosus*) purchased as juveniles by a crocodile farm 3 or 4 years earlier from Kikori, Gulf Province, were found to be infected with *Trichinella papuae*. Between 2005 and 2007 infection was detected in a number of crocodiles at the farm obtained from 6 localities other than Kikori, as well as in a few animals born on the farm. Up to 2004, all juveniles at the farm, whether wild- or farm-born, were penned together; the practice was then stopped to prevent possible infection through cannibalism. The last infected animal from Kikori was seen in 2007, 4 years after the purchase of crocodiles from there ceased. The last non-Kikori infected crocodile was seen, also, in 2007. None of the 1972 crocodiles (comprising wild- and farm-born animals) tested from 2008 to 2013, using the digestion method, was infected with *T. papuae*. This indicates that infection of non-Kikori crocodiles was the result of cannibalism within the farm during the years up to 2004 when juvenile crocodiles were kept together, and that the farm is now free of the infection.

Eberle, J.J., Gottfried, M.D., Hutchinson, J.H. and Brochu, C.A. (2014). First record of eocene bony fishes and crocodyliforms from Canada's Western Arctic. PLoS One 1;9(5):e96079.

Abstract: Discovery of Eocene non-marine vertebrates, including crocodylians, turtles, bony fishes, and mammals in Canada's High Arctic was a critical paleontological contribution of the last century because it indicated that this region of the Arctic had been mild, temperate, and ice-free during the early - middle Eocene (~53-50 Ma), despite being well above the Arctic Circle. To date, these discoveries have been restricted to Canada's easternmost Arctic - Ellesmere and Axel Heiberg Islands (Nunavut). Although temporally correlative strata crop out over 1000 km west, on Canada's westernmost Arctic Island - Banks Island, Northwest Territories - they have been interpreted as predominantly marine. We document the first Eocene bony fish and crocodyliform fossils from Banks Island. We describe fossils of bony fishes, including lepisosteid (Atractosteus), esocid (pike), and amiid, and a crocodyliform, from lower - middle Eocene strata of the Cyclic Member, Eureka Sound Formation within Aulavik National Park (~76°N. paleolat.). Palynology suggests the sediments are late early to middle Eocene in age, and likely spanned the Early Eocene Climatic Optimum (EECO). These fossils extend the geographic range of Eocene Arctic lepisosteids, esocids, amiids, and crocodyliforms west by approximately 40° of longitude or ~1100 km. The low diversity bony fish fauna, at least at the family level, is essentially identical on Ellesmere and Banks Islands, suggesting a pan-High Arctic bony fish fauna of relatively basal groups around the margin of the Eocene Arctic Ocean. From a paleoclimatic perspective, presence of a crocodyliform, gar and amiid fishes on northern Banks provides further evidence that mild, year-round temperatures extended across the Canadian Arctic during early - middle Eocene time. Additionally, the Banks Island crocodyliform is consistent with the phylogenetic hypothesis of a Paleogene divergence time between the two extant alligatorid lineages *Alligator mississippiensis* and *A. sinensis*, and high-latitude dispersal across Beringia.

Horai, S., Itai, T., Noguchi, T., Yasuda, Y., Adachi, H., Hyobu, Y., Riyadi, A.S., Boggs, A.S., Lowers, R., Guillette, L.J. Jr and Tanabe, S. (2014). Concentrations of trace elements in American alligators (*Alligator mississippiensis*) from Florida, USA. Chemosphere 108: 159-167.

Abstract: Concentrations of 28 trace elements (Li, Mg, Al, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ga, As, Se, Rb, Sr, Mo, Ag, Cd, In, Sn, Sb, Cs, Tl, Hg, Pb, and Bi) in the livers of juvenile and adult American alligators inhabiting two central Florida lakes, Lake Apopka (LA), and Lake Woodruff National Wildlife Refuge (LW) and one lagoon population located in Merritt Island National Wildlife Refuge (MINWR; NASA), were determined. In juveniles from MINWR, concentrations of 9 elements (Li, Fe, Ni, Sr, In, Sb, Hg, Pb and Bi) were significantly higher, whereas 6 elements (V, Fe, As, Sr, Hg and Bi) were elevated in adults ($p<0.05$) obtained from MINWR. Significant enrichment of some trace elements in adults, relative to juveniles, was observed at all three sampling areas. Specifically, Fe, Pb and Hg were significantly elevated in adults when compared to juveniles, suggesting age-dependent accumulation of these elements. Further, As, Se and Sn showed the same trend but only in animals collected from MINWR. Mean Fe concentrations in the livers of adults from LA, LW and MINWR were 1770 μg g^{-1} DW, 3690 μg g^{-1} DW and 5250 μg g^{-1} DW, respectively. More than half of the adult specimens from LW and MINWR exhibited elevated hepatic Fe concentrations that exceed the threshold value for toxic effects in donkey, red deer and human. These results prompted us to express our concern on possible exposure and health effects in American alligators by some trace elements derived from NASA activities.

Bierman, H.S., Thornton, J.L., Jones, H.G., Koka, K., Young, B.A., Brandt, C., Christensen-Dalsgaard, J., Carr, C.E. and Tollin, D.J. (2014). Biophysics of directional hearing in the American alligator (*Alligator mississippiensis*). J. Exp. Biol. 1;217(Pt 7): 1094-1107.

Abstract: Physiological and anatomical studies have suggested that alligators have unique adaptations for spatial hearing. Sound localization cues are primarily generated by the filtering of sound waves by the head. Different vertebrate lineages have evolved external and/or internal anatomical adaptations to enhance these cues, such as pinnae and interaural canals. It has been hypothesized that in alligators, directionality may be enhanced via the acoustic coupling of middle ear cavities, resulting in a pressure difference receiver (PDR) mechanism. The experiments reported here support a role for a PDR mechanism in alligator sound localization by demonstrating that (1) acoustic space cues generated by the external morphology of the animal are not sufficient to generate location cues that match physiological sensitivity, (2) continuous pathways between the middle ears are present to provide an anatomical basis for coupling, (3) the auditory brainstem response shows some directionality, and (4) eardrum movement is directionally sensitive. Together, these data support the role of a PDR mechanism in crocodilians and further suggest this mechanism is a shared archosaur trait, most likely found also in the extinct dinosaurs.

Hutson, J.D. and Hutson, K.N. (2014). A repeated-measures analysis of the effects of soft tissues on wrist range of motion in the extant phylogenetic bracket of dinosaurs: Implications for the functional origins of an automatic wrist folding mechanism in Crocodilia. Anat. Rec. 297: 1228-1249.

Abstract: A recent study hypothesized that avian-like wrist folding in quadrupedal dinosaurs could have aided their distinctive style of locomotion with semi-pronated and therefore medially facing palms. However, soft tissues that automatically guide avian wrist folding rarely fossilize, and automatic wrist folding of unknown function in extant crocodilians has not been used to test this hypothesis. Therefore, an investigation of the relative contributions of soft tissues to wrist range of motion (ROM) in the extant phylogenetic bracket of dinosaurs, and the quadrupedal function of crocodilian wrist folding, could inform these questions. Here, we repeatedly measured wrist ROM in degrees through fully fleshed, skinned, minus muscles/tendons, minus ligaments, and skeletonized stages in the American alligator *Alligator mississippiensis* and the ostrich *Struthio camelus*. The effects of dissection treatment and observer were statistically significant for alligator wrist folding and ostrich wrist flexion, but not ostrich wrist folding. Final skeletonized wrist folding ROM was higher than (ostrich) or equivalent to (alligator) initial fully fleshed ROM, while final ROM was lower than initial ROM for ostrich wrist flexion. These findings suggest that, unlike the hinge/ball and socket-type elbow and shoulder joints in these archosaurs, ROM within gliding/planar diarthrotic joints is more restricted to the extent of articular surfaces. The alligator data indicate that the crocodilian wrist mechanism functions to automatically lock their semi-pronated palms into a rigid column, which supports the hypothesis that this palmar orientation necessitated soft tissue stiffening mechanisms in certain dinosaurs, although ROM-restricted articulations argue against the presence of an extensive automatic mechanism.

Hamlin, H.J., Lowers, R.H., Kohno, S., Mitsui-Watanabe, N., Amano, H., Hara, A., Ohta, Y., Miyagawa, S., Iguchi, T. and Guillette, L.J. Jr. (2014). The reproductive hormone cycle of adult female American alligators from a barrier island population. Reproduction 147(6): 855-863.

Abstract: Comparatively, little data are available detailing the geographic variation that exists in the reproductive endocrinology of adult alligators, especially those living in barrier islands. The Merritt Island National Wildlife Refuge (MI) is a unique barrier island environment and home to the Kennedy Space Center (FL, USA). Seasonal patterns of sex steroids were assessed in adult female American alligators from MI monthly from 2008 to 2009, with additional samples collected at more random intervals in 2006, 2007, and 2010. Plasma 17_-estradiol and vitellogenin concentrations peaked in April, coincident with courtship and mating, and showed patterns similar to those observed in adult female alligators in other regions. Plasma concentrations of progesterone, however, showed patterns distinctly different than those reported for alligator populations in other regions and remained relatively constant throughout the year. Plasma DHEA peaked in July around the time of oviposition, decreased in August, and then remained constant for the remaining months, except for a moderate increase in October. Circulating concentrations of DHEA have not been previously assessed in a female crocodilian, and plasma concentrations coincident with reproductive activity suggest a reproductive and/or behavioral role. Interestingly, plasma testosterone concentrations peaked in May of 2008, as has been shown in female alligator populations in other regions, but showed no peak in 2009, demonstrating dramatic variability from year to year. Surveys showed 2009 to be particularly depauperate of alligator nests in MI, and it is possible that testosterone could serve as a strong indicator of breeding success.

Rehorek, S.J., Duffy, M., Zacher, J.R., Anand, K., Elsey, R.M. and Smith, T.S. (2014). An examination of the sensory structures in the oral cavity of the American alligator (*Alligator mississippiensis*). J. Morphol. (doi: 10.1002/jmor.20306).

Abstract: The location and distribution of mucosal sensory structures of the crocodilian oral cavity are poorly understood. Although there

are several descriptions of these structures in adults, nothing is known about their development. The purpose of this study was to document location, morphology, and relative abundance of these mucosal sensory structures in both hatchling and subadult alligators. Numerous mucosal sensory structures and pale staining dome-shaped papillae were observed only in the upper palate and tongue. In hatchlings, these papillae, which house either mechanoreceptive or chemosensory (taste buds) structures, were larger and more prevalent on the tongue than the upper palate. In the subadult, however, these papillae housed primarily mechanoreceptive structures and possibly degenerate taste buds. Although the presence of the mechanoreceptive structures in the palates of the subadult alligator are to be expected, the loss of most taste buds is hitherto undocumented. Thus, there is morphological support for an ontogenetic shift in the role of the sensory palate, from a prey detection gustatory sensory system in hatchlings to a prey-manipulative mechanoreceptive system in subadults.

Gredler, M.L., Seifert, A.W. and Cohn, M.J. (2014). Morphogenesis and patterning of the phallus and cloaca in the American Alligator, *Alligator mississippiensis*. Sex Dev.

Abstract: In most animals, reproduction by internal fertilization is facilitated by an intromittent organ, such as the penis in amniote vertebrates. Recent progress has begun to uncover the mechanisms of mammalian external genital development; however, comparatively little is known about the development of the reptilian penis and clitoris. Here, we describe the development of the phallus and cloaca in the American alligator, *Alligator mississippiensis*. The embryonic precursor of the penis and clitoris is the genital tubercle, which forms by the budding of genital mesenchyme beneath the ventral body wall ectoderm, adjacent to the cloacal membrane. The cloacal lips develop from another pair of outgrowths, the lateral swellings. Early development of the alligator phallus, cloaca, and urogenital ducts generally resembles that of other reptiles, suggesting that differences in adult reptilian phallus and cloacal anatomy arise at later stages. The phallic sulcus is derived from the cloacal endoderm, indicating that the crocodilian sulcus is functionally and developmentally homologous to the mammalian urethra. Initial external genital outgrowth and patterning occur prior to temperature-dependent sex determination. Our analysis of alligator phallus and cloaca development suggests that modifications of an ancestral program of urogenital development could have generated the morphological diversity found in the external genitalia of modern amniotes

---

Correia, J., Cesar, R., Marsico, E., Diniz, G.T., Zorro, M.C. and Castilhos, Z. (2015). Mercury contamination in alligators (*Melanosuchus niger*) from Mamirauá Reservoir (Brazilian Amazon) and human health risk assessment. Environ. Sci. Pollut. Res. Int.

Abstract: Mercury (Hg) concentrations in muscles of wild alligators (*Melanosuchus niger*) from the Mamirauá Reservoir (a reference area in the Brazilian Amazon) and the human health risks associated with its consumption were assessed. The mean Hg concentration in alligator muscles was 0.407±0.114 μg/g (N= 61). Close to 5% of the muscle samples showed Hg levels above the World Health Organization guideline for fish consumption (0.5 μg/g). A positive and significant relationship was observed between Hg concentrations in muscle and the age of the specimens. The dose-response approach suggests that close to 27.4 years is required for half of the exposed specimens to attain 0.5 μg/g. The hazard quotient (HQ) is a risk indicator which defines the ratio of exposure level and a toxicological reference dose. HQ resulted above the unity for all the specimens when the ingestion rate for riverine communities (200 g of muscle per day) is considered, indicating the existence of hazard. When the ingestion rate for market consumers (28.57 g/day) is considered, the risks are much lower (mean HQ= 0.55), suggesting that such group is not at risk. The establishment of local and regional ingestion rates for riverine populations and market consumers is extremely recommended.

