

**CROCODILE
SPECIALIST
GROUP
NEWSLETTER**

VOLUME 34 No. 1 • JANUARY 2015 - MARCH 2015



CROCODILE

SPECIALIST

GROUP

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VOLUME 34 Number 1
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COVER PHOTOGRAPH: Saltwater Crocodile (*Crocodylus porosus*), Australia. Photograph: Louis Guillette, Jr.

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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 crocodylians, and on the activities of the CSG. The Newsletter is distributed to CSG members and to other interested individuals and organizations. All Newsletter recipients are asked to contribute news and other materials.

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Marco Schultz, Germany.

Editorial

A report on the CSG Review Mission to Indonesia (Aug-Sep 2014) has been completed and will be available on the CSG website soon. The team conducted a limited review of some aspects of crocodilian conservation, management and farming within Indonesia, specifically: the extent to which Indonesia’s current ranching program and skin exports are compliant with CITES; options for the conservation of crocodiles in Lake Mesangat East Kalimantan; and, the increasing human-crocodile conflict. The report has recommendations, but is seen as a starting point for the CSG to renew its close connections with Indonesia, and to help where we can with crocodilian conservation and management.

The management of *Caiman crocodilus* in Colombia has long been a cause of concern to CSG members and others, because production through captive breeding is supplemented with wild harvest (ranching and wild skins), and this is not permitted under Colombian law. This may not be a conservation problem *per se*, because *C. crocodilus* is a highly productive species. But compliance with CITES, particularly the correct use of source codes, and conducting a wild harvest with no reporting in accordance with Article IV of CITES, puts Colombia’s program at risk. Following frank, positive and and conjenial discussions at the CSG Working Meeting in Lake Charles (May 2014), with both government and industry, a proposed new workplan for the conservation and management of *C. crocodilus* in Colombia has been prepared. It will be presented and discussed at the CSG

Steering Committee meeting in Siem Reap (24 May 2015).

“Christmas Croc Fest 2014” took place on 6 December 2014 at Crocodile Manor - Shawn Heflick’s facility, in Palm Bay, Florida, USA. It attracted around 200 people, and the event raised a record \$US35,000 for crocodilian conservation. Proceeds will support two conservation efforts for Philippine crocodiles (*Crocodylus mindorensis*) by the Mabuwaya Foundation and Crocodylus Porosus Philippines, Inc. (CPPI) (see pages 5-7). The AZA Crocodilian Advisory Group (CAG) has also agreed to fund Phase I of a CPPI project entitled: “Philippine Crocodile as a Flagship Species for Community-Based Sustainable Eco-tourism Model in Siargao Island: An Integration of Critical Habitat and Species Protection”.

In July 2014, the CSG welcomed news that the CITES Standing Committee had recommended the trade suspension they imposed on Madagascar (2010) with regard to Nile crocodile exports, be lifted. The trade suspension was a direct result of Madagascar’s inability to stop wild harvested skins, of all sized crocodiles, being exported as though they were the products of ranching. Madagascar was required to design and implement a series of management initiatives and safeguards, which has taken four years to complete. The CSG continues to work closely with the Malagasy authorities, helping where we can to ensure exported skins are legal, verifiable, sustainable and compliant with CITES.

There have been numerous reports of crocodiles turning up in the Maldives this year, which is a concern for the tourism industry, which is a central platform for economic development. Two of these crocodiles were captured, and media images indicated a Saltwater crocodile (*Crocodylus porosus*) and a Muggger (*C. palustris*) (Maldives authorities communicated to Brandon Sideleau that the Muggger was in fact captured in 2011). Anselm de Silva (CSG Regional Chair, South Asia and Iran) and Ralf Sommerlad (CSG Regional Vice Chair, Europe), are in contact with Government and non-government organisations, including the tourism industry, and plan to visit the Maldives in April 2015 to review and report on the situation.

In mid-February 2015 CSG Deputy Chairman Alejandro Larrera attended the CITES workshop entitled “Showcasing successful livelihoods experiences: assess and address impacts of CITES decisions on livelihoods” in Cispatá, Colombia. Participants at the workshop included 8 members of the CITES Standing Committee’s Working Group on CITES and Livelihoods, Colombian Government, CITES Secretariat, staff from the Organisation of American States staff, and other international experts. Presentations included “How to Prepare a Rapid Assessment of the impact of the implementation of CITES-listings on livelihoods of rural communities”, and “Addressing impacts on livelihoods”. Alejandro acted as a facilitator on the Crocodile group, which including a number of the representatives of the local communities currently involved in the very successful community-based management of *Crocodylus acutus* at Cispatá.

Alejandro Larrera has also been participating on the CITES

Animals Committee's Working Group on Captive Breeding, which is looking at the application of source codes and in particular the deliberate misuse of source codes. The Working Group's discussion paper will be presented to the 28th meeting of the CITES Animals Committee, in Tel Aviv, Israel (30 August-3 September 2015).

The 3rd SSC Specialist Group Chairs Meeting is scheduled to be held in Abu Dhabi on 15-18 September 2015. I will be attending, together with Executive Officer, Tom Dacey. The meeting agenda has not yet been finalized, but it will most likely follow that of the previous two Chairs' meetings. It is a great opportunity to learn how other Specialist Groups operate, and how the SSC, with such huge voluntary input through Specialist Group members, interacts with IUCN.

The Regional Meeting of Crocodile Specialist Group in Siem Reap, Cambodia, hosted by the Government of Cambodia in collaboration with the European Commission and Fauna & Flora International, will be held on 25-29 May 2015. This will be an important meeting, especially for addressing regional issues in an open and frank way. A highlight will be a Veterinary Workshop on 25 May. The CSG Steering Committee will meet on 24 May, and as usual all participants are welcome to attend. There are several agenda items to be advanced after the last meeting (May 2014), including trade issues concerning Colombia. Please make every effort to attend what promises to be a remarkably instructive meeting; details are at <http://www.csg2015cambodia.org>.

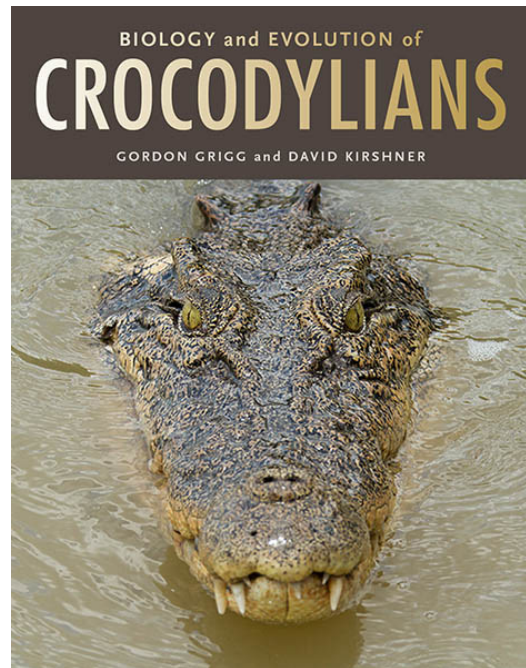
I recently endorsed the launch of a Junior Crocodile Specialist Group Program on Facebook (<http://collectiveconservation.com/programs-and-projects/junior-csg-program>) by Kelly Silvano, Director, Collective Conservation. The creation of the Junior Crocodile Specialist Group, with its own website and Facebook page, is simply a giant step in the right direction. My congratulations for the hard work that has gone into it. Some years ago the CSG realised that we were doing little to engage the youngest generations about crocodylians. Yet some young enthusiasts were knocking the door down to get involved - they wanted to learn about crocodylians and be part of the processes fostering their conservation. We have long seen our own children participating at CSG meetings, and have noted the camaraderie that develops between them, despite language and cultural differences. So why doesn't the CSG (or other Specialist Groups) reach down to the younger generations? Perhaps because it was never considered. Now, thanks to many individuals, but especially Kelly Silvano, Jennifer Andringa and Mark Merchant, it has become a reality. CSG members, like Junior CSG members, are now both going to be on a steep learning curve trying to understand and adapt to each other - profoundly important.

Heavy rainfall from Cyclone Felleng caused extensive flooding in Reunion Island, and some 16 Nile crocodiles escaped from Croc Parq into the forest of Etang-Salé, a tourist site called "Picnic Area Pond St. Louis." So far only two have been captured.

Professor Grahame Webb, CSG Chairman

Books

Biology and Evolution of Crocodylians



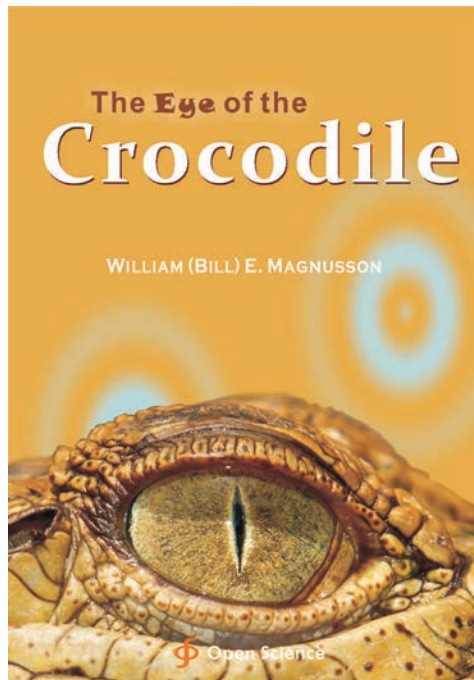
"Biology and Evolution of Crocodylians" by Professor Gordon Grigg and Dr. David Kirshner, is now available. The book is dedicated to Professor Harry Messel, who is well known to CSG members through his time as its Chairman.

Purchasers in Australia and New Zealand can obtain the book now, through CSIRO Publishing (<http://www.publish.csiro.au/pid/7185.htm>). A version of the book for the USA and rest of the world will be available from co-publisher Cornell University Press, in May 2015 (<http://www.cornellpress.cornell.edu/book/?GCOI=80140100213060>). Both versions are identical except for logo, price and bibliographic details. The ePub version, for which CSIRO Publishing has retained the worldwide rights, was made available in February 2015.

Dr. Peter Harlow, manager of the Herpetofauna Division at Taronga Zoo (Sydney), officially launched "Biology and Evolution of Crocodylians" at the Australian Society of Herpetologist's annual meeting in Eildon, near Melbourne, on 23 January 2015. Peter is a long-time friend of Gordon and David, and was a very active participant in much of their fieldwork on crocodiles in the 1970s and 1980s.

"Biology and Evolution of Crocodylians" is a comprehensive review of the current knowledge on the world's crocodylians. Gordon Grigg's authoritative text and David Kirshner's stunning artwork and color photographs (more than 500 photographs and illustrations) combine expertly in this contemporary celebration of crocodiles, alligators, caimans, and gharials. It covers the biology and ecology of the extant species of crocodylian, conservation issues, human-crocodylian interaction, and the evolutionary history of the group.

The Eye of the Crocodile



Dr. William (Bill) Magnusson has recently published “The Eye of the Crocodile”, a popular book on crocodylian research, through Open Science Publishers.

The book can be downloaded from Bill’s Researchgate page (https://www.researchgate.net/publication/272174795_The_Eye_of_the_Crocodile) - you will need to join Researchgate (it’s free) to download it.

It can also be downloaded a chapter at a time from the Openscienceonline site (<http://www.openscienceonline.com/book/newreleases/978-1-941926-14-7>), or hard copies can be purchased from the same site. If you have any problem downloading it, please contact Bill (bill@inpa.gov.br) and he will send a pdf as an attachment or a link to a copy on Google Drive.

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 January-March 2015 quarter.

1. Mayukh Dey (India): Estimation of population and habitat usage of Marsh crocodiles in Vihar Lake, Mumbai, India.
2. Pamela Leiva (Argentina): Maternal effects and their interaction with climatic factors with *Caiman latirostris* eggs and hatchlings.
3. Jessica Rhaiza Mudrek (Brazil): Population structure, diet and body condition of Cuvier’s Dwarf caiman from urban areas, mid-western Brazil.

