

# **CROCODILE SPECIALIST GROUP NEWSLETTER**

VOLUME 39 No. 1 • JANUARY 2020 - MARCH 2020



IUCN • Species Survival Commission

# CROCODILE

# SPECIALIST

# GROUP

# NEWSLETTER

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IUCN - Species Survival Commission

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COVER PHOTOGRAPH: Baited noose suspended from a drone being grabbed by a 2 m long Saltwater crocodile (*Crocodylus porosus*) in North Queensland, Australia. See pages 20-21 (Brien *et al.* 2020).

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

## CSG Newsletter

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

The CSG Newsletter provides information on the conservation, status, news and current events concerning crocodilians, and on the activities of the CSG. It is available as a free electronic, downloadable copy from "<http://www.iucncsg.org/pages/Publications.html>".

All CSG communications should be addressed to:  
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We thank all patrons who have donated to the CSG and its conservation program over many years, and especially to donors in 2019-2020 (listed below).

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Heng Long Leather Co. Pte. Ltd., Singapore.  
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Louisiana Alligators Farmers and Ranchers Association,  
Abbeville, Louisiana, USA.  
Reptile Tannery of Louisiana, Lafayette, Louisiana, USA/  
Hermes Cuirs Precieux, Paris, France.  
Singapore Reptile Skin Trade Association, Singapore.  
United Leather Products Co., Ltd. and Nakorn Sawan  
Crocodile Farm, Thailand.  
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Ebey family, New Mexico, USA.  
Paolo Martelli, Hong Kong.  
J.K. Mercado & Sons Agricultural Enterprises, Philippines.  
Phoenix Herpetological Society, Arizona, USA.

R.J. Rao, Gwalior, India.  
George Saputra, CV Alona Jaya, Jakarta, Indonesia.  
Santa Fe College Teaching Zoo, Gainesville, Florida, USA.  
Zambia Crocodile Farmers Association, Lusaka, Zambia.

#### **Contributors (\$250 - \$1000)**

Cathy Shilton, Northern Territory, Australia.  
Croc Encounters of Tampa, Florida, USA.  
Dresden Zoo, Dresden, Germany.  
James Hennessy, The National Reptile Zoo, Ireland.  
Zoo Atlanta, Georgia, USA.  
Zoological Society of Hertfordshire, UK.

## **Editorial**

Since our last Newsletter, the world has been cast into an unprecedented economic and social crisis with the spread of the COVID-19 virus (= corona virus). There has been no global incident like this in my lifetime, although there was, with my parents and grandparents (WWI, Spanish Flu, Great Depression, WWII). The profile of science and scientists - humanity's premier problem-solvers - has rocketed up, as it always does in real crises. My sincere hope is that the health of CSG members and their families can come through this crisis unscathed. We will all have to wear social and economic disadvantage to varying degrees. As Vivien Greene articulated: "*learn to dance in the rain rather than wait for the storm to pass*".

Restrictions on domestic and international travel will be impacting on many of you, but not much can be done about it. In Darwin, where I live, for once the "tyranny of distance" is an advantage - so far. I urge everyone to stay safe, help others less fortunate than themselves, and be models of compliance. What an insidious situation the world is facing.

I would like to thank Mexico, which wisely and expediently postponed the 26th CSG Working Meeting (4-7 May 2020), planned for Chetumal, Quintana Roo, Mexico. It will be held in the same place next year (3-6 May 2021). The veterinary, drone and taxonomy workshops will be on 1 May 2021, and the CSG Steering Committee meeting on 2 May 2021 ([www.biodiversidad.gob.mx/planeta/csg2020/index.html](http://www.biodiversidad.gob.mx/planeta/csg2020/index.html)). This must cause inconvenience to individuals, for which I apologise, but no other option was available.

The IUCN World Conservation Congress (11-19 June 2020), in Marseilles, France, has not yet been cancelled, but the IUCN and the Government of France continue to monitor the situation. It is unlikely to go ahead, and the planned CSG involvement at the WCC is unlikely to take place.

In California, where the proposed ban in trade in crocodiles and alligators is subject to legal challenge, the date has been transferred from late April to 15 May 2020. This case is a direct result of animal rights activism within California, in which conservation and livelihoods have been willingly thrown under the bus. If one positive thing comes out of the pandemic, it may be that people's values and priorities may be reset - people are important. This is all occurring amidst

a back drop of continuing industry problems, and hardship for many farms and conservation programs. This continually evolving situation, which we started assessing at the last CSG Working Meeting in Argentina, seems to be going from bad to worse, and the Executive Committee will prepare a briefing for everyone.

The CSG's long-standing interest in confirming the status of the Apaporis Caiman (*Caiman crocodilus apaporiensis*) was hampered for years by civil unrest in Colombia, but Sergio Balaguera-Reina led a team into the remote area (December 2018), confirmed the presence of *C. c. apaporiensis*, collected DNA samples, set up a program with local people, and was open and transparent about the whole affair. I was astounded that TV host Forrest Galante, using information from Sergio, visited the same site and fabricated a story that he discovered it! No credit to Sergio and his team's discovery, a year before, supported by CrocFest and various CSG members. Astounding! "Parachute science" has long been with us, but it leaves a bad taste in the mouths of its victims. The perpetrators deserved to be shamed. See page 10 for a summary of this bizarre case!

An important development, thanks to Sergio Balaguera-Reina, Pablo Siroski and the CSG Executive Committee, has been the rationalization of a CSG Future Leaders Program, out of the previous Future Leaders Working Group. The Executive Committee has endorsed a statement outlining its history, the original intent, and commits to the next stage of development which will require increased investment in a smaller number of key people going forward (see pages 5-6). This has been an important initiative within the CSG, to which many people have contributed, and many, including the CSG and IUCN, have benefitted. We have some simply remarkable people in the CSG - so many champions. By all means extend any comments and advice to Sergio and Pablo.

I would also draw your attention to an update on humane euthanasia/killing methods for crocodilians provided by members of the CSG Veterinary Science Group (pages 6-8).

Long-time CSG member and "icon" Phil Wilkinson has recently co-authored "Seven Days on the Santee Delta", which traces Phil's life against the backdrop of coastal South Carolina and the Santee Delta - the largest river delta on the eastern seaboard of the USA (see page 4). We were hoping to have this remarkable book available at the CSG Working Meeting, but alas .... not to be. I am sure we can work out other arrangements.

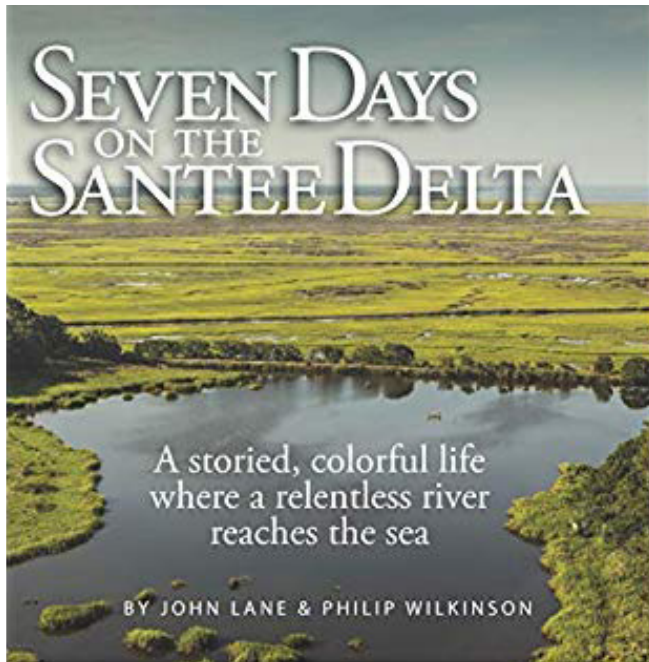
Kent Vliet, another long-time CSG member, has put together a richly illustrated and up to date account of the American alligator in "Alligators - the Illustrated Guide to their Biology, Behavior, and Conservation". This book will also be a valuable addition to anyone's collection, and especially for those interested and/or working with crocodilians (see page 4).

Professor Grahame Webb, *CSG Chair*.



## New Books

### **“Seven Days on the Santee Delta”**



Long-time CSG member and wildlife biologist Phil Wilkinson has joined with award-winning environmental writer and Wofford College professor John Lane to co-author “Seven Days on the Santee Delta”. The book traces Phil’s life against the backdrop of coastal South Carolina and the Santee Delta - the largest river delta on the eastern seaboard of the USA.

Georgetown native Phil grew up on Hopsewee Plantation on the North Santee River, and knows the Santee Delta with the intensity of time. The book is beautifully illustrated with Phil’s photographs of the delta’s people, wildlife, etc., and combined with his homespun stories, “Seven Days on the Santee Delta” makes for an amazing read. It is good to see that the Lord Berkeley Conservation Trust and Evening Post Books have managed to bring Phil Wilkinson’s legacy to a wider public audience.

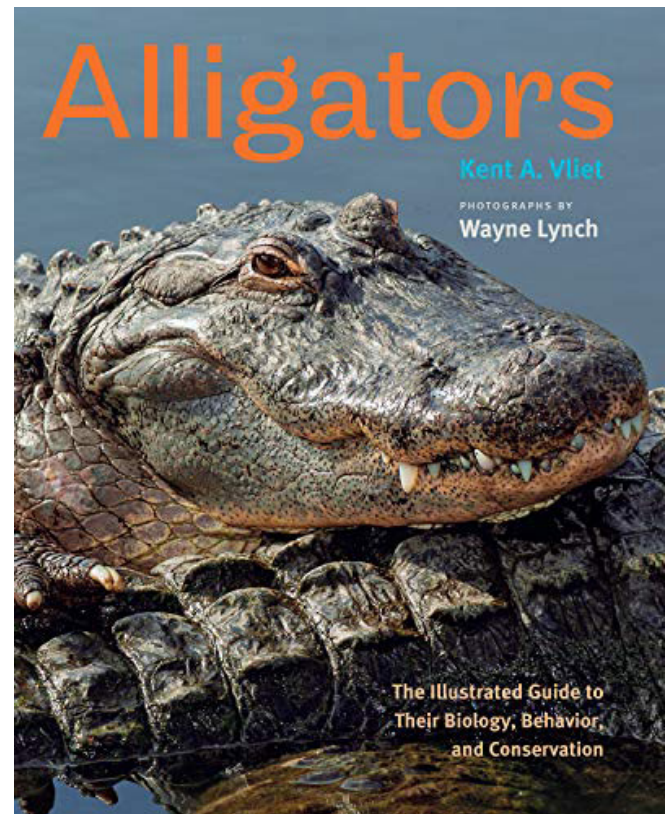
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### **“Alligators - The Illustrated Guide to Their Biology, Behavior, and Conservation”**

Dr. Kent Vliet, another long-time CSG member, has put together a richly illustrated account of the biology, behaviour and conservation of the American alligator. With over 150 photographs from wildlife photographer Wayne Lynch, through “Alligators - the Illustrated Guide to their Biology, Behavior, and Conservation” (Johns Hopkins Press, 304 pp, 2020), Kent introduces readers to one of the world’s most recognised crocodilians.