Sweazea, K.L., McMurtry, J.P., Elsey, R.M., Redig, P. and Braun, E.J. (2014). Comparison of metabolic substrates in alligators and several birds of prey. Zoology (Jena) 117(4): 253-260.

Abstract: On average, avian blood glucose concentrations are 1.5-2 times those of mammals of similar mass and high concentrations of insulin are required to lower blood glucose. Whereas considerable data exist for granivorous species, few data are available for plasma metabolic substrate and glucoregulatory hormone concentrations for carnivorous birds and alligators. Birds and mammals with carnivorous diets have higher metabolic rates than animals consuming diets with less protein whereas alligators have low metabolic rates. Therefore, the present study was designed to compare substrate and glucoregulatory hormone concentrations in several birds of prey and a phylogenetically close relative of birds, the alligator. The hypothesis was that the combination of carnivorous diets and high metabolic rates favored the evolution of greater protein and fatty acid utilization leading to insulin resistance and high plasma glucose concentrations in carnivorous birds. In contrast, it was hypothesized that alligators would have low substrate utilization attributable to a low metabolic rate. Fasting plasma substrate and glucoregulatory hormone concentrations were compared for bald eagles (*Haliaeetus leucocephalus*), great horned owls (*Bubo virginianus*), red-tailed hawks (*Buteo jamaicensis*), and American alligators (*Alligator mississippiensis*). Avian species had high circulating β-hydroxybutyrate (10-21 mg/dl) compared to alligators (2.81±0.16 mg/dl). In mammals high concentrations of this byproduct of fatty acid utilization are correlated with insulin resistance. Fasting glucose and insulin concentrations were positively correlated in eagles whereas no relationship was found between these variables for owls, hawks or alligators. Additionally, β-hydroxybutyrate concentrations were low in alligators. Similar to carnivorous mammals, ingestion of a high protein diet may have favored the utilization of fatty acids and protein for energy thereby promoting the development of insulin resistance and gluconeogenesis-induced high plasma glucose concentrations during periods of fasting in birds of prey.

Hong, B., Wu, T., Zhao, G., Sun, Y., Wang, X., Zhao, J., Yi, Z., Wu, X. and Mai, B. (2014). Occurrence of decabromodiphenyl ethane in captive Chinese alligators (*Alligator sinensis*) from China. Bull. Environ. Contam. Toxicol.

Abstract: Decabromodiphenyl ethane (DBDPE), a replacement for decabromodiphenyl ether (deca-BDE), was investigated in captive Chinese alligators from China. DBDPE was detected in adult tissues, neonates and eggs of Chinese alligators with concentrations ranging from 4.74-192, 0.24-1.94, and 0.01-0.51 ng g^{-1} lipid weight, respectively. Compared to PBDEs and PCBs, DBDPE contamination was limited in Chinese alligators. Additionally, DBDPE concentrations in adult muscles were one to three orders of magnitude higher than those in neonates and eggs, suggesting the limited maternal transfer potential of DBDPE in Chinese alligators. This is the first study to report the occurrence of DBDPE in Chinese alligators.

Wang, H., Zhang, S., Zhou, N., Wang, C. and Wu, X. (2014). Distribution of endocrine cells in the digestive tract of *Alligator sinensis* during the active and hibernating period. Tissue Cell. pii:

S0040-8166(14)00054-8 (doi: 10.1016/j.tice.2014.06.005).

Abstract: The digestive tract is the largest endocrine organ in the body; the distribution pattern of endocrine cells varies with different pathological and physiological states. The aim of the present study was to investigate the distributed density of 5-hydroxytryptamine (5-HT), gastrin (GAS), somatostatin (SS) and vasoactive intestinal peptide (VIP) immunoreactive (IR) cells in the digestive tract of Alligator sinensis during the active and hibernating period by immunohistochemical (IHC) method. The results indicated that 5-HT-IR cells were distributed throughout the entire digestive tract, which were most predominant in duodenum and jejunum. The density increased significantly in stomach and duodenum during hibernation. GAS-IR cells were limited in small stomach and small intestine. The density decreased significantly in small stomach during hibernation, while increased in duodenum. What's more, most of the endocrine cells in duodenum were generally spindle shaped with long cytoplasmic processes ending in the lumen during hibernation. SS-IR cells were limited in stomach and small stomach. The density increased in stomach while decreased in small stomach during hibernation, meanwhile, fewer IR cells occurred in small intestine. VIP-IR cells occurred in stomach and small stomach. The density decreased in small stomach, while increased in stomach during hibernation. These results indicated that the endocrine cells in different parts of digestive tract varied differently during hibernation, their changes were adaptive response to the hibernation.

Chen, I.H., Yang, W. and Meyers, M.A. (2014). Alligator osteoderms: mechanical behavior and hierarchical structure. Mater. Sci. Engf. C Mater. Biol. Appl. 35: 441-448.

Abstract: Osteoderms are bony scutes embedded underneath the dermal layers of the skin acting as a protection of the alligator (Archosauria: Crocodylia) internal organs and tissues. Additionally, these scutes function as an aid in temperature regulation. The scutes are inter-linked by fibrous connective tissue. They have properties similar to bone and thus have the necessary toughness to provide protection against predators. The scutes consist of hydroxyapatite and have a porosity of approximately 12%. They have a disc-like morphology with a ridge along the middle of the plate, called the keel; the outer perimeter of the disc has depressions, grooves, and jagged edges which anchor the collagen and act as sutures. Computerized tomography reveals the pattern of elongated pores, which emanate from the keel in a radial pattern. Micro-indentation measurements along the cross-section show a zigzag behavior due to the porosity. Compression results indicate that the axial direction is the strongest (UTS ~67 MPa) and toughest (11 MJ/m(3)); this is the orientation in which they undergo the largest external compression forces from predator teeth. Toughening mechanisms are identified through observation of the damage progression and interpreted in mechanistic terms. They are: flattening of pores, microcrack opening, and microcrack growth and coalescence. Collagen plays an essential role in toughening and plasticity by providing bridges that impede the opening of the cracks and prevent their growth.

Ezcurra, M.D., Scheyer, T.M. and Butler, R.J. (2014). The origin and early evolution of Sauria: reassessing the permian Saurian fossil record and the timing of the crocodile-lizard divergence. PLoS One 9(2):e89165.

Abstract: Sauria is the crown-group of Diapsida and is subdivided into Lepidosauromorpha and Archosauromorpha, comprising a high percentage of the diversity of living and fossil tetrapods. The split between lepidosauromorphs and archosauromorphs (the crocodile-lizard, or bird-lizard, divergence) is considered one of the key calibration points for molecular analyses of tetrapod phylogeny. Saurians have a very rich Mesozoic and Cenozoic fossil record, but their late Paleozoic (Permian) record is problematic. Several Permian specimens have been referred to Sauria, but the phylogenetic affinity of some of these records remains questionable. We reexamine and review all of these specimens here, providing new data on early saurian evolution including osteohistology, and present a new morphological phylogenetic dataset. We support previous studies that find that no valid Permian record for Lepidosauromorpha, and we also reject some of the previous referrals of Permian specimens to Archosauromorpha. The most informative Permian archosauromorph is *Protorosaurus speneri* from the middle Late Permian of Western Europe. A historically problematic specimen from the Late Permian of Tanzania is redescribed and reidentified as a new genus and species of basal archosauromorph: *Aenigmastropheus parringtoni*. The supposed protorosaur *Eorasaurus olsoni* from the Late Permian of Russia is recovered among Archosauriformes and may be the oldest known member of the group but the phylogenetic support for this position is low. The assignment of *Archosaurus rossicus* from the latest Permian of Russia to the archosauromorph clade Proterosuchidae is supported. Our revision suggests a minimum fossil calibration date for the crocodile-lizard split of 254.7 Ma. The occurrences of basal archosauromorphs in the northern (30°N) and southern (55°S) parts of Pangea imply a wider paleobiogeographic distribution for the group during the Late Permian than previously appreciated. Early archosauromorph growth strategies appear to be more diverse than previously suggested based on new data on the osteohistology of *Aenigmastropheus*.

Delfino, M. and De Vos, J. (2014). A giant crocodile in the Dubois Collection from the Pleistocene of Kali Gedeh (Java). Integr. Zool. 9(2): 141-147.

Abstract: The fauna of the Pleistocene Homo-bearing sites of Java has been well known for more than a century. A recent revision of the crocodylian remains confirmed both the validity of *Gavialis bengawanicus* and the synonymization of *Crocodylus ossifragus* with *C. siamensis*. Here we report on a still unpublished crocodylian specimen collected by Eugene Dubois in the latest Early Pleistocene of Kali Gedeh that can be tentatively referred to the genus *Crocodylus*. The size of the specimen, the approximately 1 m long lower jaw in particular, indicated that this crocodile attained a total length of approximately 6 or 7 m. Along with specimens from the Plio-Pleistocene of Africa, this material provides evidence for gigantism in *Crocodylus*. It is not clear whether or not the 'temperature-size rule' applies to fossil crocodylians, but due to the growing interest in predicting future temperature-related size changes of the extant organisms, it would be interesting to study in detail the past reaction to temperature changes of crocodylians and other terrestrial ectothermic animals.

Bouwman, H., Booyens, P., Govender, D., Pienaar, D. and Polder, A. (2014). Chlorinated, brominated, and fluorinated organic pollutants in Nile crocodile eggs from the Kruger National Park, South Africa. Ecotoxicol Environ Saf. 104: 393-402.

Abstract: Repeated annual episodes of Nile crocodile deaths in two isolated areas of the Kruger National Park prompted the investigation of possible organohalogen pollutant involvement. Crocodile eggs were collected close to one of the mortality sites (Gorge) as well as from a crocodile farm (CF) as reference. ΣDDT was significantly higher in Gorge (450ng/g wm) than in CF eggs (85ng/g wet mass). Percentage DDT of ΣDDT was significantly higher in CF (14%) than in Gorge eggs (5%). Mean ΣDDT was almost 70 times higher than mean ΣPCB in Gorge eggs. HCB, β-

HCH, mirex, brominated flame retardants (BFRs), and perfluorinated compounds (PFCs) occurred at lower concentrations. We believe that the BFR and PFCs data represent the first published results for any crocodile egg. Thickening of the outer eggshell layer of Gorge eggs was significantly associated with higher concentrations of ΣDDT. Concentrations of ΣDDT and other pollutants were in the same range as eggs from elsewhere, where there were no mortalities. Concentrations of ΣDDT in eggs from healthy Australian crocodiles were of the same orders of magnitude as the current study, making it highly unlikely that the concentrations of pollutants measured in the present study would have caused or substantially contributed towards the mortalities observed. Concerns about reproduction and behaviour remain. As large predators, crocodilians are at the apex of the freshwater aquatic food web. More research is needed to guide measures to manage African freshwater systems so that it will also sustainably accommodate these large, long-lived animals.

Qin, Z., Pugno, N.M. and Buehler, M.J. (2014). Mechanics of fragmentation of crocodile skin and other thin films. Sci. Rep. 4: 4966.

Abstract: Fragmentation of thin layers of materials is mediated by a network of cracks on its surface. It is commonly seen in dehydrated paintings or asphalt pavements and even in graphene or other two-dimensional materials, but is also observed in the characteristic polygonal pattern on a crocodile's head. Here, we build a simple mechanical model of a thin film and investigate the generation and development of fragmentation patterns as the material is exposed to various modes of deformation. We find that the characteristic size of fragmentation, defined by the mean diameter of polygons, is strictly governed by mechanical properties of the film material. Our result demonstrates that skin fragmentation on the head of crocodiles is dominated by that it features a small ratio between the fracture energy and Young's modulus, and the patterns agree well with experimental observations. Understanding this mechanics-driven process could be applied to improve the lifetime and reliability of thin film coatings by mimicking crocodile skin.

Garcia-Grajales, J. and Silva, A.B. (2014). Population ecology of *Crocodylus acutus* (Reptilia: Crocodylidae) in Palmasola lagoon, Oaxaca, Mexico. Rev. Biol. Trop. 62(1): 165-172.

Abstract: Abundance and population structure are important parameters to evaluate and compare the conservation status of a population over time in a given area. This study describes the population abundance and structure of *Crocodylus acutus* in Palmasola Lagoon, Oaxaca. The field works consisted of night surveys during the new moon phase, between 2100 and 2400 h. These were conducted during the dry and wet seasons and counted the number of individuals to obtain population estimates. Recorded encounter rates ranged from 32 to 109.3 ind/km in 40 journeys deployed with an average time of 18 minutes browsing. The estimated population size using the Messel's model ranged from 32.7 to 93 individuals. For both seasons, there was a marked dominance of subadults, followed by juveniles and to a lesser extent adult individuals, as well as undetermined individuals (ie unknown body/size/length), in both seasons. There was also a significant association with mangrove areas (26.1%) by juveniles; the sub-adults's individual use of superficial water (22.7%) and mangrove areas (15.7%); meanwhile the adults were observed on superficial water (9.7%). This information contributes to our understanding of the population ecology of *C. acutus* in the Palmasola Lagoon where the estimated population size seems to show higher values when compared to other reports in the country.

Butler, R.J., Sullivan, C., Ezcurra, M.D., Liu, J., Lecuona, A. and Sookias, R.B. (2014). New clade of enigmatic early archosaurs yields insights into early pseudosuchian phylogeny and the biogeography of the archosaur radiation. BMC Evol. Biol. 14: 128.