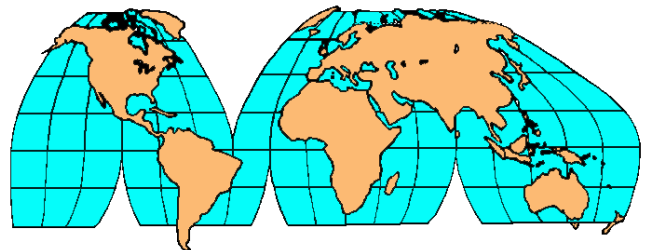
Tom Dacey, *CSG Executive Officer* (csg@wmi.com.au).

CSG Fritz Huchzermeyer Veterinary Science Student Research Assistance Scheme

The first student has been awarded funding through the Fritz Huchzermeyer Veterinary Student Research Assistance Scheme. José Fernando Aguilera González (Universidad Nacional, Costa Rica) will be carrying out an “Evaluation of the health of the American crocodile (*Crocodylus acutus*) in the Tempisque River basin, Costa Rica”.

Dr. Paolo Martelli and Dr. Cathy Shilton, *CSG Vice Chairs for Veterinary Science*.

Regional Reports



Europe

Netherlands

WORLD’S OLDEST CAPTIVE CROCODYLIAN DIES. “Hakuna”, a male Slender-snouted crocodile (*Mecistops cataphractus*), believed to be the oldest crocodylian in captivity, died in early March 2015, at an estimated 85 years of age. Hakuna and a female named “Matata” were introduced to Rotterdam Zoo as juveniles. Henk Zwartepoorte, former curator at Rotterdam Zoo, indicated in an e-mail to me in 2014 that the pair arrived at the zoo in 1933, but Weigl (2014) reported the year as 1929. The female died in July 2014, also at a ripe old age! A more detailed report is being prepared for a future CSG Newsletter.

Ralf Sommerlad, *CSG Regional Vice Chair for Europe* (crocodylians@web.de).

North America

USA

CHRISTMAS CROC FEST 2014 - A FESTIVAL FOR CROCODYLIAN CONSERVATION. Christmas Croc Fest 2014 took place on 6 December 2014 at Crocodile Manor, Shawn Heflick’s facility, in Palm Bay, Florida, USA. It attracted ~200 people (Fig. 1) and raised a new record of \$US35,000! The beneficiary was designated as the Philippine crocodile (*Crocodylus mindorensis*), which continues to be listed as Critically Endangered and is considered the rarest crocodile in the world.



Figure 1. Some of the 200 or so participants of Christmas Croc Fest 2014. Photograph: Shawn Heflick.

Event organizers were: Shawn Heflick (Director, Crocodile Manor); Curt Harbsmeier (Executive Board Member, Tampa's Lowry Park Zoo); Flavio Morrissiey (Director, Gator Adventure Productions); and, Colette Adams (General Curator, Gladys Porter Zoo). All are members of the IUCN-SSC Crocodile Specialist Group.

Proceeds will support two conservation efforts for Philippine crocodiles - one project in northern Luzon at the extreme northern part of the species' range, and one project based out of Mindanao in the south.

CrocFests are family-friendly events geared to increase awareness of and raise money for international crocodile conservation. Event-goers were treated to live animal presentations (courtesy of Gator Adventure Productions), tours of Shawn's facility, barbeque (prepared by Sonny's BBQ), Jen Heflick's legendary brownies, and an open bar. A rousing live auction was conducted by Shawn Heflick and Joe Wasilewski, keeping event-goers entertained well into the night (Fig. 2).



Figure 2. Shawn Heflick (left) and Joe Wasilewski (right) lead participants in a rowing "Toast to Crocodile Conservation" prior to the start of the auction. Photograph: Andrew Vizzacchero.

Funding will be provided to the Mabuwaya Foundation, which is continuing its work expanding and protecting the Philippine crocodile population in northern Luzon. The recovery of the population in the San Mariano area has been aided by Mabuwaya's community awareness campaigns,

crocodile nest protection and head-start programs, its establishment of economically beneficial agroforestry farms along crocodile sanctuaries, and programs to help mitigate human-crocodile conflict. Six crocodile sanctuaries have been established thanks to the work already accomplished by the Mabuwaya Foundation. Ongoing support is needed to keep researchers, team members, and community organizers on the ground to sustain these vital efforts. For more information on the Mabuwaya Foundation, see <http://www.mabuwaya.org/> and <https://www.facebook.com/mabuwaya>.

Funding will also be provided to Crocodylus Porosus Philippines, Inc. (CPPI), for the establishment of a community-based monitoring system in Paghungawan Marsh, Siargao Island Protected Landscape and Seascape. This effort is a follow-up to the 2013 release of 36 juvenile Philippine crocodiles that were hatched and raised in semi-wild conditions at Pag-asa Farm, Kapalong Davao Del Norte, Philippines. The marsh into which they were introduced has been declared a Strict Protection Zone by the Philippine Government. Funding will be used to monitor the crocodiles and to enlist and sustain local support through education and awareness campaigns. Finally, CrocFest funds will be used for a habitat suitability assessment within the Twin Lakes Balinsasayao Natural Park, Negros Oriental, for the establishment of a Philippine crocodile sanctuary there. For more information on Crocodylus Porosus Philippines, Inc. (CPPI), see http://coralfarms.com.ph/index.php?id_cms=71&controller=cms and <https://www.facebook.com/PhilippineCrocodile>.

Thanks to the generosity and commitment of the private sector, zoos, and corporate sponsors all working together, over the past 5 years, CrocFest fundraisers have so far generated over \$US120,000 for crocodiles in peril! All proceeds go directly to the crocodile projects, with event expenses covered by event organizers and sponsors.

We would like to express our appreciation to our corporate sponsors, without whose we could not easily sustain the growth this event has enjoyed over the past several years. Our sponsors for Christmas CrocFest 2014 were: Gator Adventure Productions; Crocodile Manor; Canadian Reptile Breeders Expo; ZooMed; Sonny's BBQ; The Crocodile Brothers; and, Ship Your Reptiles/The Reptile Report.

We also wish to thank all of the individuals, businesses and zoos that supported this fundraising event, including but not limited to: Shawn, Jen and Thorne Heflick; Flavio Morrissiey; Curt Harbsmeier; Colette Adams; Kelly Silvano & Collective ConSERVation; Joe Wasilewski; Megan Terry; Meghan Padgett; Crocodile Conservation Institute, Inc.; Ty Park; Norm Benoit; Kent Vliet ; Bob Krause; Trevor Watts; Jay Manchand; Phil Goss; Robert Sprackland; Jungle Island; Grahame Webb; Bruce Shwedick; Andy Daneault; Anthony Marks; Brandi-Ann; Caroline Hutchins; Central Florida Herp Society; Chris Gillette; Emily Hutchinson; Emily Maple; Gatorland; Grant Crossman; Croc U Canada Crew; Fauna Canada; Urban Jungle Radio (Danny and Andy); Paul Bodnar; Luis Izquierdo, StandUp 8 Studios; Jay Marchand; Stephanie Crockett; Claudia Harden; Katie Smith; Brooke Scharrer; Iris Griffin; Jonathan and Gus; Josh Walton; Ken Alfieri; Danielle Sheldon; Kim Titterington; Lil' Ray's Reptile Zoo; Lonnie McCaskill; Luis Carballo; Marty's Morphs; Pattie Haryn; Python Hunters; Ray Thunderhawk; Rob Art; Rob Lawracy; Tara Johnson; Temptation Boas, Mike and Devyn; Tom Crutchfield; Trey Davis; Wendy Morrissiey; Xain Lawracy; John Than ; Gary Johnson; Randal Berry; David Kledzick, Indigenous Arts; Shawn Heflick Reptiles; Gypsy Art, Barbara Nieri Hood; Omaha's Henry Doorly Zoo, Jessi Krebs; Sedgwick County Zoo, Mark Reed/Nate Nelson; Florida Association of Zoos and Aquariums; Wildlife Discovery Center, Rob Carmichael; Reptile Gardens, Terry Phillip; 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; Central Florida Zoo, David Tetzlaff; Tampa's Lowry Park Zoo, Larry Kilmar; Busch Gardens, Mike Malden; Palm Beach Zoo at Dreher Park, Andrew Aiken; and, Disney Animal Programs.



Figure 3. One of Crocodile Manor's albino American alligators symbolized the spirit of the season, the reason for Croc Fest, and the incredible spirit of giving that each participant brought along that day. Photograph: Andrew Vizzacchero.

But an important aspect that has contributed to the success of the Croc Fests has been the people who have attended time after time. Not only do participants pay an admission fee, but most also bring along an auction item - or 2, or 3... Some people spend months making a custom snake hook, a unique

knife, a personalized piece of artwork, or a hand-knitted crocodile-themed scarf - just for the auction.

Some people travel long distances to attend. One young lady from three states away makes crocodile-shaped chocolate candies and carries them to the event in an ice chest on the airplane.

And above all, despite participants having to swat bugs, dodge rain and "spend their money", they leave Croc Fest smiling and laughing and ready for next one. We are proud of our work and even more proud of the people who support it. Our sincerest thanks for your encouragement. We hope that all of you will come join us one day for a CrocFest.

Submitted on behalf of "Christmas Croc Fest 2014" organisers by Colette Adams <colettehadams@aol.com>.

Science



Recent Publications

Alvarez, G., Ceballos, F.C. and Berra, T.M. (2015). Darwin was right: inbreeding depression on male fertility in the Darwin family. *Biological Journal of the Linnean Society* 114: 474-483.

Abstract: Charles Darwin, who was married to his first cousin Emma Wedgwood, was the first experimentalist to demonstrate the adverse effects of inbreeding. He documented the deleterious consequences of self-fertilization on progeny in numerous plant species, and this research led him to suspect that the health problems of his 10 children, who were very often ill, might have been a consequence of his marriage to his first cousin. Because Darwin's concerns regarding the consequences of cousin marriage on his children even nowadays are considered controversial, we analyzed the potential effects of inbreeding on fertility in 30 marriages of the Darwin-Wedgwood dynasty, including the marriages of Darwin's children, which correspond to the offspring of four cousin marriages and three marriages between unrelated individuals. Analysis of the number of children per woman through zero-inflated regression models showed a significantly adverse effect of the husband inbreeding coefficient on family size. Furthermore, a statistically significant adverse effect of the husband inbreeding coefficient on reproductive period duration was also detected. To our knowledge, this is the first time that inbreeding depression on male fertility has been detected in humans. Because Darwin's sons had fewer children in comparison to non-inbred men of the dynasty, our findings give empirical support to Darwin's concerns on the consequences of consanguineous marriage in his own progeny.

Augustine, L. and Watkins, B. (2015). Age, fertility and reproductive behavior in Cuban crocodiles, *Crocodylus rhombifer*, at the Smithsonian's national zoological park. *Zoo Biol.* (doi: 10.1002/zoo.21204).

Abstract: The Smithsonian's National Zoological Park (NZP) has a long history with Cuban crocodiles, *Crocodylus rhombifer*,

beginning in 1900s when the first animals arrived at the NZP. Today, the Zoo has two breeding groups of *C. rhombifer* and has observed and analyzed reproductive behavior and fertility rates over the last three years. Fertility rates were determined initially by observing the formation of an opaque band that forms on the shell of a fertile egg, called banding. The fertility rates by banding were later compared to the observation made after opening the eggs to verify fertility. In addition to tracking fertility, nesting and agonistic behavior were also observed. Several notable observations were documented over the same period. These included a male predated a nesting female's eggs, increased aggression between two females housed together, the continued development of a partially banded egg, and the discovery of 19 additional egg shells post oviposition by both females in the enclosure. Here we discuss the nest phenology, fertility and behavior of the five exhibited *C. rhombifer* at the Smithsonian's National Zoological Park over a 3-year period.

Salas-Gismondi, R., Flynn, J.J., Baby, P., Tejada-Lara, J.V., Wesselingh, F.P. and Antoine, P.-A. (2015). A Miocene hyperdiverse crocodylian community reveals peculiar trophic dynamics in proto-Amazonian mega-wetlands. *Proceedings B* (doi: 10.1098/rspb.2014.2490).