The book combines Kent’s captivating storytelling with current scientific knowledge on the species, from its anatomy and physiology, to its complex social life. It will be a valuable addition to anyone’s collection, and especially for those

interested and/or working with crocodilians.



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## **CSG Student Research Assistance Scheme**

The Student Research Assistance Scheme (SRAS) provided funding to 6 students in the January-March 2020 quarter. One further application is currently under review.

1. Gaurav Vashistha (India): Gharial recruitment at Katarniaghat Wildlife Sanctuary, Uttar Pradesh, North India: Augmentation with an *in-situ* riverside hatchery, and pre-monsoon hatchling release.
2. Elyn Buitizon (Philippines): Ultrasonographic features of the liver, spleen and gallbladder of sub-adult Philippine crocodiles (*Crocodylus mindorensis*) and Saltwater crocodiles (*Crocodylus porosus*).
3. Celina Setias (Philippines): Ultrasonographic features of the urogenital organs in sub-adult Saltwater crocodiles (*Crocodylus porosus*) and Philippine crocodiles (*Crocodylus mindorensis*).
4. Robert Greco (USA): Revitalizing conservation and management of the American crocodile (*Crocodylus acutus*) in the Dominican Republic.
5. Gervais Habarugira (Rwanda): Understanding the mechanisms of West Nile virus (WNV) infection and induced lesions in *Crocodylus porosus*.
6. Surakchya Paudal (Nepal): Gharial (*Gavialis*

*gangeticus*): Population status and habitat mapping in Babai River, Bardia, Nepal.

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

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## 26th CSG Working Meeting Postponed

Due to the current situation with the COVID-19 pandemic, the 26th CSG Working Meeting to be held in Chetumal, Quintana Roo, Mexico, has been postponed to 3-6 May 2021. It will be preceded by the veterinary, drone and taxonomy workshops on 1 May 2021, and a CSG Steering Committee meeting on 2 May 2021.

Updated information is now available on the meeting website ([www.biodiversidad.gob.mx/planeta/csg2020/index.html](http://www.biodiversidad.gob.mx/planeta/csg2020/index.html)). The meeting organisers apologise for any inconvenience the postponement may cause, but appreciate your understanding given the difficult circumstances that are being faced around the world at this time.

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## CSG Future Leaders Program

### What does “leading” within the CSG entail?

The Crocodile Specialist Group (CSG), within the Species Survival Commission (SSC) of the International Union for Conservation of Nature (IUCN), was formed in 1971. The SSC appointed a Chair, who selected a small network of individuals, mainly research biologists, all knowledgeable and concerned about the declining status of crocodylians globally. Members worked independently in their own sphere of interest, and together to formulate CSG policies and provide advice and guidance to the SSC, IUCN and various other institutions.

In the 49 years since its establishment, CSG membership has expanded greatly (currently 666 members in 70 countries), and members continue to champion crocodylian conservation. The CSG Chair and four Deputy Chairs comprise the CSG Executive Committee. Chairs and Vice Chairs have been appointed to regions (8), thematic groups (8), Task Forces/Working Groups (3), and a CSG Red List Authority. The Chairs and Vice-Chairs (60+) constitute the CSG Steering Committee. Leadership skills are implicated in all these levels of operation within the CSG, and between the CSG and outside agencies.

The primary obligation of the CSG is to assist the SSC and IUCN to meet their missions with crocodylians. It is CSG members, rather than the CSG itself, that are at the coalface of *in-situ* conservation, at national and species levels. CSG members operate within a supportive and collegial atmosphere, which gives all members access to a vast knowledge base across the membership. The CSG is not a project-driven organization but rather supports and assists its members, where possible, to undertake projects. As a specialized instrument of the SSC and IUCN, the CSG

interacts with other IUCN-SSC Specialist Groups, and provides advice to Governments, NGOs, Intergovernmental bodies, commerce and industry, conservation leaders, the media and the public.

Today, some crocodylian species remain seriously depleted and require strict protective measures, whereas others are in various stages of recovery. Sustaining recovered populations has proved a growing and demanding challenge, especially where human-crocodile conflict is escalating. Incentive-driven conservation programs, based on sustainable use, have been implemented successfully in many countries over the last four decades, and they have required close collaboration between scientists, managers and industry representatives. However, sustainable use and wildlife trade are politically sensitive in some conservation circles and are treated suspiciously by many. CSG leadership has often had to negotiate stormy political waters to support sustainable use programs where science underpins management.

Within the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), the CSG has both supported and opposed petitions to transfer species from Appendix I to Appendix II, to allow commercial trade. However, when asked, the CSG has always assisted Parties with advice and guidance, encouraging improved management. CSG leadership in this context involves technical skills with management, but more important, political judgement based on sensitivity to varying cultural backgrounds and perceptions, varying socio-economic contexts, and the underlying agendas linked to competing conservation paradigms. Understanding the biopolitics involved at this level is an important part of CSG leadership.

Older CSG members have first-hand experience with the technical and biopolitical skills needed to implement diverse and adaptive approaches to crocodylian conservation. But amongst the new cadre of CSG members, skills in various research areas do not translate to ground-roots management and biopolitical skills. Yet it is from these new members that the future leadership roles within the CSG will be filled, and problems of succession overcome.

The CSG Executive and Steering Committees considered that fast-tracking the transfer of CSG-pertinent knowledge to new, young CSG members, should be a high priority, particularly to those with obvious leadership potential. Soliciting active participation and involvement of new CSG members in multinational forums, such as CITES, was considered to be essential for guaranteed future leadership within the CSG.

### Future Leaders “Working Group” and “Program”

A CSG Future Leaders Working Group (FLWG) was established by the CSG Executive in 2014 to refine and pursue these general objectives. It was successful in identifying potential leaders, demonstrating skills to new members, extending institutional memory, introducing new CSG members to CITES, facilitating involvement in IUCN Red List determinations, encouraging participation in various

other professional forums, and fostering improved networking within the CSG. It resulted in some members escalating rapidly to leadership positions within the regional and thematic groups that comprise the CSG Steering Committee. It also helped foster involvement of some individuals in other SSC and IUCN activities independent of the CSG. Most important, it exposed a selection of new members to the biopolitical complexity of dealing with diverse cultures, ethnics, socio-economic levels, competing conservation paradigms and at times, intransigent political opinions not based on science.

Whereas new CSG members tend to take for granted that the scope of solutions to crocodylian conservation problems can and should be wide, ranging from strict protection to sustainable use, few appreciate the battles the CSG has had to fight, internally and externally, to legitimize and sustain that flexibility. Hence the deliberations of the FLWG significantly advanced the concept of identifying new members with leadership potential, expanding their experience and knowledge base, and allowing them to take on more leadership roles.

Retaining the ability to practice sustainable use as a conservation tool will require future leaders to be as competent with the political aspects of this challenge as they are with the intricacies of science-based management, biology and other areas of expertise. This will require continual investment in expanding the skills and capacity of new CSG members.

What was also apparent from the deliberations of the FLWG, was that a large number of new CSG members appeared to aspire to the concept and perceived opportunities of attaining leadership positions within the CSG, some of whom had exceptional leadership skills and are already leading. Commitment to the CSG, respect for the contribution existing members have made and continue to make, the ability to solve rather than create or embellish problems, the ability to detect personal agendas, respect for different cultural and political biases, avoiding biases that are personal rather than professional, are all integral parts of leadership in any context, including the CSG.

Notwithstanding this limitation, the pioneering work of the FLWG was exceptional, and the CSG Chair and Executive Committee are committed to the continuation of a future leader initiative. They have proposed the next phase should be a dedicated Future Leaders Program (FLP), under the direction of the current Future Leaders Chair and Deputy Chair. The objective of the FLP Program will be to enable CSG members with demonstrated leadership abilities to strengthen their skills, become proficient in the complex world of biopolitics, and further the goals of the CSG.

The FLP will have two components: a core group comprising the FLP Chair, FLP Deputy Chair and 3 selected members; and a broader group, comprising members who may participate in the activities of the core group. All will have the opportunity to participate in a more formal CSG leadership program that will be developed by the FLP Chair and Deputy

Chair with assistance from other CSG members. The CSG will continue to invest in broadening the management and biopolitical experience of the core group. All FLP members will be selected by the Executive Committee.

The 5-year goal of the FLP is that its members will be active and skilled participants in the international conservation arena (eg CITES meetings, IUCN-WCC and IUCN/SSC/CSG) as well as at regional and national level decision-making forums. FLP members will provide annual and meeting reports to the Executive Committee in order to secure collaborative and constructive technical and biopolitical feedback. Our aim is that this program will build on the solid foundation that has been established by the FLWG - to identify and encourage potential young leaders to build their biopolitical capacities - and look forward to further growth of this new generation of future leaders.

Grahame Webb (*CSG Chair*), Sergio Balaguera-Reina (*Chair, CSG Future Leaders Program*) and Pablo Siroski (*Vice Chair, CSG Future Leaders Program*).