Abstract: The origin and early radiation of archosaurs and closely related taxa (Archosauriformes) during the Triassic was a critical event in the evolutionary history of tetrapods. This radiation led to the dinosaur-dominated ecosystems of the Jurassic and Cretaceous, and the high present-day archosaur diversity that includes around 10,000 bird and crocodylian species. The timing and dynamics of this evolutionary radiation are currently obscured by the poorly constrained phylogenetic positions of several key early archosauriform taxa, including several species from the Middle Triassic of Argentina (*Gracilisuchus stipanicicorum*) and China (*Turfanosuchus dabanensis*, *Yonghesuchus sangbiensis*). These species act as unstable 'wildcards' in morphological phylogenetic analyses, reducing phylogenetic resolution. We present new anatomical data for the type specimens of *G. stipanicicorum*, *T. dabanensis*, and *Y. sangbiensis*, and carry out a new morphological phylogenetic analysis of early archosaur relationships. Our results indicate that these three previously enigmatic taxa form a well-supported clade of Middle Triassic archosaurs that we refer to as Gracilisuchidae. Gracilisuchidae is placed basally within Suchia, among the pseudosuchian (crocodile-line) archosaurs. The approximately contemporaneous and morphologically similar *G. stipanicicorum* and *Y. sangbiensis* may be sister taxa within Gracilisuchidae. Our results provide increased resolution of the previously poorly constrained relationships of early archosaurs, with increased levels of phylogenetic support for several key early pseudosuchian clades. Moreover, they falsify previous hypotheses suggesting that *T. dabanensis* and *Y. sangbiensis* are not members of the archosaur crown group. The recognition of Gracilisuchidae provides further support for a rapid phylogenetic diversification of crown archosaurs by the Middle Triassic. The disjunct distribution of the gracilisuchid clade in China and Argentina demonstrates that early archosaurs were distributed over much or all of Pangaea although they may have initially been relatively rare members of faunal assemblages.

Stadler, A.M., Garvey, C.J., Embs, J.P., Koza, M.M., Unruh, T., Artmann, G. and Zaccai, G. (2014). Picosecond dynamics in haemoglobin from different species: A quasielastic neutron scattering study. Biochim. Biophys. Acta 1840(10): 2989-2999.

Abstract: Dynamics in haemoglobin from platypus (*Ornithorhynchus anatinus*), chicken (*Gallus gallus domesticus*) and saltwater crocodile (*Crocodylus porosus*) were measured to investigate response of conformational motions on the picosecond time scale to naturally occurring variations in the amino acid sequence of structurally identical proteins. Protein dynamics was measured using incoherent quasielastic neutron scattering. The quasielastic broadening was interpreted first with a simple single Lorentzian approach and then by using the Kneller-Volino Brownian dynamics model. Mean square displacements of conformational motions, diffusion coefficients of internal dynamics and residence times for jump-diffusion between sites and corresponding effective force constants (resilience) and activation energies were determined from the data. Modifications of the physicochemical properties caused by mutations of the amino acids were found to have a significant impact on protein dynamics. Activation energies of local side chain dynamics were found to be similar between the different proteins being close to the energy, which is required for the rupture of single hydrogen bond in a protein. The measured dynamic quantities showed significant and systematic variations between the investigated species, suggesting that they are the signature of an evolutionary adaptation process stimulated by the

different physiological environments of the respective protein.

Charruau, P. and Niño-Torres, C.A. (2014). A third case of amelia in Morelet's crocodile from the Yucatan Peninsula. Dis. Aquat. Organ. 109(3): 263-267.

Abstract: Congenital defects in crocodilians have received little interest. In the context of global change and increasing threats to biodiversity, data on birth defects occurring in wildlife could be of importance for estimating the health of species populations and their ecosystems. Herein, we report the first case of amelia (ie absence of limbs) in Morelet's crocodiles *Crocodylus moreletii* from Mexico and the third on the southern Yucatan Peninsula. The crocodile in question was a juvenile (41 cm TL) captured in July 2012 in the Río Hondo, the river that forms the border between Mexico and Belize south of the state of Quintana Roo. The prevalence of this malformation in the *C. moreletii* population of Río Hondo (0.35%) is similar to that reported in 2 previous cases in Belize. Several causes of birth defects in crocodilians have previously been cited in the literature. Although we do not have relevant information to elucidate this case, we discuss some plausible explanations for this birth defect.

Li, L., Guo, Y.N. and Zhang, L.P. (2014). *Dujardinascaris gigantea* sp. n. (Nematoda: Ascaridida) from the critically endangered crocodile *Alligator sinensis* Fauvel (Reptilia: Crocodylia). Parasitol. Res.

Abstract: The Chinese alligator *Alligator sinensis* Fauvel (Reptilia: Crocodylia) is considered as one of the most critically endangered species of the 23 extant crocodiles. However, our knowledge of the helminth parasites of this rare animal is completely lacking. During a helminthological survey of reptiles in China, we found a new ascaridoid nematode, *Dujardinascaris gigantea* sp. n. from *A. sinensis*. The morphology of *D. gigantea* sp. n. was studied using light and scanning electron microscopy. The new species was also characterised using molecular methods by sequencing and analysing the small ribosomal DNA (18S) and the second internal transcribed spacer (ITS-2).

La Grange, L. and Mukaratirwa, S. (2014). Assessment of selected biochemical parameters and humoral immune response of Nile crocodiles (*Crocodylus niloticus*) experimentally infected with *Trichinella zimbabwensis*. Journal of the South African Veterinary Association 85(1), Art. #1085, 10 pages.

Abstract: Fifteen crocodiles were randomly divided into three groups of five animals. They represented high-infection, medium-infection and low-infection groups of 642 larvae/kg, 414 larvae/kg and 134 larvae/kg bodyweight, respectively. The parameters assessed were blood glucose, creatine phosphokinase (CPK), lactate dehydrogenase (LDH), aspartate transaminase (AST) and alanine transaminase (ALT). The humoral immune response to *Trichinella zimbabwensis* infection was evaluated in all three groups by an indirect ELISA method. The results showed deviations from normal parameters of blood glucose, CPK, LDH, AST and ALT when compared with reported levels in uninfected reptiles. Contrary to studies involving mammals, hypoglycaemia was not observed in the infected groups in this study. Peak values of blood glucose were reached on post-infection (PI) Day 49, Day 42 and Day 35 in the high-infection, medium-infection and low-infection groups, respectively. Peak values of LDH and AST were observed on PI Day 56, Day 49 and Day 42 in the high-infection, medium-infection and low-infection groups, respectively. Peak values of CPK were observed on Day 35 PI in all three groups. Peak ALT values were reached on Day 56 in the high-infection group and on Day 28 PI in both the medium-infection and low-infection groups. No correlations between the biochemical parameters and infection intensity were observed. Peak antibody titres were reached on Day 49 PI in the medium-infection group, and on Day 42 PI in both the high-infection and low-infection groups. Infection intensity could not be correlated with the magnitude of the humoral immune response or time to sero-conversion. Results from this study were in agreement with results reported in mammals infected with other *Trichinella* species and showed that antibody titres could not be detected indefinitely.

Schmeda-Hirschmann, G., Delporte, C., Valenzuela-Barra, G., Silva, X., Vargas-Arana, G., Lima, B. and Feresin, G.E. (2014). Anti-inflammatory activity of animal oils from the Peruvian Amazon. Journal of Ethnopharmacology (doi: 10.1016/j.jep.2014.08.010).

Abstract: Animal oils and fats from the fishes *Electrophorus electricus* and *Potamotrygon motoro*, the reptiles *Boa constrictor*, *Chelonoidis denticulata* (*Geochelone denticulata*) and *Melanosuchus niger* and the riverine dolphin *Inia geoffrensis* are used as anti-inflammatory agents in the Peruvian Amazon. The aim of the study was to assess the topic anti-inflammatory effect of the oils/fats as well as to evaluate its antimicrobial activity and fatty acid composition. The oils/fats were purchased from a traditional store at the Iquitos market of Belen, Peru. The topic anti-inflammatory effect was evaluated by the mice ear oedema induced by arachidonic acid (AA) and 12-O-tetradecanoylphorbol-13-acetate (TPA) at the dose of 3 mg oil/ear. Indomethacine and nimesulide were used as reference anti-inflammatory drugs. The application resembles the traditional topical use of the oils. The antimicrobial effect of the oils/fats was assessed by the microdilution test against reference strains of *Escherichia coli*, *Staphylococcus aureus* and *Salmonella enteritidis*. The fatty acid composition of the oils/fats (as methyl esters) was determined by GC and GC-MS analysis after saponification. All oils/fats showed topic anti-inflammatory activity, with better effect in the TPA-induced mice ear oedema assay. The most active drugs were *Potamotrygon motoro*, *Melanosuchus niger* and *Geochelone denticulata*. In the AA-induced assay, the best activity was found for *P. motoro* and *Electrophorus electricus* oil. The oil of *E. electricus* also showed a weak antimicrobial effect with MIC values of 250 μg/mL against *E. coli* ATCC 25922 and *Salmonella enteritidis*-MI. The main fatty acids in the oils were oleic, palmitic and linoleic acids. Topical application of all the oils/fats investigated showed anti-inflammatory activity in the mice ear oedema assay. The effect can be related with the identity and composition of the fatty acids in the samples. This study gives support to the traditional use of animal oils/fats as ant-inflammatory agents in the Peruvian Amazon. However, new alternative should be encouraged due to the conservation status of several of the animal sources of the crude drugs.

Maffei, F. and Da Silveira, R. (2013). First record of multiple nests of yellow-spotted river turtle (*Podocnemis unifilis*) in a nest of black caiman (*Melanosuchus niger*) in Amazonia. Bol. Mus. Para. Emílio Goeldi. Cienc. Nat., Belém 8(3): 461-465. (in Portuguese).

Abstract: This communication reports the first record of communal egg-laying of yellow-spotted river turtle (*Podocnemis unifilis*) in a nest of the Black caiman (*Melanosuchus niger*). This event was recorded in a flooded savannah in the municipality of Oiapoque, northern Amapá state, Brazilian Amazonia. Inside the nest of *M. niger* we founded 182 eggs of *P. unifilis* divided into 8 clutches.

Syme, C.E. and Salisbury, S.W. (2014). Patterns of aquatic decay

and disarticulation in juvenile Indo-Pacific crocodiles (*Crocodylus porosus*), and implications for the taphonomic interpretation of fossil crocodyliform material. Palaeogeography, Palaeoclimatology, Palaeoecology 412: 108-123.

Abstract: High levels of skeletal articulation and completeness in fossil crocodyliforms are commonly attributed to rapid burial, with decreasing articulation and completeness thought to result from prolonged decay of soft tissue and the loss of skeletal connectivity during 'bloat and float'. These interpretations are based largely on patterns of decay in modern mammalian and avian dinosaur carcasses. To address this issue, we assessed the decay of buried and unburied juvenile *Crocodylus porosus* carcasses in a controlled freshwater setting. The carcasses progressed through typical vertebrate decay stages (fresh, bloated, active decay, and advanced decay), reaching the final skeletal stage on average 55 days after death. Unburied carcasses commenced floating five days post-mortem during the bloated stage, and one buried carcass only commenced floating 12 days post-mortem. While floating, skeletal elements remained articulated within the still coherent dermis, except for thoracic ribs, ischia and pubic bones. The majority of disarticulation occurred at the sediment–water interface after the carcasses sank during the advanced decay stage, ~36 days post-mortem. Based on these results we conclude that fossil crocodyliform specimens displaying high levels of articulation are not the result of prolonged subaerial and subaqueous decay in a low-energy, aqueous environment. Using extant juvenile *C. porosus* as a proxy for fossil crocodyliforms, rapid burial in an aquatic setting would have to occur prior to the carcass floating, and would also have to continually negate the positive buoyancy associated with bloating. Rapid burial does not have to be the only avenue to preservation of articulation, as other mechanisms such as physical barriers and internal physiological chemistry could prevent carcasses from floating and subsequently disarticulating upon sinking. The inference that a large proportion of skeletal elements could drift from floating carcasses in a low energy setting with minimal scavenging, thereby causing a loss of completeness, seems unlikely.

Brien, M.L., Gienger, C.M., Webb, G.J., McGuinness, K. and Christian, K.A. (2014). Out of sight or in too deep: Effect of visual barriers and water depth on agonistic behaviour and growth in hatchling saltwater crocodiles (*Crocodylus porosus*). Applied Animal Behaviour Science 158: 102-110.

Abstract: This study tests the role of visual barriers and water depth on levels of agonistic behaviour and growth in hatchling *Crocodylus porosus* within the first 3 weeks of life. Ninety-six individuals from four separate clutches hatched over 2 days were divided across three treatments containing two groups with 16 individuals each: shallow water with no visual barrier (SW), shallow water with visual barriers (VB), and deep water with no visual barrier (DW). Body mass (BM, g) was measured at introduction and after 21 days, and was used as an index of growth. Behaviour was described and quantified in the night (1700-0800 h), when there is an innate peak in behavioural interactions, for three consecutive nights on two occasions (days 9-11 and 18-20 post-hatch). Visual barriers in open shallow water (VB: mean 0.7 interactions/night) nearly eliminated agonistic behaviour relative to SW (mean10.8 interactions/night; $P<0.05$). DW did not reduce the frequency of agonistic interactions relative to SW, but did affect the outcome of interactions ($P<0.05$), with both individuals swimming off slowly. The distribution of hatchling growth after 21 days was highly bimodal regardless of treatment, with a group of slow growing (-3.6 to <6 g change in BM) and fast growing hatchlings (6-15 g increase in BM). Although this made statistical comparisons difficult, there was no clear effect of any treatment ($P<0.05$) on mean growth rates. The results of this study suggest that there may be utility in providing hatchling and juvenile *C. porosus* in captivity with a more complex raising environment in order to reduce negative social interactions, but it is not clear whether this improves growth and survival.