Abstract: Amazonia contains one of the world's richest biotas, but origins of this diversity remain obscure. Onset of the Amazon River drainage at approximately 10.5 Ma represented a major shift in Neotropical ecosystems, and proto-Amazonian biotas just prior to this pivotal episode are integral to understanding origins of Amazonian biodiversity, yet vertebrate fossil evidence is extraordinarily rare. Two new species-rich bonebeds from late Middle Miocene proto-Amazonian deposits of northeastern Peru document the same hyperdiverse assemblage of 7 co-occurring crocodylian species. Besides the large-bodied *Purussaurus* and *Mourasuchus*, all other crocodylians are new taxa, including a stem caiman - *Gnatusuchus pebasensis* - bearing a massive shovel-shaped mandible, procumbent anterior and globular posterior teeth, and a mammal-like diastema. This unusual species is an extreme exemplar of a radiation of small caimans with crushing dentitions recording peculiar feeding strategies correlated with a peak in proto-Amazonian molluscan diversity and abundance. These faunas evolved within dysoxic marshes and swamps of the long-lived Pebas Mega-Wetland System and declined with inception of the transcontinental Amazon drainage, favouring diversification of longirostrine crocodylians and more modern generalist-feeding caimans. The rise and demise of distinctive, highly productive aquatic ecosystems substantially influenced evolution of Amazonian biodiversity hotspots of crocodylians and other organisms throughout the Neogene.

Finger, Jr., J.W., Thomson, P.C., Adams, A.L., Benedict, S., Moran, C. and Isberg, S.R. (2015). Reference levels for corticosterone and immune function in farmed saltwater crocodiles (*Crocodylus porosus*) hatchlings using current Code of Practice guidelines. *General and Comparative Endocrinology* (doi:10.1016/j.ygcen.2015.01.023).

Abstract: To determine reference levels for on-farm stressors on immune responsiveness and growth rate, 253 hatchling crocodiles from 11 known breeding pairs were repeatedly measured and blood sampled during their first year. Plasma corticosterone (CORT) was used to quantify baseline stress levels in captive animals and were found to be lower (mean $1.83 \pm SE 0.16$ ng/mL) than previously reported in saltwater crocodile hatchlings. Two tests of immune function were also conducted. Innate constitutive immunity was assessed using bacterial killing assays (BKA) against two bacterial species: *Escherichia coli* and *Providencia rettgeri*, whereby the latter

causes considerable economic loss to industry from septicemic mortalities. Although the bactericidal capabilities were different at approximately 4 months old ($32 \pm 3\%$ for *E. coli* and $16 \pm 4\%$ for *P. rettgeri*), the differences had disappeared by approximately 9 months old ($58 \pm 2\%$ and $68 \pm 6\%$, respectively). To assess immune responsiveness to a novel antigen, the inflammatory swelling response caused by phytohaemagglutinin (PHA) injection was assessed but was only significantly different between Samplings 1 and 3 (5% LSD). There were no significant clutch effects for CORT or PHA but there were for both BKA traits. CORT was not significantly associated with growth (head length) or the immune parameters except for *P. rettgeri* BKA where higher CORT levels were associated with better bactericidal capability. As such, these results suggest that the crocodiles in this study are not stressed, therefore endorsing the management strategies adopted within the Australian industry Code of Practice.

Voluntary Nature Conservancy (2015). Counting Mugger Crocodiles in Charotar-2015: Report of a Survey of the Population of the Crocodile in Charotar Conducted by Voluntary Nature Conservancy, Vallabh Vidyanagar, 10th-11th January 2015. Report prepared by Voluntary Nature Conservancy, Vallabh Vidyanagar, Gujarat, India.

Corado García, V. (2014). Abundancia relativa y situación actual de la especie *Crocodylus moreletii* en regiones prioritarias de Petén en base al Manual del Programa de Monitoreo del Cocodrilo de Pantano. BSc thesis, Universidad del Valle de Guatemala, Guatemala City, Guatemala.

Abstract: Dado que en más de diez años Guatemala no ha presentado datos continuos *Crocodylus moreletii*, el presente estudio tiene como propósito proporcionar información actualizada sobre la situación de las poblaciones dentro del país. La falta de información, no permite establecer planes de manejo ni de conservación adecuados para el cocodrilo de pantano. Esta problemática se ve ejemplificada en las reuniones tri-nacionales (México-Belice-Guatemala), donde Guatemala no posee los datos necesarios para rebatir o aceptar los términos propuestos por México y Belice para la conservación de las poblaciones silvestre de *C. moreletii*. Este trabajo lo considero de gran relevancia porque se logró monitorear sitios que no se habían estudiado en investigaciones previas. Permitiéndome obtener resultados interesantes sobre el cocodrilo de pantano, que a su vez lograron y lograrán enriquecer la base de datos de fauna en Guatemala. El informe que se presenta a continuación, servirá como base para que a mediano plazo se proponga un proyecto piloto sobre el manejo y uso sustentable de *C. moreletii*. También se busca que tanto estudiantes y comunidades locales, se involucren en el tema de conservación de esta especie a través de su importancia económica, es decir, el valor comercial que representa tanto a nivel nacional como internacional. Cabe mencionar, que la recolección de datos en este estudio se basó estrictamente en un formato establecido por el Manual del Programa de Monitoreo del Cocodrilo de Pantano. Mediante este manual se incentiva, de manera tri-nacional, que se lleve un monitoreo estándar de las poblaciones silvestres de *C. moreletii*. Con la implementación de este programa, permite que Guatemala tenga un mayor involucramiento dentro de acuerdos internacionales, que conlleva a la participación activa en la toma de decisiones sobre el manejo adecuado de las poblaciones silvestres de nuestro país, y al mismo tiempo compartir información valiosa con México y Belice.

Nell, L.A. (2014). Exploring Benefits to American Alligators (*Alligator mississippiensis*) Associating With Long-Legged Wading Bird Nesting Colonies in the Everglades. MSc thesis, University of

Florida, Gainesville, Florida, USA.

Abstract: Associations where one species enhances habitat for another nearby species (facilitation) ubiquitously shape fundamental ecosystem and community dynamics. Contrary to the notion of species interactions necessarily causing ecological niche (the environmental conditions in which a species can exist) shrinkage, facilitation can promote niche expansion, thereby influencing niche evolution and species persistence/coexistence. Communities experiencing high predation pressure are predicted to have high frequencies of predation-reducing facilitative associations. Indeed many birds facing high nest predation rates nest near formidable animals for incidental physical protection. While there is considerable evidence that protectors enhance conditions for protectees, few studies assess fitness impacts on protectors from nest protection associations. Recent research suggests that long-legged wading birds actively choose nesting sites above American alligators (*Alligator mississippiensis*), presumably to take advantage of the protection from mammalian nest predators that alligator presence offers. I hypothesized that alligators also benefit from associating with wading bird nesting colonies, and tested two predictions: food dropped from nests (nestling carcasses and regurgitant) is a potentially non-trivial food source for alligators, and 10 alligators near colonies have higher body condition than those in similar habitat without them. I installed throughfall traps in colonies to catch regurgitant, modeled nestling-carcass energy using a historic nest-success dataset, and parameterized an alligator energetic budget using reported values. Food energy per nest-week from regurgitant was less than from nestling carcasses, and the probability of a large fish dropping was very low (~2% on a given week). However, the energetic value of nestling carcasses in the study area could support hundreds of alligators for months during the dry season, when aquatic refuge is relatively scarce and females are mobilizing resources for egg-laying. I also found higher morphometric body condition (Fulton's K) in colony than non-colony adult female alligators, statistically independent of environmental factors. My evidence further suggests that the nutrition offered from wading bird nesting colonies allows alligators to expand their ecological niche into deeper water than they would otherwise be able to occupy. The results indicate clearly that wading bird nesting colonies benefit nearby alligators, and that nestlings may comprise much of the nutritional benefits. This research highlights an association that could serve as fertile ground for future work on facilitation between mobile species and, given the ecological importance of these species-groups, likely constitutes a keystone process in many tropic and subtropic wetlands.

López-Luna, M.A., Hidalgo-Mihart, M.G., Aguirre-León, G., González-Ramón, M. del C. and Rangel-Mendoza, J.A. (2015). Effect of nesting environment on incubation temperature and hatching success of Morelet's crocodile (*Crocodylus moreletii*) in an urban lake of southeastern Mexico. *Journal of Thermal Biology* (doi:10.1016/j.jtherbio.2015.01.006).

Abstract: Incubation temperature is an important aspect in terms of biological performance among crocodiles, and several controlled experiments have demonstrated a significant relationship between incubation temperature, success in hatching and survival of hatchlings. However, few studies have tested these relationships in the wild. The objective of this study was to determine the relationship of nest characteristics and environment (hatch year, nest basal area and height, clutch size, distance to shore line, and vegetation cover), to incubation temperature and hatching success among Morelet's crocodile (*Crocodylus moreletii*). The study was carried out during the nesting seasons of Morelet's crocodile, from 2007 to 2009 in the Laguna de Las Ilusiones, an urban lake located in Villahermosa, Tabasco, Mexico. We physically characterized 18

nests and inserted a temperature data logger in each nest chamber. At the end of the nesting season and prior to hatching, we recovered the crocodile eggs and data loggers and calculated hatching success, under laboratory conditions. We related the environmental variables of the nest with the mean and fluctuation (standard deviation) of nest temperature, using linear models. We also related the environmental variables affecting the nest, to mean nest temperature and fluctuation in incubation temperature and to hatching success, using linear models. Although we found differences in incubation temperature between nests, mean incubation temperature did not differ between years, but there were differences in nest thermal fluctuation between years. The mean incubation temperature for 11 nests (61.1%) was lower than the suggested female-male pivotal temperature (producing 50% of each sex) for this species, and all hatchlings obtained were males. There were no differences in clutch size between years, but hatching success varied. Our study indicates that hatching success depends on certain environmental variables and nest conditions to which the eggs are subjected, including season, nest size and clutch size. We also discuss the importance of the fluctuation of incubation temperature on hatching success and sex determination.

Robinson, J.E., Griffiths, R.A., St. John, F.A.V. and Roberts, D.L. (2015). Dynamics of the global trade in live reptiles: Shifting trends in production and consequences for sustainability. *Biological Conservation* 184: 42-50.

Abstract: Biodiversity-rich countries provide wildlife for the exotic pet trade, but the implications of this for conservation, sustainable use and livelihoods remain poorly understood. CITES Appendix II import data from 1996 to 2012 were used to analyse spatial and temporal trends in live reptiles, a group comprising a substantial component of the commercial wildlife trade. Between 2001 and 2012 the trade declined by a third. The decrease was greatest in wild-caught reptiles (70%), but imports in captive-bred reptiles also decreased (40%), due to reduced trade in green iguanas. Imports originating from captive sources comprised about half of the total trade over the period. In contrast, there was a nearly 50-fold increase in imports of ranched reptiles, dominated by royal pythons from sub-Saharan Africa, but including a recent upsurge of ranched turtles from South America and Asia. Additionally, the proportion of reptiles sourced from 'range countries' (where species naturally occur in the wild) declined. Numbers of reptiles captive-bred within consumer countries to supply domestic markets are difficult to obtain, but may be impacting international trade. Captive breeding may ease collection pressure on wild populations, but might also divert benefit flows, impacting local livelihoods. Ranching may benefit livelihoods and have low impacts on natural populations, but along with captive breeding, could be detrimental if loopholes allow wild animals to be exported as ranched. Given the shift from wild to ranched reptiles, more information is required on the benefits and impacts of commercial ranching operations for traded reptile species.

De Silva, A. and Somaweera, R. (2015). Were human babies used as bait in crocodile hunts in colonial Sri Lanka? *Journal of Threatened Taxa* 7(1): 6805-6809.

Abstract: Use of live animals as bait is not an uncommon practice in hunting worldwide. However, some curious accounts of the use of human babies as bait to lure crocodiles in sport hunting exist on the island of Sri Lanka, where sport hunting was common during the British colonial period. Herein we compile the available records, review other records of the practice, and discuss the likelihood of the exercise actually having taken place.

