

**CROCODILE  
SPECIALIST  
GROUP  
NEWSLETTER**

VOLUME 35 No. 2 • APRIL 2016 - JUNE 2016



# CROCODILE

# SPECIALIST

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# NEWSLETTER

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VOLUME 35 Number 2  
APRIL 2016 - JUNE 2016

IUCN - Species Survival Commission

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**COVER PHOTOGRAPH:** Central African slender-snouted crocodile (*Mecistops* sp. nov. cf. *cataphractus*) basking on the Bongo River, Moukalaba-Doudou National Park, Gabon. Photograph: Matthew Shirley.

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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**

Life for the CSG and its members always seems to go in “ups” and “downs”, but on 27 June 2016 we hit a real “down”. Pamela Ashley, well known to most CSG members, informed us that Don Ashley had died, after a battle with cancer. Don was one of the early pioneers of sustainable use in the CSG, and one of the few people who had attended all CITES meetings. He was the CSG Vice-Chairman for Trade. We will publish more on Don’s distinguished career in the next newsletter, and on behalf of the CSG I’ve ensured the Ashley family know our thoughts are with them.

On the “up” side, in May 2016 some 352 participants, from 43 countries, attended the 24th CSG Working Meeting held in Skukuza, South Africa (23-26 May). It was a wonderful meeting, preceded by the Future Leaders Working Group workshop (19-20 May), Veterinary Workshop (21 May) and CSG Steering Committee meeting (22 May). Minutes of the Steering Committee meeting are on pages 4-10, and a summary of the working meeting on pages 10-13. The Castillo Award for Crocodile Conservation was awarded to Dr. Alison Leslie (South Africa), and the CSG Chairman’s Encouragement Award went to Nathalie Kpera (Benin).

A number of thematic and working groups met during the working meeting (eg Veterinary Science, Future Leaders, Zoos, Public Education & Community Participation, IUCN Red List, human-crocodile conflict), and their reports will be available in the Proceedings (which will be provided in electronic form).

The Executive Committee has been operating with Deputy-Chairs Dietrich Jelden and Alejandro Larriera, Executive Officer Tom Dacey, and my colleague Charlie Manolis giving

me an enormous amount of help and support. As Dietrich will be standing down, while the CSG workload is increasing, we decided to expand the Executive, with Perran Ross, Christine Lippai and Charlie Manolis as new CSG Deputy Chairs. A number of new Steering Committee members were also appointed: Nathalie Kpera (Benin), Fabian Schmidt (Germany), Adrian Sugiarto (Indonesia), Rainier Manalo (Philippines), Kornvika Youngprapakorn (Thailand), Adrian Grabriel (Sri Lanka), Matthew Brien (Australia), Sally Isberg (Australia), Pablo Siroski (Argentina), Laura Porrás Murillo (Costa Rica), Sergio Balaguera-Reina (Colombia), Luke Evans (Sabah, Malaysia), Oswald Braken (Sarawak, Malaysia) and Manuel Muñoz (Mexico).

In April 2016 I visited Indonesia, and together with Dr. Widodo Ramono, Erick Wiradinata, Adrian Sugiarto and Helen Kurniati (LIPI), met with senior Government officials, about continuing our cooperative efforts to ensure the remnant *C. siamensis* population in Lake Mesangat, East Kalimantan, remains secure. The Steering Committee recommended that the IUCN Director General should write to the Indonesian President on behalf of the IUCN to both congratulate Indonesia for its efforts to date, and to urge his support for the ongoing conservation actions needed to safeguard this population.

Mexico, Malaysia, Colombia and Madagascar have submitted amendment proposals for consideration at CITES CoP17 (Johannesburg, South Africa; 24 September-5 October 2016) (see page 7). Each of the proponents has sought review of its proposal by the CSG at different stages of their development, and these in turn were distributed to at least 120 CSG members with appropriate expertise, with comments provided back to the proponents. All four proposals have merit.

Congratulations to Dr. Matthew Shirley, CSG Regional Chair for West & Central Africa and Chair of the CSG Future Leaders Working Group, who was one of three recipients of a “Future For Nature Award 2016” (see <http://futurefornature.org/?p=1755>). This is a highly competitive award, and a measure of the caliber of some CSG members.

The CSG’s Best Management Practices for Crocodilian Farming, which provides guidance to informed and uninformed sources on current best management practices, has now been finalized. It is available on the CSG website (<http://www.iucncsg.org/pages/Best-Management-Practices-for-Crocodilian-Farming.html>), and so far, has been very well received. I am grateful to the many reviewers who assisted with the development of the CSG-BMP, and in particular to the donors who supported this long overdue CSG initiative.

Two-thirds of the Crocodile Capacity Building Manual has now been completed, and these sections have been posted on the CSG website (<http://www.iucncsg.org/pages/Crocodilian-Capacity-Building-Manual-.html>). The remaining 10-12 sections are being allocated to select CSG members for completion. Once again, this initiative actively extends a great deal of knowledge and experience on all aspects of crocodilian conservation, management and sustainable use.

A limited number of comments were received from CSG members on the draft Code of Professional Ethics, and are currently under consideration, prior to finalization of the document.

A Crocodile Symposium organized by Dr. Mark Merchant and Professor Wu Xiaobing will be held under the auspices of the 8th World Congress of Herpetology (Hangzhou, China, 15-21 August 2016). A number of CSG members are participating in the Congress. Some members of the CSG Future Leaders Working Group will also participate, and do a study tour of Chinese alligator habitats, raising facilities and relocation program prior to the Congress.

Other future meetings of interest to the CSG include: the IUCN World Congress (Hawaii, USA, 1-10 September 2016; 67th and 68th meetings of the CITES Standing Committee (Johannesburg, South Africa, 23 September 2016, 5 October 2016); 17th Conference of the Parties to CITES (CoP17), Johannesburg, South Africa, 24 September-5 October 2016).

The 25th CSG Working Meeting will be held in Santa Fe, Argentina, in May 2018. Details will be posted as soon as they become available.

Professor Grahame Webb, *CSG Chairman*.

### CSG Student Research Assistance Scheme

The CSG Student Research Assistance Scheme (SRAS; <http://www.iucncsg.org/pages/General-Information.html>) provided funding to 3 students in January-June 2016, bringing the total approvals for the year to 3.

1. Maria Soledad Moleon (Argentina): Immunological investment in Broad-snouted caiman (*Caiman latirostris*) under stressful conditions.
2. Matthew Hamilton (USA): Using crocodilian scute tissue as an integrative approach to investigating long-term environmental stressors.
3. Jessica Williams (UK): Modelling gharial movement in the Chambal Sanctuary.

Tom Dacey, *CSG Executive Officer*, <[csg@wmi.com.au](mailto:csg@wmi.com.au)>.

### Second Crocodile Attack Recorded in Iran

On 10 July 2016, a 10-year-old boy was killed by a Mugger crocodile (*Crocodylus palustris*) at Azadi Pond, in the Gandou protected area. This represents the second recorded crocodile attack in Iran. A more detailed report will be provided soon.

Asghar Mobaraki, *Department of Environment, Biodiversity and Wildlife Bureau, P.O. Box 14155-7383, Tehran, Iran, (amobaraki@yahoo.com)* and Elham Abtin, *Department of Environment, Sistan and Baluchestan Provincial office, Zahedan, Iran (ala\_saly@yahoo.co.uk)*.

## Minutes of CSG Steering Committee Meeting, Skukuza, 22 May 2016

Meeting opened at 0920 h.

Present:

SC Members: Grahame Webb, Alejandro Larriera, Tom Dacey, Charlie Manolis, John Caldwell, Mark Merchant, Simone Comparini, Christine Lippai, Lonnie McCaskill, Perran Ross, Paolo Martelli, Samuel Martin, Howard Kelly, Alison Leslie, Eric Langelet, Alvaro Velasco, Carlos Piña, Marisa Tellez, Luis Bassetti, Sergio Medrano-Bitar, Allan Woodward, Thomas Rainwater, Kevin van Jaarsveldt, Kent Vliet, Val Lance, Phil Wilkinson, Matthew Shirley, Enrico Chiesa, Cathy Shilton, Jerome Caraguel

Others: Sukenao Iida, Rainier Manalo, Michael Cruz, Samson Samuel, Sally Isberg, Agata Staniewicz, Helen Crowley, Laura Porras Murillo, Columbus Chaitezvi, Danny Govender, Paul Reilly, Maria Alejandra Camargo, Matthew Brien, Brandon Sideleau, Rob Gandola, Alba Imhof, Juan Larriera, Mick Burns, Peter Watson, Craig Watson, Sergio Balaguera, Joe Partyka, Sebastian Brackhane, Lauren Augustine, Miryam Venegas, Weber Girardi, Hannes Botha, Russell Lowers, Benjamin Parrott, Ashley Percy, Jeff Lang, Shawn Heflick, Miriam Boucher, Pablo Siroski, Mohamed Ezat, Rachel Clulee, Danielle Kelly, Csaba Geczy, Julien Medrano Hoyos, Mariana Medrano, Tapiwanashe Hanyire, Robbie McLeod, Robert Godshalk, Adrian Sugiarto, Valerie Garcia, Gowrie Mallapur, Silke Pfitzer, Manuel Muñiz, William Belo, Caren Belo, Brian Sibongga, R.J. Rao, Hector Raisa, John Calderon, Mrs. Calderon, Alexander Meurer, Georges Hedegbetan, Joni Acay, Myrna Cureg, Charles Caraguel, Stephane Korvin, Xavier Gavaldon, Rafael Zarazua, Jaimie Gongora

Apologies, Steering Committee Members: Choon Heong Koh, Yoichi Takehara, Dietrich Jelden, Guy Apollinaire Mensah, Jiang Hongxing, Giam Choo Hoo, Steve Peucker, Anslem de Silva, Ruchira Somaweera, Maheswar Dhakal, Raju Vyas, Abdul Aleem Choudhury, Asghar Mobaraki, S.M.A. Rashid, Alfonso Llobet, Hesiquio Benítez Dias, Manuel Tabet, Bernardo Ortiz, Jon Hutton, Ruth Elsey, Noel Kinler, Frank Mazzotti, Yoshio Kaneko, Hank Jenkins, Don Ashley, Jorge Saieh, Thomas Kralle, Chris Plott, James McGregor, Steve Broad, Curt Harbsmeier, Bruce Shwedick, Thomas Ziegler, Parntep Ratanakorn, Yosapong Temsiripong, Bernardo Ortiz, Nao Thuok, Uthen Youngprapakorn

Apologies, CSG Members: Chris Banks, Gordon Grigg, Pierre Charruau

#### 1. Executive Reports

##### 1.1. Chairman's Report

CSG Chairman Grahame Webb opened the meeting, welcomed participants, and thanked South African National Parks for hosting the regional meeting and

the South African crocodile industry organisations for sponsoring the meeting.

One minute's silence was held for the loss of CSG members since the last Steering Committee meeting in Cambodia: Ralf Sommerlad (Germany), Jean-Pierre Austruy (French Guiana), Professor Harry Messel (Australia), Louis J. Guillette Jr. (USA), Winston Kay (Australia), Walter Herd (France) and David Blake (South Africa).

The Chairman presented an overview of where the CSG fits within the IUCN Species Specialist Commission and how the CSG includes a wide range of members, that includes science, industry, government, etc. He also discussed how the CSG supports "sustainable use" issues within the IUCN-SSC structure.

The Chairman reported on the establishment of the Future Leaders Working Group (FLWG) and the 2-day FLWG workshop held on 19-20 May 2016, and the Executive Meeting held on 21 May 2016.

Members were advised of important future meetings covered elsewhere in the agenda:

- 8th World Herpetology Congress, Hangzhou, China, 15-21 August 2016.
- IUCN World Congress, Honolulu, Hawaii, USA, 1-10 September 2016.
- 67th meeting of the CITES Standing Committee, Johannesburg, South Africa, 23 September 2016.
- 17th Conference of the Parties to CITES (CoP17), Johannesburg, South Africa, 24 September-5 October 2016.
- 68th meeting of the CITES Standing Committee, Johannesburg, South Africa, 5 October 2016.

The report was noted.

#### 1.2. Minutes and actions from SC Meeting, Siem Reap, Cambodia

The agreed Minutes and Actions from the previous meeting were noted with the opportunity of participants to comment on any issues.

#### 1.3. Executive Officer's Report

The Executive Officer presented his report, highlighting:

- Current CSG Steering Committee membership is 67 people
- CSG membership comprises 563 people from 63 countries
- Regional offices are currently maintained in Latin America & the Caribbean (Argentina), South Asia & Iran (Sri Lanka) and East & Southern Africa (South Africa)

- The CSG Student Research Assistance Scheme has approved 99 applications since its inception in 2009, including two applications approved under the Fritz Huchzermeyer Veterinary Science Student Research Assistance Scheme.

The report was noted.

#### 1.4. CSG/IACS Financial Report

The Executive Officer reported that:

- (a) A "not-for-profit" NGO (International Association of Crocodile Specialists -USA Inc.) was now established in USA, and is managed by Perran Ross and Curt Harbsmeier. US donations to this account may be tax deductible.
- (b) The IACS bank balance, which is designed primarily as an endowment fund to financially sustain CSG operations, at 31 March 2016, was \$AUD790,507 (approximately \$US603,789).
- (c) The IACS Annual General Meeting was held on 28 October 2015, noting the Audit report and approving the re-election of office bearers.

Financial reports, IACS annual report and IACS audit statement were noted.

## 2. Regional Reports

### 2.1. East & Southern Africa

The report presented by Regional Chair Christine Lippai was coordinated with the assistance of the two Regional Vice Chairs, Alison Leslie and Howard Kelly.

Christine Lippai advised that she had been in contact with Jon Hutton regarding the African Survey Database, and will follow up with him on options to reactivate this database.

The report was noted.

**Action 1:** Christine Lippai to report back on options for reactivating the African Survey database.

### 2.2. West & Central Africa

The report was presented by Regional Chair Matthew Shirley, highlighting:

- Success of the 3rd CSG West and Central Africa Regional Meeting held in Abidjan, Cote d'Ivoire. The Proceedings will be posted on the CSG website shortly.
- Unspent funds from this meeting in Cote d'Ivoire enabled the participation of 9 people from the region at the 24th Working Meeting in South

Africa.

- Cooperation is underway with some NGOs interested in mechanisms for restricting illegal trade.
- Samuel Martin has resigned as joint Regional Chair for the region, due to work commitments, but will continue as a CSG member with special interest in the region.

The report was noted.

### 2.3. East & Southeast Asia

The report was presented by Regional Chairman Lonnie McCaskill, highlighting:

- (a) Cambodia: There have been recent changes in Government administration, but WCS and FFI continue their work on the development of a strategy for reintroducing *C. siamensis* back into the wild.
- (b) Philippines:
  1. Mabuwaya Foundation program;
  2. Crocodylus Porosus Philippines Inc. (CPPI) program; and,
  3. Progress with the development of the “Conservation and Management Plan for Crocodiles in the Philippines, 2016-2020”.

The CSG Chairman highlighted the cooperation between industry and conservation successes in the Philippines.

The report was noted.

#### 2.3.1. Lake Mesangat, East Kalimantan, Indonesia

The Chairman summarized the history of LIPI and CSG members finding a wild population of the Critically Endangered *C. siamensis* at Lake Mesangat, East Kalimantan, Indonesia, and how this stronghold for the species has been eroded by oil palm development over the last decade.

In 2014 a CSG review team visited Lake Mesangat, confirming ongoing habitat destruction for oil palm, water diversion structures designed to drain the swamp, and the adverse impacts on local people particularly fishermen.

The Chairman re-visited Indonesia in April 2016, and with CSG member Adrian Sugiarto met with the new Indonesian Director of Conservation, the Director General of Forestry, and the Provincial Regent. They all agreed that Lake Mesangat needed urgent conservation action and were committed to assisting. A survey is

being considered for the next dry season (commencing July 2016), with assistance of satellite imagery from the Wildlife Conservation Society, to quantify the extent of habitat loss due to oil palms.

Given the ongoing destruction of Lake Mesangat, the support expressed for conservation action by Indonesian Government representatives at National and Provincial level, and the complicated status with oil palm leases clashing with conservation interests, the Steering Committee agreed unanimously that the IUCN Director General and Chairman of the Species Survival Commission should write directly to the Indonesian President about the need to conserve Lake Mesangat and its *Crocodylus siamensis* population.

The report was noted.

**Action 2:** Executive Officer to coordinate preparation of letter to Indonesian President and contact IUCN Director General through the Chair of the SSC.

### 2.4. Australia & Oceania

Regional Chair Charlie Manolis provided a brief overview, highlighting human-crocodile conflict (HCC) incidents in Australia, Timor-Leste and the Solomon Islands.

The report was noted.

### 2.5. South Asia & Iran

Regional Chair Anselm de Silva was unable to attend the meeting. Jeff Lang gave a brief overview of the current situation in Nepal, particularly with regard to the abundance of wild female Gharial and the reduction in fertility and egg production in the captive population.

The Chair established a working group of Jeff Lang, Samuel Martin and the Nepalese delegates to meet and discuss the issues in Nepal and come back to the plenary with a report.

The report was noted.

**Action 3:** Working group to report on Nepalese issues at plenary.

### 2.6. Latin America & the Caribbean

Deputy Chairman Alejandro Larriera presented the report, highlighting:

- (a) Argentina: growing production with ranching operations - 35,000 skins exported annually

- (19,663 *C. latirostris* and 15,704 *C. yacare*).
- (b) Brazil: Exported 13,000 *Caiman yacare* skins and 874 *Melanosuchus niger* skins.
  - (c) Central America: discussion was held on the possibility of a CSG review mission to Central America, and possibly the Caribbean to summarise current conservation and management issues, provide information, and identify contacts (focal points) in each country (eg Guatemala, El Salvador, Panama Honduras, Belize, Mexico, Nicaragua, Costa Rica, Cuba and Jamaica).
  - (d) Colombia:
    1. Proposal to CITES CoP17 to transfer from Appendix I to Appendix II, pursuant to Resolution Conf. 11.16 (Rev. CoP15) on ranching, the population of *Crocodylus acutus* of Cispatá Bay and nearby sections of the Estuarine Delta of Sinu River in the Department of Córdoba.
    2. *Crocodylus intermedius* program.
  - (e) Mexico:
    1. Proposal to CITES CoP17
    2. National Morelet's Crocodile Monitoring Program
  - (f) Venezuela: *Caiman c. crocodilus* harvest, 17,000-19,000 per year.