Lobaina, I. (2014). Evolution of Maternal Investment Strategies for the Order Crocodylia. Honours thesis, University of South Florida, St. Petersburg, Florida, USA.

Abstract: The order Crocodylia includes 2 alligators, 6 caimans, 13 crocodiles and 2 gharial species. In this study, the maternal investments by species in the order Crocodylia in offspring number, offspring size at hatch, and female body size were determined and compared to the predictions of the Smith-Fretwell maternal investments model and an alternative maternal investment model. The findings of this study contradict the Smith-Fretwell model and support the alternative model. The Smith-Fretwell model predicts that mothers who produce a larger number of offspring must sacrifice the quality of their offspring. Results showed that hatchlings were about the same size regardless of the number of eggs produced. On the other hand, according to the alternative maternal investment model, the predation rate on crocodilian offspring is far less than that of fish offspring but far greater than that of bird or mammal offspring. In addition, offspring mortality by starvation is less of an issue for crocodilians than it is for mammals and birds but it is a greater threat for crocodilians than it is for most species of fish.

Marcó, M.V.P., Larriera, A. and Piña, C.I. (2014). Red Fire Ant (*Solenopsis invicta*) effects on Broad-snouted caiman (*Caiman latirostris*) nest success. Journal of Herpetology.

Abstract: Flooding and predation are the two major causes for the decline in hatching rate and hatchling survival in crocodilian species. Recently, *Solenopsis invicta* (Red Fire Ant) has been recognized as a formidable invasive species, causing changes in wild populations of reptiles. Because of the elevated densities of Red Fire Ants present in *Caiman latirostris* (Broad-Snouted Caiman) nests during the breeding season, experiments in captivity and in the wild were performed to verify if the presence of *S. invicta* affects nest success or care of eggs and the hatching-assistance behavior of *C. latirostris* females. Hatchling survival from eggs incubated in a lab setting in the presence of Red Fire Ants decreased by approximately 10% compared to nests without ants. In a second experiment performed in the wild, the presence of Red Fire Ant resulted in a 43% reduction in nest success including direct (14.5%) and indirect (28.5%) effects. Our study confirmed that Red Fire Ants negatively affect *C. latirostris* nest success, directly because Red Fire Ants attack and cause the hatchling's death after pipping and indirectly by preventing females from caring for eggs, providing hatching assistance, and maintaining nests.

Watanabe, A. and Slice, D.E. (2014). The utility of cranial ontogeny for phylogenetic inference: a case study in crocodylians using geometric morphometrics. Journal of Evolutionary Biology 27(6): 1078-1092.

Abstract: The degree to which the ontogeny of organisms could facilitate our understanding of phylogenetic relationships has long been a subject of contention in evolutionary biology. The famed notion that 'ontogeny recapitulates phylogeny' has been largely discredited, but there remains an expectation that closely related organisms undergo similar morphological transformations throughout ontogeny. To test this assumption, we used three-dimensional geometric morphometric methods to characterize the

cranial morphology of 10 extant crocodylian species and construct allometric trajectories that model the post-natal ontogenetic shape changes. Using time-calibrated molecular and morphological trees, we employed a suite of comparative phylogenetic methods to assess the extent of phylogenetic signal in these trajectories. All analyses largely demonstrated a lack of significant phylogenetic signal, indicating that ontogenetic shape changes contain little phylogenetic information. Notably, some Mantel tests yielded marginally significant results when analysed with the morphological tree, which suggest that the underlying signal in these trajectories is correlated with similarities in the adult cranial morphology. However, despite these instances, all other analyses, including more powerful tests for phylogenetic signal, recovered statistical and visual evidence against the assumption that similarities in ontogenetic shape changes are commensurate with phylogenetic relatedness and thus bring into question the efficacy of using allometric trajectories for phylogenetic inference.

Fujisaki, I., Hart, K.M., Mazzotti, F.J., Cherkiss, M.S., Sartain, A.R., Jeffery, B.M., Beauchamp, J.S. and Denton. M. (2014). Home range and movements of American alligators (*Alligator mississippiensis*) in an estuary habitat. Animal Biotelemetry 2: 8

Abstract: Understanding movement patterns of free-ranging top predators throughout heterogeneous habitat is important for gaining insight into trophic interactions. We tracked the movements of 5 adult American alligators to delineate their estuarine habitat use and determine drivers of their activity patterns in a seasonally-fluctuating environment. We also compared VHF- and satellite-tracks of one of the alligators to examine tradeoffs in data quality and quantity. All tracked alligators showed high site fidelity in the estuary, but estimated home range size and core-use areas were highly variable. Two alligators were relatively sedentary and remained in the upper stream zone. One alligator traveled to a transition zone between freshwater marsh and estuary habitat, but primarily remained in the upstream area. Two alligators travelled to the downstream zone into saline conditions and showed high salinity tolerance. Overall movement rates were highly influenced by salinity, temperature, and season. Both satellite and VHF radio telemetries resulted in similar home range, core-use area, and activity centers. This study reveals consistent use of estuary habitat by American alligators. The alligators showed variations in their movement pattern and seasonal habitat, with movement attributable to environmental factors. Although satellite-derived locations were more dispersed compared to locations collected using VHF radio-tags, data collected from VHF tracking omitted some habitat used for a short period of time, indicating the effectiveness of satellite telemetry to continuously track animals for ecosystem-scale studies.

Behera, S.K., Mohanta, R., Kar, C.S. and Mishra, S.S. (2014). Preliminary inventory of biodiversity at Ghodahada Reservoir: Conservation of Mugger crocodile at Ganjam District, Odisha. Journal of Biodiversity & Endangered Species 2: 130. (doi: 10.4172/2332-2543.1000130).

Abstract: The existing small population of Mugger crocodile inhabit in south Odisha near Ganjam and Parlakamundai district Border. The main habitats could be classified in two, main natural and artificial habitats. The main natural habitats are the small and large ponds along the main Ghodahada Reservoir. Most of these ponds have similar characteristics providing suitable habitats for the Mugger crocodiles. Generally, Muggers avoid running parts of the rivers, streams and prefer fairly deep and calm parts of the rivers with suitable vegetation and sandy banks. As the artificial water bodies also play essential support for the Mugger population. Small and large ponds nearby villages constructed for the rain water storage as well as the dams constructed along the Ghodahada River supposed to be important habitats for the Muggers too. The movement of Muggers between the habitats is usual recorded behavior in the area. In most habitats the Muggers have close contact with local people. Some ponds in border area are supposed to be Mugger habitats too, and some reports from local people indicating movement between the local habitats. Constructed dams on the main rivers had important effects on the habitats too. 37 species of fish, 8 amphibian 28 reptilian and 46 bird species are the main food resources for the Muggers in these habitats which also add the richness to biodiversity of area. Since 2008 the Mugger crocodile conservation program was initiated by Berhampur Forest Department. Latest 2014 census recorded 46 basking Mugger crocodiles and 7 nests were found during the nest survey in small islands/mainland in habitat.

Bashyal, A., Gross, B.A., Venegas-Anaya, M., Lowrance, F. and Densmore III, L.D. (2014). Assessment of microsatellites in estimating inter- and intraspecific variation among Neotropical *Crocodylus* species. Genetics and Molecular Research 13(3): 5492-5502.

Abstract: We tested microsatellites that were developed for the saltwater crocodile (*Crocodylus porosus*) for cross-species amplification and to provide an estimate of inter- and intraspecific variation among four species of Neotropical crocodiles (*C. rhombifer*, *C. intermedius*, *C. acutus* and *C. moreletii*). Our results indicated that with the exception of 2 loci in *C. intermedius*, all 10 microsatellite loci were successfully amplified in the 4 species, producing a set of variably sized alleles that ranged in number between 2 and 14 alleles per locus. Similarly, private alleles (ie unique alleles) also were reported in all 4 species for at least 3 loci. The mean observed and expected heterozygosities (averaged across species for all 10 loci combined) ranged from 0.39 to 0.77 and from 0.44 to 0.78, respectively. In addition to this, we evaluated these microsatellites in 2 populations of *C. acutus* and *C. moreletii* to assess their utility in estimating intraspecific levels of polymorphisms. These microsatellites also showed considerable allelic variation in population level analysis. The set of 10 microsatellite loci in our study had the potential to be used as a tool in population and conservation genetic studies of Neotropical crocodiles.

Tellez, M. and Nifong, J. (2014). Gastric nematode diversity between estuarine and inland freshwater populations of the American alligator (*Alligator mississippiensis*, Daudin 1802), and the prediction of intermediate hosts. International Journal for Parasitology: Parasites and Wildlife (doi: 10.1016/j.ijppaw.2014.07.001).

Abstract: We examined the variation of stomach nematode intensity and species richness of *Alligator mississippiensis* from coastal estuarine and inland freshwater habitats in Florida and Georgia, and integrated prey content data to predict possible intermediate hosts. Nematode parasitism within inland freshwater inhabiting populations was found to have a higher intensity and species richness than those inhabiting coastal estuarine systems. This pattern potentially correlates with the difference and diversity of prey available between inland freshwater and coastal estuarine habitats. Increased consumption of a diverse array of prey was also correlated with increased nematode intensity in larger alligators. Parasitic nematodes *Dujardinascaris waltoni*, *Brevimulticaecum tenuicolle*, *Ortleppascaris antipini*, *Goezia* sp. and *Contracaecum* sp. were present in alligators from both habitat types. *Dujardinascaris waltoni*, *B. tenuicolle* and *O. antipini* had a significantly higher abundance among inland inhabiting alligators than hosts from estuarine populations. Our findings also suggest that host specific

nematode parasites of alligators may have evolved to infect multiple intermediate hosts, particularly fishes, crabs, and turtles, perhaps in response to the opportunistic predatory behaviors of alligators.

Cervellon, M-C. (2014). Coats of Arms. Chapter 17 *in* Brand Mascots: And Other Marketing Animals, ed. by S. Brown and S. Ponsonby-McCabe. Routledge: Oxon, UK.

Iijima, M. and Kobayashi, Y. (2014). Convergences and trends in the evolution of the Archosaur pelvis. Paleobiology 40(4): 608-624.

Abstract: The pelvic structure in non-avian archosaurs plays a key role in understanding the evolution of terrestrial locomotor patterns because the pelvis contains major attachment sites for proximal hind limb musculature. In order to investigate patterns of pelvic evolution in archosaurs, this study compiled three pelvic indices, as well as femoral head orientation, for 92 archosaur taxa. With the metrics and a reconstructed supertree, we examined the correlated evolution of the pelvis and femur, the correlation among pelvic components, and temporal trends in the evolution of the pelvis. The result shows that archosaurs with medially directed femoral heads have more cranially shifted iliac centroids and more posteriorly rotated pubes than taxa with anteromedially directed femoral heads. The craniad shift of the iliac centroid might be correlated to the posterior rotation of pubis. The pelvic structures of pterosaurs, ornithischians, sauropods, and avetheropods occupy a different morphospace from basal archosaurs, pseudosuchians, basal dinosauromorphs, basal theropods, and basal sauropodomorphs in having more cranially expanded ilia, more posteriorly rotated pubes, and medially deflected femoral heads. This may imply that pterosaurs and those derived dinosaurs independently underwent similar shifts in thigh muscles and locomotion. The evolutionary model fitting supports the early-burst model for iliac and pubic metrics in more inclusive archosaur clades, indicating that larger changes of archosaur pelves occurred in early times of the clade's history.

Langer, S., Ternes, K., Widmar, D. and Mutschmann, F. (2014). The first case of intersexuality in an African dwarf crocodile (*Osteolaemus tetraspis*). Zoo Biology (doi: 10.1002/zoo.21149).

Abstract: To the authors knowledge this is the first case of intersexuality in an African dwarf crocodile (*Osteolaemus tetraspis*). An adult African dwarf crocodile with a male-typical phenotype lived at Zoo Duisburg in Germany for 10 years. It died in October 2012 despite intensive treatment as a result of terminal septicemia. After a detailed pathological examination the gonads were histologically confirmed as ovotestes. Half of the 22 extant species of crocodilians have been examined for occurrence of temperature dependent sex determination (TSD). In TSD reptiles, masculinizing temperatures yield 100% or a majority of males, whereas feminizing temperatures yield 100% or a majority of females. In the transition range of temperature (TRT), a mix of males, females and sometimes intersexes are obtained. However, the molecular mechanisms behind TSD and an explanation for the occurrence of intersexuality remain elusive.

Smolensky, N.L., Hurtado, L.A. and Fitzgerald, L.A. (2014). DNA barcoding of Cameroon samples enhances our knowledge on the distributional limits of putative species of *Osteolaemus* (African dwarf crocodiles). Conservation Genetics (doi: 10.1007/s10592-014-0639-3).

Abstract: Recent genetic and morphological evidence indicates that the African dwarf crocodile (*O. tetraspis*) is comprised of three highly divergent lineages: *O.* sp. nov., *O. tetraspis* and *O. osborni*. Their putative distributional limits correspond with the Cameroon volcanic line (CVL) and the Congo River basin. In this study, we expanded on previous phylogeographic work by conducting detailed sampling of this crocodile in Cameroon and around the CVL. We tested whether O. tetraspis is the only lineage occurring in Cameroon and whether the CVL represents the distributional limit between *O.* sp. nov. and *O. tetraspis*. We collected 65 tissue samples from individuals located throughout Cameroon, and the eastern and western sides of the CVL. We sequenced fragments of two mitochondrial genes (CO1 and 12S rDNA) and one nuclear gene (LDH-A). We found that *O. tetraspis* extends west beyond the CVL and, thus, this mountain chain does not represent the distributional limit of this lineage. We also found *O. osborni* in Cameroon. Our findings have important implications for the conservation and management of *O. tetraspis* lineages.