Rashid, S.M.A., Khan, A. and Alam, A.B.M.S (2014). Trans-boundary sanctuary between Bangladesh and India for Gharial (*Gavialis gangeticus*) conservation. Pp. 130-138 in Proceedings of the International Symposium on River Biodiversity: Ganges-Brahmaputra-Meghna River System.

Abstract: Surveys conducted to assess the status and to identify suitable habitats for Gharials (*Gavialis gangeticus*) in Bangladesh revealed that suitable habitats still exist in some secluded areas of the River Padma (Ganges). One such area is Guhomabuna (N24022'.365", E88027'.677") in Rajshahi district adjoining the Indian border where adult Gharials and hatchlings have frequently been sighted. This area shares the no-man's-land between Bangladesh and India and is relatively peaceful with low level threats. High sandy banks, deep pools serve as the nesting habitat and refuge for the Gharials. The population of Gharials in Bangladesh has reduced significantly; Gharials once used to nest at Char Khidirpur, downstream of Guhomabuna. Upstream the Farakka Barrage hinders movement of the Gharials so alternately the Gharials might have chosen the tributaries/distributaries of the Padma for their movement. Joint surveys by Bangladeshi and Indian biologists can shed more light and the area can be proposed for the creation of a trans-boundary Gharial sanctuary setting an example of transboundary cooperation.

Eversole, C.B., Henke, S.E., Ballard, B.M. and Powell, R.L. (2014). Duration of marking tags on American alligators (*Alligator mississippiensis*). Herp. Rev. 45(2): 223-226.

Stein, M., Archer, M. and Hand, S.J. (2014). Dwarfism and feeding behaviours in Oligo-Miocene crocodiles from Riversleigh, northwestern Queensland, Australia. Acta Palaeontologica Polonica (<http://dx.doi.org/10.4202/app.00134.2014>).

Abstract: Instances of dwarfism in the fossil record are of interest to palaeontologists because they often provide insight into aspects of palaeoecology. Fossil species of Australian-Pacific mekosuchine genus *Mekosuchus* have been described as dwarf, primarily terrestrial crocodiles, in contrast with the nearly ubiquitous semi-aquatic habitus of extant crocodylians (Willis 1997). This hypothesis has been difficult to test because of limited knowledge of the cranial and postcranial skeleton of extinct taxa and the continuous nature of crocodylian growth. New crocodylian vertebral material from Riversleigh, northwestern Queensland, tentatively referred to *Mekosuchus whitehunterensis* Willis, 1997, displays morphological maturity indicative of adult snout-vent length little over a half-meter, proportionally smaller than extant dwarf taxa. Further, this material displays morphology that indicates a relatively large epaxial neck musculature for its body-size. These attributes suggest this dwarf mekosuchine employed unusual feeding behaviours. The ability to perform normal death-roll, de-fleshing behaviours would be limited in a mekosuchine of such small size. Given the powerful neck muscles and other anatomical features, it is more likely that this mekosuchine killed and/or dismembered its prey using a relatively forceful lifting and shaking of the head.

Bonke, R., Whitaker, N., Rodder, D. and Bohme, W. (2015). Vocalizations in two rare crocodylian species: A comparative analysis of distress calls of *Tomistoma schlegelii* (Müller, 1838) and *Gavialis gangeticus* (Gmelin, 1789). Northwestern Journal of Zoology 11(1): art.141513.

Abstract: We analysed 159 distress calls of five individuals of *T. schlegelii* for temporal parameters and obtained spectral parameters

in 137 of these calls. Analyses of *G. gangeticus* were based on 39 distress calls of three individuals, of which all could be analysed for temporal and spectral parameters. Our results document differences in the call structure of both species. Distress calls of *T. schlegelii* show numerous harmonics, whereas extensive pulse trains are present in *G. gangeticus*. In the latter, longer call durations and longer intervals between calls resulted in lower call repetition rates. Dominant frequencies of *T. schlegelii* are higher than in *G. gangeticus*. *T. schlegelii* specimens showed a negative correlation of increasing body size with decreasing dominant frequencies. Distress call durations increased with body size. *T. schlegelii* distress calls share only minor structural features with distress calls of *G. gangeticus*.

Fey, S.B., Siepielski, A.M., Nussle, S., Cervantes-Yoshida, K., Hwan, J.L., Huber, E.R., Fey, M.J., Catenazzi, A. and Carlson, S.M. (2014). Recent shifts in the occurrence, cause, and magnitude of animal mass mortality events. Proceedings of the National Academy of Science (doi: 10.1073/pnas.1414894112).

Abstract: Mass mortality events (MMEs) are rapidly occurring catastrophic demographic events that punctuate background mortality levels. Individual MMEs are staggering in their observed magnitude: removing more than 90% of a population, resulting in the death of more than a billion individuals, or producing 700 million tons of dead biomass in a single event. Despite extensive documentation of individual MMEs, we have no understanding of the major features characterizing the occurrence and magnitude of MMEs, their causes, or trends through time. Thus, no framework exists for contextualizing MMEs in the wake of ongoing global and regional perturbations to natural systems. Here we present an analysis of 727 published MMEs from across the globe, affecting 2407 animal populations. We show that the magnitude of MMEs has been intensifying for birds, fishes, and marine invertebrates; invariant for mammals; and decreasing for reptiles and amphibians. These shifts in magnitude proved robust when we accounted for an increase in the occurrence of MMEs since 1940. However, it remains unclear whether the increase in the occurrence of MMEs represents a true pattern or simply a perceived increase. Regardless, the increase in MMEs appears to be associated with a rise in disease emergence, biotoxicity, and events produced by multiple interacting stressors, yet temporal trends in MME causes varied among taxa and may be associated with increased detectability. In addition, MMEs with the largest magnitudes were those that resulted from multiple stressors, starvation, and disease. These results advance our understanding of rare demographic processes and their relationship to global and regional perturbations to natural systems.

Nuñez Otaño, N.B., Piña, C.I., Bucsinsky, A.M. and Arambarri, A.M. (2014). Fungal diversity on broad-snouted caiman (*Caiman latirostris*) eggs, and their effects on hatchlings. The Herpetological Journal 24 (October 2014): 217-222.

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.

Ziegler, T. (2015). *In situ* and *ex situ* reptile projects of the Cologne Zoo: implications for research and conservation of South East Asia's herpetodiversity. *International Zoo Yearbook* (doi: 10.1111/izy.12084).

Abstract: In this review, some of Cologne Zoo's *in situ* and *ex situ* research and conservation projects dealing with South East Asia's reptile fauna (particularly that of Vietnam) are summarized. Diversity and ecological research linked to nature conservation within *in situ* projects are highlighted. The range of study of our German-Vietnamese research team includes taxonomy, autecology, population analyses, public awareness, and development of rescue centres and breeding stations. In the framework of *ex situ* conservation and research engagement, the roles of collection planning, species identification and biological research in zoological facilities are described with examples of monitor lizards and crocodiles.

Schmidt, F., Franke, F.A., Shirley, M.H., Vliet, K.A. and Villanova, V.L. (2015). The importance of genetic research in zoo breeding programmes for threatened species: the African dwarf crocodiles (genus *Osteolaemus*) as a case study. *International Zoo Yearbook* (doi: 10.1111/izy.12082).

Abstract: The threatened African dwarf crocodiles (genus *Osteolaemus*) are distributed throughout West and Central Africa. Traditionally two subspecies were described (*Osteolaemus tetraspis tetraspis* and *Osteolaemus tetraspis osborni*), although recent molecular studies demonstrate the presence of three allopatric lineages that should be recognized as full species. These highly divergent taxa are distributed in the three major forested biogeographic zones of western Africa: Congolian (*Osteolaemus osborni*), Lower Guinean (*Osteolaemus tetraspis*) and Upper Guinean (*Osteolaemus* sp. nov. cf. *tetraspis*). Largely because of their diminutive size, dwarf crocodiles are regularly kept in zoos and aquariums worldwide. In Europe, the collection is managed by a European studbook coordinated by Leipzig Zoo, Germany, since 2006, while American zoological institutions do not yet manage these species as part of a studbook programme. To facilitate *ex situ* conservation efforts, it is important to identify accurately each individual to the appropriate species following the latest systematic understanding of the genus. Population aggregation analysis with mitochondrial and nuclear gene sequences was used for both species identification and detection of interspecific hybridization. The results of our study show that only European collections house all three *Osteolaemus* taxa, although only a single individual *O. osborni* was confirmed. The most prevalent species present in both European and North American institutions was *O. tetraspis*. Additionally, several *O.* sp. nov. cf. *tetraspis* were identified, likely originating from the Senegambia region, especially in the North American collections. This will represent an important resource for future conservation efforts as *Osteolaemus* are highly threatened in this region of West Africa. Unfortunately, both zoo populations showed relatively high frequencies (c. 25-28%) of hybridization between *O. tetraspis* and *O.* sp. nov. cf. *tetraspis* bred in captivity. We highly recommend that zoological institutions ensure they know the species identity of the *Osteolaemus* they maintain and work together to transfer individuals into single-species colonies to avoid further hybridization. In the USA, this may necessitate the creation of a studbook programme. It may also prove valuable to consider a cooperative programme between the European Association of Zoos and Aquaria and the Association of Zoos & Aquariums,

wherein each Association focuses its resources largely on a single *Osteolaemus* species. This would, however, require trans-Atlantic transfer of individuals. The case study of dwarf crocodiles in zoological institutions reinforces the importance of genetic research in conservation-breeding programmes, highlights the potential for collaboration between European and American zoological institutions for the *ex situ* conservation of threatened wildlife, and foreshadows some of the regulatory challenges in managing captive populations internationally.

Cerda, I.A., Desojo, J.B., Trotteyn, M.J. and Scheyer, T.M. (2015). Osteoderm histology of Proterochampsia and Doswelliidae (Reptilia: Archosauriformes) and their evolutionary and paleobiological implications. *J. Morphol.* (doi: 10.1002/jmor.20348).

Abstract: Postcranial osteoderms are commonly developed in the major lineages of Archosauriformes, including forms such as proterochampsids and doswelliids. Here, we survey the histology of osteoderms of the doswelliids *Archeopelta arborensis* and *Tarjadia ruthae*, and the proterochampsids *Chanaresuchus bonapartei* and *Pseudochampsia ischigualastensis* to understand better the morphogenesis of these skeletal elements. Whereas, the Doswelliid osteoderms possess a trilaminar organization, in which two cortices (external and basal) can be differentiated from an internal core of cancellous bone, these elements are compact structures in proterochampsids. The osteoderms of *P. ischigualastensis* are avascular and they consist entirely of parallel-fibered bone. Conversely, the osteoderms of *C. bonapartei* are well vascularized structures composed of zones of woven-fibered bone and annuli of parallel-fibered bone. The rather simple microstructure observed in *P. ischigualastensis* osteoderms suggests that these elements grew at a constant, low rate. Compared with proterochampsids, doswelliid osteoderms possess a more complex histology, which appears to be linked to variations in the growth rate during the osteoderm formation and also to the development of the external ornamentation. A comparison of our findings with the results of earlier studies on other archosauriforms (phytosaur and pseudosuchians) reveals that the general osteoderm histology of doswelliids bears a closer resemblance to that of phytosaurs and pseudosuchians than the proterochampsid osteoderm microstructure. If all archosauriform osteoderms are homologous structures, the closer resemblance of doswelliid osteoderm microstructures to that of phytosaurs and pseudosuchians is in agreement with the hypothesis that doswelliids are more closely related to archosaurs than proterochampsids.

Cerda, I.A., García, R.A., Powell, J.E. and Lopez, O. (2015). Morphology, microanatomy, and histology of titanosaur (Dinosauria, Sauropoda) osteoderms from the Upper Cretaceous of Patagonia. *Journal of Vertebrate Paleontology* (doi: 10.1080/02724634.2014.905791).