In respect of the suggestion for a separate Central America and Caribbean region, the Chairman suggested that those interested should form a Working Group to meet during the meeting and come back with a suggested way forward on this issue.

The report was noted.

**Action 4:** Working group to report back to meeting at plenary on possible establishment of Central American and Caribbean region.

#### 2.6.1. & 2.6.2. Jamaica update

Perran Ross addressed the paper, highlighting:

- (a) Successful fund raising events raised over \$US26,000 to support conservation of *C. acutus* in Jamaica, including relocations and the “Crocodile Conservation Fair” organized by the “Jamaica Crocodile Working Group”.
- (b) The persecution and killing of crocodiles continues at an alarming rate.
- (c) Particular concern over the situation with the Goat Islands, where a Chinese corporation is planning to build an international trans-shipping terminal.

The report was noted.

**Action 5:** Perran Ross was requested to draft a CSG letter that the Chairman could send to the Jamaican authorities.

#### 2.7. Europe

Thomas Ziegler and Fabian Schmidt were unable to attend the meeting - the report was noted.

#### 2.8. North America

Joint Regional Chair for North America, Allan Woodward, presented the report, highlighting:

- (a) There are 11 States with alligator programs (8 undertaking ranching and 3 undertaking wild harvesting).
- (b) The successful conservation programs are also now experiencing HCC problems. They are currently developing policies on alligator removal.
- (c) Louisiana and Florida are working on developing CITES tags with a barcode.
- (d) There was a general discussion on the benefits/non-benefits of the TV “alligator” programs (Swamp People in Louisiana and Gator Boys in Florida). Generally, it was thought that such programs were beneficial to the conservation of alligators and crocodiles.

The report was noted.

### 3. Thematic Group Reports

#### 3.1. CITES

Vice Chair Hank Jenkins did not attend the meeting. The Executive Officer highlighted:

- (a) Four amendment proposals were submitted for consideration at CoP17; Colombia (*C. acutus* in Cispatá Bay), Mexico (*C. moreletii*), Malaysia (*C. porosus*) and Madagascar (*C. niloticus*).
- (b) CSG representatives Hank Jenkins and Matthew Shirley participated at CITES Animals Committee (AC28) (Tel Aviv, 2015) and participated in discussions on: application of correct CITES codes; and, global traceability system for reptile skins, prepared by RESP and submitted by Mexico and Italy.

Matthew Shirley provided an overview on what happened with these issues at AC28.

The CSG Chairman provided some background on the RESP group and issued a warning for people to be very careful when dealing with RESP, because they appear to be promising traceability outcomes to fashion companies, and funding support to producer nations, but delivering neither. The technical expertise required to assess crocodylian production in any country is considerable as evidenced by the newly published CSG Best Management Practices

for Crocodilian Farming. He suggested it was more an industry than conservation issue and that industry members should take the opportunity to discuss the RESP issue and see if there might be a positive way forward.

The report was noted.

#### 3.1.1. Colombia proposal (*Crocodylus acutus*)

The paper was addressed by the Chairman, advising that this was a unique project that had been operating for some 10 years, in a small but clearly defined area. Colombia was now seeking to have a formal ranching program that will have benefits for the local community. The CSG had offered comments to Colombia on early drafts of its proposal.

The report was noted.

#### 3.1.2. Mexico Proposal (*Crocodylus moreletii*)

Mexico is seeking to remove the “zero quota” for trade in the wild population of *C. moreletii*. The CSG had offered comments to Mexico on a proposal summary during the drafting stage, but the final version of the proposal was not provided to CSG before it was submitted to the CITES Secretariat.

The report was noted.

#### 3.1.3. Malaysia proposal (*Crocodylus porosus*)

The CSG Chairman provided the background to this proposal. Sarawak was seeking a down-listing for *C. porosus* that would allow for controlled use, that could be integrated into its overall conservation and management program increasingly threatened by increasing HCC. The CSG offered comments to Malaysia on its proposal during the drafting stage.

The report was noted.

#### 3.1.4. Madagascar proposal (*Crocodylus niloticus*)

The Chairman provided the background on the current Appendix-II ranching program, how it was initially implemented, the role of the artisanal industry, the inability of Madagascar to manage use of the resource, which eventually led to trade in *C. niloticus* from Madagascar being banned by CITES for 4 years. To rectify the situation Madagascar was now proposing to retain the Appendix-II listing, but under Resolution Conf. 9.24 (Rev. CoP15), with several notations. This allows more flexibility with management and

an opportunity to sustain the artisanal leather industry that has significant livelihood advantages.

The report was noted.

#### 3.1.5. Notes on sustainable use of crocodilians

The paper submitted by Yoichi Takehara was addressed by the Chairman, emphasizing the statement - “If only we, CSG, can somehow devise a system that distributes the profits from ranching to all the people whose habitat overlaps with that of crocodiles, I think the situation will improve”.

The report was noted.

#### 3.1.6. Colombia Update

The CSG Chairman addressed the issue of *Caiman c. fuscus* farming in Colombia, highlighting:

- (a) Within Colombia, the farming of *Caiman c. fuscus* is legally restricted to closed captive breeding (since 1990), which is a stricter domestic measure (not required by CITES).
- (b) But considerable numbers of caimans come from the wild through ranching and wild skin harvest, which contravenes Colombian laws and thus CITES.
- (c) Export of wild skins using CITES source codes for captive-bred, is a further ongoing CITES infraction. The EU has picked up on the source code issue.
- (d) At the CITES Standing Committee meeting in January 2016, the EU held fruitful bilateral meetings with Colombia that resulted in a formal “Declaration” by Colombia, to stop the export of large wild harvested skin pieces, particularly flanks (by 28 February 2016), and to legalise the current illegal ranching program in Colombia (by 31 May 2016).
- (e) Colombia needs to be congratulated for its commitment to the EU to rectify the wild harvest and ranching problems, which after 25 years have become institutionalized.
- (f) Delivery on the first deadline (CITES Notification 2016/017) did not restrict the export of wild skins, and had various other problems. The time frame Colombia committed itself to, to solve the wild harvest problem, was unrealistically short, and production

and exports of ranches and wild skins continues unabated.

- (g) The second deadline (31 May 2016) has only just passed, and CSG anticipates Colombia will indeed stop the export of wild harvested skins and legalise ranching by that time.
- (h) Resolution of these issues by Colombia, first raised in Standing Committee in the early 1990s, will ideally be fully reported at the next Standing Committee meeting prior to CITES CoP17 (Johannesburg, South Africa, 24 September-5 October 2016).
- (i) Clear demonstration that Colombia is implementing the many laws it has concerning crocodilians, and specifically *Caiman crocodilus fuscus*, before CoP17, will be critical to the Parties having confidence in the Colombian proposal to transfer its Cispatá Bay population of *C. acutus* from Appendix I to Appendix II for ranching.

The report was noted.

### 3.2. Industry

In the absence of Vice Chair Don Ashley, the Chairman addressed the report. Two major issues include:

- (a) Animal welfare issues - it is important for all crocodilian producers and the industry to recognize the need to be pre-emptive and proactive concerning animal welfare issues, and to rely on science-based rather than emotion-based evidence.
- (b) The CSG has produced a manual “Best Management Practices for Crocodilian Farming”, now available on the CSG website, which should assist managers and industry to better understand the role of animal welfare in the production of crocodilians.

The report was noted.

### 3.3. Trade Monitoring

The report was presented by Vice Chair John Caldwell, who highlighted:

- (a) Two further IACTS reports have been completed (Caldwell 2014 and Caldwell 2015) and these can be accessed through links on the CSG website (<http://www.iucncsg.org/pages/Farming-and-the-Crocodile-Industry.html>).
- (b) Missing CITES Annual Reports for 2014 include Argentina, Indonesia, Lao PDR, Malawi and Uganda. Reports for 2013 are also

missing for Uganda and Zambia.

The report was noted.

### 3.4. Veterinary Science

The report was presented by Joint Vice Chair Paolo Martelli, highlighting:

- (a) Continuation of the Fritz Huchzermeyer Veterinary Science Student Research Assistance Scheme (FHVS-SRAS).
- (b) The veterinary science group currently has 20 members.
- (c) Preparation of the “Health Assessment Guidelines for Crocodile Releases” is progressing.
- (d) List of most important veterinary conditions of farmed crocodilians is proceeding.
- (e) The veterinary science website is being updated in four languages.
- (f) Continue to hold veterinary workshops preceding CSG Working Meetings. In Skukuza 50 participants were able to attend the veterinary workshop.

The report was noted.

### 3.5. Zoos

The report was addressed in some detail by Vice Chair Kent Vliet, highlighting a wide range of matters, including:

- (a) Passing of Ralf Sommerlad.
- (b) 16th annual training course in “Crocodilian Biology and Captive Management”.
- (c) The CAG maintains official studbooks on 8 species of Critically Endangered and Endangered crocodilian species.
- (d) CAG has provided funding for a number of crocodilian projects.
- (e) Organizing of “Croctober” fundraising events.
- (f) Various activities in Europe and Latin America.
- (g) Promotion of World Tomistoma Day in August 2016 by Bruce Shwedick (CSG-TTF) and Rob Stuebing.

The report was noted.

### 3.6. Public Education & Community Participation

The paper was addressed by Vice Chair Myrna C. Cureg, highlighting:

- (a) Establishment of the PECP group and its Terms of Reference (July 2014)
- (b) A number of case studies have been gathered for presentation at the Working Meeting.
- (c) An out-of-session workshop with interested people will be held during the Working Meeting,

which will report back to the Plenary session on the last day.

The report was noted.

**Action 6:** PECP to report back to plenary of working meeting.

### 3.7. General Research

The paper was addressed by Joint Vice Chair Mark Merchant highlighting:

- (a) Publication of special issue of the South American Journal of Herpetology, using some of the papers presented at the 23rd CSG Working Meeting (May 2014).
- (b) The 8th World Herpetology Congress being held in Hangzhou, China, 15-21 August 2016, which will include a Crocodylian Symposium. Papers are being presented by various CSG members (Charlie Manolis, Mark Merchant, Marisa Tellez-Kohlman, Pablo Siroski, Paolo Martelli, Matthew Shirley) and Chinese researchers.
- (c) Proceedings from the Louisiana meeting are now available from Mark Merchant.
- (d) Proposal by Mark Merchant to host a "Crocodylian Genetics Meeting" in the 2nd week of August 2017.

The report was noted.

**Action 7:** Executive Officer to follow up on details for proposed genetics meeting with Mark Merchant.

### 3.8. Legal Affairs

Vice Chair Curt Harbsmeier was unable to attend the meeting. Issues discussed included:

- (a) Establishment of a charitable (not-for-profit) organisation in the USA (International Association of Crocodile Specialists-USA Inc.) to support the CSG. Donations to this organization may be tax deductible.
- (b) Bank Account established for IACS-USA Inc.
- (c) Development with the Chairman of a proposed CSG Code of Professional Conduct to act as an interim code pending the development of an overarching SSC Code.

The report was noted.

### 3.9. IUCN Red List Authority

Vice Chair Perran Ross addressed his report, highlighting:

- (a) Significant advances have been made in training a cadre of Red List assessor/coordinators. Sally Isberg, Robbie McLeod and Olivia Plume have completed the on-line SSC Red List training.

- (b) Draft assessment for *C. johnstoni*, currently in review, suggesting it may be Least Concern (LC).
- (c) *C. suchus* may be Vulnerable (VU A2bd; C1). An assessment team of Nathalie Kpera, Ekke Waitkuwait, Stephane Kehou, Gabriel Segniabeto and Shawn Heflick will refine the draft.
- (d) A re-assessment of *Alligator sinensis* confirms its status remains Critically Endangered [CR Aib,B1ab+2ab(ii);C1+2a(i)].

The report was noted.

## 4. Task Forces/Working Groups

### 4.1. Tomistoma Task Force

CSG-TTF Vice Chair Bruce Shwedick was unable to attend the meeting. It was subsequently learned that the TTF report that was provided to the Steering Committee was not the current report, and the correct report will be circulated to CSG Steering Committee members out-of-session.

**Action 8:** Executive Officer to circulate CSG-TTF report to SC members out-of-session.

### 4.2. Siamese Crocodile Task Force

SCTF Chair Parntep Ratanakorn was unable to attend the meeting - the report was noted.

### 4.3. Future Leaders Working Group

The report was presented by FLWG Chair Matthew Shirley, highlighting:

- (a) History on the recent formation of the Future Leaders Working Group.
- (b) Intensive 2-day workshop at Skukuza, just prior to the SC meeting, involving a group of young and senior CSG members.
- (c) Considerable discussion on the future directions of the CSG.
- (d) Proposed FLWG side-event to be held during the working meeting, with a report back to Plenary.

The report was noted.

**Action 9:** FLWG to report back to Plenary.

## 5. General Business

### 5.1. Best Management Practices

Charlie Manolis advised that version 1 of the Best Management Practices for Crocodylian Farming has

been completed and is now accessible on the CSG website. The BMP is considered to be a “living” document that will be updated as new knowledge becomes available, etc.

The report was noted.

## 5.2. Crocodilian Capacity Building Manual

Charlie Manolis provided an explanation on the background and current progress with this project. Two-thirds of the sections are complete and will be added to the CSG website by Colin Stevenson very shortly. The remaining 10-12 sections will be allocated to select members during the course of the working meeting.

The report was noted.

**Action 10:** Completed sections of the CCBM to be loaded onto CSG website as a matter of urgency.

**Action 11:** Charlie Manolis and Colin Stevenson to identify authors of remaining sections of the CCBM.

## 5.3. Junior CSG Program

Mark Merchant and Shawn Heflick provided an electronic version of a report, as there was insufficient time to provide it to the Steering Committee for discussion.

**Action 12:** Executive Officer to circulate the Junior CSG Report to SC members out-of-session.

## 6. 25th CSG Working Meeting

Deputy Chairman Alejandro Larriera advised that the 25th Working Meeting will be held in Santa Fe, Argentina, in the second or third week of May 2018 - possibly 7-11 May. He also provided an overview of the proposed meeting venue, accommodation options, meeting sponsors, etc. A formal submission has been made to the Chairman.

Meeting closed at 1530 h.

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## 24th CSG Working Meeting, Skukuza, South Africa, 23-26 May 2016

The CSG’s 24th Working Meeting was convened at the Nombolo Mdluli Conference Centre at Skukuza Rest Camp, Kruger National Park, South Africa, from 23-26 May 2016. It was attended by 292 delegates and 60 accompanying family, who took over 95% of the Camp. South African National Parks (SANParks), represented by Dr. Danie Pienaar, hosted the meeting, and many sponsors provided financial support. The principal non-government sponsors were Exotic Leather

South Africa (ELSA; Stefan van As) and the Ranchers Association of South Africa (Rob Reader).

The theme for the meeting was “Crocodiles, Communities and Livelihoods”, and included a strong emphasis on crocodile-related issues from the southern African region. Presentations covered: species conservation, veterinary disease and research, markets and trade, human-crocodile conflict, and crocodilian husbandry. The organising committee (Christine Lippai, Howard Kelly, Alison Leslie, Danny Govender, Xander Combrink, Silke Pfitzer, Jan Myburgh) ensured that the venue, program, sponsors, entertainment, etc., were in place. An event organiser, “Inside Edge” (Tersia Tegmann, Hendrik Tegmann, Angus Morton), was contracted to assist with the complex logistic arrangements required to bring delegates from 43 countries (Argentina, Australia, Benin, Brazil, Burkina Faso, Cambodia, Colombia, Costa Rica, Cote d’Ivoire, Czech Republic, Denmark, France, Gabon, Germany, Egypt, Ghana, Guatemala, Hong Kong (China), India, Indonesia, Ireland, Israel, Italy, Japan, Mexico, Mozambique, Namibia, Nepal, Netherlands, Nigeria, Norway, Panama, Papua New Guinea, Philippines, Slovakia, South Africa, Spain, Taiwan, United Arab Emirates, United Kingdom, United States of America, Venezuela, Zimbabwe), and SANParks and the organising committee are especially grateful to Inside Edge.

The CSG’s Future Leaders Working Group (FLWG) took the opportunity to hold a 2-day workshop on 19-20 May 2016, where a number of senior CSG members were able to “mentor” some younger CSG members in the history of the CSG, how it operates under the IUCN, involvement with CITES, etc.

The working meeting was preceded by a Veterinary Workshop on 21 May 2016 in the Elephant Reception Room at the Game Processing Plant (Skukuza). Unfortunately, participation had to be capped at 50 participants. Enormous thanks are extended to Dr. Danny Govender (SANParks) for organising the venue and coordinating the event together with Dr. Paolo Martelli and Dr. Cathy Shilton (Vice Chairmen of CSG’s Veterinary Science Group), Dr. Jan Myburgh and Dr. Silke Pfitzer. The Veterinary Workshop concluded with a safari drive and “sundowners” atop a rock in the bush.

The CSG Steering Committee meeting was held on 22 May 2016 and was attended by 30 Steering Committee members and 64 observers. Prior to addressing the packed agenda, the Chairman called for 1-minute silence in memory of CSG members who had passed away since the previous meeting. The Steering Committee meeting was followed by a cocktail reception and welcome (Dr. Danie Pienaar), including loud and enthusiastic traditional drumming and dancing.