Hennigan, T. (2014). An initial estimate toward identifying and numbering the Ark Turtle and Crocodile Kinds. Answers Research Journal 7(2014): 1-10.

Abstract: Biosystematics is in great flux today because of the plethora of genetic research continually shedding light on organism relationships. Despite the large amount of data being published, the challenge is having enough knowledge about genetics to draw conclusions regarding the biological history of organisms and their taxonomy. Based on the analyses of molecular data, hybridization capability, and statistical baraminology it is estimated that 11 extant turtle kinds and three extant crocodile kinds were brought on the Ark.

Fortier, D.C., De Souza-Filho, J.P., Guilherme, E., Maciente, A.A.R. and Schultz, C.L. (2014). A new specimen of *Caiman brevirostris* (Crocodylia, Alligatoridae) from the late Miocene of Brazil. J. Vertebrate Paleontology 34(4): 820-834.

Abstract: *Caiman brevirostris* was described based on the basis of late Miocene materials that included a rostral fragment and a right mandibular ramus, but photographs were not provided at that time. In this study, for the first time, we present the holotype materials of this species and a new specimen from the late Miocene of southwestern Amazonia, Brazil. The diagnosis was expanded, and a phylogenetic analysis was conducted. The results from the analysis consistently recover *Caiman brevirostris* within a clade that includes *Caiman latirostris*, *Caiman* cf. *C. lutescens* and *Melanosuchus*. The oldest fossil record of the genus *Caiman* is from the Oligocene of southeastern Brazil, but these materials are regarded in this study as a *nomen dubium* due to the absence of any diagnostic features for the specimen. Thus, the oldest record considered valid by this study derives from the middle Miocene of Colombia and may represent the initial radiation of the genus.

Somaweera, R., Woods, D. and Sonneman, T. (2014). A note on the Australian freshwater crocodiles inhabiting Tunnel Creek Cave, West Kimberley. Records of the Western Australian Museum 29(1): 82-87.

Masova, S. (2014). Parasitic Nematodes (Nematoda) of Selected Cold-blooded Vertebrates - Systematics, Taxonomy, Morphology. PhD thesis, Masaryk University, Czech Republic.

Abstract: This thesis focuses on descriptions or redescriptions and taxonomy of parasitic nematodes of selected cold-blooded

vertebrates from Africa (Senegal, Kenya, Sudan). Most of the samples are from freshwater fishes; but, data on reptile nematodes are also provided. In this study the detailed morphology of selected nematode species was identified [*Cithariniella khalili* Petter, Vassiliadès *et* Troncy 1972; *Multicaecum heterotis* Petter, Vassiliadès *et* Marchand 1979; *Procamallanus* (*Procamallanus*) sp.; *P.* (*P.*) *laeviconchus* (Wedl 1862); *Mexiconema africanum* Moravec, Jirku, Charo-Karisa *et* Masova 2009; *Dujardinascaris madagascariensis* Chabaud *et* Caballero 1966; *Parapharyngodon micipsae* (Seurat 1917); *P. echinatus* (Rudolphi 1819)] using various methods of light and scanning electron microscopy. *Parapharyngodon echinatus*, *D. madagascariensis* and *M. heterotis* were differentiated and characterised with molecular techniques. New knowledge on the morphometric variability of selected taxa were added. Determination keys for the species of *Multicaecum* and *Brevimulticaecum*; and to the species of *Dujardinascaris* (parasitizing crocodiles) were also compiled.

Tellez, M., Haghighi, A. and Lavihim, M. (2014). Distribution and abundance of *Sebekia mississippiensis* (Sebekidae) in the American alligator, *Alligator mississippiensis*. Comparative Parasitology 81(2): 232-239.

Abstract: Pentastomids are the most common endoparasite that infects the respiratory tracts of saurapsid reptiles, such as crocodilians. In this study we examined lung pentastomid parasitism in the American alligators, *Alligator mississippiensis* from northern Florida and southern Louisiana, USA. (partitioned into the Louisiana West Zone and Louisiana East Zone) to determine the potential effects of alligator gender, size, and location on pentastomid distribution and abundance. In total, 1405 lung pentastomids identified as *Sebekia mississippiensis* were found in 69 alligators (81.2% prevalence). Male alligators were found to have a higher pentastomid prevalence and intensity in comparison to females, which may be the effect of disparate life-history traits between the sexes and the larger size of males. Host size classes were found to be a significant trait influencing parasitism, as pentastomid prevalence and intensity increased in conjunction with alligator maturation. Our results also indicated that *S. mississippiensis* has a higher prevalence among Louisiana West Zone alligators, whereas the intensity was found to be higher among Florida alligators. Variation of intermediate host abundance is likely the primary cause for the differing pentastomid distribution among study locations. As such, these data further our understanding of the patterns of alligator pentastomiasis.

Osugi, T., Ubuka, T. and Tsutsui, K. (2014). Review: Evolution of GnIH structure and function. Front. Neurosci. 8: 255.

Abstract: Discovery of gonadotropin-inhibitory hormone (GnIH) in the Japanese quail in 2000 was the first to demonstrate the existence of a hypothalamic neuropeptide inhibiting gonadotropin release. We now know that GnIH regulates reproduction by inhibiting gonadotropin synthesis and release via action on the gonadotropin-releasing hormone (GnRH) system and the gonadotrope in various vertebrates. GnIH peptides identified in birds and mammals have a common LPXRF-amide (X= L or Q) motif at the C-terminus and inhibit pituitary gonadotropin secretion. However, the function and structure of GnIH peptides are diverse in fish. Goldfish GnIHs possessing a C-terminal LPXRF-amide motif have both stimulatory and inhibitory effects on gonadotropin synthesis or release. The C-terminal sequence of grass puffer and medaka GnIHs are MPQRF-amide. To investigate the evolutionary origin of GnIH and its ancestral structure and function, we searched for GnIH in agnathans, the most ancient lineage of vertebrates. We identified GnIH precursor gene and mature GnIH peptides with C-terminal QPQRF-amide or RPQRF-amide from the brain of sea lamprey. Lamprey GnIH fibers were in close proximity to GnRH-III neurons. Further, one of lamprey GnIHs stimulated the expression of lamprey GnRH-III peptide in the hypothalamus and gonadotropic hormone β mRNA expression in the pituitary. We further identified the ancestral form of GnIH, which had a C-terminal RPQRF-amide, and its receptors in amphioxus, the most basal chordate species. The amphioxus GnIH inhibited camp signaling *in vitro*. In sum, the original forms of GnIH may date back to the time of the emergence of early chordates. GnIH peptides may have had various C-terminal structures slightly different from LPXRF-amide in basal chordates, which had stimulatory and/or inhibitory functions on reproduction. The C-terminal LPXRF-amide structure and its inhibitory function on reproduction may be selected in later-evolved vertebrates, such as birds and mammals.

Ganswindt, S.B., Myburgh, J.G., Cameron, E.Z. and Ganswindt, A. (2014). Non-invasive assessment of adrenocortical function in captive Nile crocodiles (*Crocodylus niloticus*). Comparative Biochemistry and Physiology Part A: Molecular & Integrative Physiology 177: 11-17.

Abstract: The occurrence of stress-inducing factors in captive crocodilians is a concern, since chronic stress can negatively affect animal health and reproduction, and hence production. Monitoring stress in wild crocodiles could also be beneficial for assessing the state of health in populations that are potentially threatened by environmental pollution. In both cases, a non-invasive approach to assess adrenocortical function as a measure of stress would be preferable, as animals are not disturbed during sample collection, and therefore sampling is feedback-free. So far, however, such a non-invasive method has not been established for any crocodilian species. As an initial step, we therefore examined the suitability of two enzyme-immunoassays, detecting faecal glucocorticoid metabolites (FGMs) with a 11β,21-diol-20-one and 5β-3α-ol-11-one structure, respectively, for monitoring stress-related physiological responses in captive Nile crocodiles (*Crocodylus niloticus*). An adrenocorticotropic hormone (ACTH) challenge was performed on 10 sub-adult crocodiles, resulting in an overall increase in serum corticosterone levels of 272% above the pre-injection levels 5 h post-injection. Saline-treated control animals (n= 8) showed an overall increase of 156% in serum corticosterone levels 5 h post-administration. Faecal samples pre- and post-injection could be obtained from 3 of the 6 individually housed crocodiles, resulting in FGM concentrations 136-380% above pre-injection levels, always detected in the first sample collected post-treatment (7-15 days post-injection). FGM concentrations seem comparatively stable at ambient temperatures for up to 72 h post-defaecation. In conclusion, non-invasive hormone monitoring can be used for assessing adrenocortical function in captive Nile crocodiles based on FGM analysis.

Hastings, A.K., Bloch, J.I. and Jaramillo, C.A. (2014). A new blunt-snouted dyrosaurid, *Anthracosuchus balrogus* gen. et sp. nov. (Crocodylomorpha, Mesoeucrocodylia), from the Palaeocene of Colombia. Historical Biology: An International Journal of Paleobiology (doi: 10.1080/08912963.2014.918968).

Abstract: A new exceptionally brevirostrine dyrosaurid is described from the middle Palaeocene (58-60 million years ago) Cerrejón Formation, northeastern Colombia, based on four partial skulls and associated postcrania. This taxon is unique among dyrosaurids not only in skull shape, but also in having orbital tuberosities, and osteoderms that are dorsoventrally thick and unpitted, a trait otherwise unknown in Crocodylomorpha. Results from a cladistic

analysis of Dyrosauridae suggest that the new taxon, together with Cretaceous-Palaeocene *Chenanisuchus lateroculi* from Africa and *Cerrejonisuchus improcerus* also from the Cerrejón Formation, are the most basal members of the family. Results from a biogeographic analysis indicate at least three independent dispersals of dyrosaurids from Africa to the New World occurred in the Late Cretaceous or early Palaeocene. Widely set orbits in the new taxon indicate a deviation from surface-based predation, characteristic of other dyrosaurids, to sub-surface predation, as in modern *Gavialis*. Tooth impressions found on turtle shells recovered from the same locality match well with teeth of the new taxon indicating possible predation.

Newberger, D.R. (2014). Transition Metal Accumulation in Caudal Scutes of American Crocodiles (*Crocodylus acutus*) from Belize. Honours Thesis, Baylor University, Texas, USA.

Abstract: Contamination of aquatic environments is a global concern that poses risks to wildlife and human health. Due to their high trophic status, broad diet, long life span, and occurrence in a variety of aquatic habitats, crocodilians are susceptible to exposure and accumulation of numerous persistent environmental contaminants, including metals. Exposure to these metals may have potential health hazards and have a more pronounced effect on populations already subject to other stressors (eg habitat loss, deliberate killing). Previous studies have documented transition metals in caudal (tail) scutes of crocodiles from remote areas of mainland Belize; however, no such data are available for crocodiles living on the country's offshore islands (cays). In this study, we examined transition metal concentrations in caudal scutes from American crocodiles (*Crocodylus acutus*) sampled from various localities on Ambergris Cay, Belize. In addition, a smaller number of *C. acutus* scutes from Costa Rica werealso examined for comparative purposes. Sixteen metals were detected in scutes: Pb, As, Cu, Ag, Be, Cd, Al, Cr, Ni, Co, Mo, Sb, Se, Tl, Sn, and Zn, with Al, Zn, Cu, and Sn exhibiting the highest concentrations. Metal concentrations differed by sex, body size, site, and proximity to putative contaminant sources. Juvenile crocodiles generally contained the highest metal concentrations, and for many metals concentrations decreased with increasing body size.

Olivieri, D.N., Von Haeften, B., Sanchez-Espinel, Faro, J. and Gambon-Deza, F. (2014). Genomic V exons from whole genome shotgun data in reptiles. Immunogenetics 66(7-8): 479-492.

Abstracts: Reptiles and mammals diverged over 300 million years ago, creating two parallel evolutionary lineages amongst terrestrial vertebrates. In reptiles, two main evolutionary lines emerged: one gave rise to Squamata, while the other gave rise to Testudines, Crocodylia, and Aves. In this study, we determined the genomic variable (V) exons from whole genome shotgun sequencing (WGS) data in reptiles corresponding to the 3 main immunoglobulin (IG) loci and the 4 main T cell receptor (TR) loci. We show that Squamata lack the TRG and TRD genes, and snakes lack the IGKV genes. In representative species of Testudines and Crocodylia, the 7 major IG and TR loci are maintained. As in mammals, genes of the IG loci can be grouped into well-defined IMGT clans through a multi-species phylogenetic analysis. We show that the reptilian IGHV and IGLV genes are distributed amongst the established mammalian clans, while their IGKV genes are found within a single clan, nearly exclusive from the mammalian sequences. The reptilian and mammalian TRAV genes cluster into 6 common evolutionary clades (since IMGT clans have not been defined for TR). In contrast, the reptilian TRBV genes cluster into 3 clades, which have few mammalian members. In this locus, the V exon sequences from mammals appear to have undergone different evolutionary diversification processes that occurred outside these shared reptilian clans. These sequences can be obtained in a freely available public repository.