## Humane Euthanasia/Killing Methods for Crocodilians - An Update

The issue of humane welfare, including slaughter/killing, of crocodilians, is of critical importance for the global crocodilian farming industry, and has been discussed and addressed by the CSG at various times over the last 30 years in order to safeguard the industry by continuing to meet contemporary animal welfare standards. Also to this end, wildlife agencies, farms, fashion houses, etc., have developed various codes of practice and standard operating procedures. Some key actions involved with the development of crocodilian welfare and humane slaughter guidelines, include:

- 1992 Hutton (1992) addresses slaughter methods on farms, and recommends further research to ensure methods are humane. This was largely in response to "ludicrous" animal rights claims that crocodiles were being skinned alive and vertebrae broken to prevent crocodiles injuring handlers.
- 2009 Australia develops a Code of Practice for the Humane Treatment of Wild and Farmed Australian Crocodiles (NRMMC 2009).
- 2011 Swiss Government assembles an Expert Panel (including CSG members Paolo Martelli, Charlie Manolis, Javier Nevarez, Tomas Waller and Don Ashley) to review and develop guidelines for humane slaughter of reptiles (Expert Panel 2013), to be submitted to the World Organisation for Animal Health (see below).
- 2011 Louisiana develops Best Management Practices for Louisiana Alligator Farming (LDWF and LSU 2011).
- 2012 Zimbabwe develops a Code of Practice, based to a large extent on the Australian Code (CFAZ 2012).
- 2012 CSG Veterinary Science Group summarizes acceptable crocodilian slaughter methods for the



	CSG website (under Veterinary Science Resources).
2013	Zambia develops Code of Practice (ZaCFA 2013).
2014	South Africa develops standards for captive crocodiles (SABS 2014).
2015	CSG develops Best Management Practices for Crocodilian Farming, which included methods for humane slaughter (Manolis and Webb 2015).
2016	Thailand legislation incorporates standards for crocodiles (ACFS 2016).
2014-19	Fashion houses develop their own internal standards for welfare of farmed crocodilians.
2019	Recommendations of the World Organisation for Animal Health (OIE) directly address the need to ensure the welfare of chelonians, crocodilians, lacertilians and ophidians, during the process of killing for skins, meat and other products (OIE 2019), with CSG members contributing.
2020	American Veterinary Medicine Association (AVMA) publishes guidelines for euthanasia of animals (2020 edition). AVMA (2020) states that <i>“While some euthanasia methods may be utilized in slaughter (which refers to humane killing of animals destined for human consumption) or harvest and depopulation, recommendations related to humane slaughter and depopulation fall outside the purview of the Guidelines”</i> .

This document updates the current status of humane methods for the slaughter/killing of crocodilians that are considered “best practice” and/or “acceptable”. In doing so, the CSG Veterinary Science Group recognizes that certain methods (eg shooting) may not be suitable in some contexts, and that recommended methods are not intended to override the national legislation of different countries. The methods outlined here apply to crocodilians in zoos and farms, and not to wild harvesting, particularly where indigenous people are involved (traditional harvesting/hunting).

We also recognize that research may lead to the development of new and/or improved methods (eg Nevarez *et al.* 2014),

and so methods that are not mentioned here should not be automatically considered as being acceptable or unacceptable.

**Best Practice:** achieving rapid death without stress or pain. It is accepted that painful stimuli will take 0.2 seconds to reach the brain and be perceived as pain by the brain. Therefore trauma leading to death must achieve destruction of the brain in less than 0.2 seconds. Where that is not possible, the animal should be rendered unconscious first.

Acceptable methods of slaughter/euthanasia (Table 1) are in harmony with published documents, with the notable exceptions of use of carbon dioxide and flash freezing, which are considered acceptable only by the American Veterinary Medical Association (AVMA 2020), but which are considered unacceptable by most other sources (eg OIE 2019).

The following methods are considered unacceptable for the slaughter/euthanasia of crocodilians:

- Exsanguination
- Freezing or cooling
- Heating or boiling
- Suffocation or drowning
- Inflation using compressed gas or liquid
- Live evisceration or skinning
- Constriction bands to induce cardiac arrest
- Inhalation of asphyxiating gases (carbon dioxide, carbon monoxide or nitrogen)
- Use of neuromuscular blocking drugs alone
- Cervical dislocation, decapitation or cord severance without pithing

Some of these unacceptable methods may still be encountered, and it is recommended that they should cease to be used.

#### Literature Cited

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Table 1. Acceptable methods of slaughter/euthanasia for crocodilians based on current knowledge.

**Captive Bolt (penetrating or non-penetrating):** Immobilization is required, manual or electric. Although not required, pithing is often performed after animal has been killed.

**Shooting (free bullets):** Immobilization is sometimes required before shooting. There is higher risk to the operator and higher risk of failure. Although not required, pithing is often performed after the animal has been killed.

**Percussive blow to the head:** Immobilization is required, manual or electric. Not practical for crocodilians larger than 3 kg, or for large numbers of crocodilians. There is higher risk for operator and higher risk of failure.

**Spinal cord severance immediately followed by pithing (including decapitation for very small individuals):** This is the most common method; Immobilization is required, manual or electric. Electric immobilization appears to also produce loss of consciousness and is recommended.

**Chemical agents:** Immobilization is required, manual or electric. Rarely employed in the crocodilian farming industry.

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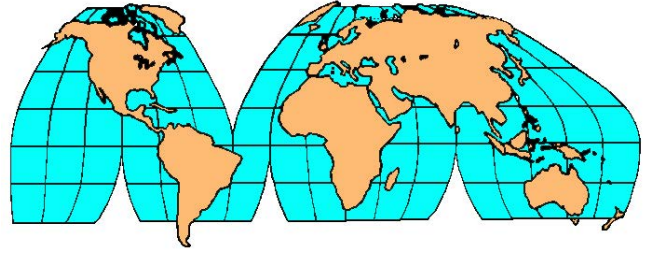
OIE (2019). Killing reptiles for their skins, meat and other products. Chapter 7.14 in OIE Terrestrial Health Code. OIE: Paris.

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Paolo Martelli, Cathy Shilton (*Vice Chairs, CSG Veterinary Science Group*) and Charlie Manolis (*CSG Deputy Chair*).

## Regional Reports



### Europe

#### Switzerland

PHILIPPINE CROCODILE (*CROCODYLUS MINDORENSIS*) INJURES ANIMAL KEEPER AT ZURICH ZOO, SWITZERLAND. On 23 December 2019, a female animal-keeper at Zurich Zoo (Switzerland) was injured by a male *Crocodylus mindorensis* during routine work in the indoor enclosure. The crocodile was around 1.5 m long and about 15 kg body weight.

The injury occurred while the keeper was doing some adjustments at the water's edge of the pool. The crocodile bit the woman through the iron bars which divide the enclosure, biting her right hand, holding tight and trying to rotate. Thus, there was no way to separate the keeper from the crocodile, and the animal was shot in the head by an alerted, trained animal-keeper with a hand-gun. The female keeper was severely injured at her right hand, with one finger having to be restored during a 5-hour operation at the nearby University-hospital of Zurich. The keeper is making satisfactorily recovery and will be back on her work after optimal medical rehabilitation.

René Honegger, *founding member of CSG and retired Curator of Zurich Zoo, CH 8802 Kilchberg, Switzerland.*

### Latin America and the Caribbean

#### Belize

NEW RIVER ENVIRONMENTAL CRISIS. The New River is considered to be the longest, relatively flat-water stream entirely confined to Belize from its headwaters to the sea. In early 2017, the Crocodile Research Coalition (CRC) began hearing reports of dead fish and sick, white or pink crocodiles along the New River, around Orange Walk Town, in northern Belize. In March 2018, residents began contacting Belize media with reports of mass fish kills and isolated reports of other wildlife deaths, particularly crocodiles. The media was flooded with disturbing images of murky-grey steaming waters, and riverbanks with rotting fish and wildlife carcasses. The Department of the Environment (DOE) responded to this crisis by launching an official investigation in order to provide the public with an official assessment of the situation.



According to the DOE, New River was experiencing eutrophication caused by increased algal growth blocking sunlight and reducing oxygen levels within the water. Additionally, in 2019 Belize experienced its worst drought since 1983. June to October, which is usually Belize's rainy season, received as little as 100 mm of rain per month, technically qualifying it as an extended dry season for 2019. This drought contributed to stagnate the water in several sections of the New River, which naturally causes reduced oxygen levels. However, the New River has also been subject to long-term agricultural pollution from neighbouring rice, corn and sugar farms (including Belize's largest sugar processing factory). Pesticides, fertilizers and other chemicals have leached and been dumped into the river along with effluent waste from Belize Sugar Industries (BSI). Though the DOE has worked with BSI to improve the treatment of its effluent waste over the past 4 years, the extreme drought conditions have exacerbated years of unmonitored agricultural pollution. The environmental crisis has resulted in a biofilm over much of the river and the release of hydrogen sulfide gas resulting from the anoxic conditions. This caused the shut-down of an entire primary school in the first week of the school year, as the stench from hydrogen sulfide was so strong it was sickening both students and teachers. The DOE has responded with emergency environmental assessments of the New River.

During spotlight and capture surveys carried out in March and April 2018, in conjunction with the countrywide Morelet's crocodile population survey, CRC witnessed the concerns of community members. The team observed many lethargic crocodiles of all sizes, illustrating white skin (Fig. 1) or skin with a metallic bluish tint, in addition to pockets of dead fish and eutrophication. Besides extreme lethargy, some crocodiles were also exhibiting "star-gazing," a neurological symptom that is often associated with paralysis.

CRC conducted necropsies on two male Morelet's crocodiles (2 m and 3 m TL) that were captured in the New River near Orange Walk Town. Both crocodiles exhibited lethargy and white skin, in addition to some skin sloughing. The CRC team conducted necropsies immediately upon the death of the animals, to obtain the "fresh" samples for heavy metal analysis, but collection of samples proved difficult as organs in both crocodiles were already disintegrating (especially kidneys and liver; Fig. 2). Given the state of some of the organs, these animals had most likely been chronically exposed to contaminant/s and slowly dying over a few months.