Abstract: Titanosaurs are the only group of sauropodomorph dinosaurs that possesses osteoderms. The Anacleto and Allen formations (Upper Cretaceous) from northern Patagonia (Argentina) have provided an abundance of these elements, isolated or associated with more or less complete skeletons. Here, we study the morphology, microanatomy, and histology of titanosaur osteoderms found in these stratigraphic units. The size and gross anatomy of the osteoderms are strongly variable, as well as their microanatomy, which ranges from compact structures to those with strong development of cancellous bone. The primary bone tissue is composed of structural fiber bundles that are ossified by dermal metaplasia. Bone pathologies were identified in at least two osteoderms. Bone histology suggests that the osteoderms were entirely imbedded in the stratum compactum of the dermis. Titanosaur osteoderms were probably employed for

multiple functions, including mineral storage and defense.

Nomura, T., Yamashita, W., Gotoh, H. and Ono, K. (2015). Genetic manipulation of reptilian embryos: toward an understanding of cortical development and evolution. *Frontiers in Neuroscience* 9: 45. (doi:10.3389/fnins.2015.00045).

Abstract: The mammalian neocortex is a remarkable structure that is characterized by tangential surface expansion and six-layered lamination. However, how the mammalian neocortex emerged during evolution remains elusive. Because all modern reptiles have a homolog of the neocortex at the dorsal pallium, developmental analyses of the reptilian cortex are valuable to explore the origin of the neocortex. However, reptilian cortical development and the underlying molecular mechanisms remain unclear, mainly due to technical difficulties with sample collection and embryonic manipulation. Here, we introduce a method of embryonic manipulations for the Madagascar ground gecko and Chinese softshell turtle. We established *in ovo* electroporation and an *ex ovo* culture system to address neural stem cell dynamics, neuronal differentiation and migration. Applications of these techniques illuminate the developmental mechanisms underlying reptilian corticogenesis, which provides significant insight into the evolutionary steps of different types of cortex and the origin of the mammalian neocortex.

Cruze, L., Roark, A.M., Rolland, G., Younas, M., Stacy, N. and Guillette, L.J. Jr. (2015). Endogenous and exogenous estrogens during embryonic development affect timing of hatch and growth in the American alligator (*Alligator mississippiensis*). *Comp. Biochem. Physiol. B Biochem. Mol. Biol.* 184C: 10-18.

Abstract: Prenatal exposure to estrogenic endocrine disrupting chemicals (EDCs) can affect length of gestation and body mass and size of offspring. However, the dose, timing, and duration of exposure as well as sex and strain of the experimental animals determine the direction and magnitude of these effects. In this study, we examined the effects of a one-time embryonic exposure to either 17 β -estradiol (E2) or bisphenol A (BPA) on rate of development and growth in American alligators (*Alligator mississippiensis*). Our results indicate that BPA and E2-treated alligators hatched approximately 1.4 days earlier than vehicle-treated (control) alligators, suggesting that estrogenic chemicals hasten hatching in these animals. We assessed growth rates, growth allometry, and body condition for 21 weeks after hatching and found that BPA-treated alligators grew more quickly shortly after hatching but more slowly thereafter compared to control alligators. Conversely, E2-treated alligators grew more slowly shortly after hatching but more quickly thereafter compared to control alligators. As a result of differences in growth rate, BPA-treated alligators were heavier, longer, and fatter than control alligators at age 5 weeks but were similar in size and leaner than control alligators at age 21 weeks. Biochemical analytes were examined at the end of the 21-week study to assess overall metabolic condition. We found that E2-treated alligators had significantly higher circulating plasma concentrations of cholesterol and triglycerides than control alligators while BPA-treated alligators had blood profiles comparable to control alligators. Our results provide important insights into the effects of exogenous estrogens on morphology and metabolism in an oviparous, semi-aquatic reptile.

Stevenson, C. (2014). Conservation of the Indian Gharial *Gavialis gangeticus*: successes and failures. *International Zoo Yearbook* (doi: 10.1111/izy.12066).

Abstract: The Gharial *Gavialis gangeticus*, a long-snouted crocodylian endemic to the Indian subcontinent, is Critically Endangered and has teetered on the brink of extinction for the past several decades. From historical populations of perhaps 10,000 animals, Gharials numbered in the hundreds by 1974. Project Crocodile - an Indian Government initiative - became a poster boy for crocodile conservation. Based almost entirely around a head-starting programme, the effectiveness of Project Crocodile was called into question when populations crashed again in the late 1990s. In the 21st Century, with the support of the international zoo community and the International Union for Conservation of Nature/Species Survival Commission's Crocodile Specialist Group, Madras Crocodile Bank Trust began to address the shortcomings of Gharial conservation up to that point, to ensure that future plans for the species would succeed.

Sigler, L. (2015). The Crocodile Museum at Zoológico Regional Miguel Álvarez del Toro (ZooMAT), Mexico: 'How to exhibit a bullfrog' put into reality. *International Zoo Yearbook* (doi: 10.1111/izy.12090).

Abstract: Staff at the Zoológico Regional Miguel Álvarez del Toro (ZooMAT), Mexico, have acquired over several decades extensive background knowledge about various aspects of the biology and conservation of the three species of crocodylians inhabiting Chiapas; the Chiapas' caiman *Caiman crocodilus chiapasius*, American crocodile *Crocodylus acutus* and Morelet's crocodile *Crocodylus moreletii*. This knowledge was put into practice when designing a new exhibit to provide visitors with a better understanding of crocodylians. In 2003, an initiative by the government of Chiapas State to support ZooMAT with new projects and renovations, resulted in the adaptation of an unfinished building, originally constructed as an aquarium, into a Crocodile Museum, which opened in 2004. The public enters via the open jaws of a scale model of an American crocodile, and inside visitors can view graphics and displays describing the natural history and ecology of the three species in a national and international context. Murals, dioramas with mounted animals, aqua-terrariums with living crocodiles and caimans, tanks containing animals that are part of the crocodylian food chain and the skeletons of specimens of diverse sizes are all on display. Outside the building there is a contact area where guides talk to the public and provide information, and visitors are allowed to touch materials laid out on a table. There is also an amphitheatre where formal lectures are given and visitors can view the enclosures containing breeding crocodylians. From here the visitors are able to access the remaining living collection of ZooMAT.

Balaguera-Reina, S.A. and Densmore III, L.D. (2014). Legislation and conservation efforts concerning crocodiles in Colombia: A historical review. *Herpetological Review* 45(4): 638-642.

Dinets, V. (2015). Play behavior in crocodylians. *Animal Behavior and Cognition* 2(1): 49-55.

Abstract: Play behavior in crocodylians is not uncommon, but it remains virtually undescribed in scientific literature. I present the first overview of play behavior of three types (locomotor play, object play and social play) in crocodylians based on original observations, published reports and anecdotal evidence. Object play is the type most often reported; social play can include interactions with conspecifics and mammals. Apparently, play behavior is not particularly rare in crocodylians, but is underreported due to the difficulties of observing it and interpreting the observations.

Chong, A.Y., Kjeldsen, S.R. and Gongora, J. (2015). Surveys of endogenous retroviruses (ERVs) in the freshwater crocodile (*Crocodylus johnstoni*) suggest that ERVs in *Crocodylus* spp. vary between species. *Virus Genes*.

Abstract: Endogenous retroviruses (ERVs) are one of many families of transposable elements present in vertebrate genomes. We have examined the ERV complement of the freshwater crocodile (*Crocodylus johnstoni*) in order to investigate the diversity of ERVs present and possibility of ERV or retroviral activity in a diseased individual of this species. Amplification and sequencing of the highly conserved retroviral pro-pol domains revealed high levels of sequence variation in these ERVs. Phylogenetic analyses of these ERVs and those previously identified in other crocodylian species suggest that although many crocodylians share the same ERV lineages, the relative numbers of retroelement insertions from each of these lineages may vary greatly between species. The data generated in this study provide evidence for the presence of a unique and varied complement of ERVs in crocodylians. This study has also demonstrated the presence of species-specific evolution in ancient retroviral infections.

Finger, J.W. Jr., Williams, R.J., Hamilton, M.T., Elsey, R.M., Oppenheimer, V.A., Holladay, S.D. and Gogal, R.M. Jr. (2015). Influence of collection time on hematologic and immune markers in the American alligator (*Alligator mississippiensis*). *J. Immunoassay Immunochem*.

Abstract: Crocodylians are important keystone species and indicators of environmental health. Much remains unknown, however, regarding utility of field-collected crocodylian blood samples for ecologic assessments. Field sampling sites are also often distant to analysis centers, necessitating development of new techniques and panels of assays that will yield environmentally-relevant data. Stability and viability of hematological and immunological indices have been of particular interest for linking ecosystem health to biomarkers in resident species. In this study, we investigated the effect of time at analysis post-blood sampling at 4 and 24 hr on a panel of potential biomarkers in alligator blood. Our results suggest alligator blood samples can be reliably evaluated for both hematologic and immunologic profile 24 hr after sampling.

Rosenblatt, A.E., Nifong, J.C., Heithaus, M.R., Mazzotti, F.J., Cherkiss, M.S., Jeffery, B.M., Elsey, R.M., Decker, R.A., Silliman, B.R., Guillette, L.J. Jr., Lowers, R.H. and Larson, J.C. (2015). Factors affecting individual foraging specialization and temporal diet stability across the range of a large “generalist” apex predator. *Oecologia*.

Abstract: Individual niche specialization (INS) is increasingly recognized as an important component of ecological and evolutionary dynamics. However, most studies that have investigated INS have focused on the effects of niche width and inter- and intraspecific competition on INS in small-bodied species for short time periods, with less attention paid to INS in large-bodied reptilian predators and the effects of available prey types on INS. We investigated the prevalence, causes, and consequences of INS in foraging behaviors across different populations of American alligators (*Alligator mississippiensis*), the dominant aquatic apex predator across the southeast US, using stomach contents and stable isotopes. Gut contents revealed that, over the short term, although alligator populations occupied wide ranges of the INS spectrum, general patterns were apparent. Alligator populations inhabiting lakes exhibited lower INS than coastal populations, likely driven by variation in habitat type and available prey types. Stable

isotopes revealed that over longer time spans alligators exhibited remarkably consistent use of variable mixtures of carbon pools (eg marine and freshwater food webs). We conclude that INS in large-bodied reptilian predator populations is likely affected by variation in available prey types and habitat heterogeneity, and that INS should be incorporated into management strategies to efficiently meet intended goals. Also, ecological models, which typically do not consider behavioral variability, should include INS to increase model realism and applicability.

Zhang, R., Zhang, S., Zhu, X., Zhou, Y. and Wu, X. (2015). Molecular characterization of the Chinese alligator follicle-stimulating hormone β subunit (FSH β) and its expression during the female reproductive cycle. *Comp. Biochem. Physiol. B Biochem. Mol. Biol.* 183C: 49-57.

Abstract: The Chinese alligator *Alligator sinensis* is an endangered species endemic to China, it has a highly specialized reproductive pattern with low fecundity. Up to date, little is known about the regulation of its female reproductive cycle. Follicle-stimulating hormone (FSH), a glycoprotein hormone, plays a key role in stimulating and regulating ovarian follicular development and egg production. In this study, the complete FSH β cDNA from the ovary of the Chinese alligator was obtained for the first time, it consists of 843-bp nucleotides, including 120-bp nucleotides of the 5'-untranslated region (UTR), 396-bp of the open reading frame, and 3'-UTR of 327-bp nucleotides. It encodes a 131-amino acid precursor molecule of FSH β with a signal peptide of 18 amino acids followed by a mature protein of 113 amino acids. Its deduced amino acid sequence shares high identities with the American alligator (100%) and birds (89-92%). Phylogenetic tree analysis of the FSH β amino acid sequence indicated that alligators cluster into the bird branch. Tissue distribution analyses indicated that FSH β mRNA is expressed in ovary, intestine and liver with the highest level in the ovary, while not in stomach, pancreas, heart, thymus and thyroid. Expression of FSH β in ovary increases in May (breeding prophase) and peaks in July (breeding period), it is maintained at high levels through September, then decreases significantly in November (post-reproductive period) and remains relatively low from January to March (hibernating period). These temporal changes of FSH β expression implicated that it might play an important role in promoting ovarian development during the female reproductive cycle.

Turner, A.H. and Pritchard, A.C. (2015). The monophyly of Suisuchidae (Crocodyliformes) and its phylogenetic placement in Neosuchia. *PeerJ* 3:e759.