Botfalvi, G., Prondvai, E. and Osi, A. (2014). Inferred bite marks on a Late Cretaceous (Santonian) bothremydid turtle and a hylaeochampsid crocodilian from Hungary. Cretaceous Research 50: 304-317.

Abstract: The Iharkút locality in the Bakony Mountains of western Hungary has provided a rich and diverse assemblage of Late Cretaceous vertebrates. Here we present two specimens of this assemblage, a plate fragment of the bothremydid turtle *Foxemys trabanti*, and a partial skull roof of the hylaeochampsid crocodilian, *Iharkutosuchus makadii*, that exhibit pathological traits, such as shallow and deep pits, bisected pits, and scores on their surface, and in the case of the skull roof, also a hole piercing through the entire bone thickness. Morphological and bone histological features of these pathological traits imply that they probably represent bite marks rather than deformations due to pre-mortem shell diseases, infections or post-mortem invertebrate bioerosion, and microbial activity. Morphological similarities with experimentally investigated crocodilian tooth marks suggest that both elements bear the bite marks of a crocodilian predator with typical conical teeth, possibly the *Allodaposuchus*-like crocodile, also known from the locality. The inferred tooth marks on the dorsal surface of the *Iharkutosuchus* skull roof indicate a rarely documented predator–prey interaction between two different crocodilian taxa rather than antagonistic behaviour over common resources. Nevertheless, more comparative studies are needed on different traumatic as well as non-traumatic bone pathologies that may eventuate in bite-mark-like abnormalities.

Van Hoek, M.L. (2014). Antimicrobial peptides in reptiles. Pharmaceuticals 7(6): 723-753.

Abstract: Reptiles are among the oldest known amniotes and are highly diverse in their morphology and ecological niches. These animals have an evolutionarily ancient innate-immune system that is of great interest to scientists trying to identify new and useful antimicrobial peptides. Significant work in the last decade in the fields of biochemistry, proteomics and genomics has begun to reveal the complexity of reptilian antimicrobial peptides. Here, the current knowledge about antimicrobial peptides in reptiles is reviewed, with specific examples in each of the four orders: Testudines (turtles and tortosises), Sphenodontia (tuataras), Squamata (snakes and lizards), and Crocodilia (crocodilans). Examples are presented of the major classes of antimicrobial peptides expressed by reptiles including defensins, cathelicidins, liver-expressed peptides (hepcidin and LEAP-2), lysozyme, crotamine, and others. Some of these peptides have been identified and tested for their antibacterial or antiviral activity; others are only predicted as possible genes from genomic sequencing. Bioinformatic analysis of the reptile genomes is presented, revealing many predicted candidate antimicrobial peptides genes across this diverse class. The study of how these ancient creatures use antimicrobial peptides within their innate immune systems may reveal new understandings of our mammalian innate immune system and may also provide new and powerful antimicrobial peptides as scaffolds for potential therapeutic development.

Jandaruang, J., Siritapetawee, J., Songsiriritthigul, C., Preecharram, S., Azuma, T., Dhiravisit, A., Fukumori, Y. and Thammasirirak, S. (2014). Purification, characterization, and crystallization of

Crocodylus siamensis hemoglobin. The Protein Journal 33(4): 377-385.

Abstract: *Crocodylus siamensis* hemoglobin was purified by a size exclusion chromatography, Sephacryl S-100 with buffer containing dithiothreitol. The purified Hb was dissociated to be two forms (α chain and β chain) which observed by SDS-PAGE, indicated that the *C. siamensis* Hb was an unpolymerized form. The unpolymerized Hb (composed of two α chains and two β chains) showed high oxygen affinity at 3.13 mmHg (P_{50}) and 1.96 (n value), and a small Bohr effect (δH+= -0.29) at a pH of 6.9-8.4. Adenosine triphosphate did not affect the oxygenation properties, whereas bicarbonate ions strongly depressed oxygen affinity. Crude *C. siamensis* Hb solutions were showed high O_2 affinity at P50 of 2.5 mmHg that may assure efficient utilization of the lung O_2 reserve during breath holding and diving. The purified Hbs were changed to cyanmethemoglobin forms prior crystallization. Rod- and plate-shaped crystals were obtained by the sitting-drop vapor-diffusion method at 5°C using equal volumes of protein solution (37 mg/ml) and reservoir [10-13 % (w/v) PEG 4000, with 0.1 M Tris buffer in present of 0.2 M MgCl2·6H2O] solution at a pH of 7.0-8.5.

Ihlow, F., Bonke, R., Hartmann, T., Geissler, P., Behler, N. and Rodder, D. (2014). Habitat suitability, coverage by protected areas and population connectivity for the Siamese crocodile *Crocodylus siamensis* Schneider, 1801. Aquatic Conservation: Marine and Freshwater Ecosystems (doi: 10.1002/aqc.2473).

Abstract: With estimates of fewer than 1000 mature individuals in the wild, the critically endangered Siamese crocodile, *Crocodylus siamensis* Schneider 1801, is one of the least known and at the same time most threatened crocodilian species in the world. Populations have already been depleted to approximately 20% of their former size with habitat destruction, alterations, and loss being the main drivers of population declines. Habitat suitability models were computed using a combination of bioclimatic and remote sensing variables as environmental predictors to evaluate habitat suitability and coverage by designated protected areas across the species' distributional range. In addition, population connectivity as well as current and future habitat fragmentation through dam construction was assessed by performing population connectivity models. Habitat suitability models show the spatial extent of suitable habitat to be high (46%), although only a small proportion is covered by designated reserves (11%). Population connectivity models showed remnant populations to be highly fragmented. Considering habitat suitability, coverage of reserves and population connectivity the lower Mekong River Basin stretching from the Xe Champhon and Xe Xangxoy Rivers in Lao PDR to the Srepok and Sekong Rivers in eastern Cambodia seem to be particularly important for future conservation prioritization for *C. siamensis*. The presently established protected area network is unsatisfactory in terms of size and population connectivity and needs to be significantly improved to successfully sustain viable populations of the critically endangered Siamese crocodile in the future.

Lewis, J.D., Cain, III, J.W. and Denkhaus, R. (2014). Home range and habitat selection of an inland alligator (*Alligator mississippiensis*) population at the northwestern edge of the distribution range. Southeastern Naturalist 13(2): 261-279.

Abstract: Although well studied in coastal ecosystems, comparatively little information exists on the ecology of inland *Alligator mississippiensis* (American alligator) populations, particularly at the periphery of their range. Our specific objectives were to estimate homerange area and assess diel (ie day vs. night) habitat-selection patterns of an urban, inland American alligator population at the northwestern edge of the species' range. During 2010-2011, we captured 14 (6 female, 5 male, 3 unknown sex) American alligators, 9 (5 female and 4 male) of which were fitted with VHF transmitters. Mean home range (95% kernel) was 68.9 ha (SD= 31.6) and 40.9 ha (SD= 20.7) and the mean core area (50% kernel) was 20.6 ha (SD= 18.5) and 10.1 ha (SD= 6.6) for males and females, respectively. American alligators primarily selected river channels and open-canopy shorelines during both day and night. The amount of emergent or floating vegetation and canopy cover in a particular habitat influenced the probability of selection by American alligators but this probability was dependent on the diel time period. During the day, the probability of selection was higher in areas with emergent or floating vegetation and more canopy cover, whereas at night the probability of selection decreased with increasing canopy cover. American alligators did not select open water at either the study-area level or within the home range, which may have been due at least in part to the presence of recreational boaters or differences in food availability between open-water areas and other areas occupied by American alligators on the Fort Worth Nature Center and Refuge. Overall, the results of our study are largely incongruent with patterns of home-range size and habitat selection reported for the species elsewhere, suggesting that further study of other American alligator populations at the periphery of the distribution range is warranted.

Brien, M., Webb, G.J.W., McGuiness, K. and Christian, K.A. (2014). The relationship between early growth and survival of hatchling Saltwater Crocodiles (*Crocodylus porosus*) in captivity. PLoS ONE 9(6): e100276.

Abstract: Hatchling fitness in crocodilians is affected by "runtism" or failure to thrive syndrome (FTT) in captivity. In this study, 300 hatchling *C. porosus*, artificially incubated at 32°C for most of their embryonic development, were raised in semi-controlled conditions, with growth criteria derived for the early detection of FTT (within 24 days). Body mass, four days after hatching (BM4d), was correlated with egg size and was highly clutch specific, while snout-vent length (SVL4d) was much more variable within and between clutches. For the majority of hatchlings growth trajectories within the first 24 days continued to 90 days and could be used to predict FTT affliction up to 300 days, highlighting the importance of early growth. Growth and survival of hatchling *C. porosus* in captivity was not influenced by initial size (BM4d), with a slight tendency for smaller hatchlings to grow faster in the immediate post-hatching period. Strong clutch effects (12 clutches) on affliction with FTT were apparent, but could not be explained by measured clutch variables or other factors. Among individuals not afflicted by FTT (N= 245), mean growth was highly clutch-specific, and the variation could be explained by an interaction between clutch and season. FTT affliction was 2.5 times higher among clutches (N= 7) that hatched later in the year when mean minimum air temperatures were lower, compared with those clutches (N= 5) that hatched early in the year. The results of this study highlight the importance of early growth in hatchling *C. porosus*, which has implications for the captive management of this species.

Campos, Z. and Mourao, G. (2014). Camera traps capture images of predators of *Caiman crocodilus yacare* eggs (Reptilia: Crocodylia) in Brazil's Pantanal wetland. Journal of Natural History (doi: 10.1080/00222933.2014.930757).

Abstract: Camera traps were set up in forest nests in 2009, 2010 and 2012 to capture images of possible predators eating eggs of the Pantanal caiman, *Caiman crocodilus yacare*. We monitored 57 caiman nests; 42 nests were opened and the eggs were counted

(mean= 25 eggs/nest, SD= 4.3). Females were present and captured at 38 of those nests. The remaining 15 nests were used as controls, and we did not capture the females or open the egg cavities of these nests. Most of the nests had the eggs eaten by predators, in both the disturbed group (38 nests) and the control group (13 nests). The main predators were carnivorous mammals, such as crab-eating foxes (*Cerdocyon thous*), coatis (*Nasua nasua*) and tayras (*Eira barbara*), although feral pigs (*Sus scrofa*) and armadillos (*Dasypus novemcinctus*) were also photographed eating caiman eggs. The lizard *Salvator merianae* was photographed eating eggs of two nests.

Schneider, L., Eggins, S., Maher, W., Vogt, R.C., Krikowa, F., Kinsley, L., Eggins, S.M. and Da Silveira, R. (2015). An evaluation of the use of reptile dermal scutes as a non-invasive method to monitor mercury concentrations in the environment. Chemosphere 119: 163-170.

Abstract: Reptiles are ideal organisms for the non-invasive monitoring of mercury (Hg) contamination. We have investigated Hg bioaccumulation in tissue layers of reptile dermis as a basis for establishing a standardized collection method for Hg analysis. Tissue samples from freshwater turtle species *Podocnemis unifilis* and *Podocnemis expansa* and caiman species *Melanosuchus niger* and *Caiman crocodilus*, all from the Amazonian region, were analysed in this study. We first tested the relationships between Hg concentrations in keratin and bone to Hg concentrations in muscle to determine the best predictor of Hg concentration in muscle tissue. We then investigated the potential for measuring Hg concentrations across turtle carapace growth rings as an indicator of longer term changes in Hg concentration in the environment. Hg concentrations were significantly lower in bone (120 ng g^{-1} caimans and 1 ng g^{-1} turtles) than keratin (3600 ng g^{-1} caimans and 2200 ng g^{-1} turtles). Keratin was found to be a better predictor of exposure to Hg than muscle and bone tissues for both turtles and caimans and also to be a reliable non-invasive tissue for Hg analysis in turtles. Measurement of Hg in carapace growth rings has significant potential for estimating Hg bioaccumulation by turtles over time, but full quantification awaits development and use of a matrix-matched reference material for laser ablation ICPMS analysis of Hg concentrations in keratin. Realising this potential would make a valuable advance to the study of the history of contamination in mining and industrial sites, which have until now relied on the analysis of Hg concentrations in sediments.

Phisri, S., Mahakunakorn, P., Lueangsakulthai, J., Jangpromma, N., Swatsitang, P., Daduang, S., Dhiravisit, A. and Thammasirirak, S. (2014). An investigation of antioxidant and anti-inflammatory activities from blood components of crocodile (*Crocodylus siamensis*). The Protein Journal (doi: 10.1007/s10930-014-9581-y).

Abstract: Antioxidant and anti-inflammatory activities were found from *Crocodylus siamensis* blood. The 2,2_-azino-bis(3-ethylbenzthiazoline-6-sulfonic acid) (ABTS) radical scavenging, nitric oxide scavenging, hydroxyl radical scavenging and linoleic peroxidation assays were used to investigate the antioxidant activities of the crocodile blood. Results show that crocodile blood components had antioxidant activity, especially hemoglobin (40.58% nitric oxide radical inhibition), crude leukocyte extract (78% linoleic peroxidation inhibition) and plasma (57.27% hydroxyl radical inhibition). Additionally, the anti-inflammatory activity of the crocodile blood was studied using murine macrophage (RAW 264.7) as a model. The results show that hemoglobin, crude leukocyte extract and plasma were not toxic to RAW 264.7 cells. Also they showed anti-inflammatory activity by reduced nitric oxide (NO) and interleukin 6 (IL-6) productions from lipopolysaccharide (LPS)-stimulated cells. The NO inhibition percentages of hemoglobin, crude leukocyte extract and plasma were 31.9, 48.24 and 44.27%, respectively. However, only crude leukocyte extract could inhibit IL-6 production. So, the results of this research directly indicate that hemoglobin, crude leukocyte extract and plasma of *C. siamensis* blood provide both antioxidant and anti-inflammatory activities, which could be used as a supplementary agent in pharmaceutical products.