The opening of the working meeting on 23 May 2016 began with the CSG Chairman Professor Grahame Webb being led into the conference venue by Praise Singer Shadrack, who gave a traditional blessing for the meeting in three languages - English, Zulu and Shangaan. The South African National Anthem was beautifully performed by infant children from

the Skukuza Village School. The meeting was opened by Professor Webb following an official welcome by Mr. Glen Phillips, the Managing Executive of SANParks.

In addition to the oral presentations, working groups and thematic groups met during the meeting [eg Veterinary Science (Dr. Paolo Martelli and Dr. Cathy Shilton), CSG IUCN Red List Authority (Dr. Perran Ross), Public Education and Community Participation (PECP; Dr. Myrna Cureg), Zoos (Dr. Kent Vliet), Future Leaders Working Group (Dr. Matt Shirley)], as did members interested in human-crocodile conflict (HCC). A particularly interesting non-crocodilian side event presentation on Rhino Poaching & Rhino Health in Kruger National Park was given by Markus Hofmeyer (SANParks).

The first day of the meeting was dedicated to “Africa’s Crocodiles: From Kruger to Beyond”, beginning with a keynote address from Dr. Danie Pienaar on the Research History in the Kruger National Park and ending with a variety of presentations from the North, West and Central Africa regions. For some presenters, this was their first time participating in a CSG meeting, and some made presentations in English, which is not their primary language. An afternoon dealing with HCC culminated in a PECP-dedicated session which then continued in a working group meeting at the end of the first day.

A thematic day focused on Veterinary, Genetics and Behavioural Ecology began with a keynote address on the “Wicked Problem of a large scale crocodile mortality event” by Dr. Danny Govender, and several presentations explored the veterinary and dietary aspects of the pansteatitis crisis, the environmental health, chemical pollution and exotoxicology in the Olifants River of South Africa, and the possibility of using non-invasive means to measure physiological stress as a biomonitoring tool. Pollution and poisoning were highlighted through two presentations of research carried out on American alligators, as well as through poster presentations.

By special request, and following an interactive e-mail dialogue between CSG members, Larissa McLeod spoke about Hidden Danger in Working with Crocodiles; several images will linger in many delegates’ memories for quite some time! Presentations on the fascinating response of crocodilian mothers to the calls of their offspring, as well as the acoustics of American crocodiles in Belize, kicked off the session on Behavioural Ecology, which also showcased the new research being carried out on crocodilian colour change in response to exposure to visible light (Agata Staniewicz) and adaptation to its environment (Dr. Mark Merchant).

An afternoon session dedicated to Reproductive Biology, Genetics and Immunology, and Captive-breeding & *In-situ* Conservation included a diversity of presentations, including: variations in nest temperature; semen collection; hatching success and nest inundation; genetic diversity in the Okavango; cave isolation and ecological/evolutionary divergence in the African Dwarf crocodile; preserving Orinoco crocodiles; and Siamese crocodile conservation in Cambodia.

A session dealing with Crocodilian Conservation Biology saw presentations on the Conservation and Spatial Ecology of the American alligator, the American crocodile, the Philippine crocodile, Morelet’s crocodile, the Saltwater crocodile and the Muggler. This was followed by an intensive session devoted to the Gharial, including another captivating update on the Chambal Gharial Ecology Project (Dr. Jeff Lang).

As a lead-in to a day dedicated to Husbandry, Production and Trade, an afternoon session dealt with Sustainable Use and case histories from India and Mexico. The Husbandry session included a keynote address on research-based approaches to developing best practices along the value chain, particularly in relation to improving sustainability of South Africa’s exotic leather industry. The current perspective of animal welfare at slaughter was discussed, as well as an example of a new model for sustainable use at an intensive Morelet’s crocodile breeding farm in Mexico. Production and Trade examined the fashion industry’s desire for sustainably sourced exotic skins for the luxury market and the use of information technology in the crocodile industry to promote traceability and value chain integration. The final session of the meeting, a Panel Discussion on ‘The Classics in Trade and Conservation’, was opened by Mr. Rob Davies, South African Minister of Trade & Industry, who highlighted the opportunities for trade and investment that the Ministry was providing to the crocodile industry. The Panel was chaired by Jimmyson Kazangarare from Zimbabwe.

The poster session was coupled with a Cheese & Wine event, which encouraged delegates to spend quality time at each of the posters and connect with the authors who could elaborate on their work. Following the poster session, a buffet dinner was served and prizes were handed out to students for oral presentations (Theresa Cantu, Agata Staniewicz, Jonathan Warner, Lauren Augustine) and posters (Joey Brown, Donn  van der Westhuizen, Evelyn Lopez Fernandez, Laura Romito, Sebastian Brackhane). Howard Kelly announced Enrico Chiesa (Italy) as the winner of the “International Golf Tournament”, although he modestly claimed that his win was most likely a result of poor maths! The CSG Chairman’s Encouragement Award was presented to Nathalie Kpera (Benin). Following the presentation of awards, the CSG Chairman announced that the CSG Executive Committee would include three new Deputy Chairmen - Perran Ross, Charlie Manolis and Christine Lippai.

The traditional CSG Auction then commenced, and was once again skilfully choreographed by Carlos Pi a and Joe Wasilewski. A variety of items were on offer and a total of \$US11,944 was raised, with 50% allocated to the Orinoco Crocodile program (Venezuela) and 50% to the Olifants River crocodile program (South Africa).

The African Bush Gala Banquet was a highlight of the social agenda, with a procession of safari vehicles taking everyone on a 2-hour game drive with spectacular sightings such as Lesser Galago, White Rhinoceros, African Elephant, Giraffe, Nile Crocodiles and even Spotted Hyena at the Bush Braai (BBQ) venue. An amazing setting for a candle-lit banquet in the bush, telescopes at the ready for some southern sky star-

gazing, bottles of white and red wines on each table (courtesy of Villiera Wine Estate), a Mbira band and traditional dancers.

In a brief speech, the CSG Chairman honoured the late Tony Pooley and Fritz Huchzermeyer, who had contributed so much to conservation, management and research on South African crocodiles. It was good to see the participation of Elsa Pooley and Hildegard Huchzermeyer at the meeting, and to see their respective children, Simon Pooley, David and Philippa Huchzermeyer, follow in their fathers' footsteps and work with crocodiles. The culmination of the banquet was the presentation of the Castillo Award for Crocodile Conservation to Dr. Alison Leslie (Stellenbosch University, South Africa) for her (often) behind-the-scenes but untiring dedication to crocodile research and nurturing of future generations of crocodylian scientists.

Unfortunately, due to recent rhino poaching incidents in Kruger National Park, participants were returned to Skukuza by 10 pm, where many continued to party and dance until the early hours. As with every CSG Working Meeting, the degree of camaraderie is a delight for old and new participants! Enormous thanks go to Louw the Audio-Visual Technician for setting up the music system in the reception area!

Christine Lippai, member of 24th Working Meeting Organising Committee ([lippainomad@gmail.com](mailto:lippainomad@gmail.com)).



Figure 1. Argentina was well represented at the meeting. Photograph: Alvaro Velasco.



Figure 2. From left; Miriam Boucher, Danielle Kelly, Rachel Clulee, Marisa Tellez and Valerie Garcia. Photograph: Alvaro Velasco.



Figure 3. Matt Shirley (left) and Perran Ross (centre) with West African participants; from left, Georges Hedebegetan, Regis Kema Kema, Nathalie Kpera, Michel Ahizi, Elie Tobi, Emmanuel Amoah. Photograph: Alvaro Velasco.



Figure 4. Howard Kelly (left) and Enrico Chiesa, winner of the golf tournament. Photograph: Alvaro Velasco.

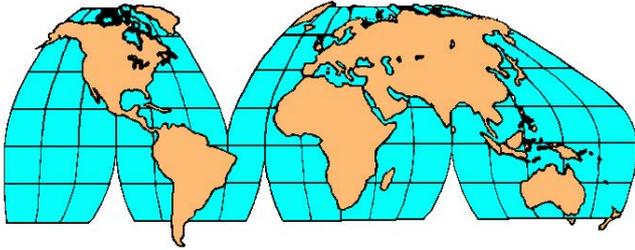


Figure 5. Dr. Alison Leslie (centre), winner of the Castillo Award for Crocodile Conservation, with Christine Chowfin and Subir Chowfin. Photograph: Alvaro Velasco.



Figure 6. Joseph Brown, one of the student poster award recipients. Photograph: Joseph Brown.

## Regional Reports



### Latin America and the Caribbean

#### Venezuela

SIXTH COURSE IN ECOLOGY AND CONSERVATION OF THE CROCODYLIA OF VENEZUELA. The 6th Course in Ecology and Conservation of the Crocodylia of Venezuela was held on 2-4 March 2016, at Masagual Ranch in Guárico State, Venezuela. The course was hosted by the Crocodile Specialist Group of Venezuela (GECV), with the support of the Krokodille Zoo (Denmark), the Dallas World Aquarium (USA), Fudeci, Fauna Silvestre Products and Services, and Ecoposada La Fe. It was attended by 22 undergraduate students of biology, veterinary medicine and natural resource management from 8 Venezuelan universities.



Figure 1. Participants in the Sixth Course in Ecology and Conservation of the Crocodylia of Venezuela. Photographs: Alvaro Velasco.

The main goal of the course was to introduce participants (all at the final stage of their studies) to the study of crocodylians, and spark interest in postgraduate work on ecological and veterinary aspects of these species.

Theory topics included: an introduction to the Crocodylian order; conservation plan and status of *Crocodylus intermedius* and *C. acutus* in Venezuela; survey techniques and population estimations; captive breeding and ranching programs with *C. intermedius*; factors affecting crocodile captive rearing; sanitary aspects of eggs, hatchlings and adult crocodiles in captivity; threats to survival of crocodiles; the Dallas World Aquarium captive breeding program; human-crocodile conflict; *Caiman crocodilus* commercial program in Venezuela; remote sensors in crocodile studies; crocodiles as habitat indicators; international skin trade and ecotourism; food, farms and national parks related with crocodiles.

In the field, all participants took part in night counts, size class estimations, habitat description, capture, body measures, sexing and analysis of stomach content of wild individuals of *C. crocodilus* and collection of eggs and management of juveniles of *C. intermedius* at the Masagual Ranch breeding facility.

Alvaro Velasco B., *Fauna Silvestre Products and Services*; *Secretary General, Crocodile Specialist Group of Venezuela.*

#### Colombia

NAVIGATING WITH THE ORINOCO CROCODILE. This is a project that resulted from research carried out by the National University of Colombia and “Cormacarena” (Environmental Authority of Meta State of Colombia) since 2009. All research is directed to support management actions by the National Conservation Program of Orinoco Crocodile. We identified potential areas for reintroduction in Meta State, and we generated protocols and pilot plans to reintroduce the species, in accordance with the specific features of each area.

We developed a plan to reintroduce the species within the whole area of its historical distribution (Moreno-Arias and Ardila-Robayo, in press). Data of wildlife movement are nonexistent in Colombia, and Venezuelan data were too heterogeneous to be applied to Colombian populations. This information is relevant tool for two activities: to take decisions of management of reintroduced populations and to management the human-crocodile conflict if it exists. These activities are key to Environmental Authorities which are responsible to the reintroductions in Colombia.

Since 31 October 2015 we have tracked four adult Orinoco crocodiles (2 males, 2 females) using satellite telemetry, to better understand their movement patterns and habitat use in real-time, and to identify and manage human-crocodile conflict. One male and one female were released at the Guayabero River (2.288774°, -73.869580°, 236 m asl) and the Lozada River (2.210956°, -73.876162°, 238 m asl) - the first reinforcement of an Orinoco crocodile population in Colombia. We released each crocodile with a KiwiSat

202 platform (Sirtrack Inc.) attached on its nuchal rosette (see Brien *et al.* 2010 for method). Crocodiles were named after crocodilian conservationists: “Federico” (Federico Medem) (Fig. 1), “Cristina” (Cristina Ardila), “John” (John Thornbjarnarson) and “Myriam” (Myriam Lugo). Platforms were configured to transmit at intervals of two hours across the day (12 hours) every second day.



Figure 1. “Federico”, a male released in the Guayabero River.

Up until now, we had received more than 5000 positions of crocodiles! Data to mid-January 2016 shows three main peaks of activity; 0200-0800 h, 1500-1600 h and 1900-2000 h. Our data indicate that crocodiles are continually active in the early hours of the day while in the afternoon and first hours of the night they show pulses of activity (Fig. 2). We did not see any differences in activity time between males and females.

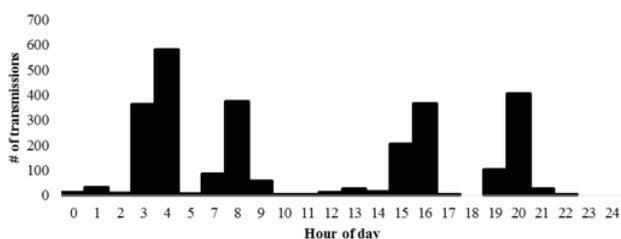


Figure 2. Periods of activity for Orinoco crocodiles based on numbers of transmissions.

Table 1. Movements and home range of Orinoco crocodiles.

Crocodile	Mean km per day	Home Range	Furthest distance from release site
<u>Guayabero R.</u>			
Federico (3.1 m)	0.6	6 km	3 km
Cristina (2.5 m)	0.5	4 km	2 km
<u>Lozada R.</u>			
John (2.9 m)	1.3	34 km	28 km
Myriam (2.4 m)	1.5	4 km	16 km

Estimated home ranges for all crocodiles were similar except to John (Table 1). By pairs John and Myriam moved farthest

than Federico and Cristina. In addition, estimated home range for each crocodile overlapped with its release site, but there was no overlap between crocodiles released at different rivers. More information about the project and future locations of crocodiles can be tracked on the project’s home page (<http://rafamorearias.wix.com/cocodrilodelorinoco>).

#### Acknowledgements

We thank Professor Carlos A. Moreno-Torres of Veterinary Faculty-UNAL who led all procedures to install transmitters on crocodiles. The Project “Navigating with the Orinoco Crocodile” was supported by the Universidad Nacional de Colombia-UNAL and Corporación para el desarrollo sostenible del Área de Manejo especial La Macarena-CORMACARENA (Convenio interadministrativo P.GDE.1.4.7.1.12.016), Ministerio de Ambiente y Desarrollo Sostenible-MADS (Convenio interadministrativo 38 de 2012). We thank the Instituto Alexander von Humboldt-IAvH and WCS Colombia, and Fuerza Aérea Colombiana Base Apiay and Defensa Civil-La Macarena for the transportation of crocodiles between Villavicencio and La Macarena and, La Macarena and release sites, respectively. Finally, we thank Charlie Manolis for his valuable comments and editing.

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ESTIMATING POPULATION STATUS OF BROWN CAIMAN IN THE CARIBBEAN REGION OF COLOMBIA. This project is managed by the National University of Colombia (UNAL) and the Ministerio de Ambiente y Desarrollo Sostenible (MADS; main environmental authority in Colombia). It aims to generate quantitative baseline data on wild populations of Brown caiman (*Caiman crocodilus fuscus*), which is important for the management of the species.

Since August 2015 we have been studying caiman populations at four swamps in the Caribbean region of Colombia: Matatigres (8.857473°, -74.142222°, 17 m asl, 45 km of shoreline), Ciénaga Grande (9.215344°, -74.774932°, 15 m asl, 48 km), Luruaco (10.606487°, -75.158810°, 61 m asl, 10 km) and Guájaro (10.483177°, -75.102409°, 21 m asl, 96 km).

We estimated the abundance of each populations through spotlight survey. To estimate population size we are using a capture-mark-recapture design with several sampling occasions to perform a Robust Population Model. Over periods of 3-6 days (depending on the size of the swamp), five teams worked simultaneously between 1800 and 2400 h. We spotted and captured caimans across a track which represents almost the total shoreline at all swamps except Guájaro, where we sampled around 50% of the shoreline. Size of individuals was visually estimated during spotlight surveys and measured on captured individuals. Sex was determined on 78 captured individuals, but could not be determined on 39 animals.

With two sampling occasions performed to date, we have recorded 439 sightings at all swamps; 260 in August 2015 and 179 in November 2015. There was a decrease in abundance between August and November at Matatigres (148 vs 95), Guájaro (57 vs 33). In Ciénaga Grande (47 vs 43) and Luruaco (8 vs 8) numbers were the similar/same.

Matatigres had the highest relative densities (Aug. 3.29 ind/km, Nov. 2.12 ind/km) followed by Ciénaga Grande (Aug. 0.98 ind/km, Nov. 0.90 ind/km), Luruaco (Aug. and Nov. 0.80 ind/km) and Guájaro (Aug. 0.59 ind/km, Nov. 0.34 ind/km).

Across all swamps we captured 117 individuals, and recaptured 7 animals. Capture success was lower in August than in November: Matatigres (0.24 vs 0.33), Ciénaga Grande (0.13 vs 0.23), Luruaco (0.00 vs 0.37) and Guájaro (0.23 vs 0.35). These values support the idea that animals did not become wary due to capture but indicate a real decline of caiman abundance.

The size structures of the populations were dissimilar (Fig. 1). At Matatigres we detected all size classes, including large adults (Class IV). All areas showed recruitment of Class-I individuals, from both “young” and “old” mature Class-III and Class-IV individuals. In Ciénaga Grande and Guájaro, the recruitment of Class-I individuals seems to occur mainly through Class-III individuals, while in Luruaco they appear to be from the oldest Class-II individuals (Fig. 1).

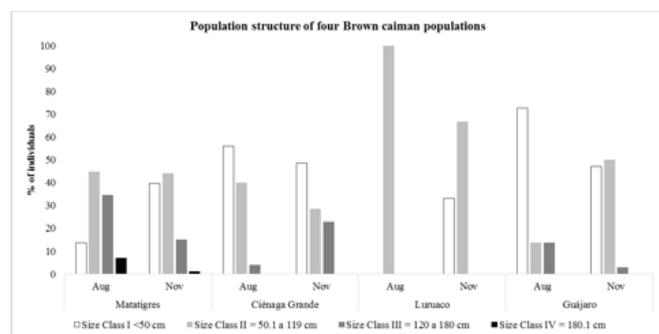


Figure 1. Population structure of four populations of *Caiman crocodilus fuscus* in Caribbean region, Colombia.