Abstract: Eusuchian crocodyliforms, which include all living crocodylians, have historically been characterized by two anatomical specializations: a ball-in-socket vertebral joint and an extensive secondary hard palate with a pterygoid-bound internal choana. The Early Cretaceous neosuchian clade Suisuchidae is typically regarded as phylogenetically near Eusuchia. The putative susisuchid *Isisfordia duncani* was initially described as a transitional form exhibiting incipient versions of these eusuchian traits. Here we examine aspects of the morphology of *Isisfordia* and comment on the morphology of its putative sister taxon *Suisuchus*. Our reexamination supports the notion of *Isisfordia* possessing transitional vertebral morphology but we present a new interpretation of its palate construction that shows it to be more plesiomorphic than previously thought. The secondary choana of *Isisfordia* is not pterygoid bound. Instead, long palatines expand distally lapping under the pterygoid to form the anterior border of the choana as is common among many advanced neosuchians. Incorporation of these observations into an expanded

phylogenetic dataset of neosuchian crocodyliforms results in a new phylogenetic hypothesis for Susisuchidae. *Isisfordia* and *Susisuchus* form a monophyletic Susisuchidae that sits near the base of Neosuchia, and is not the sister taxon of Eusuchia.

Brown, C.M., VanBuren, C.S., Larson, D.W., Brink, K.S., Campione, N.E., Vavrek, M.J. and Evans, D.C. (2015). Tooth counts through growth in diapsid reptiles: implications for interpreting individual and size-related variation in the fossil record. *J. Anat.* (doi: 10.1111/joa.12280).

Abstract: Tooth counts are commonly recorded in fossil diapsid reptiles and have been used for taxonomic and phylogenetic purposes under the assumption that differences in the number of teeth are largely explained by interspecific variation. Although phylogeny is almost certainly one of the greatest factors influencing tooth count, the relative role of intraspecific variation is difficult, and often impossible, to test in the fossil record given the sample sizes available to palaeontologists and, as such, is best investigated using extant models. Intraspecific variation (largely manifested as size-related or ontogenetic variation) in tooth counts has been examined in extant squamates (lizards and snakes) but is poorly understood in archosaurs (crocodylians and dinosaurs). Here, we document tooth count variation in two species of extant crocodylians (*Alligator mississippiensis* and *Crocodylus porosus*) as well as a large varanid lizard (*Varanus komodoensis*). We test the hypothesis that variation in tooth count is driven primarily by growth and thus predict significant correlations between tooth count and size, as well as differences in the frequency of deviation from the modal tooth count in the premaxilla, maxilla, and dentary. In addition to tooth counts, we also document tooth allometry in each species and compare these results with tooth count change through growth. Results reveal no correlation of tooth count with size in any element of any species examined here, with the exception of the premaxilla of *C. porosus*, which shows the loss of one tooth position. Based on the taxa examined here, we reject the hypothesis, as it is evident that variation in tooth count is not always significantly correlated with growth. However, growth trajectories of smaller reptilian taxa show increases in tooth counts and, although current samples are small, suggest potential correlates between tooth count trajectories and adult size. Nevertheless, interspecific variation in growth patterns underscores the importance of considering and understanding growth when constructing taxonomic and phylogenetic characters, in particular for fossil taxa where ontogenetic patterns are difficult to reconstruct.

Lainoff, A.J., Moustakas-Verho, J.E., Hu, D., Kallonen, A., Marcucio, R.S. and Hlusko, L.J. (2015). A comparative examination of odontogenic gene expression in both toothed and toothless amniotes. *J. Exp. Zool. B Mol. Dev. Evol.* (doi: 10.1002/jez.b.22594).

Abstract: A well-known tenet of murine tooth development is that BMP4 and FGF8 antagonistically initiate odontogenesis, but whether this tenet is conserved across amniotes is largely unexplored. Moreover, changes in BMP4-signaling have previously been implicated in evolutionary tooth loss in Aves. Here we demonstrate that Bmp4, Msx1, and Msx2 expression is limited proximally in the red-eared slider turtle (*Trachemys scripta*) mandible at stages equivalent to those at which odontogenesis is initiated in mice, a similar finding to previously reported results in chicks. To address whether the limited domains in the turtle and the chicken indicate an evolutionary molecular parallelism, or whether the domains simply constitute an ancestral phenotype, we assessed gene expression in a toothed reptile (the American alligator, *Alligator mississippiensis*) and a toothed non-placental mammal (the gray short-tailed opossum,

Monodelphis domestica). We demonstrate that the Bmp4 domain is limited proximally in *M. domestica* and that the Fgf8 domain is limited distally in *A. mississippiensis* just preceding odontogenesis. Additionally, we show that Msx1 and Msx2 expression patterns in these species differ from those found in mice. Our data suggest that a limited Bmp4 domain does not necessarily correlate with edentulism, and reveal that the initiation of odontogenesis in non-murine amniotes is more complex than previously imagined. Our data also suggest a partially conserved odontogenic program in *T. scripta*, as indicated by conserved Pitx2, Pax9, and Barx1 expression patterns and by the presence of a Shh-expressing palatal epithelium, which we hypothesize may represent potential dental rudiments based on the Testudinata fossil record.

Riede, T., Li, Z., Tokuda, I.T. and Farmer, C. (2015). Functional morphology of the *Alligator mississippiensis* larynx and implications for vocal production. *J. Exp. Biol.*

Abstract: Sauropsid vocalization is mediated by the syrinx in birds, and the larynx in extant reptiles; but while avian vocal production has received much attention, the vocal mechanism of basal reptilians is poorly understood. The American alligator (*Alligator mississippiensis*) displays a large vocal repertoire during mating and in parent-offspring interactions. Although vocal outputs of these behaviors have received some attention, the underlying mechanism of sound production remains speculative. Here, we investigated the laryngeal anatomy of juvenile and adult animals by macroscopic and histological methods. Observations of the cartilaginous framework and associated muscles largely corroborate earlier findings, but one muscle, the cricoarytenoideus, exhibits a heretofore unknown extrinsic insertion that has important implications for effective regulation of vocal fold length and tension. Histological investigation of the larynx revealed a layered vocal fold morphology. The thick lamina propria consists of non-homogenous extracellular matrix containing collagen fibers that are tightly packed below the epithelium but loosely organized deep inside the vocal fold. We found few elastic fibers but comparatively high proportions of hyaluronan. Similar organizational complexity is also seen in mammalian vocal folds and the labia of the avian syrinx - convergent morphologies that suggest analogous mechanisms for sound production. In tensile tests, alligator vocal folds demonstrated a linear stress-strain behavior in the low strain region and nonlinear stress responses at strains larger than 15%, which is similar to mammalian vocal fold tissue. We have integrated morphological and physiological data in a two-mass vocal fold model providing a systematic description of the possible acoustic space that could be available to an alligator larynx. Mapping actual call production onto possible acoustic space validates the model's predictions.

Bishop, B.M., Juba, M.L., Devine, M.C., Barksdale, S.M., Rodriguez, C.A., Chung, M.C., Russo, P.S., Vliet, K.A., Schnur, J.M. and Van Hoek, M.L. (2015). Bioprospecting the American alligator (*Alligator mississippiensis*) host defense peptidome. *PLoS ONE* 10(2): e0117394.

Abstract: Cationic antimicrobial peptides and their therapeutic potential have garnered growing interest because of the proliferation of bacterial resistance. However, the discovery of new antimicrobial peptides from animals has proven challenging due to the limitations associated with conventional biochemical purification and difficulties in predicting active peptides from genomic sequences, if known. As an example, no antimicrobial peptides have been identified from the American alligator, *Alligator mississippiensis*, although their serum is antimicrobial. We have developed a novel approach for the discovery of new antimicrobial peptides from these

animals, one that capitalizes on their fundamental and conserved physico-chemical properties. This sample-agnostic process employs custom-made functionalized hydrogel microparticles to harvest cationic peptides from biological samples, followed by de novo sequencing of captured peptides, eliminating the need to isolate individual peptides. After evaluation of the peptide sequences using a combination of rational and web-based bioinformatic analyses, forty-five potential antimicrobial peptides were identified, and eight of these peptides were selected to be chemically synthesized and evaluated. The successful identification of multiple novel peptides, exhibiting antibacterial properties, from *Alligator mississippiensis* plasma demonstrates the potential of this innovative discovery process in identifying potential new host defense peptides.

Nesbitt, S.J., Sidor, C.A., Angielczyk, K.D., Smith, R.M.H. and Tsuji, L.A. (2014). A new archosaur from the Manda beds (Anisian, Middle Triassic) of southern Tanzania and its implications for character state optimizations at Archosauria and Pseudosuchia. *Journal of Vertebrate Paleontology* 34(6): 1357-1382.

Abstract: The presence of early pseudosuchians and avemetatarsalians in Anisian beds of Africa demonstrates that the archosaur radiation was well underway by the beginning of the Middle Triassic. The rapid radiation produced a variety of forms, but many of the unique, well-diagnosed Late Triassic clades (eg Aetosauria, Ornithosuchidae) lack diagnosable members from the Middle Triassic. Here, we introduce a new Middle Triassic archosaur, *Nundasuchus songeaensis*, gen. et sp. nov., with an unusual mix of apomorphic character states found within Pseudosuchia and just outside Archosauria. The holotype consists of partial skeleton, including representative postcranial elements and parts of the skull. We added *Nundasuchus songeaensis*, gen. et sp. nov., into the two most comprehensive early archosaur phylogenetic data sets available, and in both analyses the new taxon falls within Pseudosuchia. However, a number of plesiomorphic archosaurian character states (eg posterolaterally directed tuber of the calcaneum) optimize as local autapomorphies of the new taxon within Pseudosuchia in our analyses. Therefore, we tested alternative hypotheses of relationships for the new taxon by utilizing constraint trees. The analyses resulted in little change in the relationships and structure of other Triassic archosaur clades, but changed optimizations of certain character states and character support at the base of Pseudosuchia and Archosauria. Our analyses suggest that the complex evolution of character-state changes at the base of Archosauria is inhibiting our understanding of the relationships of early Pseudosuchia and, in turn, Archosauria.

May, M., Balish, M.F. and Blanchard, A. (2014). The Order Mycoplasmatales. Pp. 515-550 in *The Prokaryotes - Firmicutes and Tenericutes*, ed. by E. Rosenberg, E.F., DeLong, S. Lory, E. Stackebrandt and F.Thompson. Springer-Verlag: Berlin.

Abstract: Within the class Mollicutes, the order Mycoplasmatales contains more than 160 distinct *Mycoplasma* species and 8 *Ureaplasma* species. All these species are characterized by a small genome, the result of regressive evolution from a common ancestor with *Firmicutes*. This limited genetic information is associated with numerous growth requirements and for most of them, only undefined media are available. As some of the mycoplasmas illustrate among bacteria the best concept of a minimal cell, they were selected among the first bacteria for which the genome was completely sequenced. More recently, their cell biology was further explored by a combination of “omics” approaches, and they were used as platforms for the development of new methods of synthetic biology such as genome cloning in yeast, genome transplantation, and engineering. One of the goals of these studies is the de novo

assembly of a minimal cell. The availability of genome sequences for several species, including in some cases for several strains from the same species, resulted in new methods for typing isolates, allowing improved epidemiological studies. The lack of a cell wall and a minimal genome lead to innovative solutions for cellular organization. In some species, there is a cell polarity with a tip involved in adhesion to host cells and in motility. The molecular structure of this tip is complex, and its assembly is coordinated with DNA replication and cell division. A number of *Mycoplasma* and *Ureaplasma* species are associated with significant pathologies of humans and animals. The infections caused by these organisms are chronic for most of them, which means that the bacteria have developed means to evade from the immune system of their hosts. Immune evasion by mycoplasmas takes several forms. A major one for which abundant evidence exists is variation of surface antigens. A second one, established more indirectly, is molecular mimicry by surface proteins. Finally, invasion of host cells is employed by many *Mycoplasma* species and may have a role in immune evasion. A number of virulence factors have been identified for different species; they include a small number of secreted toxins, surface polysaccharides, and several enzymes that interfere with their host’s metabolism and produce toxic products. Finally, there is a need for improved methods to control mycoplasmoses as their societal impact, in particular, in agriculture is important and in some cases increasing.