These necropsies, along with several observations of individuals with "white" skin during CRC surveys, prompted Government to take immediate action to understand the cause and the pollutants causing the pollution crisis within New River. Given the current and on-going research, the Belize Government asked the CRC to independently conduct an investigation of the New River utilizing crocodiles as sentinel species over the foreseeable future to complement the current research into mitigating the environmental crisis by Government.

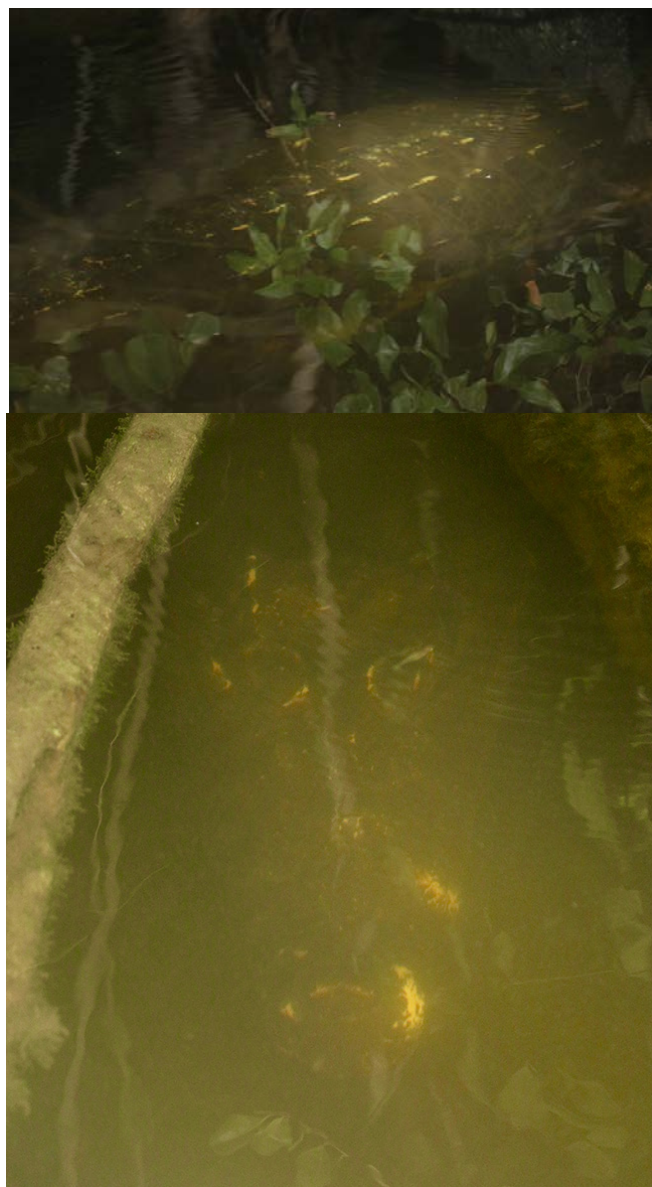


Figure 1. White markings observed on crocodiles in the New River.



Figure 2. Stomach of 2 m long Morelet's crocodile after necropsy.

Starting September 2019, the CRC began conducting surveys along the New River ecosystem between Shipyard and Corozal Bay. CRC is collecting data every other month, which includes: spotlight surveys to quantify population status

and demographics for *Crocodylus moreletii* and *C. acutus*; and, capture efforts to obtain tissue and blood samples and morphometric data. Water and soil samples were collected in September 2019, and we will begin monthly sampling beginning in January 2020, in addition to fish tissue sampling. Through a collaboration with University of Belize, Centre d' Etud Biologique de Chizé, el Laboratorio de Biología Acuática de Universidad Michoacana de San Nicolás de Hidalgo, and a laboratory at North Carolina State University, the CRC will be able to analyze various samples and acquire the necessary data to further understand the pollution crisis of New River.

Initially, the CRC was authorized to rehabilitate individuals exhibiting “white” skin to confirm whether the condition could be treated through exposure to clean water environments and proper nutrition. This was attempted with a juvenile (80 cm TL) captured in October 2019 that was exhibiting preliminary “whitening” on the head and back and a distended abdomen. The crocodile was taken to CRC’s headquarters in southern Belize where it was placed in a clean pond and fed fresh fish, but it died after a month. Based on this case, the CRC is requesting permission to perform necropsies on other individuals from the New River ecosystem in order to obtain more information on the level of pollutants present in crocodiles at different life stages and exposure.

The CRC accompanies this ongoing research with its community outreach and education platform. Student volunteers from Galen University and the University of Belize’s Natural Resource Management Bachelor’s Program have been invited to assist in surveys. In addition, monthly outreach events at schools, along with a presence at community and national conservation festivals and events to enhance public education and outreach continue in hopes to bring widespread awareness about crocodile and wildlife protection, and conservation to the public to safeguard Belize’s most valuable ecosystems and resources.

The CRC welcomes suggestions and comments in regards to its study of pollution’s impact on the Morelet’s crocodiles in the New River. Updates to CRC’s project can be found at: <https://crocodilresearchcoalition.org/save-the-new-river>. Jonathan Triminio ([crc.biologist@crcbelize.org](mailto:crc.biologist@crcbelize.org)) or Dr. Marisa Tellez ([marisa.tellez@crcbelize.org](mailto:marisa.tellez@crcbelize.org)) can be contacted by e-mail.

Gliselle Marin, *Crocodile Research Coalition, Placencia Peninsula, Belize* ([www.crocodilresearchcoalition.org](http://www.crocodilresearchcoalition.org)).

## Colombia

“PARACHUTE SCIENCE RAISES ITS UGLY HEAD”. Andrew Wight recently reported (Undark, 3 April 2020) on claims by Forrest Galante, an American TV “adventurer”, that he had found the Apaporis caiman (*Caiman crocodilus apaporiensis*). The CSG has had a long-time interest in this subspecies (eg population status, taxonomic status), and supported Sergio Balaguera-Reina’s recent efforts to confirm

the status of *C. c. apaporiensis* in Colombia.

Around one year ago, and within months of each other, Sergio and Galante visited the subspecies’ habitats. Interestingly, in November 2018 Sergio had given Galante’s team all the information required for them to reach areas inhabited by the caiman, and had even connected them with a guiding company that could help them.

In the first week of December 2019 the men separately announced success in finding the Apaporis caiman - Galante in his TV show and Balaguera-Reina in a major scientific journal (Journal of Herpetology). According to Markus Eichhorn, a forest ecologist at the University College Cork, who has studied exploitative practices in field ecology, Galante’s claiming of a discovery that had already been made a year before, without giving appropriate credit, are emblematic of a bigger, more common problem. He states that these actions echo a longstanding issue called “parachute science,” a colonial-style practice that sees scientific collaborators in developing countries as suppliers of data and specimens, rather than equals.

Sergio’s expedition to the middle Apaporis River basin documented 105 Apaporis caimans across five survey areas, carried out interviews with local indigenous people about their relationship to the creature, and collected tissue samples to clarify taxonomic status. On the last day of the expedition, photographs of the rediscovered caiman were posted, and rightly so Sergio’s success was celebrated all over the world. But soon after the findings were published, Sergio learned about an episode of Galante’s “Extinct or Alive,” featuring the Rio Apaporis caiman.

Galante’s claim received an online backlash from those who had already seen Sergio’s posts from a year before. Press releases and Galante’s social media posts were hastily modified to acknowledge Sergio’s paper and that the expeditions had been carried out “within a month” of each other. In later statements Galante acknowledged that questions about the Apaporis caiman were best directed to “Sergio and his team”. Galante also claimed to have re-discovered the the Fernandina giant tortoise in the Galapagos (last sighted in 1906) - a claim which has also been challenged by local scientists.

There is little doubt that the scientific community feels that Galante has acted unethically, even if he is a TV host (albeit with a biology degree). But he is considered to be part of the bigger problem of parachute science, “when a foreign scientist drops in, makes use of local infrastructure, talent, and resources, then returns to write a paper for a prestigious scientific journal”.

I strongly suggest that CSG members and colleagues read Andrew Wight’s article (In the Bombast of an American TV Host, Colonial Science Lives On), that was published in Undark (<https://undark.org/2020/03/04/colombia-reptile-parachute-science-forrest-galante/>), and from which this article in the CSG Newsletter was extracted.



## Mexico

AN UNUSUAL RECORD OF NON-FATAL CROCODILE ATTACK ON THE COAST OF OAXACA, MEXICO. Crocodile attacks in Mexico most commonly occur when there is human activity in the crocodiles' territories (Conover 2002; Treves *et al.* 2006). In these situations, the most common activities involved in fatal and non-fatal attacks are fishing, playing at the water's edge, and fishing - diving and with cast nets in shallow water, all of which occur mainly during the day (García-Grajales and Buenrostro-Silva 2019).

In recent years, the state of Oaxaca has had the highest number of crocodile attacks in seven hotspot areas, of which the Pinotepa Nacional region represents the highest risk area (García-Grajales and Buenrostro-Silva 2019). Herein, we provide a record of an unusual non-fatal crocodile attack in the region of second highest risk in Oaxaca; the implications of the aforementioned activities under the "Protocolo de atención a contingencias humano-cocodrilo", and our perspective on this.

On 7 November 2019, at 0230 h, in the Río Colotepec estuary on the central coast of Oaxaca (Fig. 1), a man (around 65 y) experienced a negative interaction with a crocodile while sleeping at the water's edge. The situation was unusual in that the person had "problems" with his mental faculties, and therefore was not aware of the risk in his decision to sleep near the water's edge. Although the person was accompanied by his brother when the event occurred, his brother was fishing and didn't realize the dangerous situation. As a result, the victim received injuries to the head, arm and right leg (Fig. 2), and was attended to in "30 Camas Hospital" in Puerto Escondido, Oaxaca.