The sex ratio, based on captured individuals, and expressed as the proportion of females, was: all areas combined (0.385, N= 78); Matatigres (0.400, N= 40); Ciénaga Grande (0.267,

N= 15); Luruaco (0.500, N= 2); and, Guájaro (0.429, N= 21).

The project continues and we hope acquire more data to perform the Robust Population Model and estimate accurately populations size, survival rate per size class, and transition rates between classes. With these parameters we can calculate the growth rates of every population through the projection matrix. Projections matrices are a quantitative tool to adaptive management of species through matrix population models (eg Green *et al.* 2001; Wallace *et al.* 2013). Currently we also studied the habitat, diet and threats on caimans to relate to population trends. Therefore, we hope that the project continues through time with funding support from MADS or non-government organizations, to provide a good tool for the rational management of the species.

#### Acknowledgements

We thank biologists Vladimir Bernal, Nidia Farfán, Felipe Parra, Álvaro Velásquez and Thomas Viloría, who led the teams in surveys and capture-recapture work in the field. We also thank the fishing communities of San Antonio-Barranco de Loba and Madrid-Magangué in Bolívar, and Luruaco and Repelón in Atlántico. The project “Estimating Population Status of Brown Caiman in Caribbean Region” is funded by “Convenio interadministrativo 298 de 2015 suscrito entre el Ministerio de Ambiente y Desarrollo Sostenible y La Universidad Nacional de Colombia”. Finally, we thank Charlie Manolis for his valuable comments and editing.

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## North America

### USA

PALMETTO ALLIGATOR RESEARCH AND MANAGEMENT SYMPOSIUM ATTRACTS A DIVERSITY OF STAKEHOLDERS. The state of South Carolina (USA) is known as the “Palmetto State”. On 11 March 2016 the first Palmetto Alligator Research and Management Symposium

was held at the Clemson University Baruch Institute of Coastal Ecology and Forest Science in Georgetown, South Carolina. Eighteen speakers from a diversity of backgrounds gave presentations on alligator management, stressors and general biology, mostly focusing on South Carolina populations. Over 60 people, representing state and federal agencies, municipalities, private landowners, universities, and NGOs attended the symposium. Of special note, the three pioneers of alligator management and research in South Carolina - Mark Bara, Tom Murphy and Phil Wilkinson - were all in attendance, and the latter two made presentations.

The symposium was followed by a dinner/social at a rustic, outdoor locality where speakers and attendees slaked their thirst, sated their hunger, and continued conversations about alligator research, management, and conservation in a relaxed and jovial atmosphere. Plans for the next symposium are underway.



Figure 1. Speakers at the first Palmetto Alligator Research and Management Symposium. Front Row (L-R): Tara Gancos Crawford, Thomas Galligan, Thomas Rainwater, Stacey Lance, Russ Lowers, Phil Wilkinson. Back Row (L-R): Jim Glover, Tom Murphy, Shane Boylan, Matthew Hale, Matthew Hamilton, Jessica Tipton, Arnold Brunell, Abby Lawson, Jackie Bangma, Frannie Nilsen, Nicole McNabb, Jay Butfiloski. Photograph: Ben Parrott.



Figure 2. The three pioneers of alligator research in the state of South Carolina (USA). (L-R): Tom Murphy, Mark Bara, Phil Wilkinson. Photograph: Ben Parrott.

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## Europe

### Germany

PHILIPPINE CROCODILE (*CROCODYLUS MINDORENSIS*) TARGET TRAINING AT COLOGNE ZOO. In this report we provide a brief overview of our outcomes with Philippine crocodile target training at Cologne Zoo. The public enclosure, where 1.1 *Crocodylus mindorensis* are held, comprises ca. 70 m<sup>2</sup> and consists of three parts combinable by sliding gates, enabling visual, acoustic and olfactory communication (Ziegler *et al.* 2011). Due to intraspecific aggression, the pair is housed separately except during the mating season.

Since the opening of the public enclosure in 2011, target training is conducted for management reasons (eg pairing, enclosure shift, work safety) as well as for behavioural enrichment (Rauhaus and Ploetz 2014). The training, which was introduced to us by the late Ralf Sommerlad, follows the principle of operant conditioning. The crocodile has to fulfil a requested behavior on cue [eg approaching the target, consisting of a 3 m bamboo stick with a yellow ending (adhesive textile band)]. Afterwards we use an acoustic and/or tactile bridge as secondary reinforcer, before the crocodile is rewarded with a food item (primary reinforcer). The tactile bridge (stroking with the target over head and body) also desensitizes the crocodiles towards being touched (eg in the course of veterinary treatment), while the acoustic bridge (the word “good”) serves for precise timing and is useful when we cannot reach it with the target. As food rewards, depending on individual preference and food demand, all small food items which can easily be taken up by the crocodiles and thrown by the keeper are suitable, as long as they are not too rich for daily use and the crocodiles do not get overfed. At first, we trained on fixed times (0700 h and 1500 h) to get the animals used to the training process, meanwhile we mostly practice one extended training sequence per day (as long as we do not establish a new command) and vary the times. Initially, we only conducted a few tasks per session to not overstrain the crocodiles; later on, we increased the length of the sessions and requested more tasks. Anyhow, we try to finalize each session positively for the animal, so we rather exercise less commands than too many.

Our first command was “here”. The crocodile has to approach the target and touch it with its snout (Fig. 1) without biting inside. Afterwards, we say “good”, stroke with the target over the head (Fig. 2) and reward the crocodile with a food item. As the crocodiles are conditioned that the food reward follows when they keep calm during the stroking, they meanwhile keep still when being stroked on every part of the body. As the crocodiles felt most safe in the water, the target was first placed into shallow water at the transition to the land part; subsequently we gradually increased the distance to the water. When the animals felt safe enough to completely come onto land, we also increased the distance to the target between the commands.

The second command was “water”, which was introduced by

pointing with the target towards the water. Subsequently, the target was slowly faded out, so that after some days (female 6 days, male 10 days), the crocodiles moved into the water only by the acoustic cue. Next step was switching them between the enclosures (the female was locked in the nesting part; the male was called into the middle part to enter land section there, and afterwards back). As the crocodiles already had learned to follow the keeper's voice and the target stick, they soon swam quickly from one enclosure to the other on command. It was important to avoid any negative association with closing the slide gates, so for both animals opening and closing was a familiar situation, which also worked without water in the enclosure (during cleaning).



Figure 1. Female Philippine crocodile touching the target. Photograph: Thomas Ziegler.



Figure 2. Stroking female Philippine crocodile with the target after successfully performed command. Photograph: Thomas Ziegler.



Figure 3. Crate training: female Philippine crocodile follows the target towards the opening of the crate. Photograph: Anna Rauhaus.



Figure 4. Crate training: At first, female Philippine crocodile was guided inside the crate with the target being inserted through the upper crate opening; later on, the upper crate opening was closed and the target positioned at the opposite crate entrance. Photograph: Anna Rauhaus.

Another command was “up”. Here, we used normal head lifting behaviour and tried to cue it by placing the target above the crocodile’s head and saying “up”. We practice this (eg when training a new command), as it is at rather low costs for the crocodiles, to avoid frustration by requesting and rewarding a simple task in between more difficult ones.

Since January 2015 we practice crate training to enable medical examinations or stress-free transports (Figs. 3 and 4). The crate has openings at the sides and on top, for habituating the crocodiles getting touched and treated there. In the beginning, we left the crate open. The first goal was to let a crocodile pass through the crate on command, to be later on able to close the slide gates and lock the crocodile inside. In the first training session, both crocodiles strongly reacted to the unfamiliar element (eg by increased “bubbling” in the water in front of the crate, not reacting to the target, or biting inside), but after they had the chance to explore the crate for some hours, in the second session both crocodiles moved through the crate with one rewarded stop in the middle and one at the end. After 3 weeks, both crocodiles

mostly immediately entered and passed through the crate on cue, and after 5 weeks, we could also make them enter and pass the crate from the other side. Meanwhile the target as visual stimulus for this exercise is almost completely left out and only the knocking of the target stick on the wood together with the command “box” is used to cue the entering and passing through the crate with only one reward at the end. In a next step, we will start to train closing the entrances of the crate for some time when the crocodiles are inside.

During mating, the training allows us to introduce and separate the animals in a controlled and stress-free way. Even in situations when aggressions occurred, we never had to intervene directly, because crocodiles can be called away from the other individual and subsequently swim into their enclosure part on command. After the first successful reproduction in Europe (Ziegler *et al.* 2013) we extended the training to the likewise solitarily kept juveniles, once they were habituated to the keepers and their enclosures and solidly feeding. We started to train the 5-month-old juveniles by introducing the target and the command “here”. In the beginning, they were rather shy and stopped feeding for some days. But after few weeks they followed the target both on land and in the water.

In general, we found that not only species-specific, but also individual characteristics should be considered in developing the training. Patience and consequence are important in training crocodiles, as they for example often stop shortly before the target, but we always wait until it is actually touched. If the target is not approached after a period of waiting, we rather place the target further distant so that the crocodiles recognize that they have to further invest to reach the reward. In case of not requested behavior, we avoid negative feedback like saying “no”. We only leave the reward and wait or give the command somewhat later again. If after some attempts the animal still does not show the requested behavior, we use another command or in the worst case interrupt the training session and come back later (“time out”). We try to avoid generating too much noise with the target not to address an instinctive prey reflex but training a given cue. If training is done by several persons, consistency in cues and reinforcers is crucial. We also found that training pauses of several days do not affect the success in longer-time trained animals, but should be avoided in the first phase of new commands.

It seems to be of importance to stay variable in training duration as well as in command order and rewards. For example, if exercises are always trained in a consistent sequence, crocodiles start to offer the respective behavior on their own, without previous command. Furthermore, we do not always start with the same animal and have no signal which finishes the session. We also do not use a steady number of commands and rewards per session and try to alternate high and low value rewards in an unpredictable manner as well as the level of difficulty in the commands. The most time intensive aspect seems to build up trust. Once the target and the voice of the keeper are positively associated, new commands can be established quite fast. As important element in modern animal training, the crocodiles always have the choice to participate in the training and can leave it

at any time. One indicator that they seem to enjoy the training is that the Philippine crocodiles participate in the training even after larger food portions have been consumed, and when only insects are offered as rewards. Thus, the form of rewarding seems to have less priority than the activity itself. Furthermore, since we started the training, the crocodiles never left the session without return. We could notice that the Philippine crocodiles are much calmer and less nervous since we started the training; they also built up a bond with the training keeper (eg strongly react to his voice). As further positive secondary effects we observed an increase in activity and use of space during day time, also before and after the sessions.

The behaviour of the female during the induced natural breeding in 2015 also clearly showed that the training also works and is accepted under exceptional circumstances. Although we had to switch the female several times between the sections of the enclosure and by doing so had to separate her from the hatchlings, she immediately continued with the parental care after the training and did not show any signs of stress caused by the disturbance (Ziegler and Rauhaus 2015). Besides eased work sequences and a secured and stress-free crocodile handling, the training is also important for the so far often disregarded crocodile enrichment. By doing so, the enclosure surface is better used by the crocodiles during daytime and visitors benefit from active crocodiles and get a better understanding of their intelligence and learning aptitude.

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# Science



## Recent Publications

Nell, L.A., Frederick, P.C., Mazzotti, F.J., Vliet, K.A. and Brandt, L.A. (2016). Presence of breeding birds improves body condition for a crocodylian nest protector. *PLoS ONE* 11(3): e0149572.

**Abstract:** Ecological associations where one species enhances habitat for another nearby species (facilitations) shape fundamental community dynamics and can promote niche expansion, thereby influencing how and where species persist and coexist. For the many breeding birds facing high nest-predation pressure, enemy-free space can be gained by nesting near more formidable animals for physical protection. While the benefits to protected species seem well documented, very few studies have explored whether and how protector species are affected by nest protection associations. Long-legged wading birds (Pelecaniformes and Ciconiiformes) actively choose nesting sites above resident American alligators (*Alligator mississippiensis*), apparently to take advantage of the protection from mammalian nest predators that alligator presence offers. Previous research has shown that wading bird nesting colonies could provide substantial food for alligators in the form of dropped chicks. We compared alligator body condition in similar habitat with and without wading bird nesting colonies present. Alligator morphometric body condition indices were significantly higher in colony than in non-colony locations, an effect that was statistically independent of a range of environmental variables. Since colonially nesting birds and crocodylians co-occur in many tropical and subtropical wetlands, our results highlight a potentially widespread keystone process between two ecologically important species-groups. These findings suggest the interaction is highly beneficial for both groups of actors, and illustrate how selective pressures may have acted to form and reinforce a strongly positive ecological interaction.

Petrozzi, F., Amori, G., Franco, D., Gaubert, P., Pacini, N., Eniang, E.A., Akani, G.C., Politano, E. and Luiselli, L. (2016). Ecology of the bushmeat trade in west and central Africa. *Tropical Ecology* 57(3): 545-557.

**Abstract:** The bushmeat trade in West and Central Africa embraces a broad range of ecological, economic, and conservation issues. To date, most studies have focused on the economic and conservation aspects of the bushmeat trade, with less emphasis on the ecological implications of wildlife extraction. Here, we analysed available literature on the bushmeat trade in 5 countries in west and central Africa exploring ecological traits such as niche width breadth and trophic position of the species involved, and habitats impacted. We also examine temporal changes over a 40-year period. Our results confirm that mammals dominated the trade in all studied areas and time periods, in terms of (i) number of species, (ii) number of traded individuals, and (iii) overall biomass. Herbivores were the most common trophic animal guild traded. Forest-specialists were the most abundant in the trade, and in riverine habitats reptile biomass almost as important as mammals. Overall, the most traded species and individuals were non-threatened according to the IUCN Red List. Our temporal analyses indicated that more habitat generalist and water-linked species were traded during 1971-2000, but forest dependent taxa predominated during the following decade (2001-2010). Additionally, the number of individuals of large-bodied

herbivores rose relative to small and medium-sized ones, whereas traded biomass over time increased: (a) in the consumption of super-predators; (b) of large-bodied herbivores, but (c) a significant decrease in consumed biomass of medium and small-bodied herbivores. We suggest that the observed trends may suggest an imminent reduction of large-bodied herbivores and, as a cascade effect, also of super-predators in African moist forests.

Brandt, L.A., Beauchamp, J.S., Jeffery, B.M., Cherkiss, M.S. and Mazzotti, F.J. (2016). Fluctuating water depths affect American alligator (*Alligator mississippiensis*) body condition in the Everglades, Florida, USA. *Ecological Indicators* 67: 441-450.

**Abstract:** Successful restoration of wetland ecosystems requires knowledge of wetland hydrologic patterns and an understanding of how those patterns affect wetland plant and animal populations. Within the Everglades, Florida, USA restoration, an applied science strategy including conceptual ecological models linking drivers to indicators is being used to organize current scientific understanding to support restoration efforts. A key driver of the ecosystem affecting the distribution and abundance of organisms is the timing, distribution, and volume of water flows that result in water depth patterns across the landscape. American alligators (*Alligator mississippiensis*) are one of the ecological indicators being used to assess Everglades restoration because they are a keystone species and integrate biological impacts of hydrological operations through all life stages. Alligator body condition (the relative fatness of an animal) is one of the metrics being used and targets have been set to allow us to track progress. We examined trends in alligator body condition using Fulton's K over a 15 year period (2000-2014) at seven different wetland areas within the Everglades ecosystem, assessed patterns and trends relative to restoration targets, and related those trends to hydrologic variables. We developed a series of 17 *a priori* hypotheses that we tested with an information theoretic approach to identify which hydrologic factors affect alligator body condition. Alligator body condition was highest throughout the Everglades during the early 2000s and is approximately 5-10% lower now (2014). Values have varied by year, area, and hydrology. Body condition was positively correlated with range in water depth and fall water depth. Our top model was the "Current" model and included variables that describe current year hydrology (spring depth, fall depth, hydroperiod, range, interaction of range and fall depth, interaction of range and hydroperiod). Across all models, interaction between range and fall water depth was the most important variable (relative weight of 1.0) followed by spring and fall water depths (0.99), range (0.96), hydroperiod (0.95) and interaction between range and hydroperiod (0.95). Our work provides additional evidence that restoring a greater range in annual water depths is important for improvement of alligator body condition and ecosystem function. This information can be incorporated into both planning and operations to assist in reaching Everglades restoration goals.

Barão-Nóbrega, J.A.L., Marioni, B., Dutra-Araújo, D., Botero-Arias, R., Nogueira, A.J.A., Magnusson, W.E. and Da Silveira, R. (2016). Nest attendance influences the diet of nesting female spectacled caiman (*Caiman crocodilus*) in Central Amazonia, Brazil. *The Herpetological Journal* 26(2): 65-71.

**Abstract:** Although nesting ecology is well studied in crocodylians, there is little information on the diet and feeding habits of nesting females. During the annual dry season (November-December) of 2012, we studied the diet of female spectacled caiman (*Caiman crocodilus*) attending nests (n= 33) and far from nests (n= 16) in Piagaçu-Purus Sustainable Development Reserve (PPSDR),

Central Amazonia, Brazil. The proportion of empty stomachs in nest-attending females was larger, and the occurrence of fresh food items was lower when compared to females not attending nests. Fish was the most frequent prey item for non-nesting females, while terrestrial invertebrates and snail operculae were the prey items most commonly recovered from stomachs of nesting females. Our study demonstrates that, despite enduring periods of food deprivation associated with nest attendance, nesting females of *C. crocodilus* still consume nearby available prey, possibly leaving their nest temporarily unattended.