John R. Foster, J.R. and Hunt-Foster, R.K. (2015). First report of a giant neosuchian (Crocodyliformes) in the Williams Fork Formation (Upper Cretaceous: Campanian) of Colorado. *Cretaceous Research* 55: 66-73.

Abstract: A large osteoderm found in a channel sandstone in the Williams Fork Formation (“Mesaverde Group”) of northwestern Colorado represents the first reported evidence of a large neosuchian crocodyliform in the formation in northwestern Colorado. The osteoderm is of a size and pit pattern that resembles the large alligatoroid *Deinosuchus* but the thickness and shape of the bone suggest possible affinities with the goniopholidid or pholidosaurid crocodyliform material known from the Campanian of southern Utah; smaller, similar osteoderms from the formation may suggest that this form was relatively abundant as juveniles. Overall faunal similarities of the Williams Fork Formation are closest to the Kaiparowits Formation of southern Utah also, but few lower level taxa can be confirmed from the Williams Fork that are not also known from other areas north and south, suggesting that the Williams Fork vertebrate fauna comes from the southern end of a transition zone between possible latitudinal provinces of Laramidia.

Milic, N.L., Davis, S., Carr, J.M., Isberg, S., Beard, M.R. and Helbig, K.J. (2015). Sequence analysis and characterisation of virally induced viperin in the saltwater crocodile (*Crocodylus porosus*). *Developmental & Comparative Immunology* (doi:10.1016/j.dci.2015.03.001).

Abstract: A number of pathogens have been detected in crocodiles, however little is known about their ability to control these pathogens. The interferon stimulated gene (ISG), viperin, has gained attention recently as an important host protein involved in multiple arms of the immune response. Viperin in concert with a number of other ISGs was upregulated in response to viral nucleic acid mimics and sendai virus in the *C. porosus* cell line, LV-1, indicating an intact early innate response to viral infection in these animals for the first time. Viperin was cloned from the LV-1 cell line and shown to have similar localisation patterns as human viperin, as well as demonstrating extremely high conservation with the human

orthologue, excepting at the N-terminus. Interestingly, *C. porosus* viperin was also able to inhibit Dengue virus replication *in vitro*, showing a high level of intact functionality for this protein across divergent animal species, and perhaps demonstrating its importance in the early innate response to pathogens in the animal kingdom.

Patathananone, S., Thammasirirak, S., Daduang, J., Chung, J.G., Temsiripong, Y. and Daduang, S. (2015). Bioactive compounds from crocodile (*Crocodylus siamensis*) white blood cells induced apoptotic cell death in hela cells. *Environ. Toxicol.* (doi: 10.1002/tox.22108).

Abstract: Crocodile (*Crocodylus siamensis*) white blood cell extracts (WBCex) were examined for anticancer activity in HeLa cell lines using the MTT assay. The percentage viability of HeLa cells significantly decreased after treatment with WBCex in a dose- and time-dependent manner. The IC50 dose was suggested to be approximately 225 µg/mL protein. Apoptotic cell death occurred in a time-dependent manner based on investigation by flow cytometry using annexin V-FITC and PI staining. DAPI nucleic acid staining indicated increased chromatin condensation. Caspase-3, -8 and -9 activities also increased, suggesting the induction of the caspase-dependent apoptotic pathway. Furthermore, the mitochondrial membrane potential ($\Delta\Psi_m$) of HeLa cells was lost as a result of increasing levels of Bax and reduced levels of Bcl-2, Bcl-XL, Bcl-Xs, and XIAP. The decreased $\Delta\Psi_m$ led to the release of cytochrome c and the activation of caspase-9 and -3. Apoptosis-inducing factor translocated into the nuclei, and endonuclease G (Endo G) was released from the mitochondria. These results suggest that anticancer agents in WBCex can induce apoptosis in HeLa cells via both caspase-dependent and -independent pathways.

Willberg, E.W. (2015). A new metriorhynchoid (Crocodylomorpha, Thalattosuchia) from the Middle Jurassic of Oregon and the evolutionary timing of marine adaptations in thalattosuchian crocodylomorphs. *Journal of Vertebrate Paleontology* (doi: 10.1080/02724634.2014.902846).

Abstract: Metriorhynchid thalattosuchians represent the most extreme archosaurian adaptation to the marine realm. Metriorhynchids possess aquatic adaptations throughout the skeleton. These adaptations were so extensive that some have suggested that they lost the ability to move on land, yet their evolutionary timing remains unresolved. The closest relatives of the metriorhynchoids, the teleosauroids, lack these aquatic adaptations, and the earliest metriorhynchoids are known exclusively from cranial material. Here I describe a partial skull with associated forelimb elements of a new marine crocodylomorph, *Zoneait nargorum*, gen. et sp. nov., of Aalenian-Bajocian age from the Snowshoe Formation of east-central Oregon. Phylogenetic analysis identifies *Zoneait* as the sister taxon to Metriorhynchidae. It possesses a derived skull with orbits that are more laterally directed and prefrontals that are more expanded than in other basal metriorhynchoids. The preserved forelimb elements are less derived. The humerus is elongate in comparison with that of other metriorhynchoids. The ulna is slightly reduced in length and flattened but resembles the teleosauroid condition more so than the plate-like element of metriorhynchids. This suggests that marine adaptations in metriorhynchoids were acquired in mosaic fashion, with modifications of the skull preceding forelimb reduction, with this forelimb reduction occurring first in the zeugopodial elements, prior to reduction of the humerus. This evolutionary timing has important implications for the transition from nearshore ambush predation to pelagic open-marine predation in Thalattosuchia, suggesting that adaptations related to prey detection and capture preceded the locomotor adaptations that allowed these organisms to

fully invade the oceans.

Aureliano, T., Ghilardi, A.M., Guilherme, E., Souza-Filho, J.P., Cavalcanti, M. and Riff, D. (2015). Morphometry, bite-force, and paleobiology of the Late Miocene Caiman *Purussaurus brasiliensis*. *PLoS ONE* 10(2): e0117944.

Abstract: *Purussaurus brasiliensis* thrived in the northwestern portion of South America during the Late Miocene. Although substantial material has been recovered since its early discovery, this fossil crocodylian can still be considered as very poorly understood. In the present work, we used regression equations based on modern crocodylians to present novel details about the morphometry, bite-force and paleobiology of this species. According to our results, an adult *P. brasiliensis* was estimated to reach around 12.5 m in length, weighing around 8.4 metric tons, with a mean daily food intake of 40.6 kg. It was capable of generating sustained bite forces of 69,000 N (around 7 metric tons-force). The extreme size and strength reached by this animal seems to have allowed it to include a wide range of prey in its diet, making it a top predator in its ecosystem. As an adult, it would have preyed upon large to very large vertebrates, and, being unmatched by any other carnivore, it avoided competition. The evolution of a large body size granted *P. brasiliensis* many advantages, but it may also have led to its vulnerability. The constantly changing environment on a large geological scale may have reduced its long-term survival, favoring smaller species more resilient to ecological shifts.

Kumal, P.M. and Maharjan, M. (2014). Some helminth parasites of Gharial from Chitwan National Park, Nepal. *Nepal Journal of Science and Technology* 25(2): 37-40.

Abstract: A study on helminth parasites on captive gharial (*Gavialis gangeticus*) was conducted during July-December 2012 at Gharial Breeding Centre, Kasara, Chitwan National Park to isolate, identify and find out their prevalence. Dead Gharial hatchlings were collected directly from the centre in fresh and frozen conditions. Out of 85 samples examined, 40 samples 47.06% as prevalence rate of helminth parasites. During the study three helminth parasites were first reported from the Gharials of Nepal; Pentastomid (*Sebekia* sp.), Capillarioids and Ascaridoids. The dead hatchlings were found to be infected with Pentastomid (41.17%), Ascaridoids (7.05%), Capillarioids (1.17%), *Proctocaecum gairhei* (3.52%) and *Exotidendrium* sp. (36.47%). In the month of December helminth parasites showed highest prevalence; *Sebekia* sp. (100%) and *Proctocaecum gairhei* (75%) and *Exotidendrium* sp. (100%) and the lowest prevalence in the month of July; *Sebekia* sp. (4%), Capillarioids (4%) and *Exotidendrium* sp. (8%).

Hernández, O., Graterol, G., Espín, R., Ernesto, E., Forti, M. and Amauci, J. (2014). Evaluation of the use of fish as food supplement for *Crocodylus intermedius* hatchlings. *Bol. Acad. C. Fís., Mat. y Nat.* Vol. LXXIV No. 2

In FUDECI (ZF) and Rancho Masagueral (ZFPM) breeding farms are sought determine the best conditions for growth of offspring from crocodiles at the lowest cost. Normally fed horse meat, but every time the offer is limited, so alternatives must be sought. During 2011-2012 the Puripargo28® and fish were evaluated as potential dietary supplements. In the ZF two diets were evaluated for 233 days (August to April), containing 70% horse and 30% Puripargo28® (D1) and another with 33.3% horse, 33.3% fish, and 33.3% Puripargo28® (D2), with a density of 0.88 ind/m², with 2 groups (n= 49 c/u). In ZFPM two diets were evaluated for 307 days

(June-April), with 100% horse (D3) and another with 70% horse and 30% Puripargo28® (D4), a density of less than 0.62 ind/m², with two groups (n= 50 each). They were fed a ration of 8% of live weight, 5 (ZF) and 6 (ZFPM) times a week, supplementing with vitamins and minerals. Both tests showed homogeneity of variance and t-tests were applied. In ZF were no significant differences in length and weight to both diets was found. In ZFPM significant differences were found. We discussed the results and their implications.

Parlin, A., Dinkelacker, S. and McCall, A. (2015). Do habitat characteristics influence American alligator occupancy of barrier islands in North Carolina? *Southeastern Naturalist* 14(1): 33-40.

Abstract: The geographic range of the American alligator (*Alligator mississippiensis*) extends to North Carolina, where information on populations is limited. In North Carolina, American alligators are found near the coast, but typically not on the extensive barrier-island chain known as the Outer Banks. The goal of our study was to determine if habitat varied among sites occupied by American alligators on islands - the Outer Banks and Roanoke Island - and sites on the adjacent mainland. Water depth, variance in water depth, turbidity, salinity, conductance, and pH varied among sites on Roanoke Island from sites on the mainland (P= 0.008) and the Outer Banks (P= 0.001). However, sites on the mainland and the Outer Banks were similar (P= 0.536). Ultimately, American Alligators may access the Outer Banks and find suitable habitat, but to date, little research has examined American alligator habitat use in this portion of its geographic range; long-term occupancy is probably limited by of the effects of human disturbance and major storm events.

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 *P. 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.

Submitted Publications

NETTOSUCHUS AND SOME RULES LIMITING CROCODYLIAN NOSE HOLE LOCATION. In the living and fossil Crocodylia, all of the teeth on each mandibular ramus erupt and then grow and elongate to stick vertically upwards (or very rarely point essentially horizontally outwards) from dentary bone. At the ventral front end of the head there is an anterior midline suture (the mandibular symphysis) dividing the left lower jaw from its symmetrically opposite right ramus, and separately there are some more or less transverse sutures located clearly behind and posterior to the back end of the tooth row on each lower jaw, but neither the left nor the right mandible's ramal tooth row has a suture located within it and transversely crossing it. There are only two rows of teeth on the combined and articulated lower-jaws (one left, and one right), and thus each of these two mandibular tooth rows is uninterrupted and is itself an independent and continuous dental series (and each is on its own dentary bone).

In contrast to the lower jaws, the left and right rows of teeth on the skull each have an upper-jaw suture transversely crossing within them, and this inflexible and rigid joint separates the teeth and alveoli of the premaxillary bone from those of the maxillary bone. Thus, on each of the lateral edges of the crocodylian head, the oppositional and biting relation between the superior and inferior tooth rows consists of two upper jaw (skull) bones versus one individual bone on the lower jaw. All of the premaxillary teeth interdigitate with some (more anterior) dentary teeth, and separately also of all of the maxillary teeth interdigitate with some other (more posterior) dentary teeth.