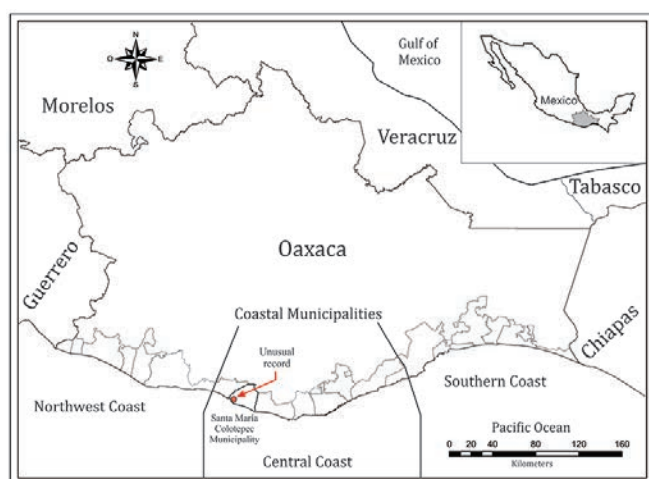


Figure 1. Location of non-fatal attack on the central coast of Oaxaca, Mexico.

Three days later on 10 November 2019, through the coordination of biologist Gabriel Cruz, the Sociedad Cooperativa de Servicios Ecoturístico La Ventanilla caught a



Figure 2. Injuries to head and arm as a result of non-fatal attack on central coast of Oaxaca, Mexico. Source: World Wide Web.

crocodile of 3.30 m TL in the region of attack. The decision to capture this individual was probably to reduce the social pressure created by the attack. However, there was no thorough analysis of the characteristics of the attack and the animal involved in the incident. The specimen was released in Palmasola estuary, a few hundred metres from where the attack occurred.

Based on photographic evidence of the injuries to the victim's head, the distance between the teeth marks corresponds with a specimen of probably less than 1.80 m TL, which indicates a sub-adult. In Palmasola Lagoon, close to the attack, sub-adults represent a high proportion of the crocodile population, followed by juveniles and to a lesser extent adults (García-Grajales and Buenrostro Silva 2014; Barragán 2019). On the other hand, Fukuda *et al.* (2015) explains that the probability of survival in a crocodile attack is related to the differences in body mass between crocodile and victim. The authors point out that the size of the crocodile has a much greater influence than that of the victim because crocodile body mass increases exponentially with the length. Based on this, we believe that there was no relationship between the captured specimen and the one involved in the attack.

According to "Protocolo de atención a contingencias humano-cocodrilo" (SEMARNAT 2018), this record was classified as Level 4 (non-fatal interaction without provocation). In addition, the criteria for relocating (capturing and releasing) a crocodile are as follows: 1) the crocodile exhibits too much confidence and shows intentions of interacting with humans; 2) the crocodile has interacted at Level 3 on more than one occasion; and 3) the crocodile has interacted at Levels 4 or 5. None of these criteria were met in the incident described here. Therefore, all the errors indicated are results of the non-implementation of the aforementioned protocol by the Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT) and the Procuraduría Federal de Protección al Ambiente (PROFEPA), who are the governmental entities responsible for coordinating the protocol's actions.



Finally, as mentioned previously (García-Grajales and Buenrostro-Silva 2018), it is necessary that local authorities establish a public safety program with the goal of raising awareness of the risk of crocodile attacks. Additionally, the established crocodile conflict network must resume its activity and be more proactive in implementing this initiative.

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## Brazil

PROJETO JACARÉ HIGHLIGHTED AT 30TH “VASCONCELOS SOBRINHO AWARD 2019”. The project “Ecology and Conservation of Crocodilians in Pernambuco’s Atlantic Forest”, developed in the Federal Rural University of Pernambuco (UFRPE), was awarded first place in the Environmental Research category at the 30th Vasconcelos Sobrinho Award. “Projeto Jacaré”, as it is popularly known, was presented with the award at Cais do Sertão Auditorium, Recife City, Pernambuco, on 16 December 2019.

Created in 1990 by the State Environmental Agency (CPRH), the Award aims to disseminate good practices in environmental segments, and bears the name of João Vasconcelos Sobrinho (1908-1989, born in Pernambuco), former teacher and Dean of UFRPE and one of the pioneers in environmental studies in Brazil. By promoting this contest, CPRH aims to give visibility to the efforts of those who are acting to improve the environmental conditions and the life quality of the population.

Started in 2013, “Projeto Jacaré” is one of the actions carried out by UFRPE’s Interdisciplinary Amphibian and Reptile Laboratory (LIAR), coordinated by Professors Jozelia Correia and Ednilza Maranhão, both researchers linked to the Department of Biology. In this laboratory, teaching, research and extension activities are priorities. The “Projeto Jacaré” initiative seeks to draw attention to the importance of natural environments in crocodilians conservation (*Caiman latirostris* and *Paleosuchus palpebrosus*), investigating ecological aspects of populations in Pernambuco, aiming its monitoring and generating subsidies to obtain a real diagnosis of these populations in the region.



Figure 1. Professor Jozélia Correia, Projeto Jacaré’s Coordinator, receives award in the Environmental Research category.

“It was with great joy and emotion that we received the news of the award, Projeto Jacaré team is a committed, fearless, professional, ethical and above all passionate group for

the conservation of our greatest wealth, Biodiversity. At this moment, represented by our caimans”, said the project coordinator, Professor Correia (Fig. 1).

The professor congratulated Pernambuco’s State Government for the initiative to value and recognize the efforts of many projects and people in environment defense. She also congratulated the representative of the submitted proposals (more than 70 environmental projects), for knowing how difficult it is to make science and scientific dissemination to the population in a scenario of very limited financial resources. “We share this award with all partners who are with us on this journey,” she said.



Figure 2. Projeto Jacaré Team, from the Interdisciplinary Laboratory of Amphibians and Reptiles, UFRPE.

Paulo Braga (*Universidade Federal Rural de Pernambuco, Brazil*) and Luís Bassetti (*CSG Regional Vice Chair for Latin America and the Caribbean and University of São Paulo, Brazil*).

**PROJETO CAIMAN RELEASES NEW BOOK.** In November 2019, Projeto Caiman, through a partnership between Instituto Marcos Daniel and Instituto Últimos Refúgios, released the book “*Marginals*”: *Caimans of the Atlantic Forest*, a work that brings together texts, infographics and photographs aimed at deconstructing popular prejudice towards the species.

With 208 pages, the scientific content and environmental awareness in the book reinforces the biological importance of caimans in the wild, and promotes reflection on the conservation of these animals.

The chapters provide information on the Atlantic Forest - caiman habitat - as well as rich content on the evolutionary history, physical characteristics of the species, and the numerous challenges it faces for survival. The photographs immerse the reader in the world of these great reptiles.

The book offers a somewhat unique reflective experience. The first cover, in black and white, features in its title the adjective “*Marginals*” - representing the hostile view of society in relation to the species. The second cover, coloured,

features a charismatic puppy next to the title “*Caimans of the Atlantic Forest*” in bold letters. After reading, if sensitized, the reader can choose which of the covers represents his concept of caimans.

The book was written by many hands, with an introduction by Leonardo Merçon (President, Instituto Últimos Refúgios), Marcelo Santos (President, Marcos Daniel Institute) and Yhuri Nóbrega (Coordinator, Projeto Caiman). The preface was provided by Pablo Siroski (CSG Regional Chair for Latin America and the Caribbean), and other contributors of text were Luis Bassetti, Leonardo Merçon, Yhuri Nóbrega, Marcelo Santos, Benjamin M. Baptista Filho, Rodrigo Giesta Figueiredo, André Felipe Barreto-Lima, Sérgio Lucena Mendes, Flávio Curbani, Thiago Simon Marques, Igor Joventino Roberto, Ana Carolina Srbek de Araújo, Rodrigo Barbosa Ferreira, Iago Silva Ornellas, Paulo Roberto de Jesus Filho, Thassiane Targino Silva, Paulo Quadros de Menezes, Daniel Santos Neves, Victor Santos Neves, Daniela Neris Nossa, Ygor Machado, Marcos Eduardo Coutinho, Thatiane Corona Borlini, Eduardo Lázaro de Faria Silva and João Bosco Reis da Silva.



Figure 1. (from left to right) Pablo Siroski, Yhuri Nóbrega and Marcelo Santos.

Photographs were provided by Leonardo Merçon and guest photographers (Rodrigo Giesta, Yhuri Barichvich, Luiz Effgen, Gustavo Pedro de Paula, Lindolfo Souto, Julio Cezar Gonzelez Filipino, Ilka Westermeyer, Gustavo Magnago, Jozélia Correia, William Alcântara, Beto Moraes, Marcelo Calazans, Kátia Carvalho, Joarley Rodrigues, Cristina Zampa, Sérgio Gomes da Silva Filho, Luis Bassetti).

The book release was held at the ArcelorMittal Tubarão Environmental Education Center, sponsor of Projeto Caiman. The ceremony was honored by members and volunteers of the Instituto Marcos Daniel and Instituto Últimos Refúgios, ArcelorMittal employees, and people linked to the environmental area. The project’s creators, Marcelo Santos and Yhuri Nóbrega, and personalities such as João Bosco (General Manager, Sustainability and Institutional Relations at ArcelorMittal), Marcos Coutinho (representing the Chico Mendes Institute for Biodiversity Conservation) and Pablo Siroski were speakers at the event.



The representatives talked about the satisfaction of being part of the team responsible for the accomplishment of this important project of social, cultural and environmental value, that above all, aims at the permanence of the Broad-snouted caiman in Espírito Santo state and the awareness about the important role they play to the ecological balance. The event also featured exhibition of photographs of the book, cocktail party for the guests and moment for autographs with the authors, who gave interviews to the media.

Projeto Caiman is one of the pioneers in research, conservation and environmental awareness of the populations of Broad-snouted caimans (*Caiman latirostris*) in Brazil. In recognition of this work, the project was invited by ArcelorMittal to produce a children's book next year, leaving everyone eager to release another rich cultural product.

"Marginals - Atlantic Forest Caimans" can be ordered by e-mail (marcelo@institutomarcosdaniel.org.br) or via Whatsapp (+55.27.988272334). All money obtained from sales are used for conservation actions of Projeto Caiman.