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Hastings, A.K. and Hellmund, M. (2016). Evidence for prey preference partitioning in the middle Eocene high-diversity crocodylian assemblage of the Geiseltal-Fossilagerstätte, Germany utilizing skull shape analysis. *Geological Magazine* (doi: <http://dx.doi.org/10.1017/S0016756815001041>).

**Abstract:** The Geiseltal fossil collection from southern Sachsen-Anhalt Germany contains remarkably well-preserved fossils of middle Eocene age. These include several crocodylian skulls, representing at least four different genera with a fifth genus represented by two mandibular rami. As sites with this many crocodylian genera are unknown in modern ecosystems, it has been hypothesized that these crocodylians may have differences in habit as compared to living crocodylians. In order to test similarities between the Geiseltal crocodylians and extant species, an analysis was conducted using geometric morphometrics to quantify shape in crocodylian skulls of all living species (n= 218) and all well-preserved crocodylian skulls of the Geiseltal fauna (n= 28). A relative warps analysis was used to quantify and compare skull shape, revealing *Allognathosuchus* and *Boverisuchus* to be very distinct from each other as well as from *Asiatosuchus* and *Diplocynodon*. Overlap in shape alone exists between some *Diplocynodon* and some *Asiatosuchus*, but there was significant difference in adult size. When compared with extant crocodylians, three Geiseltal genera occupied distinctly non-modern morphospace in the first two relative warps axes. Comparison of the diets of living crocodylians with similarly shaped skulls was used to reconstruct the prey preferences of the Geiseltal crocodylians, revealing differences in specialization. During the middle Eocene high global temperatures, partitioning of prey preference may have allowed this group to attain its higher than usual diversity, reducing the amount of direct competition.

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Iijima, M., Takahashi, K. and Kobayashi, Y. (2016). The oldest record of *Alligator sinensis* from the Late Pliocene of Western Japan, and its biogeographic implication. *Journal of Asian Earth Sciences* (doi:10.1016/j.jseas.2016.04.017).

**Abstract:** The late Cenozoic fossil record of alligators in East Asia is crucial in understanding the origin and past distribution of Asian alligators that are now represented by a single species, *Alligator sinensis*. This study reports a partial skeleton of *A. sinensis* from the Late Pliocene (approximately 3.0 Ma) of western Japan. This Japanese *A. sinensis* is large in size (>200 cm total length), comparable to the maximum size of extant individuals. It demonstrates the oldest record of *A. sinensis* and wider distribution of this species in the past. Tectonic and geographic history of East Asia suggests that alligators presumably dispersed into Japan before 25 Ma or after 10 Ma, yet finally were wiped out from Japan due to the semi-isolated condition of the Japanese island arc and the deteriorated climate during the Plio-Pleistocene.

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Campos, Z., Muniz, F., Desbiez, A.L.J. and Magnusson, W.E. (2016). Predation on eggs of Schneider's dwarf caiman, *Paleosuchus*

*trigonatus* (Schneider, 1807), by armadillos and other predators. *Journal of Natural History* (<http://dx.doi.org/10.1080/00222933.2016.1155782>).

**Abstract:** Nests of Schneider's dwarf caiman, *Paleosuchus trigonatus*, were located in the forests around three streams that drain into the Xingu River, Brazilian Amazonia, in October 2014. Camera traps were installed at the edge of four nests to document predators and female parental care. At two nests, females unsuccessfully defended their nests against one or more giant armadillos, *Priodontes maximus*, and nine-banded armadillos, *Dasyplus novemcinctus*. Both armadillo species responded to the attack by fleeing and returning on the opposite side of the nest by going around the tree under which the nest was located. Giant armadillos have never before been recorded consuming caiman eggs and their diet has been described as consisting mostly of ants and termites. Another species of armadillo, *Cabassous unicinctus*, was also registered digging into a nest and probably consuming eggs, though it is generally considered to be primarily insectivorous. A tayra (*Eira barbara*), lizard (*Tupinambis teguixin*) and coati (*Nasua nasua*) were also registered taking eggs from nests during the day, but we obtained no registers of nest defence by caimans during the day. The three nests were attacked after 60 days of incubation, when the eggs were well developed.

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Tate, K.B., Rhen, T., Eme, J., Kohl, Z.F., Crossley, J., Elsey, R.M. and Crossley, D.A. (2016). Periods of cardiovascular susceptibility to hypoxia in embryonic American alligators (*Alligator mississippiensis*). *American Journal of Physiology - Regulatory, Integrative and Comparative Physiology* (doi: 10.1152/ajpregu.00320.2015).

**Abstract:** During embryonic development, environmental perturbations can affect organisms' developing phenotype, a process known as developmental plasticity. Resulting phenotypic changes can occur during discrete, critical windows of development. Critical windows are periods when developing embryos are most susceptible to these perturbations. We have previously documented that hypoxia reduces embryo size and increases relative heart mass in American alligator, and this study identified critical windows when hypoxia altered morphological, cardiovascular function and cardiac gene expression of alligator embryos. We hypothesized that incubation in hypoxia (10% O<sub>2</sub>) would increase relative cardiac size due to cardiac enlargement rather than suppression of somatic growth. We exposed alligator embryos to hypoxia during discrete incubation periods to target windows where the embryonic phenotype is altered. Hypoxia affected heart growth between 20-40% of embryonic incubation, whereas somatic growth was affected between 70-90% of incubation. Arterial pressure was depressed by hypoxic exposure during 50-70% of incubation, whereas heart rate was depressed in embryos exposed to hypoxia during a period spanning 70-90% of incubation. Expression of Vegf and PdgfB was increased in certain hypoxia-exposed embryo treatment groups, and hypoxia towards the end of incubation altered  $\beta$ -adrenergic tone for arterial pressure and heart rate. It is well known that hypoxia exposure can alter embryonic development, and in the present study we have identified brief, discrete windows that alter the morphology, cardiovascular physiology, and gene expression in embryonic American alligator.

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Bontemps, D.R., Cuevas, E., Ortiz, E., Wunderle, Jr., J.M. and Joglar, R.L. (2016). Diet of the non-native spectacled caiman (*Caiman crocodilus*) in Puerto Rico. *Management of Biological Invasions* 7.

**Abstract:** The spectacled caiman (*Caiman crocodilus*) was introduced to Puerto Rico over 50 years ago with the Tortuguero

Lagoon Natural Reserve (TLNR) as its epicenter, where it is now established as an apex predator. Although concerns have been raised regarding the potential impact of this naturalized predator on Puerto Rico's native fauna, little was known of the caiman's diet on the island. Therefore this study was conducted to determine the diet of the spectacled caiman and its potential impact on island animals. For this study, measurements were obtained from 138 caimans across all life stages (12-94 cm snout-vent length; SVL) from October 2014 to May 2015 within the TLNR. Stomach contents were retrieved and analyzed based on prey category occurrence frequency. In addition, caiman muscle samples were obtained to determine their nitrogen and carbon isotopic signature. Insects were the most abundant prey items encountered with 90.7% and 68.8% in hatchling (SVL<20 cm) and juvenile (SVL= 20-59.9 cm) stomach respectively. In adult (SVL>60 cm) caimans, fish remains were the most significant prey items with 38.3% frequency of occurrence. Fish, insects, and gastropods were the only categories of 10 designated prey categories to show significant variation among the three caiman age classes. This study provides novel information on dietary habits of spectacled caimans in Puerto Rico relevant to the design of management strategies.

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Cunningham, S.W., Shirley, M.H. and Hekkala, E.R. (2016). Fine scale patterns of genetic partitioning in the rediscovered African crocodile, *Crocodylus suchus* (Saint-Hilaire 1807). PeerJ 4:e1901.

Abstract: Landscape heterogeneity, phylogenetic history, and stochasticity all influence patterns of geneflow and connectivity in wild vertebrates. Fine-scale patterns of genetic partitioning may be particularly important for the sustainable management of widespread species in trade, such as crocodiles. We examined genetic variation within the rediscovered African crocodile, *Crocodylus suchus*, across its distribution in West and Central Africa. We genotyped 109 individuals at 9 microsatellite loci from 16 sampling localities and used three Bayesian clustering techniques and an analysis of contemporary gene flow to identify population structure across the landscape. We identified up to 8 genetic clusters that largely correspond to populations isolated in coastal wetland systems and across large distances. Crocodile population clusters from the interior were readily distinguished from coastal areas, which were further subdivided by distance and drainage basin. Migration analyses indicated contemporary migration only between closely positioned coastal populations. These findings indicate high levels of population structure throughout the range of *C. suchus* and we use our results to suggest a role for molecular tools in identifying crocodile conservation units for this species. Further research, including additional sampling throughout the Congo and Niger drainages, would clarify both the landscape connectivity and management of this species.

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Drumheller, S.K., Wilberg, E.W. and Sadleir, R.W. (2016). The utility of captive animals in actualistic research: A geometric morphometric exploration of the tooth row of *Alligator mississippiensis* suggesting ecophenotypic influences and functional constraints. Journal of Morphology (doi: 10.1002/jmor.20540).

Abstract: Captive broad snouted crocodylians are generally thought to have wider, shorter rostra than their wild counterparts. Interpreted to reflect morphological change in response to the conditions of captivity, this qualitative pattern could affect the utility of these animals in a variety of fields of research. However, due to relative ease of access and availability of life history data, captive animals are often utilized in actualistic research. Thus, this issue should be addressed in more detail. Here we explore snout shape variation between captive and wild members of *Alligator mississippiensis*

using two-dimensional (2D) morphometric techniques. Several landmark schemes are used to assess the utility of different aspects of morphology in distinguishing the groups. While statistical analyses consistently differentiated between the groups, the area of morphospace occupied by wild members of *A. mississippiensis* generally overlapped with the larger area encompassing the captive specimens. This indicates that the captive condition is not as uniform as previously thought and instead encompasses a large spectrum of morphologies, ranging from the stereotypical broad, shortened snouts to outlines that are indistinguishable from the wild morphotype. These results align well with the interpretation that this change reflects an extreme example of ecophenotypy, since ranched, farmed, or zoo organisms are held in an array of enclosures, ranging from indoor, climate controlled pens to outdoor, more natural areas. This variation in environments should be reflected in different reactions to the animals' surroundings, resulting in a broad spectrum of morphotypes. While wild specimens are still preferred, especially for fine scale analyses, these results indicate that not all captive members of *A. mississippiensis* exhibit the extreme morphological alterations often cited in the literature. Weighing the conditions in which the animals are held and exploring the possibility of morphological differences against the benefits of using captive specimens should be part of any actualistic study.

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Du Preez, M., Govender, D. and Bouwman, H. (2016). Heavy metals in muscle tissue of healthy crocodiles from the Kruger National Park, South Africa. African Journal of Ecology (doi: 10.1111/aje.12308).

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Cawthorn, D.-M. and Hoffman, L.C. (2016). Controversial cuisine: A global account of the demand, supply and acceptance of "unconventional" and "exotic" meats. Meat Science (doi:10.1016/j.meatsci.2016.04.017).

Abstract: In most societies, meat is more highly prized, yet more frequently tabooed, than any other food. The reasons for these taboos are complex and their origins have been the focus of considerable research. In this paper, we illustrate this complexity by deliberating on several "unconventional" or "exotic" animals that are eaten around the world, but whose consumption evokes strong emotions, controversy and even national discourse: dogs, equids, kangaroos, marine mammals, primates, rodents and reptiles. We take a systematic approach, reflecting on the historical and current demand for the meat, the manner in which this demand is met, and how individual and societal attitudes towards these species shape their approval as food. What emerges from this synthesis is that conflicting views on the aforementioned species exist not only between Western societies and elsewhere, but also in nations where these animals are readily consumed. Moreover, such taboos are seldom based on functionalist explanations alone, but rather have overwhelming symbolic and psychological groundings.

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Clarac, F., Souter, T., Cubo, J., De Buffrénil, V., Brochu, C. and Cornette, R. (2016). Does skull morphology constrain bone ornamentation? A morphometric analysis in the Crocodylia. Journal of Anatomy (doi: 10.1111/joa.12470).

Abstract: Previous quantitative assessments of the crocodylians' dermal bone ornamentation (this ornamentation consists of pits and ridges) has shown that bone sculpture results in a gain in area that differs between anatomical regions: it tends to be higher on the skull table than on the snout. Therefore, a comparative phylogenetic analysis within 17 adult crocodylian specimens representative of the morphological diversity of the 24 extant species has been performed, in order to test if the gain in area due to ornamentation depends on

the skull morphology, ie shape and size. Quantitative assessment of skull size and shape through geometric morphometrics, and of skull ornamentation through surface analyses, produced a dataset that was analyzed using phylogenetic least-squares regression. The analyses reveal that none of the variables that quantify ornamentation, be they on the snout or the skull table, is correlated with the size of the specimens. Conversely, there is more disparity in the relationships between skull conformations (longirostrine vs. brevisrostrine) and ornamentation. Indeed, both parameters GAPit (ie pit depth and shape) and OArelet (ie relative area of the pit set) are negatively correlated with snout elongation, whereas none of the values quantifying ornamentation on the skull table is correlated with skull conformation. It can be concluded that bone sculpture on the snout is influenced by different developmental constraints than on the skull table and is sensible to differences in the local growth 'context' (allometric processes) prevailing in distinct skull parts. Whatever the functional role of bone ornamentation on the skull, if any, it seems to be restricted to some anatomical regions at least for the longirostrine forms that tend to lose ornamentation on the snout.

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Guillette, L.J. Jr., Parrott, B.B., Nilsson, E., Haque, M.M., Skinner, M.K. (2016). 3/16 epigenetic programming alterations in alligators from environmentally contaminated lakes. *General and Comparative Endocrinology* (doi:10.1016/j.ygcen.2016.04.012).

**Abstract:** Previous studies examining the reproductive health of alligators in Florida lakes indicate that a variety of developmental and health impacts can be attributed to a combination of environmental quality and exposures to environmental contaminants. The majority of these environmental contaminants have been shown to disrupt normal endocrine signaling. The potential that these environmental conditions and contaminants may influence epigenetic status and correlate to the health abnormalities was investigated in the current study. The red blood cell (RBC) (erythrocyte) in the alligator is nucleated so was used as an easily purified marker cell to investigate epigenetic programming. RBCs were collected from adult male alligators captured at three sites in Florida, each characterized by varying degrees of contamination. While Lake Woodruff (WO) has remained relatively pristine, Lake Apopka (AP) and Merritt Island (MI) convey exposures to different suites of contaminants. DNA was isolated and methylated DNA immunoprecipitation (MeDIP) was used to isolate methylated DNA that was then analyzed in a competitive hybridization using a genome-wide alligator tiling array for a MeDIP-Chip analysis. Pairwise comparisons of alligators from AP and MI to WO revealed alterations in the DNA methylome. The AP vs. WO comparison identified 85 differential DNA methylation regions (DMRs) with  $\geq 3$  adjacent oligonucleotide tiling array probes and 15,451 DMRs with a single oligo probe analysis. The MI vs. WO comparison identified 75 DMRs with the  $\geq 3$  oligo probe and 17,411 DMRs with the single oligo probe analysis. There was negligible overlap between the DMRs identified in AP vs. WO and MI vs. WO comparisons. In both comparisons DMRs were primarily associated with CpG deserts which are regions of low CpG density (1-2 CpG/100bp). Although the alligator genome is not fully annotated, gene associations were identified and correlated to major gene class function functional categories and pathways of endocrine relevance. Observations demonstrate that environmental quality may be associated with epigenetic programming and health status in the alligator. The epigenetic alterations may provide biomarkers to assess the environmental exposures and health impacts on these populations of alligators.

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Tensen, L. (2016). Under what circumstances can wildlife farming benefit species conservation? *Global Ecology and Conservation* 6: 286-298.

**Abstract:** Wild animals and their derivatives are traded worldwide. Consequent poaching has been a main threat to species conservation. As current interventions and law enforcement cannot circumvent the resulting extinction of species, an alternative approach must be considered. It has been suggested that commercial breeding can keep the pressure off wild populations, referred to as wildlife farming. During this review, it is argued that wildlife farming can benefit species conservation only if the following criteria are met: (i) the legal products will form a substitute, and consumers show no preference for wild-caught animals; (ii) a substantial part of the demand is met, and the demand does not increase due to the legalized market; (iii) the legal products will be more cost-efficient, in order to combat the black market prices; (iv) wildlife farming does not rely on wild populations for re-stocking; (v) laundering of illegal products into the commercial trade is absent. For most species encountered in the wildlife trade, these criteria are unlikely to be met in reality and commercial breeding has the potential to have the opposite effect to what is desired for conservation. For some species, however, none of the criteria are violated, and wildlife farming can be considered a possible conservation tool as it may help to take the pressure off wild populations. For these species, future research should focus on the impact of legal products on the market dynamics, effective law enforcement that can prevent corruption, and wildlife forensics that enable the distinction between captive-bred and wild-caught species.

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Cieri, R.L. and Farmer, C.G. (2016). Unidirectional pulmonary airflow in vertebrates: a review of structure, function, and evolution. *Journal of Comparative Physiology B*: 1-12.

**Abstract:** Mechanisms explaining unidirectional pulmonary airflow in birds, a condition where lung gases flow in a consistent direction during both inspiration and expiration in some parts of the lung, were suggested as early as the first part of the twentieth century and unidirectional pulmonary airflow has been discovered recently in crocodylians and squamates. Our knowledge of the functional anatomy, fluid dynamics, and significance of this trait is reviewed. The preponderance of the data indicates that unidirectional airflow is maintained by means of convective inertia in inspiratory and expiratory aerodynamic valves in birds. The study of flow patterns in non-avian reptiles is just beginning, but inspiratory aerodynamic valving likely also plays an important role in controlling flow direction in these lungs. Although highly efficient counter and cross-current blood-gas exchange arrangements are possible in lungs with unidirectional airflow, very few experiments have investigated blood-gas exchange mechanisms in the bird lung and blood-gas arrangements in the lungs of non-avian reptiles are completely unknown. The presence of unidirectional airflow in non-volant ectotherms voids the traditional hypothesis that this trait evolved to supply the high aerobic demands of flight and endothermy, and there is a need for new scenarios in our understanding of lung evolution. The potential value of unidirectional pulmonary airflow for allowing economic lung gas mixing, facilitating lung gas washout, and providing for adequate gas exchange during hypoxic conditions is discussed.