Because it contains a suture within it, each total row of upper-jaw teeth includes a special structural situation where it is not possible for a tooth to erupt. Thus, on each upper jaw there is this one special place where the suturing together between the premaxillary and maxillary bones creates an edentulous (toothless) space, and this obligatory diastema (space between teeth) is always located between premaxillary tooth #5 and maxillary tooth #1. It is therefore not surprising that when, as in the *Alligator* and *Crocodylus* families, there is one particularly differentially enlarged lower tooth (invariably dentary #4), it will always stick up between premaxillary #5 and maxillary #1. Separately and yet relatedly, although not differentially enlarged, there is also a mandibular tooth (dentary #4) that sticks up into the diastema in question in *Gavialis*.

Note that the earliest crocodylian fossils also had the 4th dentary tooth sticking up outside the skull and interdigitating with (and between) premaxillary #5 and maxillary #1. As evidenced by the obvious notch in the edge of the skull to accommodate it, the 4th mandibular tooth in the *Protosuchia* was differentially and clearly the largest individual on each lower jaw, and in this respect the *Protosuchus* dentition closely resembled *Crocodylus* (and slightly less so *Alligator*), as compared with and differing from *Gavialis* (and slightly less so *Tomistoma*), in the latter of which dentary #4 is present and correctly situated, but not notably enlarged in comparison

with its immediate lower jaw neighbors.

It is generally predicted that when dentary #4 (at the level of the lateral ends of the premaxillo-maxillary suture) is considerably larger and longer and stronger than its immediately neighboring lower jaw teeth, then by consequence and compensating for it, somewhere on the premaxillary bone and usually separately somewhere on the maxillary bone there will be at least one similarly specially enlarged upper jaw tooth sticking down from each of the two germane skull bones, and thereby a three-parted (tripartite) oppositional relationship of two uppers (sticking down) and between them one lower tooth sticking up mechanism for grabbing and holding prey is created. The premaxillary component of this common and often encountered tripartite arrangement is ordinarily premaxillary tooth #3 or #4, and sometimes #3 and #4 can both enlarge and then work together to produce this effect. The maxillary component is tooth #5, or #4, or (only in selected fossils) #3, and sometimes maxillary #5 and #4 become functionally co-enlarged and the two work together. Oddly however, in the extremely peculiar genus *Sarcosuchus* it is maxillary #10 which is differentially enlarged and performs the traditional maxillary #5 function, partly because the skull is so enormously large and long, and partly because of an extraordinary development (an experiment that failed to survive the test of time) in the premaxillary tooth-row region.

Throughout the Crocodylia the limiting factor in all of the discussion above is that there are never more than five alveoli on each premaxillary bone. Five is the primitive number, and when the count of premaxillary teeth that are present is reduced to four, it is premaxillary #2 that has been deleted. Thus, premaxillary #5 is always present, and it is always followed posteriorly by a projection of tooth-row bone that is genetically controlled to absolutely never generate a tooth. Similarly maxillary #1 is always present to some degree, and there is some amount bone, located immediately anterior to it, that will not ever produce a tooth.

The premaxillo-maxillary suture across each of the two lateral total tooth-rows of the skull is bordered both fore and aft by the bone required for creating the alveoli of its immediately adjacent teeth (premaxillary #5 and maxillary #1). The length of this diastematic space between these two upper-jaw teeth is dictated by the distance required for accomplishing the sutured joint between the maxillary and premaxillary bones, and includes additionally the surface bone required for constructing the alveolar socket for maxillary #1, and even more so for premaxillary #5.

Another dorsal surface of the skull rule that is true throughout the Crocodylia is that the maxillary bones are excluded from the surface edges of the opening(s) for the external nares. Regardless of whether there is one hole with two nostrils in it, or two holes (one for each nostril), the external narial opening(s) are always separated from the maxillaries by a surface space of premaxillary bone. This fact, coupled with the rule that no more than five premaxillary teeth are possible on each side of the crocodylian rostrum, and the fact that fewer than four is extremely uncommon (and extinct), creates a set

of restrictions that limits the range of variation in head shape.

Further, the nose hole(s) are always separated from the actual anteriormost tip(s) of the snout by premaxillary bone, and this also includes the absolute forward end of the rostral midline. Additionally the lateral bony surface edges of the combined pair of external nares are always separated from the skull's germane outside edges by dorsal premaxillary bone, and there is always at least some premaxillary surface bone posterior to the nose hole(s), although not always along exactly all of the posterior narial edge(s), because in some taxa the nasal bones reach and variously enter (but never completely cross) the nostrils region along the midline, and thus in these cases the posterior edge(s) of the external nares consists of premaxillary bone on both the left and the right sides, but between them there is nasal bone located along the dorsal midline region. Note that the rostral tip end of the bony internarial septum is, when present, composed of premaxillary bone. Similarly, when the septum is not completely ossified, its anterior fraction is cartilage of premaxillary origins.

The dorsal view shape and locational position of the external narial aperture(s) are variable within a set of limits that involve the presence of premaxillary bone on the forward, and the lateral, and at two parts of the total posterior edge of the germane dorsal opening(s). The nose hole(s) can extend posteriorly to, and sometimes even slightly beyond, the transverse level of the 4th mandibular tooth. This special level is simultaneously also the upper tooth-row and skull-edge level of the premaxillo-maxillary suture, and also simultaneously always distinctly related to the obligatory diastema between premaxillary alveolus #5 and maxillary tooth #1, which is the phenomenon most crucial and fundamental in the evolutionary formation of the suite of rostral region rules that keep crocodiles from becoming too much like phytosaurs. In a theoretical sense, the order Phytosauria had heads shaped like those of crocodiles, but with their nostrils obeying only a selected few of the crocodylian rules, and the difference is remarkable.

Factors limiting how far posteriorly the nose hole(s) can extend are the rule that the maxillary bones on the dorsal surface can not reach and contact the external nares, and the rule that the premaxillary bones that perform this function are limited to no more than five alveoli each. Note that the length of the tooth row part of the modern eusuchian premaxillary bone is little influenced by whether there are five teeth or four (or possibly fewer in selected fossils), because when the reduction to four occurs (as in at least some adult *Tomistoma*), it is to accommodate an enlarged mandibular tooth that functionally fills the space. However, there may possibly have been some selected extinct crocodylians in which the number of premaxillary teeth was reduced to a widely spaced three, which is still less than five, and if real I presume that premaxillary #5 is still the most posterior of the germane teeth present, as illustrated by Westphal (1962; p. 5 and 102).

Because of the internarial septum that separates one nostril from the other, there are significant interpretational difficulties concerning the anterior and posterior ends of the nose hole(s), and therefore I suggest that the transverse level

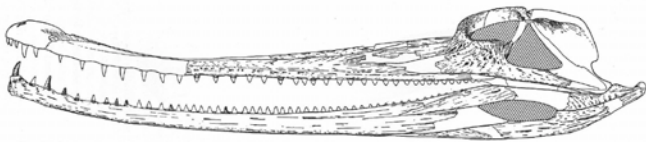


Figure 1. Lateral view of the bones of the head of the remarkably “duckbilled” fossil *Nettosuchus atopus*. From Langston (1965; p. 66).

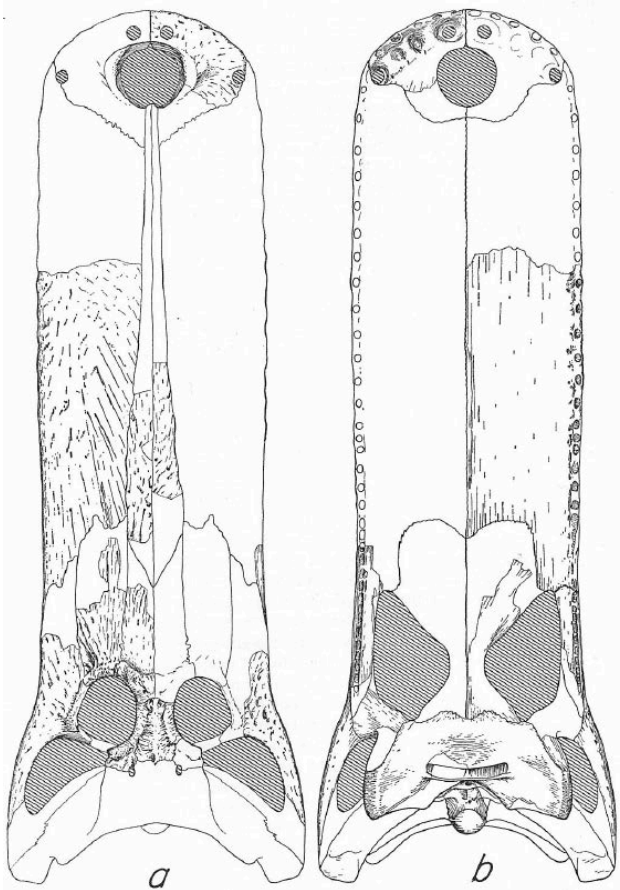


Figure 2. Dorsal (a) and ventral (b) views of the skull of *Nettosuchus atopus*. From Langston (1965; p. 67).

of the maximal front and maximal back ends of this skull-opening(s) structure is most meaningfully and homologously measured through points that are offset (left and right) and are thus located an appropriate distance away from and to either side of the absolute midline. I suspect that the position and shape details of the external nares are probably of relatively limited value. However, it is important that the crocodylian nose is always situated in the same basic place that has its center rarely located at, or more commonly and normally located some variable but limited midline distance forward of the transverse level of the 4th dentary tooth. The distal limiting factor is that left and right premaxillary bone always separates the narial orifice(s) from the absolute anterior tip(s) of the skull.

Problematically, any “turtle-jawed crocodylian” is probably outside of the Crocodylia if toothless, but hypothetically if a turtle-jawed crocodylian had a strongly modified dentition with rows of chisel-pointed teeth that, side by side, form continuous knifelike cutting edges, then it was merely an inventive evolutionary “dead end” experiment that died out

relatively quickly. There may also be fossils, for example *Steneosaurus bollensis* and *Platysuchus multiscrobiculatus* as illustrated by Westphal (1962), in which the spaces between adjacent upper jaw and separately lower jaw teeth are larger than expected, producing a long and thin snout with fewer than expected thin teeth.

In contrast to the uncertainty associated with the various few extinct crocodylian (or almost crocodylian) fossils that have dramatically reduced their number of teeth, I note that the relatively modern (Late Miocene) eusuchian fossil with the largest number of teeth, all of them small and all of them pretty much (but not exactly) the same size as each other, is the monotypic South American (Colombia: La Venta) genus *Nettosuchus* Langston, 1965, with its single known species *N. atopus*. In this taxon, as shown in Figure 1, the 4th premaxillary upper tooth is slightly larger than its neighbors, and on the lower jaw there are two relatively large teeth (dentary #1 and dentary #4) that work in opposition to it, creating a tripartite grabbing and holding mechanism, although not particularly strongly. In this *Nettosuchus* case with two differentially enlarged (and widely separated) mandibular teeth sticking up in opposition to one enlarged skull tooth sticking down in the center of the wide space between them, it is not merely an accidental coincidence that dentary #4 is one of the three teeth in question. Not shown, the mandibular symphysis is remarkably short. The lower jaws suture together to make an anterior end curve that transversely crosses the midline without differentially thickening, as illustrated in Langston (1965; p. 58).

Nettosuchus atopus obeys the five premaxillary teeth rule (Fig. 2), and its dorsal view maxillary bone is separated from the nose hole by rostral surface premaxillary bone, and the lateral ends of the transverse dorsal premaxillo-maxillary suture is correlated with the diastema between premaxillary alveolus #5 and maxillary tooth #1, and further correlated with a differentially enlarged dentary #4. Note that in this particular extreme example the center of the nose hole coincides closely with the level of the 4th dentary teeth, as opposed to the narial center being distinctly anterior to the 4th mandibular tooth level, and note also that the lateral edge of the maxillary bone reaches slightly farther forward than expected and normal in the Crocodylia, accomplishing an extreme of variation but without violating the rostral region’s several rules.

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