Yhuri Nóbrega (*Coordinator, Projeto Caiman, Brazil*) and Luís Bassetti (*CSG Regional Vice Chair for Latin America and the Caribbean (Brazil) and University of São Paulo, Brazil*).

**PHOTOGRAPHIC EXHIBITION PROJETO CAIMAN - "MARGINALS CAIMANS OF THE ATLANTIC FOREST" - VITORIA INTERNATIONAL AIRPORT.** Like several other species of the Brazilian Atlantic Forest, the Broad-snouted caiman (*Caiman latirostris*) is listed as "Endangered" on the Espírito Santo State's Red List (since 2019). At a global level the species is listed as "Least Concern" on the IUCN Red List, but this local classification places the species as a priority for actions to conserve natural populations and their habitats. Among the various threats faced by this wild population of *C. latirostris*, hunting, loss of habitat due to deforestation, drainage for agriculture and pollution are considered the most significant.

To promote the conservation of the Atlantic Forest, Projeto Caiman uses *C. latirostris* as a flag species, in addition to carrying out various scientific dissemination actions, to sensitize the Brazilian population and bring information to people outside academic fields, and at the same time proposing conservation actions. Adopting clear and objective language, in addition to targeted access to all public sectors, over the last 6 years more than one million people were reached directly through events, exhibitions, lectures and school visits. Projeto Caiman also disseminates scientific information by publishing books in partnership with the Instituto Últimos Refúgios. The newest publication, together with the company ArcelorMittal, is "Marginals - Atlantic Forest Caimans", in Portuguese and English (see pages 11-12).

To raise people's awareness of the importance of conserving *C. latirostris* and the Atlantic Forest, Projeto Caiman, Instituto Últimos Refúgios and ArcelorMittal held a photographic

exhibition at the Eurico de Aguiar Sales International Airport in the city of Vitória, Espírito Santo. This is the main airport in the state and operates national and international passenger and cargo services, with a capacity of about 8.7 million people per year.

The photographic exhibition took place in the departure lounge area, from 18 December 2019 to 8 January 2020, with approximately 70,000 visitors during this period. The exhibition featured photographs from "Marginals - Atlantic Forest Caimans", through the eyes of renowned nature photographer Leonardo Merçon.

The photographs drew the attention of all types of people in different age groups, who stopped to admire, photograph and learn a little more about the species and the results obtained through the research of Projeto Caiman.



Julie Borchardt, Lucas Yu Fraga, Fernando Paulino, Gabriel Gomes Dias, Bárbara N. S. Mello, Yhuri C. Nóbrega, Leonardo Merçon and Marcelo Renan de Deus Santos, *Projeto Caiman, Marcos Daniel Institute, Av. Eugenio Pacheco de Queirós, S/N, Jardim Camburi, Vitória, Espírito Santo, 29090-160, Brazil (www.imd.org.br)*.



“NATURE IS CLOSER THAN YOU THINK” PHOTOGRAPHIC EXHIBITION. One of the biggest challenges nowadays is to convince citizens to perceive themselves as an integral part of the environment, dependent and transforming agents, capable of promoting significant improvements, especially in their lifestyle. The significant changes in communication technology during the 20th century make it necessary to adapt communication methodologies to promote a better understanding of reality. Visual language can expand the possibilities for capturing knowledge, either through perception, symbolization and communication. Therefore, visual resources are essential tools for acquiring knowledge through different physical or virtual formats.

Thus, Projeto Caiman and Instituto Últimos Refúgios created the photographic exhibition entitled “Nature is closer than you think”. The exhibition used photography to inform and raise public awareness about the proximity of urban caimans to people’s daily lives. Instituto Marcos Daniel (IMD), founded in 2004 in Vitória, Espírito Santo State, is a non-profit association that seeks to promote the conservation of biodiversity in the Atlantic Forest and the associated marine ecosystems. Among IMD projects, Projeto Caiman promotes research and conservation of *Caiman latirostris* at Espírito Santo. Instituto Últimos Refúgios (UR) is a non-profit socio-environmental and cultural organization that, since 2011, has been active in publicizing and raising environmental awareness, encouraging dialogue between society, environmental organizations, private and governmental institutions.

Shopping Vitória is the largest mall in Espírito Santo state, and every year it promotes leisure attractions for children and gives all takings to non-profit entities to apply in their social and environmental projects. From 15 January to 15 February 2019, the attraction offered by Shopping Vitória was a theme park based on the movie “Jurassic World”. The park had several entertainment activities for children and money raised went to Projeto Caiman. At the same time, the mall opened space for the “Nature is closer than you think” photographic exhibition, manned by Projeto Caiman team members for the 30 days of the exhibition. Approximately one million people went through the exhibition - an impressive number!



Bárbara N.S. Mello, Yhuri C. Nóbrega and Marcelo R.D. Santos, *Projeto Caiman, Marcos Daniel Institute, Av. Eugenio Pacheco de Queirós, S/N, Jardim Camburi, Vitória, Espírito Santo, 29090-160, Brazil* ([www.imd.org.br](http://www.imd.org.br), [www.ultimosrefugios.org.br](http://www.ultimosrefugios.org.br)).

## South Asia and Iran

### India

**CROCODILE-VEHICLE COLLISION: NEW THREAT TO MUGGER CROCODILE (*CROCODYLUS PALUSTRIS*) IN GUJARAT, INDIA.** At a global level, development is emerging as a threat to many wildlife populations and their habitats. Linear intrusion (railway lines, roads, canals, electricity cable networks), is one of the largest worldwide threats to biodiversity, including habitat loss and fragmentation (Forman *et al.* 2003; Benítez-López *et al.* 2010; van der Ree *et al.* 2015). The negative impacts of vehicular traffic on herpetofauna are well-reviewed (Andrews and Jochimsen 2007). Roads and railway networks act as physical



and behavioural barriers to movement of wildlife, and disturb populations living close to them (Rajvanshi *et al.* 2001).

This threat has direct negative implications on many species, including crocodilians. Direct mortality of crocodiles by collision with trains or other fast-moving vehicles (Crocodile-Vehicle Collision; CVC) has been documented for various crocodilian species (Vyas and Vasava 2019). Recently, Vyas and Vasava (2019) discussed and evaluated the threat of CVC on Mugger crocodiles (*Crocodylus palustris*), which has been detected over the entire geographical range of the species (Parchizadeh 2019; Vyas and Vasava 2019).

Vyas and Vasava (2019) recorded 38 incidences of CVC on Muggers over a 14-year period (2005-2018), which included 24 (63%) on roads and 14 (23%) on railway lines. Here, we add further records of CVC from 2019, on the basis of data from different agencies, including NGOs (who actively work for Mugger rescue), forest department, and print and electronic media. Also, primary observations were recorded by visiting the scene in person.

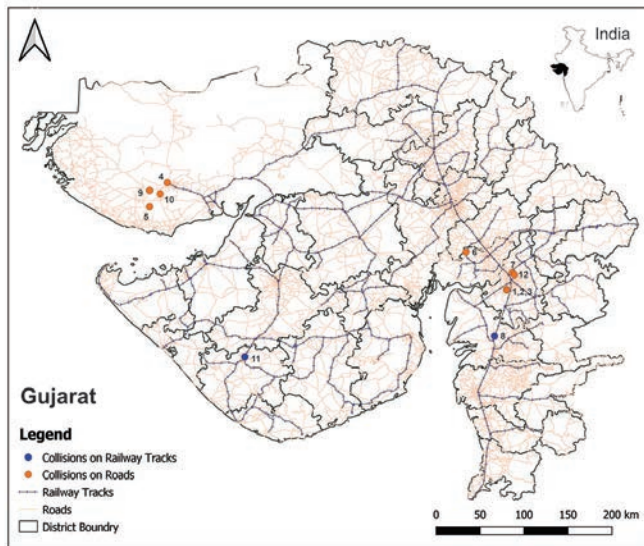


Figure 1. Locations of 12 Muggers involved in vehicle collisions on roads and rail networks in Gujarat in 2019 (see Table 1).

Twelve (12) cases of CVC were recorded in Gujarat in 2019 (Table 1; Fig. 1), including 10 on roads (Figs. 2 and 3) and two on railway lines (Fig. 5). Muggers of different sizes were involved, including 6 hatchling-juveniles (30-95 cm TL), 3 sub-adults (102-138 cm TL) and 3 adults (208-256 cm TL). Sex was determined for 6 individuals (3M, 3F). The incidents involved: 9 individuals being found dead; 1 sub-adult with minor injuries (it disappeared into a nearby water body after the collision); and, 2 adults found alive and treated for minor to severe injuries, but only one survived and it was released back to the wild a week later (Fig. 4).

Two further cases of CVC were reported in local newspapers from other states. The first was on 19 July 2019, involving a large Mugger (>2.5 m TL) found dead on a road at Inampura, Bijnor District, Uttar Pradesh (Fig. 6), and the second on 21 September 2019, involving an injured animal (<3 m TL) found alive on a flyover of National Highway-44 at Doodgoan (18°58'29.20"N; 78°22'32.26"E), Mendora, Nizambabad, Telangana State (Fig. 7). These two incidents support the statement of Vyas and Vasava (2019) that the CVC threat occurs in other parts of India (eg Chhattisgarh, Rajasthan and Uttar Pradesh).

It is unclear why there was a much higher incidence of CVC in 2019 (N= 12) relative to 2005-2018 (mean= 2.71/year) (Table 2). A possible factor could be the longer monsoon season in 2019 relative to the last 10 years. CVC most frequently occurred in the monsoon season (72% of incidents), followed by winter (18%) and summer (10%) (Table 2). The mortality rate in 2019 (83.3%) was very similar to that reported for 2005-2018 (89.5%) (Vyas and Vasava 2019).

For Gujarat in particular, due to breeding trends of the Mugger population and the inter-connected expansive network of irrigation canals, the Mugger's distribution is estimated to gradually expand across the state (Vyas 2008; Vyas and Basu 2008; Vyas *et al.* 2012; Vyas and Stevenson 2017). While the irrigation canal network expanses have a positive impact on the Mugger population, road and railway networks have negatively impacted the species.