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Montefeltro, F.C., Andrade, D.V. and Larsson, H.C.E. (2016). The evolution of the meatal chamber in crocodylians. *Journal of Anatomy* (doi: 10.1111/joa.12439).

**Abstract:** The unique outer ear of crocodylians consists of a large meatal chamber (MC) concealed by a pair of muscular earflaps that shape a large part of the animal's head. This chamber is limited medially by the enlarged tympanic membrane. Yet, the anatomy of this distinctive and complex region is underexplored and its

evolutionary history untraced. The osteology and soft tissues of the MC in extant crocodylians was analysed to describe it and establish osteological correlates within this region. A broad survey of the osteological correlates was conducted in major clades of fossil crocodyliforms to estimate evolutionary trends of the MC. The reorganization of the MC at the origin of crocodyliforms includes characters also present in more basal taxa such as 'sphenosuchians' as well as unique traits of crocodyliforms. Three major patterns are recognized in the MC of basal mesoeucrocodylians. The distinct 'thalattosuchian pattern' indicates that extensive modifications occurred in this clade of aquatic fossil crocodyliforms, even when multiple alternative phylogenetic positions are taken into account. Some traits already established in putative closely related clades are absent or modified in this group. The 'basal notosuchian/sebecian pattern' is widespread among basal metasuchians, and establishes for the first time characters maintained later in neosuchians and extant forms. The 'advanced notosuchian pattern' includes modifications of the MC possibly related to a terrestrial lifestyle and potentially a structure analogous to the mammalian pinna. The main variation in the MC of neosuchians is associated with the homoplastic secondary opening of the cranioquadrate passage. The inferred phylogenetic trends in the crocodyliform MC suggest the great anatomical disparity in this region followed a complex evolutionary pattern, and tympanic hearing played an important role in the origin and diversification of Crocodyliformes.

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Srikulnath, K., Thapana, W. and Muangmai, N. (2015). Role of chromosome changes in *Crocodylus* evolution and diversity. *Genomics Informatics* 13(4): 102-111.

**Abstract:** The karyotypes of most species of crocodylians were studied using conventional and molecular cytogenetics. These provided an important contribution of chromosomal rearrangements for the evolutionary processes of Crocodylia and Sauropsida (birds and reptiles). The karyotypic features of crocodylians contain small diploid chromosome numbers (30~42), with little interspecific variation of the chromosome arm number (fundamental number) among crocodiles (56~60). This suggested that centric fusion and/or fission events occurred in the lineage, leading to crocodylian evolution and diversity. The chromosome numbers of *Alligator*, *Caiman*, *Melanosuchus*, *Paleosuchus*, *Gavialis*, *Tomistoma*, *Mecistops*, and *Osteolaemus* were stable within each genus, whereas those of *Crocodylus* (crocodylians) varied within the taxa. This agreed with molecular phylogeny that suggested a highly recent radiation of *Crocodylus* species. Karyotype analysis also suggests the direction of molecular phylogenetic placement among *Crocodylus* species and their migration from the Indo-Pacific to Africa and The New World. *Crocodylus* species originated from an ancestor in the Indo-Pacific around 9~16 million years ago (MYA) in the mid-Miocene, with a rapid radiation and dispersion into Africa 8~12 MYA. This was followed by a trans-Atlantic dispersion to the New World between 4~8 MYA in the Pliocene. The chromosomes provided a better understanding of crocodylian evolution and diversity, which will be useful for further study of the genome evolution in Crocodylia.

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Alibardi, L. and Minelli, D. (2016). Sites of cell proliferation during scute morphogenesis in turtle and alligator are different from those of lepidosaurian scales. *Acta Zoologica* 97(1): 127-141.

**Abstract:** Cell proliferation in forming shield scutes has been studied by immunofluorescence in embryos of turtle, alligator and snake after injection of 5-bromo-deoxy-uridine. Hinge regions of scutes in alligator and turtle carapace derive from an initial waving and invagination of the epidermis that contains 5-bromo-deoxy-uridine-labelled cells. This suggests that down growth of the epidermis into

the dermis is driven by local proliferation in addition to dermal anchorage and stabilization of hinge regions. Few keratinocytes migrate into suprabasal layers 1 day after injection of 5-bromo-deoxy-uridine and keratinocytes reach the precorneous layer in about 5 days. Proliferating keratinocytes are randomly distributed in the outer scale surface of symmetric scutes but are more numerous in the outer scale surface of asymmetric or overlapped scutes indicating epidermal expansion. Higher localization of proliferating cells along hinge regions of embryonic turtle and alligator scutes is maintained in adult scutes where most growth occurs. In snake, skin proliferation becomes prevalent on the elongating outer side of the asymmetric scale. Comparison between proliferation sites in turtle-alligator-chick scales with lepidosaurian scales indicates that placodes are present only in turtle-alligator-chick scales. Conversely, scale primordia detected only using gene markers are found in most crocodylian and lepidosaurians embryonic skin.

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Wise, S.S., Wise, C., Xie, H., Guillette, L.J. Jr., Zhu, C., Wise, J.P. Jr. and Wise, J.P. Snr. (2016). Hexavalent chromium is cytotoxic and genotoxic to American alligator cells. *Aquatic Toxicology* 171: 30-36.

**Abstract:** Metals are a common pollutant in the aquatic ecosystem. With global climate change, these levels are anticipated to rise as lower pH levels allow sediment bound metals to be released. The American alligator (*Alligator mississippiensis*) is an apex predator in the aquatic ecosystem and is considered a keystone species; as such it serves as a suitable monitor for localized pollution. One metal of increasing concern is hexavalent chromium [Cr(VI)]. It is present in the aquatic environment and is a known human carcinogen and reproductive toxicant. We measured the cytotoxicity and genotoxicity of Cr(VI) in American alligator cells derived from scute tissue. We found that particulate and soluble Cr(VI) are both cytotoxic and genotoxic to alligator cells in a concentration-dependent manner. These data suggest that alligators may be used as a model for assessing the effects of environmental Cr(VI) contamination as well as for other metals of concern.

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Jensen, B., Elfving, M., Elsey, R.M., Wang, T. and Crossley, D.A. II (2016). Coronary blood flow in the anesthetized American alligator (*Alligator mississippiensis*). *Comparative Biochemistry and Physiology Part A: Molecular & Integrative Physiology* 191: 44-52.

**Abstract:** Coronary circulation of the heart evolved early within ectothermic vertebrates and became of vital importance to cardiac performance in some teleost fish, mammals and birds. In contrast, the role and function of the coronary circulation in ectothermic reptiles remains largely unknown. Here, we investigated the systemic and coronary arterial responses of five anesthetized juvenile American alligators (*Alligator mississippiensis*) to hypoxia, acetylcholine, adenosine, sodium nitroprusside, isoproterenol, and phenylephrine. We recorded electrocardiograms, monitored systemic blood pressure, blood flows in both aortae, and blood flow in a major coronary artery supplying most of the right ventricle. Coronary arterial blood flow was generally forward, but there was a brief retrograde flow during a ventricular contraction. Blood pressure was significantly changed in all conditions. Acetylcholine decreased coronary forward flow, but this response was confounded by the concomitant lowered work of the ventricles due to decreased heart rate and blood pressure. Coronary forward flow was poorly correlated with heart rate and mean arterial pressure across treatments. Overall changes in coronary forward flow, significant and not significant, were generally in the same direction as mean arterial pressure and ventricular power, approximated as the product of systemic cardiac output and mean arterial pressure.

Katsu, Y., Kohno, S., Oka, K. and Baker, M.E. (2016). Evolution of corticosteroid specificity for human, chicken, alligator and frog glucocorticoid receptors. *bioRxiv* (doi: <http://dx.doi.org/10.1101/036665>).

**Abstract:** We investigated the evolution of the response of human, chicken, alligator and frog glucocorticoid receptors (GRs) to dexamethasone, cortisol, corticosterone, 11-deoxycorticosterone, 11-deoxycortisol and aldosterone. We find significant differences among these vertebrates in the transcriptional activation of their full length GRs by these steroids, indicating that there were changes in the specificity of the GR for steroids during the evolution of terrestrial vertebrates. To begin to study the role of interactions between different domains on the GR in steroid sensitivity and specificity for terrestrial GRs, we investigated transcriptional activation of truncated GRs containing their hinge domain and ligand binding domain (LBD) fused to a GAL4 DNA binding domain (GAL4 DBD). Compared to corresponding full length GRs, transcriptional activation of GAL4 DBD-GR hinge/LBD constructs required higher steroid concentrations and displayed altered steroid specificity, indicating that interactions between the hinge/LBD and other domains are important in glucocorticoid activation of these terrestrial GRs.

Di Minin, E., Leader-Williams, N. and Bradshaw, C.J.A. (2016). Banning trophy hunting will exacerbate biodiversity loss. *Trends in Ecology & Evolution* 31(2): 99-102.

**Abstract:** International pressure to ban trophy hunting is increasing. However, we argue that trophy hunting can be an important conservation tool, provided it can be done in a controlled manner to benefit biodiversity conservation and local people. Where political and governance structures are adequate, trophy hunting can help address the ongoing loss of species.

Rodríguez-Vivas, R.I., Apanaskevich, D.A., Ojeda-Chi, M.M., Trinidad-Martínez, I., Reyes-Novelo, E., Esteve-Gassent, M.D. and Pérez de León, A.A. (2016). Ticks collected from humans, domestic animals, and wildlife in Yucatan, Mexico. *Veterinary Parasitology* 215: 106-113.

**Abstract:** Domestic animals and wildlife play important roles as reservoirs of zoonotic pathogens that are transmitted to humans by ticks. Besides their role as vectors of several classes of microorganisms of veterinary and public health relevance, ticks also burden human and animal populations through their obligate blood-feeding habit. It is estimated that in Mexico there are around 100 tick species belonging to the Ixodidae and Argasidae families. Information is lacking on tick species that affect humans, domestic animals, and wildlife through their life cycle. This study was conducted to bridge that knowledge gap by inventorying tick species that infest humans, domestic animals and wildlife in the State of Yucatan, Mexico. *Amblyomma* ticks were observed as euryxenous vertebrate parasites because they were found parasitizing 17 animal species and human. *Amblyomma mixtum* was the most eryxenous species found in 11 different animal species and humans. Both *A. mixtum* and *A. parvum* were found parasitizing humans. *Ixodes nearaffinis* was the second most abundant species parasitizing 6 animal species (dogs, cats, horses, white-nosed coati, white-tail deer and black vulture) and was found widely across the State of Yucatan. Ixodid tick populations may increase in the State of Yucatan with time due to animal production intensification, an increasing wildlife population near rural communities because of natural habitat reduction and fragmentation. The diversity of ticks across host taxa documented here highlights the relevance of ecological information

to understand tick–host dynamics. This knowledge is critical to inform public health and veterinary programs for the sustainable control of ticks and tick-borne diseases.

Stein, M., Archer, M. and Hand, S.J. (2016). Dwarfism and feeding behaviours in Oligo-Miocene crocodiles from Riversleigh, northwestern Queensland, Australia. *Acta Palaeontologica Polonica* 61 (1): 135-142.

**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*, 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.

Whiting, E.T., Steadman, D.W. and Krigbaum, J. (2016). Paleoecology of Miocene crocodylians in Florida: Insights from stable isotope analysis. *Palaeogeography, Palaeoclimatology, Palaeoecology* (doi:10.1016/j.palaeo.2016.03.009).

**Abstract:** Fossils from late Miocene localities in north Florida offer new information about the paleoecological relationships between sympatric alligatorine and tomistomine crocodylians. Large, robust tomistomines (traditionally referred to *Gavialosuchus americanus*) outnumber *Alligator* fossils at localities representing coastal/estuarine depositional environments. Stable isotope analysis of carbon ( $\delta^{13}\text{C}$ ) and oxygen ( $\delta^{18}\text{O}$ ) values in fossil crocodylian tooth enamel carbonate ( $\text{CO}_3^{2-}$ ) provides evidence for niche partitioning between these two taxa, which may have co-inhabited estuarine paleoenvironments. Our isotopic results imply that alligators procured prey from primarily freshwater or terrestrial sources, whereas tomistomines fed mainly on marine-based prey items. As indicators of saltwater paleoenvironments, the fossil tomistomines may therefore be informative for tracking Miocene sea level change.

Klenner, S., Witzel, U., Paris, F. and Distler, C. (2016). Structure and function of the septum nasi and the underlying tension chord in crocodylians. *Journal of Anatomy* 228(1): 113-124.

**Abstract:** A long rostrum has distinct advantages for prey capture in an aquatic or semi-aquatic environment but at the same time poses severe problems concerning stability during biting. We here investigate the role of the septum nasi of brevirostrine crocodylians for load-absorption during mastication. Histologically, both the septum nasi and the septum interorbitale consist of hyaline cartilage and therefore mainly resist compression. However, we identified a strand of tissue extending longitudinally below the septum nasi that is characterized by a high content of collagenous and elastic

fibers and could therefore resist tensile stresses. This strand of tissue is connected with the m. pterygoideus anterior. Two-dimensional finite element modeling shows that minimization of bending in the crocodylian skull can only be achieved if tensile stresses are counteracted by a strand of tissue. We propose that the newly identified strand of tissue acts as an active tension chord necessary for stabilizing the long rostrum of crocodylians during biting by transforming the high bending stress of the rostrum into moderate compressive stress.

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Srivastava, R., Patnaik, R., Shukla, U.K. and Sahni, A. (2016). Crocodylian nest in a Late Cretaceous sauropod hatchery from the Type Lameta Ghat Locality, Jabalpur, India. *PLoS One* 10(12):e0144369.

**Abstract:** The well-known Late Cretaceous Lameta Ghat locality (Jabalpur, India) provides a window of opportunity to study a large stable, near shore sandy beach, which was widely used by sauropod dinosaurs as a hatchery. In this paper, we revisit the eggs and eggshell fragments previously assigned to lizards from this locality and reassign them to crocodylomorphs. Several features point to a crocodylian affinity, including a subspherical to ellipsoidal shape, smooth, uneven external surface, discrete trapezoid shaped shell units with wide top and narrow base, basal knobs and wedge shaped crystallites showing typical inverted triangular extinction under crossed nicols. The crocodylomorph eggshell material presented in this paper adds to the skeletal data of these most probably Cretaceous-Eocene dryosaurid crocodylians.

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Christie, I., Reiner, J.L., Bowden, J.A., Botha, H., Cantu, T.M., Govender, D., Guillette, M.P., Lowers, R.H., Luus-Powell, W.J., Pienaar, D., Smit, W.J. and Guillette, Jr., L.J. (2016). Perfluorinated alkyl acids in the plasma of South African crocodylians (*Crocodylus niloticus*). *Chemosphere* 154: 72-78.

**Abstract:** Perfluorinated alkyl acids (PFAAs) are environmental contaminants that have been used in many products for over 50 years. Interest and concern has grown since 2000 on the widespread presence of PFAAs, when it was discovered that PFAAs were present in wildlife samples around the northern hemisphere. Since then, several studies have reported PFAAs in wildlife from many locations, including the remote regions of Antarctica and the Arctic. Although there are a multitude of studies, few have reported PFAA concentrations in reptiles and wildlife in the Southern Hemisphere. This study investigated the presence of PFAAs in the plasma of Nile crocodylians (*Crocodylus niloticus*) from South Africa. Crocodylians were captured from 5 sites in and around the Kruger National Park, South Africa, and plasma samples examined for PFAAs. Perfluorooctane sulfonate (PFOS) was the most frequent PFAA detected; with median values of 13.5 ng/g wet mass in crocodylians. In addition to PFOS, long chain perfluorinated carboxylic acids were also detected. Correlations between total length and PFAA load were investigated, as were differences in PFAA accumulation between sexes. No correlations were seen between crocodile size, nor were there sex-related differences. Spatial differences were examined and significant differences were observed in samples collected from the different sites ( $p < 0.05$ ). Flag Boshielo Dam had the highest PFOS measurements, with a median concentration of 50.3 ng/g wet mass, when compared to the other sites (median concentrations at other sites below 14.0 ng/g wet mass). This suggests a point source of PFOS in this area.

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Zisadza-Gandiwa, P., Gandiwa, E. and Muboko, N. (2016). Preliminary assessment of human-wildlife conflicts in Maramani

Communal Area, Zimbabwe. *African Journal of Ecology* (doi:10.1111/aje.12282).

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McCoy, K.A., Roark, A.M., Boggs, A.S.P., Bowden, J.A., Cruze, L., Edwards, T.M., Hamlin, H.J., Cantu, T.M., McCoy, J.A., McNabb, N.A., Wenzel, A.G., Williams, C.E. and Kohno, S. (2016). Integrative and comparative reproductive biology: From alligators to xenobiotics. *General and Comparative Endocrinology* (doi:10.1016/j.ygcen.2016.03.026).

**Abstract:** Dr. Louis J. Guillette Jr. thought of himself as a reproductive biologist. However, his interest in reproductive biology transcended organ systems, life history stages, species, and environmental contexts. His integrative and collaborative nature led to diverse and fascinating research projects conducted all over the world. He doesn't leave us with a single legacy. Instead, he entrusts us with several. The purpose of this review is to highlight those legacies, in both breadth and diversity, and to illustrate Dr. Guillette's grand contributions to the field of reproductive biology. He has challenged the field to reconsider how we think about our data, championed development of novel and innovative techniques to measure endocrine function, helped define the field of endocrine disruption, and lead projects to characterize new endocrine disrupting chemicals. He significantly influenced our understanding of evolution, and took bold and important steps to translate all that he has learned into advances in human reproductive health. We hope that after reading this manuscript our audience will appreciate and continue Dr. Guillette's practice of open-minded and passionate collaboration to understand the basic mechanisms driving reproductive physiology and to ultimately apply those findings to protect and improve wildlife and human health.