Submitted Publications

HUCHZERMEYER'S (2003) LEFT-BENDING TRACHEA HYPOTHESIS. Dr. Fritz Huchzermeyer (2003; page 12) said that "in crocodiles (but not in alligators) the trachea bends to the left inside the thorax before its bifurcation, a substantial distance before entering the lungs", and illustrated this assertion with this a photograph (figure 1.18) of the dissection of a *Crocodylus palustris*. It is clear from this photograph that the windpipes system bends to the animal's left when the crocodile is normally oriented on its own feet, but when the reptile is overturned for dissection purposes and is lying on its back, then the mirror image occurs (an obverse), and with the head still at the top of the picture the tracheal "left" bend is seen turning to the right.

In correspondence with Dr. J. Perran Ross, in around 2002-2003, Fritz said that based on his own experience in Africa, *C. niloticus* and *Osteolaemus tetraspis* also exhibit the bent and convoluted trachea (J.P. Ross, pers. comm.), as opposed to the more straight and direct windpipes system that Perran and other anatomists have noticed in *Alligator mississippiensis*. The windpipes system in *A. mississippiensis* is convoluted in neither juveniles nor adults (J.P. Ross, pers. comm.). In contrast, Fritz's personal communication to Perran included the fact that the Nile crocodile starts life with an unconvoluted and relatively straight trachea, but at 3-4 years of age they start developing the left bending (and compensating by later bending back to the right) phenomenon that continues to develop into the proper convolutions of *C. niloticus* adults, regardless of sex.

The juvenile Nile crocodile has the American alligator's adult (and juvenile) condition, but Fritz did not explicitly say that juvenile *C. palustris* and *O. tetraspis* exhibit ontogenetic variation in this character. However, it is safe to presume that Fritz thought that among those crocodilian taxa that exhibit the pronounced left bend in the posterior half of their tracheas, all begin their life without it and are born with relatively straight and direct windpipes. However, this subject is far from clear (see Fig. 1). There is a statement in Reese (1915a) that in *C. niloticus* the tracheal loop starts forming in the embryo, and clearly the author was relying on the old literature.

The lack of a convoluted windpipes system in *A. mississippiensis* has been variously documented, but whether all of the caimans (and separately *A. sinensis*) share the American alligator's relatively straight tracheal path is less clear. One minor and incidental assertion in Rathke (1866), that "*Alligator cynocephalus*" (today's *Caiman latirostris*)

has the short and unconvoluted trachea, needs confirmation. Thus, I am unsure about how to interpret the word "alligators" in Fritz's assertion that the trachea bends to the animal's left inside the thorax in crocodiles, but not in alligators.

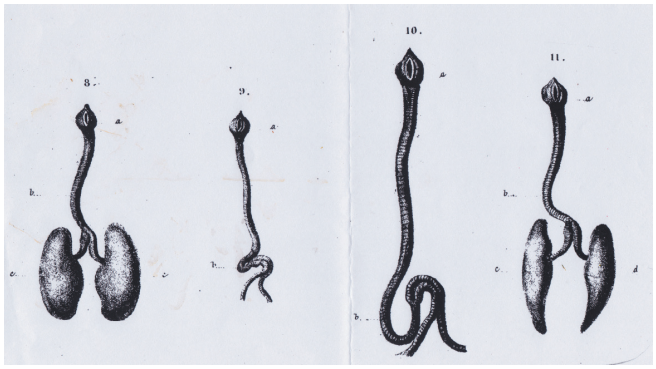


Figure 1. Four isolated windpipes systems depicted in dorsal view (head at the top), from plate 4 in Rathke (1866), each have the glottis shown. #8 "eines reifen Embryo von *Croc acutus*" with its lungs attached. #9 "eines 3' 7" 5"'' langen Exemplar von *Croc. acutus*". #10 "einem 4' 7" langen Exemplar von *Croc. acutus*". #11 "eines Embryo von *Gavialis Schlegelii*" (sic = *Tomistoma schlegelii*) with its lungs attached.

Taxonomically separately, Perran asked a friend who had dissected a *Gavialis gangeticus*, and it had a convoluted and strongly bending trachea. Further, Perran did his own dissections on *Tomistoma schlegelii* and found pronounced windpipes convolutions in all three individuals, with both sexes represented, but none were extremely young. Additionally, Richardson *et al*. (2002; pages 24 and 86-87) described a strongly bending and reflected (including a significant lengthwise component, as opposed to being essentially entirely transverse) trachea as characteristic of the living Crocodylia, except babies, because "in small crocodilians, the trachea runs directly from the pharynx to the tracheal bifurcation without extensive looping" (page 87). The Richardson *et al*. (2002) model surely applies to the two Australian species *C. porosus* and *C. johnstoni*. Another *Crocodylus* known to develop convolutions that become more and more pronounced as the animal grows from an embryo to an adult is *C. acutus*. Thus, tracheas that make the sharp left bend and then make a sharp bend back to the right again, or alternatively make a graceful and simple large loop (Perran's *T. schlegelii* had looped windpipes without any sharp bends, and to some degree resemble the model illustrated in Richardson *et al*. 2002) are presumed to be the normal condition in *Gavialis*, *Tomistoma*, *Crocodylus* and *Osteolaemus* adults, but this phenomenon is expected to be far less dramatic in the young of the Gavialidae and Crocodylidae families. Extrapolating from the illustrations and discussion in Rathke (1866), it appears to have long been known that embryos and hatchlings in the gharial and crocodile species start life with a relatively and remarkably gently bending windpipes system (8. in Fig. 1), and this is tentatively presumed to also characterize the very young of all alligatorids (including the caimans).

The respiratory system has the glottis located at its anterior end and the two lungs are at its posterior end. As illustrated accurately by Huchzermeyer (2003), the glottis is an adjustable opening at the dorsal and anterior end of the larynx, and out of the larynx's opposite end the trachea exits from it and then proceeds fairly straight for some distance before making the bend to the normally oriented (four feet on the floor) animal's left side, or not. The tracheal windpipe does not always include any obvious bends, but in some taxa at some ages it does suddenly become convoluted at a fairly predictable level (namely when it enters the thorax). In either case, somewhere beyond the level where the bending can sometimes commence, the continuing stem of the trachea eventually bifurcates into a left bronchus and a right bronchus. The place where the single trachea splits into a pair of bronchi is called the syrinx, and in cases of extreme windpipes convolutions, part of the bending and looping is the posterior half of the tracheal tube, and part of the convoluted region can include the syrinx and also the adjacent parts of the two bronchial windpipe tubes.

In the old pictures of isolated and complete respiratory systems, if the slit of the glottis is visible on the larynx [as it is in figures 8-11 on plate 4 in Rathke (1866)], then the view is dorsal and from above the normally oriented animal that is upright and standing on all four of its limbs (see Fig. 1). However, in other published illustrations the view is as it would be seen during dissection through the reflected (lifted) or removed skin of the throat. Recent examples of these latter ventral views include *C. palustris* (fig. 1.18 in Huchzermeyer 2003) and *C. porosus* (tracheal route diagram imposed on figure 2 in Toledo *et al*. 2013). Unfortunately neither of these illustrations included the larynx, and thus it is unclear about exactly what proportion of the trachea is "straight" before the bend. Therefore, in cases that are illustrated as published figures, a little extra dissection to show the actual anterior end of the trachea at the larynx is worth doing, and the same applies to the posterior end(s) of the windpipes system at the lungs.

The convention apparently adopted by both Huchzermeyer (2003) and Toledo *et al*. (2013) is that a left-bend (as in title of this article) starts from near the animal's midline and goes towards the left lateral side of the normally oriented (dorsal view) crocodilian. Similarly, Richardson *et al*. (2002) mean the dorsal view animal's left side when they say that the trachea "occupies a midventral position in the neck, is on the left of the midline at the thoracic entrance, and lies dorsally on the left side until it reaches the middle of the left lobe of the liver. Here the trachea bends medially upon itself, and extends forwards to the left side of the pericardium" (page 87). However, in Huchzermeyer's (2003) figure 1.18 ventral view, if interpreted that the discussion (first the glottis, then the larynx, then the trachea and later the syrinx and bronchi) is in terms of the oxygen flow towards the lungs, and this flow is visualized in ventral view, then the proximal (anterior) part of the tracheal tube leaves the larynx and runs posteriorly along the midline before making a left turn as shown in the ventral view illustration. This hypothetical (and not recommended) orientation puts the head at the bottom of the picture, and is obverse to what I believe was really meant. Thus, I fear that

without conscious attention to the anatomical convention that a left turn is really a turn toward the left side of the dorsal view crocodilian, misunderstandings will occur, and it would be helpful if all illustrations are vertical with the head at the top, and are clearly identified as dorsal versus ventral views.

It is parenthetically noteworthy that the tracheas described and illustrated in Richardson *et al*. (2002) very gently bend to the animal's left side, and this gradual drifting starts fairly soon after leaving the larynx, and thus the first normally notable loop is distinctly directed to the animal's right. Thus, in their figured page 24 example (unidentified species), the fact that the trachea gently and gradually bends to the left so much that it reaches the left edge of its cavity before relatively suddenly bending to the right (back toward the midline) technically contradicts the prediction for *Crocodylus* in Huchzermeyer (2003) in which the trachea starts remarkably "straightish", and only later deviates from the midline region by sharply bending to the animal's left side. None the less, the first major deviation from the midline occurs to the animal's left side in the Richardson *et al*. (2002) page 24 drawing that shows the convoluted path of the windpipes system as including two dramatic U-turn loops (bends), and that they reflect each other back and forth along the midline, as opposed to transversely across it.

The figure 1.18 caption in Huchzermeyer (2003) characterizes the shown condition as a "tracheal loop" but this illustrated example is simpler and less three dimensional than in the three *T. schlegelii* examined by Perran Ross, who observed that the windpipes made an actual and entire loop that came completely around and then physically crossed over itself before separating at the syrinx to become bronchi that each finally reaches and then enters its lung.

In figure 1.18 in Huchzermeyer (2003), the meandering route and path of the posterior half of the windpipes system is collectively horizontal, and this agrees with the comparative anatomy literature which distinguishes between vertical windpipe loops in some birds, as compared with the transverse and horizontal convolutions in the living Crocodylia. Thus, it is the current hypothesis that when the trachea makes its first obvious bend, if it does, then the bend is toward the normally oriented animal's left side, and it will be horizontal (left and right across the breadth of the thorax) as opposed to vertical (dorsal and ventral within the midline region). Some kinds of turtles, including some tortoises, also exhibit bends and loops in their tracheal (and syrinx and bronchial) region, and in those vertebrates (some chelonians, some birds and some crocodilians) that possess these windpipes convolutions it has been noted that the bending part is always located closest to the lungs, and thus farthest from the mouth.

Huchzermeyer's (2003) illustrated *C. palustris* dramatic meander is less extreme that what Perran Ross found in the same region of the windpipes system in *Tomistoma*, because when the trachea makes a proper loop and crosses over itself in *T. schlegelii* adults, male and female, there is a very slight vertical component, and the convolution is newly and technically not a simple horizontal serpentine course. Further and separately, there are some cases where the trachea bends only gently to the animal's left and then turns again only gently to the right when it returns to the midline before bifurcating at the syrinx and running as bronchi to the lungs. An example is my Figure 2. Note that in this individual *G. gangeticus* there is also an extremely gentle bend to the right, preceding the stronger bend to the left (the latter shown as bending to the right in this ventral view). Part of the problem is that any bends to the left receive compensation from bends to the right, and it is again relevant that dorsal and ventral views are left-right obverses of each other. In Figure 2 it is notable also that the lateral tracheal bending is not restricted to the posterior half, but rather it occupies and occurs in more like the posterior two thirds of the tracheal length. Also, the bronchi are proportionally shorter in *Gavialis* (Fig. 2), as compared with what is implied (not completely shown) in Huchzermeyer's (2003) *Crocodylus* photograph, and in the Richardson *et al*. (2002) page 24 diagram. Unfortunately the Toledo *et al*. (2013) diagram includes neither the syrinx nor any part of the two bronchi.

Figure 2. This very young gharial has neither a properly straight nor a properly convoluted trachea. Its windpipes system is what I would call serpentine. Ventral view, edited and simplified by me from plate 5, figure 4 in Rathke (1857), and also plate 9, figure 1 in Rathke (1866).

The old anatomists often had extremely small samples, but they accumulated enough data that by Rathke (1866) it was generally thought that the study was complete. However, and in contrast, I today believe that the subject of the path, shape and proportions of the windpipes system in the Crocodylia is worthy of renewed attention, and this time with tens, or even hundreds of observations with the size, sex and species recorded. A start is Lolong, a male *C. porosus* that died at 6.11 m TL, and inside which "the trachea measured over 1 m long and veered to the left side of the chest before looping up towards the right side [and] then down on the same side and finally towards the midline of the body before bifurcating into the bronchi" (Toledo *et al*. 2013). It is clear from their diagram that Lolong's tracheal windpipe was significantly longer than the distance between the crocodile's anterior larynx and his posterior syrinx, and that the extra length of the pipe is horizontal (unlike the vertical condition in some birds), and side-to-side (first to the animal's left side, then looping (U-turning) around and reversing direction and going back all the way to its right side, and then bending and looping back in the opposite direction to the midline) across the chest cavity of this very large saltwater crocodile.