Table 1. Details of Muggers found killed or injured on road and railways in Gujarat, in 2019. H= hatchling; J= juvenile; SA= sub-adult; A= adult. TL is in cm.

No.	Date	Location	Type	Latitude	Longitude	Category (TL)	Sex	Fate
1	8 Apr	Chansad, Padra, Vadodara District	Road	22°12'32.32"N	73° 7'57.74"E	H (30)	-	Dead
2	18 May	Chansad, Padra, Vadodara District	Road	22°12'32.32"N	73° 7'57.74"E	J (45)	-	Dead
3	10 Jul	Chansad, Padra, Vadodara District	Road	22°12'32.32"N	73° 7'57.74"E	J (60)	-	Dead
4	3 Aug	Bhuj Airport Road, Bhuj, Kutch District	Road	23°16'16.44"N	69°39'59.77"E	J (80)	-	Dead
5	3 Aug	Dhoonai, Bhuj-Mandvi Road, Kutch District	Road	23° 1'52.70"N	69°29'3.83"E	SA (102)	-	Minor injury
6	3 Aug	Sojitra-Dhaboo Road, Anand District	Road	22°34'48.51"N	72°43'3.81"E	J (95)	F	Dead
7	12 Aug	Ganpatpura, Dumad-Savali Road, Vadodara District	Road	22°22'45.33"N	73°11'28.06"E	SA (120)	F	Dead
8	5 Sep	Chavaj, Nr. Bharuch, Bharuch District	Railway	21°45'3.49"N	73° 0'33.66"E	A (208)	F	Treated, died
9	6 Sep	Sumantra-Nakhatrana Rd, Nr Sumantra, Kutch Dist.	Road	23°11'37.49"N	69°29'7.93"E	SA (138)	M	Dead
10	12 Sep	Khatri Talav, Mandavi, Bhuj, Kutch District	Road	23° 9'37.88"N	69°35'33.73"E	J (75)	-	Dead
11	27 Sep	Junagadh City, Junagadh District	Railway	21°32'42.87"N	70°27'31.75"E	A (210)	M	Dead
12	26 Nov	NHv-48 Road, Nr. Chhani, Vadodara District	Road	22°21'26.16"N	73°12'46.03"E	A (256)	M	Treated, released





Figure 2. Dead Muggers found on village roads at Chansad, Padra, Vadodara District, Gujarat.



Figure 3. Sub-adult Mugger found dead on Sumantra-Nakhatrana Road, Nr Sumantra, Kutch District, Gujarat.



Figure 4. Injured adult Mugger found on National Highway-48, near Chhani, Vadodara District, Gujarat. After treatment it was released into the Vishwamitri River. Photograph: Raju Vyas.



Figure 5. Adult Mugger found dead on railway track, Junagadh City, Junagadh District, Gujarat. Photograph: Pranav Vaghashiya.



Figure 6. Dead Mugger found on road near Inampur, Bijnor District, Uttar Pradesh (Anon 2019).



## Crocodile creates scare on NH-44

After seeing the crocodile on the highway, motorists were aghast and soon informed the police

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By Telangana Today | Published: 21st Sep 2019 8:32 pm



**Nizamabad:** A crocodile, which strayed on to National Highway-44 at Dusgaon village of Mendora mandal, created a scare on Saturday. After seeing the crocodile on the highway, motorists were aghast and soon informed the police. Due to heavy flow of water into the Godavari, the crocodile was washed ashore and scaled the flyover, which is beside the NH-44. On seeing the crocodile the villagers and some

Figure 7. Newspaper clipping of a large, injured Mugger falling down from a flyover of National Highway-44 at Doodgoan, Mendora, Nizamabad of Telangana.

Table 2. Months in which CVC with Muggers was reported in Gujarat. Data for 2005-2018 are from Vyas and Vasava (2019).

Month	2005-2018	2019	2005-2019
November	6	1	7
December	0	0	0
January	1	0	1
February	1	0	1
<b>Totals - Winter</b>	<b>8 (21%)</b>	<b>1 (8%)</b>	<b>9 (18%)</b>
March	2	0	2
April	1	1	2
May	0	1	1
June	0	0	0
<b>Totals - Summer</b>	<b>3 (8%)</b>	<b>2 (17%)</b>	<b>5 (10%)</b>
July	6	1	7
August	10	4	14
September	4	4	8
October	7	0	7
<b>Totals - Monsoon</b>	<b>27 (71%)</b>	<b>9 (75%)</b>	<b>36 (72%)</b>
<b>Totals</b>	<b>38</b>	<b>12</b>	<b>50</b>

The present situation of economy and development along with growing linear intrusion within Gujarat needs to be addressed, especially with respect to the status of the state's wildlife and Mugger populations. With increasing numbers of collisions and transport corridors, there are signs that this threat is increasing. Therefore, now is the time for science-based strategies to be developed to control and mitigate linear intrusion, especially with a heightened concern towards

wildlife, both rural and urban.

Gujarat is one of the fastest-growing economic zones of India, with a variety of ambitious projects at proposal and execution stages. Government is equally focusing on developing relevant infrastructure to cope with these megaprojects. Expansion of roadways, railway networks, electric transmission lines, and irrigation canals, are all on agendas for most 10-year development plans of cities across the state. Inevitable to the growth of any economy, roadways and railways are lifelines for any state, with electricity transmission lines and irrigation canals further strengthening the basis of industrialization, urbanization and agricultural growth. But with all this development, one cannot overlook the sensitive co-relationship to ecological sustainability. The balance between economic development and natural resources lies in evaluating the short-term economic gains in comparison to long-term ecological sensitivity.

Although the rate of CVC is very low relative to the size of the Mugger population, Vyas and Vasava (2019) caution that it should not be ignored. With the overall economic progress and the quickening pace of infrastructural upgrading across India, this emerging threat is likely to increase with time, in line with the steadily increasing Mugger population within Gujarat (Vyas 2012, 2018). As information on CVC has come from only a few known areas (Khabbaz 2015), the extent of CVC for Muggers may be underestimated.

## Acknowledgments

We are thankful for to all the wildlife enthusiasts and staff of the forest department who helped us in gathering the data. Special thanks to Kartik Upadhyay, Nitin Patel, Pranav M. Vaghashiya (Vasundhara Nature Club, Junagadh), Dhaval Patel (Voluntary Nature Conservancy, Anand), Dax Padhi (Bhuj-Kutch) and friends who shared valuable information and evidential images. We also thank Niyati Patel for preparing the collision map. Finally, we thank Principal Chief Conservator of Forest, Gujarat State, Conservator of Forest and Deputy Social Forestry Vadodara Division, Forest Department of Gujarat for their valuable support for this study.

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RESULTS OF ANNUAL CENSUS OF ESTUARINE CROCODILES IN BHITARKANIKA WILDLIFE SANCTUARY, ODISHA, INDIA. The annual census of the river systems of Bhitarkanika Wildlife Sanctuary/National Park (Fig. 1) was undertaken from 26 December 2019 to 4 January 2020. A total of 1757 daytime sightings of Estuarine crocodiles was recorded, comprising 620 hatchlings, 325 yearlings, 288 juveniles, 185 sub-adults and 339 adults. The crocodile population continues to increase, with density increasing from 0.87/km (96 sightings) in 1976 to 13.5/km in 2020. More than 103 female *C. porosus* (both released and wild) bred successfully in 2019, a 16 times increase compared to the situation in the mid-1970s.

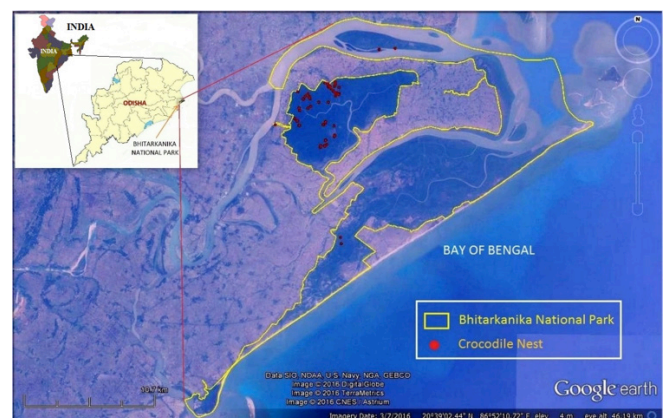


Figure 1. Google Earth image showing location of Bhitarkanika National Park. Red dots indicate *C. porosus* located in mangrove habitat.

With initiation of the Government of India/FAO/UNDP “Crocodile Breeding and Management Project”, the Crocodile Conservation and Research Project was launched in different states of India in early 1975. The Estuarine Crocodile Conservation and Research Program, implemented in the state of Odisha has been a great success, as evidenced by the current status of *C. porosus* population.

The Bhitarkanika River (from Khola to Pathasala), Thanapati, Mahinsamada and Suhajore Creeks, Baunsagada River, Kalibhanjadia, etc., have the highest concentration of crocodiles due to habitat characteristics and low anthropogenic activities (eg no fishing). Bhitarkanika now holds the largest



wild population of *C. porosus* in all regional range states, and it represents about 75% of the total population in India.

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**BIG CATS LOSING OUT TO MUGGERS AT GIR FOREST, GUJARAT, INDIA.** Gir Forest is one of the largest protected areas comprised by Gir Wildlife Sanctuary, Gir National Park and Pania Wildlife Sanctuary. Gir Province is a dry deciduous forest, located in Western Gujarat, and inhabits a rich diversity of flora and fauna, including two large felines - Leopard (*Panthera pardus fusca*) and Asiatic Lion (*P. leo persica*). Both of these cats are large apex predators, and govern the terrestrial ecosystems of Gir.

Official records show that the Gir forest region supports over 625 lions and over 1000 leopards (Singh 2017). Gir also supports a noteworthy population of Mugger crocodiles (*Crocodylus palustris*) - the Gir Freshwater Ecosystem is home to some 648 Muggers of different sizes (Vyas 2019). With such sizeable populations of these large apex carnivores, the probabilities of encounters and competition for habitat are increased. In the last few years, two remarkable interactions have been recorded from Gir Forest region involving Muggers and large cats. This note details these interspecific interactions, based on available evidence, reports, and interviews with eyewitnesses and forest staff.