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Escobedo-Galván, A.H., López-Luna, M.A., Cupul-Magaña, F.G. (2016). Thermal fluctuation within nests and predicted sex ratio of Morelet's crocodile. *Journal of Thermal Biology* (doi:10.1016/j.jtherbio.2016.03.006).

**Abstract:** Understanding the interplay between thermal variations and sex ratio in reptiles with temperature-dependent sex determination is the first step for developing long-term conservation strategies. In case of crocodylians, the information is fragmentary and insufficient for establishing a general framework to consider how thermal fluctuation influence sex determination under natural conditions. The main goal of this study was to analyze thermal variation in nests of *Crocodylus moreletii* and to discuss the potential implications for predicting offspring sex ratio. The study was carried out at the Centro de Estudios Tecnológicos del Mar N° 2 and at the Sistemas Productivos Cocodrilo, Campeche, Mexico. Data was collected in the nesting season of Morelet's crocodylians during three consecutive seasons (2007 to 2009). Thermal fluctuations for multiple areas of the nest chamber were registered by data loggers. We calculate the constant temperature equivalent based on thermal profiles among nests to assess whether there are differences between the nest temperature and its equivalent to constant temperature. We observed that mean nest temperature was only different among nests, while daily thermal fluctuations vary depending on the depth position within the nest chamber, years and nests. The constant temperature equivalent was different among and within nests, but not among survey years. We observed differences between constant temperature equivalent and mean nest temperature both at the top and in the middle of the nest cavities, but were not significantly different at the bottom of nest cavities. Our results enable examine and discuss the relevance of daily thermal fluctuations to predict sex ratio of Morelet's crocodile.

Van Schingen, M., Ziegler, T., Boner, M., Streit, B., Nguyen, T.Q., Crook, V. and Ziegler, S. (2016). Can isotope markers differentiate between wild and captive reptile populations? A case study based on crocodile lizards (*Shinisaurus crocodilurus*) from Vietnam. *Global Ecology and Conservation* 6: 232-241.

**Abstract:** The international wildlife trade in allegedly “captive-bred” specimens has globally increased during recent years, while the legal origin of respective animals frequently remains doubtful. Worldwide, authorities experience strong challenges to effectively control the international trade in CITES-listed species and are struggling to uncover fraudulent claims of “captive-breeding”. Forensic analytical methods are being considered as potential tools to investigate wildlife crime. The present case study is the first of its kind in reptiles that investigates the application of  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  stable isotope ratios to discriminate between captive and wild crocodile lizards from Vietnam. The CITES-listed crocodile lizard *Shinisaurus crocodilurus* is listed as endangered on the IUCN Red List mainly due to habitat loss and unsustainable exploitation for the international pet trade. Our results revealed significant differences in the composition of the two tested isotope systems between captive and wild individuals. Isotope values of skin samples from captive specimens were significantly enriched in  $^{13}\text{C}$  and  $^{15}\text{N}$  as compared to specimens from the wild. We also used the weighted k-Nearest Neighbor classifier to assign simulated samples back to their alleged place of origin and demonstrated that captive bred individuals could be distinguished with a high degree of accuracy from specimens that were not born in captivity. We conclude that isotope analysis appears to be highly attractive as a forensic tool to reduce laundering of wild caught lizards via breeding farms, but acknowledge that this potential might be limited to range restricted or ecologically specialist species.

Colafrancesco, K.C. and Gridi-Papp, M. (2016). Vocal sound production and acoustic communication in amphibians and reptiles. *Vertebrate Sound Production and Acoustic Communication* 53: 51-82.

**Abstract:** Most amphibians and reptiles produce sounds with a larynx containing a pair of vocal cords. Clicking and hissing are common in both groups whereas tonal sounds are found most frequently in anurans and geckos. Calls can exceed 90 dB SPL at a distance of 1 m and they can have fundamental frequencies above 20 kHz. Calling is used mostly by males for courtship and territorial displays. Offspring and females call to synchronize hatching and to mediate maternal care. Adults and juveniles in many groups produce hissing when threatened. Amphibians and reptiles include more than 17,000 species. As a result of this diversity, major advances in the field of vocalization are made through exploratory research but also through careful experimentation and the use of novel technologies. Combining the study of vocal and auditory systems is important to explain issues such as the diversity of frequency tuning in the group. Many questions can also be answered through comparative studies in amphibians and reptiles because these groups have evolved independent solutions to common communication problems.

Nixon, B., Anderson, A.L., Smith, N.D., McLeod, R. and Johnston, S.D. (2016). The Australian saltwater crocodile (*Crocodylus porosus*) provides evidence that the capacitation of spermatozoa may extend beyond the mammalian lineage. *Proceedings of the Royal Society B, Biological Sciences* (doi: 10.1098/rspb.2016.0495).

**Abstract:** Although mammalian spermatozoa only acquire functional maturity as they are conveyed through the male (epididymal maturation) and female (capacitation) reproductive tracts, the

degree of post-testicular development necessary to achieve fertilization in other vertebrate species remains far less clear. Indeed, despite reports that the epididymis of birds and reptiles is capable of secreting proteins that bind and modify the sperm surface characteristics, it remains unclear whether capacitation is a pre-requisite for fertilization in these species. Using the ancient reptilian Australian saltwater crocodile as a model, this study was undertaken to explore whether reptile sperm do undergo capacitation-like changes following ejaculation. Our studies revealed that crocodile spermatozoa experienced a rapid and sustained, cyclic-AMP mediated increase in progressive motility following incubation under conditions optimized for the induction of capacitation in mammalian species such as the mouse and human. This response was coupled with elevated levels of phosphorylation associated with both protein kinase A and tyrosine kinase substrates, the latter of which were predominantly localized within the sperm flagellum. In findings that also accord with mammalian spermatozoa, we confirmed a homologue of outer dense fibre 2 as one of the principal substrates for tyrosine phosphorylation. Overall, our findings support the concept that crocodile spermatozoa do undergo a process that is homologous to capacitation in preparation for fertilization of an ovum.

Rochford, M.R., Krysko, K.L., Mazzotti, F.J., Shirley, M.H., Parry, M.W., Wasilewski, J.A., Beauchamp, J.S., Gillette, C.R., Metzger, E.F., Squires, M.A. and Somma, L.A. (2016). Molecular analyses confirming the introduction of Nile crocodiles, *Crocodylus niloticus* Laurenti 1768 (Crocodylidae), in southern Florida, with an assessment of potential for establishment, spread, and impacts. *Herpetological Conservation and Biology* 11(1): 80-89.

**Abstract:** The state of Florida, USA, has more introduced herpetofauna than any other governmental region on Earth. Four species of nonnative crocodylians have been introduced to Florida (all since 1960), one of which is established. Between 2000-2014 we field-collected three nonnative crocodylians in Miami-Dade County, Florida, and one in Hendry County, Florida. We used DNA barcoding and molecular phylogenetics to determine species identification and native range origin. Also, we described diet, movement, and growth for one crocodile. Our molecular analyses illustrated that two of the crocodiles we collected are most closely related to Nile Crocodiles (*Crocodylus niloticus*) from South Africa, suggesting this region as a source population. We, thus, documented the first known introduction of *C. niloticus* in Florida. Two, and possibly three of the introduced crocodiles shared the same haplotype, suggesting they are likely from the same introduction pathway or source. One animal was captured, measured, marked, and released, then recaptured 2 y later allowing us to calculate growth rate (40.5 cm/y) and movement. The most likely route of travel by waterway (ie canal) illustrates that this animal traveled at least 29 km from its original capture site. One crocodile escaped from a facility in Hendry County, Florida, and survived in 1012 ha of semi-wild habitat for three to four years, confirming that this species can survive in southern Florida.

Smith, G.D., Adams, G.L. and Dinkelacker, S.A. (2016). Important habitat characteristics for American alligators (*Alligator mississippiensis*) on the edge of their range. *Herpetological Conservation and Biology* 11(1):72-79.

**Abstract:** Once threatened with extinction, American Alligators (*Alligator mississippiensis*) have recovered across most of their historic range. Alligators reach the northwestern boundary of their range in Arkansas, where habitat characteristics might limit populations. Although low population densities have been dismissed by local managers as a consequence of poor habitat, no

habitat studies of alligators have been performed to confirm this. It is crucial that habitat requirements of alligators throughout their range be understood for effective management and conservation. We conducted habitat assessments and population surveys for 19 bodies of water within the known range of American Alligators in southern Arkansas to determine which habitat characteristics were the most important predictors of relative population abundance. Ten habitat characteristics were incorporated into a stepwise multiple regression model with alligator relative population abundance as the dependent variable. Vegetative cover along the shoreline was the most important variable followed by land ownership (private or public). Water clarity and total vegetative cover were also important to the overall model, which explained 73% of the variation in relative population abundance. Although private water bodies had significantly higher population densities of alligators than publicly owned sites, a subsequent multi-response permutation procedure revealed no significant differences in measured habitat variables between private and publicly owned sites. Considering that measured habitat variables were not statistically different, there could be anthropogenic factors limiting American Alligators on public lands that have otherwise suitable habitat.

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Tuberville, T.D., Scott, D.E., Metts, B.S., Finger, Jr., J.W. and Hamilton, M.T. (2016). Hepatic and renal trace element concentrations in American alligators (*Alligator mississippiensis*) following chronic dietary exposure to coal fly ash contaminated prey. *Environmental Pollution* 214: 680-689.

**Abstract:** Little is known about the propensity of crocodylians to bioaccumulate trace elements as a result of chronic dietary exposure. We exposed 36 juvenile alligators (*Alligator mississippiensis*) to one of four dietary treatments that varied in the relative frequency of meals containing prey from coal combustion waste (CCW)-contaminated habitats vs. prey from uncontaminated sites, and evaluated tissue residues and growth rates after 12 mo and 25 mo of exposure. Hepatic and renal concentrations of arsenic (As), cadmium (Cd) and selenium (Se) varied significantly among dietary treatment groups in a dose-dependent manner and were higher in kidneys than in livers. Exposure period did not affect Se or As levels but Cd levels were significantly higher after 25 mo than 12 mo of exposure. Kidney As and Se levels were negatively correlated with body size but neither growth rates nor body condition varied significantly among dietary treatment groups. Our study is among the first to experimentally examine bioaccumulation of trace element contaminants in crocodylians as a result of chronic dietary exposure. A combination of field surveys and laboratory experiments will be required to understand the effects of different exposure scenarios on tissue residues, and ultimately link these concentrations with effects on individual health.

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Elbers, J.P. and Taylor, S.S. (2016). Major histocompatibility complex polymorphism in reptile conservation. *Herpetological Conservation and Biology* 11(1): 1-12.

**Abstract:** Genes of the major histocompatibility complex (MHC) are closely related to disease resistance and immune response in vertebrates. Although many groups are well represented in the MHC literature, less attention has been given to reptiles. Here we summarize reptile MHC studies, review published accounts investigating links between MHC polymorphism, parasite resistance, and mate choice, evaluate current limitations, and discuss prospects of new technologies for future research. MHC polymorphism appears to be extensive in reptile populations, and current evidence suggests MHC polymorphism may influence parasite resistance and mate choice as in other vertebrates. Prior research strategies

have been limited by the type of molecular markers available, the nature of the sequences being amplified, the number of individuals and populations analyzed, the immunology and biology of the host-parasite relationship, and the conditions under which subjects are studied. Finally, reptiles offer special challenges: as ectotherms their susceptibility to pathogens may change dramatically depending on the time of year due to seasonal variations in their immunity. Including a temperature and/or seasonal variable may thus provide new insights into the genetic mechanisms of disease resistance. New technologies and techniques should help to alleviate problems of MHC gene characterization and multi-locus amplification associated with past research and contribute to our understanding of MHC polymorphism in reptile conservation.

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Telemeco, R.S., Gangloff, E.J., Cordero, G.A., Mitchell, T.S., Bodensteiner, B.L., Holden, K.G., Mitchell, S.M., Polich, R.L. and Janzen, F.J. (2016). Reptile embryos lack the opportunity to thermoregulate by moving within the egg. *The American Naturalist* (doi: 10.1086/686628).

**Abstract:** Historically, egg-bound reptile embryos were thought to passively thermoconform to the nest environment. However, recent observations of thermal taxis by embryos of multiple reptile species have led to the widely discussed hypothesis that embryos behaviorally thermoregulate. Because temperature affects development, such thermoregulation could allow embryos to control their fate far more than historically assumed. We assessed the opportunity for embryos to behaviorally thermoregulate in nature by examining thermal gradients within natural nests and eggs of the common snapping turtle (*Chelydra serpentina*; which displays embryonic thermal taxis) and by simulating thermal gradients within nests across a range of nest depths, egg sizes, and soil types. We observed little spatial thermal variation within nests, and thermal gradients were poorly transferred to eggs. Furthermore, thermal gradients sufficiently large and constant for behavioral thermoregulation were not predicted to occur in our simulations. Gradients of biologically relevant magnitude have limited global occurrence and reverse direction twice daily when they do exist, which is substantially faster than embryos can shift position within the egg. Our results imply that reptile embryos will rarely, if ever, have the opportunity to behaviorally thermoregulate by moving within the egg. We suggest that embryonic thermal taxis instead represents a play behavior, which may be adaptive or selectively neutral, and results from the mechanisms for behavioral thermoregulation in free-living stages coming online prior to hatching.

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Narváez, I., Brochu, C.A., Escaso, F., Pérez-García, A. and Ortega, F. (2016). New Spanish Late Cretaceous eusuchian reveals the synchronic and sympatric presence of two allodaposuchids. *Cretaceous Research* (doi:10.1016/j.cretres.2016.04.018).

**Abstract:** The recently described clade Allodaposuchidae includes European eusuchian crocodyliforms restricted to the Late Cretaceous (Campanian and Maastrichtian). A new allodaposuchid crocodyliform is here described based on two specimens from the upper Campanian-lower Maastrichtian fossil site of Lo Hueco (Cuenca, Spain). This new taxon, *Agaresuchus fontisensis* gen. et sp. nov., is described by two complete skulls and a lower jaw associated with one of them. This new species can be distinguished unambiguously from *Lohuecosuchus megadontos*, the other allodaposuchid known from the same fossil site. The presence of two allodaposuchid crocodyliforms in Lo Hueco allows the recognition of the synchronic and sympatric existence of two representatives of this clade for the first time. The new genus *Agaresuchus*, comprises a previously described Iberian allodaposuchid species,

“*Allodaposuchus*” *subjuniperus*, as *Agaresuchus subjuniperus*, new combination.

Nagloo, N., Collin, S.P., Hemmi, J.M. and Hart, N.S. (2016). Spatial resolving power and spectral sensitivity of the saltwater crocodile, *Crocodylus porosus*, and the freshwater crocodile, *Crocodylus johnstoni*. *Journal of Experimental Biology* 219: 1394-1404.

**Abstract:** Crocodylians are apex amphibious predators that occupy a range of tropical habitats. In this study, we examined whether their semi-aquatic lifestyle and ambush hunting mode are reflected in specific adaptations in the peripheral visual system. Design-based stereology and microspectrophotometry were used to assess spatial resolving power and spectral sensitivity of saltwater (*Crocodylus porosus*) and freshwater crocodiles (*Crocodylus johnstoni*). Both species possess a foveal streak that spans the naso-temporal axis and mediates high spatial acuity across the central visual field. The saltwater crocodile and freshwater crocodile have a peak spatial resolving power of 8.8 and 8.0 cycles deg<sup>-1</sup>, respectively. Measurement of the outer segment dimensions and spectral absorbance revealed 5 distinct photoreceptor types consisting of 3 single cones, one twin cone and a rod. The three single cones (saltwater/freshwater crocodile) are violet (424/426 nm  $\lambda_{max}$ ), green (502/510 nm  $\lambda_{max}$ ) and red (546/554 nm  $\lambda_{max}$ ) sensitive, indicating the potential for trichromatic colour vision. The visual pigments of both members of the twin cones have the same  $\lambda_{max}$  as the red-sensitive single cone and the rod has a  $\lambda_{max}$  at 503/510 nm (saltwater/freshwater). The  $\lambda_{max}$  values of all types of visual pigment occur at longer wavelengths in the freshwater crocodile compared with the saltwater crocodile. Given that there is a greater abundance of long wavelength light in freshwater compared with a saltwater environment, the photoreceptors would be more effective at detecting light in their respective habitats. This suggests that the visual systems of both species are adapted to the photic conditions of their respective ecological niche.

Dzul-Caamal, R., Hernández-López, A., Gonzalez-Jáuregui, M. Padilla, S.E., Girón-Pérez, M.I. and Vega-López, A. (2016). Usefulness of oxidative stress biomarkers evaluated in the snout scraping, serum and peripheral blood cells of *Crocodylus moreletii* from Southeast Campeche for assessment of the toxic impact of PAHs, metals and total phenols. *Comparative Biochemistry and Physiology Part A: Molecular & Integrative Physiology* (doi:10.1016/j.cbpa.2016.05.006).