Regardless of the species and the number of observations represented, it is notable that the tracheal path of multiple bendings or loops in Richardson *et al*. (2002) is remarkably different from those in Huchzermeyer (2003) and Toledo *et al*. (2013), because the former's boustrophedonic region (where it goes back and forth like the furrows in a field plowed by oxen) is along the animal's long axis, while in contrast the two latter examples exhibit a lateral and transverse boustrophedonic region. Both kinds (lengthwise versus transverse) have parts of the windpipes system that are parallel to each other (and yet in opposite directions), and thus the two kinds differ primarily in their orientation within the horizontal plane.

I predict that there is always ontogenetic variation concerning crocodilian tracheal straightness, even in *A. mississippiensis* when carefully examined. Further, in those cases where and when strong tracheal bends do happen, I predict that there will be taxonomic variation in the form and the shape or path of the windpipe structures, and also variation in the age at which various kinds and strengths of bends and loops develop.

I thank Perran Ross for asking me in 2003 to read the old anatomy literature on this subject, and for sharing his data about *A. mississippiensis* (N= >30) and *T. schlegelii* (N= 3), and also the personal communications that he had received about *Gavialis*, *Osteolaemus* and *C. niloticus*. The composition of Perran's American alligator sample is detailed in Ross *et al*. (2002). There is a statement that "in the genus *Alligator* the trachea is straight" (Reese 1915a), and his figure 57 drawing of the respiratory organs in *A. mississippiensis* show the path of the tube as remarkably straight from the larynx to the syrinx. This information was apparently repeated in Reese (1915b) including its plate 9 (J.P. Ross, pers. comm.), but I have not yet seen this shorter monograph. None the less, I strongly suspect that rather than being perfectly straight, the American alligator's trachea is actually a combination of several gentle curves that are so gradual that the overall smoothness and general directness of the route approaches straightness, although only in contrast to the serpentine and boustrophedonic (doubling back or across in a parallel fashion) and looped conditions. There is also a page 35 drawing in Chiasson (1962) that shows the relatively straight tracheal route in *A. mississippiensis*, and in this case the larynx and the anterior end of the trachea have been dissected free from their ventral view adjacent tissues, but his figure 17 is misleading (what does he mean by "reflected"?) because the glottis is visible, which it should not be in ventral view. Theoretically the slit of the vent and the slit of the glottis should not be in the same picture, and in this case it is the glottis that is wrong.

Perhaps someone already knows if the adults of the various caiman taxa (including *Paleosuchus* and *Melanosuchus*) either all possess or alternatively all lack the Huchzermeyer left-bending trachea, and to what degree ontogenetic variation influences the answer.

Concerning the species identity of Figure 2, Rathke (1857) said that he had "einem 1' 4" 10"' langen *Gavialis gangeticus*" (page 90), and later said that his figure 4 on plate 5 depicted the "Kopf, Hals und einige Eigenweide der Rumpfhöhle von einem *Gavialis gangeticus*" (page 141), but the tip of the snout was not shown in 1857 (black and white). Note that although the Rathke (1866) plate 9, figure 1 version ("einem *Gavialis gangeticus* in natürlicher Grösse") is colored and therefore less clear for the trachea, the snout is complete and therefore I have combined the 1857 details of the trachea with the 1866 head's outline, and I have removed numerous extraneous details. My identification of Figure 2 follows Rathke (1857, 1866), and lastly I stress my concern that in many cases, his *Alligator cynocephalus* for example, there is no locality data, and no description of the external appearance of the animal (no scale counts, no coloration, no cranial proportions nor diagnostic sutures nor dentition data). Thus, based on decades of working experience in zoological museums, I warn that anatomists are often given specimens (sometimes incomplete, for example missing the head or the skin or both) with uncertain (often a casual guess) provenance (and unverifiable taxonomic identification) for dissections. It is often extremely difficult to identify an embryo to species.

Literature Cited

Chiasson, R.B. (1962). Laboratory Anatomy of the Alligator. W.C. Brown Co.: Dubuque, Iowa.

Huchzermeyer, F.W. (2003). Crocodiles: Biology, Husbandry and Diseases. CABI Publishing: Wallingford, UK, and Cambridge, USA.

Rathke, H. (1857). Untersuchungen über die Aortenwurzeln und die von ihnen ausgehenden Arterien der Saurier. Denkschriften der kaiserlichen Akademie der Wissenschaften: mathematisch-naturwissenschaftliche Classe 13(2): 51-142 pp., pls. 1-6. [cited in an 1858 Rathke paper as "Denkschriften der mathematisch-

naturwissenschaftlichen Klasse der Akademie der Wissenschaften zu Wien (Bd. XIII, Wien 1857)"].

Rathke, H. (1866). Untersuchungen über die Entwickelung und den Körperbau der Krokodile. Friedrich Vieweg & Sohn: Braunschweig, Germany. viii+275 pp., 11 pls.

Reese, A.M. (1915a). The Alligator and its Allies. G.P. Putnam's Sons: New York and London.

Reese, A.M. (1915b). Development of the lungs of the American alligator. Smithsonian Miscellaneous Collections, Pub. 2356 [not seen, from Reese, 1947] = 65(2) [from J.P. Ross].

Reese, A.M. (1947). Bibliography of the Crocodilia. Herpetologica 4(2): 43-54.

Richardson, K.C., Webb, G.J.W. and Manolis, S.C. (2002). Crocodiles: Inside Out. A Guide to the Crocodilians and their Functional Morphology. Surrey Beatty & Sons: Sydney.

Ross, J.P., Carbonneau, D., Terrell, S., Schoeb, T., Honeyfield, D., Hinterkopf, J., Finger, A. and Owen, R. (2002). Continuing Studies of Mortality of Alligators on Central Florida Lakes: Pathology and Nutrition. St. Johns River Water Management District, Technical report series SJ202-SP6: 34 pp., 8 annexes. [not seen].

Toledo, S., Lastica, E., Aquino, M.T., Rebong, G. and Manalo, R. (2013). Necropsy report of the largest Indo-pacific Crocodile "Lolong", in captivity at Bunawan, Agusan Del Sur, Philippines. Pp. 159-163 *in* Crocodiles. Proceedings of the 22nd Working Meeting of the IUCN-SSC Crocodile Specialist Group. IUCN: Gland, Switzerland.

Franklin D. Ross, *Naturalis Biodiversity Center, P.O. box 9517 Leiden 2300RA, the Netherlands*.

SOMETHING NEW AND HELPFUL IN CROCODILIAN CRANIAL MORPHOMETRICS. If, when measured in dorsal view, one crocodilian skull or head is found to have a comparatively longer midline length than another, then this difference does not necessarily mean that it is the larger of the two, because cranial length is a shape variation, as opposed to pure size (Pearcy 2010, 2011a,b; Pearcy and Wijtten 2011). Similarly, when measured in dorsal view, if one crocodilian skull or head is posteriorly wider than another, it is not always the biggest of the compared two crania, because the maximum transverse width of the head is itself a shape variation, as opposed to pure size (Pearcy 2010, 2011a,b; Pearcy and Wijtten 2011). What is meant by dorsal view is the subject of Pearcy and Wijtten (2010), and is Chapter 2 in Pearcy (2011a,b).

Pearcy (2011b) is a repaginated but otherwise unchanged copy of Pearcy's (2011a) PhD thesis (except that some illustrations in color in the thesis are black and white in the book). Thus, with Pearcy (2011a) available on line through the Leiden University website, and Pearcy (2011b) available from its publisher in Germany (printed on demand), her whole dissertation is recommended by me as a good read that includes some remarkably important insights and developments about the subject of size in crocodilian morphometrics.

Although the Pearcy (2010) and Pearcy and Wijtten (2010, 2011) are parts of Pearcy (2011a,b), the latter both additionally include numerous informative and thought provoking chapters about the global distribution and conservation of these apex reptilian predators, and most importantly about cranial (and also whole animal) size and shape variations in general, and examples of physical and ecological differences (and the avoidance of competition) between selected sympatric crocodilian taxa. Pearcy (2011b; ISBN-13 = 978-3-8465-1213-5) has color covers, but is otherwise black and white illustrated. It costs 59 euros, plus postage, and can be purchased through the publisher's distributor at "order@morebooks.de".

Pearcy (2011a) is available at "https://openaccess.leidenuniv.nl/handle/1887/17708" and in "Search Leiden and Repository" at the Leiden University website. This electronic document can be downloaded at no cost, and has the advantage that some of the graphics are in color, but except for a very limited number of printed copies distributed at Ashley's thesis defense (with the colored illustrations), there is no publicly available hard copy of Pearcy (2011a) with the original pagination.

Literature Cited

Pearcy, A.G. (2010). Kälin's 12-12 as an indicator of size in Crocodylia. Herpetological Review 41: 434-437.

Pearcy, A.G. (2011a). Implications of Skull Shape for the Ecology and Conservation Biology of Crocodiles. PhD Thesis, Leiden University, Netherlands.

Pearcy, A.G. (2011b). Skull Shape Analysis in the Ecology and Conservation of Crocodiles: Integrating Morphology and Conservation. Lambert Academic Publishing: Saarbrücken, Germany.

Pearcy, A.G. and Wijtten, Z. (2010). Suggestions on photographing crocodile skulls for scientific purpose. Herpetological Review 41: 445-447.

Pearcy, A.G. and Wijtten, Z. (2011). A morphometric analysis of crocodilian skull shapes. Herpetological Journal 21: 213-218.

Franklin D. Ross, *Naturalis Biodiversity Center, PO box 9517, Leiden 2300RA, the Netherlands*.

Steering Committee of the Crocodile Specialist Group

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

Deputy Chairmen: Dr. Dietrich Jelden <Dietrich.Jelden@BfN.de>. Alejandro Larriera <alelarriera@hotmail.com>.

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

Regional Chairman, Southern and East Africa: Christine Lippai <lippainomad@gmail.com>. **Regional Vice Chairmen**: Dr. Alison Leslie <aleslie@sun.ac.za>; Howard Kelly <crocfarm@venturenet.co.za>.

Regional Chairman, West and Central Africa: Dr. Samuel Martin <s.martin@lafermeauxcrocodiles.com>. **Regional Vice Chairmen**: Prof. Guy Apollinaire Mensah <mensahga@gmail.com>; Christine Lippai <lippainomad@gmail.com>.

Regional Chairmen, East and Southeast Asia: Lonnie McCaskill <Lonnie.McCaskill@disney.com>, Dr. Jiang Hongxing <jianghongxingcaf@163.com>. **Regional Vice Chairmen**: Dr. Choo Hoo Giam <giamc@singnet.com.sg>; Dr. Nao Thuok <naothuok.fia@maff.gov.kh>; Uthen Youngprapakorn <thutcroc@ksc.th.com>; Yosapong Temsiripong <yosapong@srirachamoda.com>.

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

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

Regional Chairmen, Latin America and the Caribbean: Alfonso Llobet (Management Programs) <alfyacare@yahoo.com>; Dr. Carlos Piña (Human Resources Development) <cidcarlos@infoaire.com.ar>; Alvaro Velasco (Incentives for Conservation) <velascocaiman@gmail.com>; **Regional Vice Chairmen**: Hesiquio Benítez Diaz <hbenitez@conabio.gob.mx>; Marisa Tellez <marisatellez13@gmail.com>; Dr. Luis Bassetti <luisbassetti@terra.com.br>; Sergio Medrano-Bitar <faunasilvestre@gmail.com>; Manuel Tabet; Bernardo Ortiz (Regional Trade) <bernardo.ortiz@traffic.sur.iucn.org>.

Regional Chairmen, Europe: Dr. Jon Hutton <Jon.Hutton@unep-wcmc.org>; Dr. Samuel Martin <s.martin@lafermeauxcrocodiles.com>. **Regional Vice Chairman**: Ralf Sommerlad <crocodilians@web.de>.

Regional Chairmen, North America: Dr. Ruth Elsey <relsey@wlf.la.gov>; Allan Woodward <allan.woodward@myfwc.com>. **Regional Vice Chairmen**: Noel Kinler <nkinler@wlf.louisiana.gov>; Dr. Frank Mazzotti <fjma@ufl.edu>; Dr. Thomas Rainwater <trrainwater@gmail.com>.

Vice Chairman for CITES: Hank Jenkins <hank.jenkins@consol.net.au>; **Deputy Vice Chairman**: Dr. Yoshio Kaneko <gtrust@wa2.so-net.ne.jp>.

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

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

Vice Chairmen, Veterinary Science: Dr. Paolo Martelli <paolo.martelli@oceanpark.com.hk>; Dr. Cathy Shilton (Cathy.Shilton@nt.gov.au).

Vice Chairman, Zoos: Dr. Kent Vliet <kvliet@ufl.edu>.

Vice Chairman, Public Education and Community Participation: Myrna Canilan-Cureg (myrna_cauilan_cureg@yahoo.com.ph).

Vice Chairmen, General Research: Dr. Valentine Lance <valcrocdoc@gmail.com> and Dr. Mark Merchant <mmerchant@mcneese.edu>.

Vice Chairman, Legal Affairs: Curt Harbsmeier <charbsmeier@hdalaw.com>.

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

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

Task Force/Working Group Chairmen: Siamese Crocodile, Dr. Parntep Ratanakorn <parntep.rat@mahidol.ac.th>; Chinese Alligator, Dr. Jiang Hongxing <jianghongxingcaf@163.com>; Tomistoma, Bruce Shwedick <Bshwedick@aol.com>; Human-Crocodile Conflict, Allan Woodward <allan.woodward@myfwc.com>.