**Abstract:** In this study, we assessed the effects of inorganic and organic pollutants [As, Cu, Fe, Mn, Pb, Zn, PAHs (11 compounds) and total phenols] from a panel of biomarkers [O<sub>2</sub>•, H<sub>2</sub>O<sub>2</sub>, thiobarbituric acid reactive substances (TBARS), carbonyl proteins (RC = O), superoxide dismutase (SOD), catalase (CAT), glutathione peroxidase (GPx) and total cytochrome P450 activities] evaluated in the Snout Scraping (SS), Serum (S) and Peripheral Blood Cells (PBC) of the Morelet's crocodile (*Crocodylus moreletii*) inhabiting the reference locality (Lake Mocu) and polluted locality (Champton River) using Principal Component Analysis (PCA). In male crocodiles from the reference site, only H<sub>2</sub>O<sub>2</sub> in PBC was related to levels of fluoranthene on the Keel of Caudal Scales (KCS), but, in females, no association was detected. In contrast, a sex-linked response was detected in specimens from the polluted locality. Levels of benzo[a]pyrene, benzo[a]anthracene, chrysene, pyrene, phenanthrene, acenaphthene, Zn, Cu, and Pb in KCS of the female crocodile were related to the oxidative stress biomarkers on PBC, including the total CYP450 activity and levels of O<sub>2</sub>•, H<sub>2</sub>O<sub>2</sub> in serum. However, in male crocodiles, the oxidative stress in SS and in the serum (TBARS, RC = O, CAT, GPx), and SOD

in PBC was related to As, Pb, Cu, Fe, and benzo[a]pyrene water concentrations and to the burdens of As, Fe, Mn, indeno[1,2,3 cd]pyrene in KCS. These results confirm the usefulness of minimal or non-invasive methods of evaluating the oxidative stress response for the environmental monitoring program on the wild Morelet's crocodile that is subject to special protection in Mexican guidelines.

Sayão, J.M., Bantim, R.A.M., Andrade, R.C.L.P., Lima, F.J., Saraiva, A.A.F., Figueiredo, R.G. and Kellner, A.W.A. (2016). Paleohistology of *Susisuchus anatoceps* (Crocodylomorpha, Neosuchia): Comments on growth strategies and lifestyle. *PLoS ONE* 11(5): e0155297.

**Abstract:** *Susisuchus anatoceps* is a neosuchian crocodylomorph lying outside the clade Eusuchia, and associated with the transition between basal and advanced neosuchians and the rise of early eusuchians. The specimen MPSC R1136 comprises a partially articulated postcranial skeleton and is only the third fossil assigned to this relevant taxon. Thin sections of a right rib and right ulna of this specimen have been cut for histological studies and provide the first paleohistological information of an advanced non-eusuchian neosuchian from South America. The cross-section of the ulna shows a thick cortex with 17 lines of arrested growth (LAGs), a few scattered vascular canals, and primary and secondary osteons. This bone has a free medullary cavity and a spongiosa is completely absent. Thin sections of the rib show that remodeling process was active when the animal died, with a thin cortex and a well-developed spongiosa. In the latter, few secondary osteons and 4 LAGs were identified. According to the observed data, *Susisuchus anatoceps* had a slow-growing histological microstructure pattern, which is common in crocodylomorphs. The high number of ulnar LAGs and the active remodeling process are indicative that this animal was at least a late subadult, at or past the age of sexual maturity. This contradicts previous studies that interpreted this and other *Susisuchus anatoceps* specimens as juveniles, and suggests that full-grown adults of this species were relatively small-bodied, comparable in size to modern dwarf crocodiles.

Whiting, E. (2016). Constraining Neogene Temperature and Precipitation Histories in the Central Great Plains using the Fossil Record of Alligator. MSc thesis, University of Nebraska, Lincoln, Nebraska, USA.

**Abstract:** Most amphibians and reptiles (excluding birds) are poikilothermic; their internal body temperature varies with that of their external environment. This makes them useful as climate proxies, especially when linked to geographic distributions of ambient climate. I evaluate the utility of the extant crocodylian genus *Alligator* as a paleoclimate proxy for the Central Great Plains (CGP) using species distribution modeling. *Alligator* is a readily identifiable taxon with a good CGP fossil record during the Neogene (~23-2.6 Ma). *Alligator* first appeared in the CGP in the late Eocene (~37 Ma), was absent during most of the Oligocene, reappeared in the early Miocene (~19 Ma), and was extirpated in the late Miocene (~9-6 Ma). This history of occurrence and extirpation implies substantial climatic and environmental changes through time. To quantify these changes, I constructed species distribution models for extant American alligators using 19 climatic variables and the Maximum Entropy algorithm. I found that living *Alligator* occupies most of its potential geographic range based on modern climatic parameters and is therefore a useful climate proxy. Driest quarter precipitation is the primary variable constraining *Alligator* distributions, which contrasts with results from other studies suggesting that coldest month mean temperature is the most important factor. Model results and the fossil distribution of *Alligator* suggest that the CGP

witnessed increasing aridity and decreasing temperatures during the late Miocene before the spread of C4 grasslands; this agrees with several other independent proxy reconstructions. The presence or absence of fossil *Alligator*, used in concert with these other proxies, can therefore help constrain paleoclimatic conditions in the CGP during the Neogene.

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Zhang, R., Hua, Y., Wang, H., Yan, P., Zhou, Y., Wu, R. and Wu, X. (2016). Molecular cloning, characterization, tissue distribution and mRNA expression changes during the hibernation and reproductive periods of estrogen receptor alpha (ESR1) in Chinese alligator, *Alligator sinensis*. *Comparative Biochemistry and Physiology Part B: Biochemistry and Molecular Biology* 200: 28-35.

**Abstract:** Chinese alligator, *Alligator sinensis*, is a critically endangered reptile species unique to China. Little is known about the mechanism of growth- and reproduction-related hormones gene expression in Chinese alligator. Estrogens play important roles in regulating multiple reproduction- and non-reproduction-related functions by binding to their corresponding receptors. Here, the full-length cDNA of estrogen receptor alpha (*Era/ESR1*) was cloned and sequenced from Chinese alligator for the first time, which comprises 1764 bp nucleotides and encodes a predicted protein of 587 amino acids. Phylogenetic analysis of *ESR1* showed that crocodylians and turtles were the sister-group of birds. The results of real-time quantitative PCR indicated that the *ESR1* mRNA was widely expressed in the brain and peripheral tissues. In the brain and pituitary gland, *ESR1* was most highly transcribed in the cerebellum. But in other peripheral tissues, *ESR1* mRNA expression level was the highest in the ovary. Compared with hibernation period, *ESR1* mRNA expression levels were increased significantly in the reproductive period ( $P < 0.05$ ) in cerebellum, pituitary gland, liver, spleen, lung, kidney and ovary, while no significant change in other examined tissues ( $P > 0.05$ ). The *ESR1* mRNA expression levels changes during the two periods of different tissues suggested that ESR1 might play an important role in mediation of estrogenic multiple reproductive effects in Chinese alligator. Furthermore, it was the first time to quantify *ESR1* mRNA level in the brain of crocodylians, and the distribution and expression of *ESR1* mRNA in the midbrain, cerebellum and medulla oblongata was also reported for the first time in reptiles.

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Refsnider, J.M. (2016). Nest-site choice and nest construction in non-avian reptiles: Evolutionary significance and ecological implications. *Avian Biology Research* 9(2): 76-88.

**Abstract:** In oviparous animals, nest-site choice is both a critical determinant of an individual's lifetime fitness, and an important demographic parameter of populations. At the individual level, the location and characteristics of a nest site impact survival of both the nesting female and the nestling or hatchling stage, and can also influence offspring phenotype and the survival of emerging juveniles. At the population level, survival rates of females and offspring, and phenotypes affected by incubation conditions, affect population trends. Reptiles differ from birds in several key life-history traits associated with nesting behaviour in that they have long incubation periods, bury eggs within a substrate, and have minimal parental care. However, studies in reptile systems have also demonstrated several evolutionary drivers of nest-site choice that are also likely to be important in avian systems. These include the role of incubation conditions in affecting offspring phenotype, and the contribution of nest-site choice to survival of the juvenile life stage. Overall, studies on the evolution and ecology of nest-site choice in reptiles and birds have much to offer each other in terms of both theoretical basis and applications to conservation and management. Incorporating

knowledge gained from a range of taxa into our research, and testing hypotheses in one system that have demonstrated importance in other systems, will provide a richer understanding of the ecology and evolution of nest-site choice.

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Han, B., Yuan, H., Wang, T., Li, B., Ma, L., Yu, S., Huang, T., Li, Y., Fang, D., Chen, X., Wang, Y., Wiu, S., Guo, Y., Fei, J., Ren, L., Pan-Hammarström, Q., Hammarström, L., Wang, J., Wang, J., Hou, Y., Pan, Q., Xu, X. and Zhao, Y. (2016). Multiple IgH isotypes including IgD, subclasses of IgM, and IgY are expressed in the common ancestors of modern birds. *The Journal of Immunology* (doi: 10.4049/jimmunol.1600307).

**Abstract:** Although evolutionarily just as ancient as IgM, it has been thought for many years that IgD is not present in birds. Based on the recently sequenced genomes of 48 bird species as well as high-throughput transcriptome sequencing of immune-related tissues, we demonstrate in this work that the ostrich (*Struthio camelus*) possesses a functional  $\delta$  gene that encodes a membrane-bound IgD H chain with seven CH domains. Furthermore,  $\delta$  sequences were clearly identified in many other bird species, demonstrating that the  $\delta$  gene is widely distributed among birds and is only absent in certain bird species. We also show that the ostrich possesses two  $\mu$  genes ( $\mu 1$ ,  $\mu 2$ ) and two  $\nu$  genes ( $\nu 1$ ,  $\nu 2$ ), in addition to the  $\delta$  and  $\alpha$  genes. Phylogenetic analyses suggest that subclass diversification of both the  $\mu$  and  $\nu$  genes occurred during the early stages of bird evolution, after their divergence from nonavian reptiles. Although the positions of the two  $\nu$  genes are unknown, physical mapping showed that the remaining genes are organized in the order  $\mu 1$ - $\delta$ - $\alpha$ - $\mu 2$ , with the  $\alpha$  gene being inverted relative to the others. Together with previous studies, our data suggest that birds and nonavian reptile species most likely shared a common ancestral IgH gene locus containing a  $\delta$  gene and an inverted  $\alpha$  gene. The  $\delta$  gene was then evolutionarily lost in selected birds, whereas the  $\alpha$  gene lost in selected nonavian reptiles. The data obtained in this study provide significant insights into the understanding of IgH gene evolution in tetrapods.

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Pacheco-Sierra, G., Gompert, Z., Domínguez-Laso, J. and Vázquez-Domínguez, E. (2016). Genetic and morphological evidence of a geographically widespread hybrid zone between two crocodile species, *Crocodylus acutus* and *C. moreletii*. *Molecular Ecology* (doi: 10.1111/mec.13694).

**Abstract:** Hybrid zones represent natural laboratories to study gene flow, divergence and the nature of species boundaries between closely related taxa. We evaluated the level and extent of hybridization between *Crocodylus moreletii* and *C. acutus* using genetic and morphological data on 300 crocodiles from 65 localities. To our knowledge, this is the first genetic study that includes the entire historic range and sympatric zone of the two species. Contrary to expectations, Bayesian admixture proportions and maximum likelihood estimates of hybrid indexes revealed that most sampled crocodiles were admixed and that the hybrid zone is geographically extensive, extending well beyond their historical region of sympatry. We identified a few geographically isolated, non-admixed populations of both parental species. Hybrids do not appear to be F1s or recent backcrosses, but rather are more likely later-generation hybrids, suggesting that hybridization has been going on for several to many generations and is mostly the result of natural processes. *C. moreletii* is not the sister species of *C. acutus*, suggesting that the hybrid zone formed from secondary contact rather than primary divergence. Non-admixed individuals from the two species were distinguishable based on morphological characters, whereas hybrids had a complex mosaic of morphological characters that hinders identification in the wild. Very few non-

admixed *C. acutus* and *C. moreletii* populations exist in the wild. Consequently, the last non-admixed *C. moreletii* populations have become critically endangered. Indeed, not only the parental species but also the naturally occurring hybrids should be considered for their potential conservation value.

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Olaniyan, S.T., Adeosun, A.O. and Owoade O.A. (2016). Effect of Ebola Virus disease outbreak on bush meat consumption in Ibarapa region of Oyo State, Nigeria. *International Journal of Agriculture and Earth Science* 2(2): 1-8.

**Abstract:** Bush meat is a special delicacy of the Ibarapas, hence, a survey of the effects of Ebola Virus disease outbreak on consumption of bush meat in Ibarapa region of Oyo state was conducted. Questionnaires were randomly administered on 630 respondents in the three local governments in the region. Data were analyzed using descriptive statistics and likert rating scale. Findings revealed that outbreak of Ebola virus disease has implication on consumption of bush meat in the study area and has affected the livelihood of the marketer. Bush meats consumed in the area were also found to include squirrel, rodents, antelope, snake, alligator, bush fowl, etc. Investigation revealed that consumption of animals such as bats and big rats were forbidden in some places in the studied area. Also, choices of bush meat consumed were found to depend on availability, delicacy, price, nutrition and custom. Respondents agreed that bush meat if not properly cooked can transmit not only EBOV but other diseases. Respondent agreed that not all wild animals can transmit EBOV. The study therefore concluded that there should be adequate education on mode of transmission and prevention of EBOV by stakeholders, such as Health officer and extension workers.

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Ijeomah, H.M. and Ugwu, C.C. (2016). Utilization of selected edible forest and wildlife resources in Nsukka Zone of Enugu State, Nigeria. *Nigerian Journal of Agriculture, Food and Environment* 12(1): 44-51.

**Abstract:** Edible forest and wildlife resources are utilized in every part of eastern Nigeria but their rate of utilization, reasons and parts of species utilized in Nsukka zone of Enugu State is yet to be documented. Utilization of edible forest and wildlife resources in Nsukka zone was therefore studied. Data used for the study were collected through oral interview, focus group discussion and administration of two sets of structured questionnaires. Data collected were analyzed using descriptive statistics such as frequencies. Result showed many species of forest and wildlife resources are utilized and marketed in the study area. Different parts of forest products (leaves, seeds, fruits and barks.) and wildlife products (blood, flesh and feather), are utilized for different reasons in the study area. Forest and wildlife resources are mostly utilized for food. All respondents (100%) admitted that seeds and leaves of some forest products are the most utilized parts, whereas the most utilized part of the tortoise in the study area is the blood (90%), which is used for treatment of anemia. *Irvingia garbonensis*, *Irvingia excelsa*, *Treulia africana*, *Cola acuminata*, *Chrysophyllum albidum* and *Piper guineense* were among the many forest species planted in the study area while *Parkia biglobosa*, *Dialium guineense* and *Azelia africana* were listed as species that are not deliberately planted. *Pentaclethra macrophylla*, *Garcinia cola* and *Pterocarpus santalinoides* were among the frequently utilized species in the study area but rarely planted by respondents. The major medicinal species in the locality includes *Moringa oleifera*, *Azadirachta indica*, *Alstonia boonei*, *Milicia excelsa*, *Vernonia amygdalina*, *Anacardium occidentale*, *Daniella oliveri*, *Zingiber officinale* and *Garcinia cola*. The wildlife species utilized and marketed (as food, medicine, charm, and traditional purpose) includes; tortoise, snail and edible termite. Some of the species are utilized whole while

parts of others such as skin, flesh, and blood are utilized. Sustainable harvesting and utilization of forest and wildlife resources should be adopted by stakeholders in order to avoid the extinction of these vital resources in the study area.

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Hamilton, M.T., Kupar, C.A., Kelley, M.D., Finger Jr., J.W. and Tuberville, T.D. (2016). Blood and plasma biochemistry reference intervals for wild juvenile American alligators (*Alligator mississippiensis*). *Journal of Wildlife Diseases* (<http://dx.doi.org/10.7589/2015-10-275>).

**Abstract:** American alligators (*Alligator mississippiensis*) are one of the most studied crocodylian species in the world, yet blood and plasma biochemistry information is limited for juvenile alligators in their northern range, where individuals may be exposed to extreme abiotic and biotic stressors. We collected blood samples over a 2-yr period from 37 juvenile alligators in May, June and July to establish reference intervals for 22 blood and plasma analytes. We observed no effect of either sex or blood collection time on any analyte investigated. However, our results indicate a significant correlation between a calculated body condition index and aspartate aminotransferase and creatine kinase. Glucose, total protein, and potassium varied significantly between sampling sessions. In addition, glucose and potassium were highly correlated between the two point-of-care devices used, although they were significantly lower with the i-STAT 1 CG8+ cartridge than with the Vetscan VS2 Avian/Reptile Rotor. The reference intervals presented herein should provide baseline data for evaluating wild juvenile alligators in the northern portion of their range.

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Godoy, P.L., Bronzati, M., Eltink, E., Marsola, J.C.d.A., Cidade, G.M., Langer, M.C. and Montefeltro, F.C. (2016). Postcranial anatomy of *Pissarrachampsia sera* (Crocodyliformes, Baurusuchidae) from the Late Cretaceous of Brazil: insights on lifestyle and phylogenetic significance. *PeerJ* 4:e2075.

**Abstract:** The postcranial anatomy of Crocodyliformes has historically been neglected, as most descriptions are based solely on skulls. Yet, the significance of the postcranium in crocodyliforms evolution is reflected in the great lifestyle diversity exhibited by the group, with members ranging from terrestrial animals to semi-aquatic and fully marine forms. Recently, studies have emphasized the importance of the postcranium. Following this trend, here we present a detailed description of the postcranial elements of *Pissarrachampsia sera* (Mesoeucrocodylia, Baurusuchidae), from the Adamantina Formation (Bauru Group, Late Cretaceous of Brazil). The preserved elements include dorsal vertebrae, partial forelimb, pelvic girdle, and hindlimbs. Comparisons with the postcranial anatomy of baurusuchids and other crocodyliforms, together with body-size and mass estimates, lead to a better understanding of the paleobiology of *P. sera*, including its terrestrial lifestyle and its role as a top predator. Furthermore, the complete absence of osteoderms in *P. sera*, a condition previously known only in marine crocodyliforms, suggests osteoderms very likely played a minor role in locomotion of baurusuchids, unlike other groups of terrestrial crocodyliforms. Finally, a phylogenetic analysis including the newly recognized postcranial features was carried out, and exploratory analyses were performed to investigate the influence of both cranial and postcranial characters in the phylogeny of Crocodyliformes. Our results suggest that crocodyliform relationships are mainly determined by cranial characters. However, this seems to be a consequence of the great number of missing entries in the data set with only postcranial characters and not of the lack of potential (or synapomorphies) for this kind of data to reflect the evolutionary history of Crocodyliformes.

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