The first incident occurred at Khodiar Ghuna (Ghuna= large deep-water pool in the river, which retains water in summer) (21° 7'8.53"N, 70°59'7.07"E), near Ghudzinzuva Ness (ness= huts of a traditional pastoralist community), Hadala range, in the eastern parts of Gir forest. Khodiar Ghuna is part of the natural catchment area of Mancchhundri Dam, situated in the upper stream of the dam, and contains over one dozen Muggers of various sizes. On 4 May 2016 A sub-adult male lion was sighted drinking water on the edge of the waterbody. In no time, a few large Muggers were observed to attack the lion, and were able to pull down and kill it. The carcass of the lion was retrieved, and sent for a post-mortem. There were numerous bite marks on the forehead and posterior parts of the lion's body.

The second incident was noted on 26 January 2017, at Ambajal Dam (21° 17' 2.05" N, 70° 44' 10.07" E), Satadhar, near Visavadar, Junagadh. This waterbody is located on the northern fringe of Gir forest region, and contained 34 Muggers of various sizes as per the 2017 crocodile survey (Vyas 2019). An adult male leopard was sighted drinking water on the banks of the waterbody at night. The leopard was suddenly attacked by 3-4 large Muggers, which managed to catch hold of it. The local livestock pastoralists were eyewitnesses to the viscera being eaten in the morning. Upon further inquiry, it was noted that most body parts of the cat were eaten except for some posterior parts of the body.

Vyas (2008) also reported an interaction between a lion and a Mugger at Gir forest, where the lion survived and the Mugger

lost its life. Pandit (2012) reported on a Bengal tiger (*P. tigris*) being killed during an encounter with a Saltwater crocodile (*C. porosus*) in the Sunderban Tiger Reserve, West Bengal. At Ranthambhore Tiger Reserve, Rajasthan, India, a female Bengal tiger [known as “Machali”; [https://en.wikipedia.org/wiki/Machali\\_\(tigress\)](https://en.wikipedia.org/wiki/Machali_(tigress))] killed a large crocodile (Somaweera *et al.* 2013). Encounters have also been reported between crocodilians and other large cats (eg Ocelot *Leopardus pardalis*, Puma *Puma concolor*, Scognamillo *et al.* 2003; Jaguar *Panthera onca*, Da Silveira *et al.* 2010; Pérez-Flores 2018) which are potentially capable of tackling an adult crocodilian (Somaweera *et al.* 2013).



Figure 1. Depiction of conflict between a Bengal tiger and a Mugger. Source: “The struggle in the stream”, page 384 in Lydekker (1894).

#### Acknowledgements

Special thanks to Principal Chief Conservator of Forest Wildlife & Chief Wildlife Warden, Gujarat for support. Thanks to Conservator of Forest, Wildlife Circle, Junagadh, Deputy Conservator of Forest, Sasan Gir for support and sharing information.

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**SIGHTINGS OF MUGGER CROCODILES AT KUTCH, GUJARAT, INDIA.** The Mugger crocodile (*Crocodylus palustris*) is widely distributed throughout India (De Silva and Lenin 2010), occupying a wide variety of habitats including hillside streams, reservoirs, seasonal tanks, large rivers, small pools, irrigation channels, urban drainage sewage puddles, etc. (Vyas 2010).

Table 1. Numbers of Muggers sighted in various waterbodies in Kutch, Gujarat, India.

Waterbody	Date	Latitude/Longitude	Numbers Sighted
Tankat Vandhay	28 August 2015	23°11'45.07"N, 69°26'31.32"E	4
Mavaji Talavadi	21 January 2016	-	1
Admad Lake	21 January 2016	-	2
Samatra Village Tank	31 January 2016	23°11'10.92"N, 69°29'58.41"E	2
Devisat Tank	10 April 2016	-	1
Madhapur Upper Dam	26 May 2018	-	1
Pragsar Tank	14 February 2019	23° 9'6.57"N, 69°28'42.37"E	8
Khatri Pond	31 March 2019	23° 9'37.88" N, 69°35'33.73"E	7
Lair Reservoir	12 November 2019	-	1
Dhonsa Jheel	4 January 2020	23°19'23.76"N, 69°37'33.68"E	1

Kutch is very dry district in Gujarat, and is the second largest district after Jaisalmer District of Rajasthan, India. During bird watching trips Kutch at different times, I came across Muggers in various waterbodies. Here, I report on those opportunistic daytime sightings in those areas (Table 1).

The highest sightings of Muggers were at Pragsar Tank and Khatri Pond. It should be noted that some waterbodies may dry out completely in summer, and animals may migrate to other areas.

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## Nepal

**SURVIVAL OF WILD GHARIAL (*GAVIALIS GANGETICUS*) HATCHLINGS IN THE RAPTI AND NARAYANI RIVERS, CHITWAN NATIONAL PARK, NEPAL.** The Gharial Conservation Breeding Center (GCBC) was established at Kasara, Chitwan National Park (CNP; Fig. 2) in 1978, with the aim of reinforcing the plummeting population of wild Gharials (*Gavialis gangeticus*) and to maintain a viable wild population (Maskey 1989). The GCBC has been collecting Gharial eggs from the Rapti and Narayani Rivers, incubating eggs at its facilities, rearing hatchlings until at least 1.5 m long, and eventually releasing them into rivers within the species geographic range (Maskey 1989; Khadka 2013).

Although Gharial populations in the Narayani and Rapti Rivers were still very low, and showing little sign of recovery (Acharya *et al.* 2017), from 2017 Gharial populations and nests started to gradually increase in these rivers, and the GCBC began to collect only those nests that were deemed to be vulnerable to negative impacts of flooding, human disturbance, wildlife movement, etc.

Fishermen from the indigenous Bote and Mushar tribe were recruited as nest watchers to follow nesting female Gharial throughout the entire nesting season (mid-March to early-April). Once eggs were laid, well-trained staff from the GCBC visited nests and collected eggs from potentially vulnerable nests and left the remaining nests *in-situ*, without any manipulation. During the hatching season in June, *in-situ* nests were visited to determine numbers of hatchlings. Some counts were made as hatchlings came out of nests, but the “final” count of hatchlings was conducted after all nests had hatched, and hatchlings in the water were counted (Fig. 1). Hatchlings were likely to have been 1-10 days of age at the time of the final count.



Figure 1. New (1-2 days) hatchlings with female Gharial at Dhudhaura, Rapti River, on 6 June 2019. Photograph: Bed Khadka.

In January 2018, 2019 and 2020, around 6 months after hatching, we conducted daytime population surveys in the Narayani and the Rapti Rivers within the jurisdiction of CNP, to estimate hatchling survival post-monsoon.

Between 2017 and 2019, 31 nests were left *in-situ*, including one nest in the Khageri River (tributary of the Rapti River), from which no nests had been recorded previously (Table 1). In 2017 two nests did not hatch - one in the Narayani (GaidaKhasa) and one in the Rapti (Itcharni) were flooded. Locations where hatchlings were sighted in January 2018, 2019 and 2020, relative to the locations of *in-situ* nests are on Figure 2.

Notwithstanding the effects of various factors such as emigration, mortality in the first 10 days after hatching and sightability during surveys in June and January, the data indicate relatively low rates of survival in the first 6 months after hatching (0.9%, 8.2% and 0.4% in 2017, 2018 and 2019, respectively; Table 1). Lang *et al.* (2019) reported hatchling mortality to be high (70-90%) within the first 6 months throughout the species' range. Hussain (1999) reported mean hatchling mortality rate of 92.3% within the first year in Chambal (India). Similarly, none of the 100 Gharial hatchlings reported by Bashyal *et al.* (2019) in the Babai River (Nepal), in June 2019, were observed in February 2020 (Ashish Bashyal, pers. comm. 2020).

Hatchlings are hypothesized to be swept away by the monsoon flood in Nepalese rivers, thus resulting in a very low natural recruitment rate (Maskey 1989). My long-term observations suggest that hatchling survival (retention) rates are lower in years when flooding is more extensive. In 2017 and 2019, when severe flooding occurred in the Rapti and Narayani Rivers, the lowest retention rates were estimated (Table 1). However, hatchling mortality is also due to predation by birds such as the Grey-headed fish eagle (*Ichthyophaga gaichthyaetus*) and Mugger crocodile (*Crocodylus palustris*) (B. Khadka, pers. obs.).

Gharials are not unique amongst other crocodilians in having low hatchling survival rates. Given the numbers of Gharials released by the GCBC over many years, and the low rate of

Table 1. Numbers of *in-situ* Gharial nests and hatchling counts pre- (June) and post- (January) monsoon. Estimated survival (retention) rates are shown in brackets. \* = Mean of annual means.

Nesting Year	River	No. of <i>in-situ</i> Nests	No. of Damaged (Unhatched) Nests	No. of Hatchlings June	No. of Hatchlings following January
2017	Narayani	6	0	182 (1.1%)	2
2017	Rapti	2	0	34 (0.0%)	0
<b>Sub-totals</b>	<b>All</b>	<b>8</b>	<b>0</b>	<b>216 (0.9%)</b>	<b>2</b>
2018	Narayani	5	1	63 (14.3%)	9
2018	Rapti	3	1	34 (2.9%)	1
2018	Khageri	1	0	25 (0.0%)	0
<b>Sub-totals</b>	<b>All</b>	<b>9</b>	<b>2</b>	<b>122 (8.2%)</b>	<b>10</b>
2019	Narayani	4	0	75 (1.3%)	1
2019	Rapti	10	0	170 (0.0%)	0
<b>Sub-totals</b>	<b>All</b>	<b>14</b>	<b>0</b>	<b>245 (0.4%)</b>	<b>1</b>
<b>Totals</b>	<b>All areas/years</b>	<b>31</b>	<b>2</b>	<b>583 (3.2%) *</b>	<b>13</b>



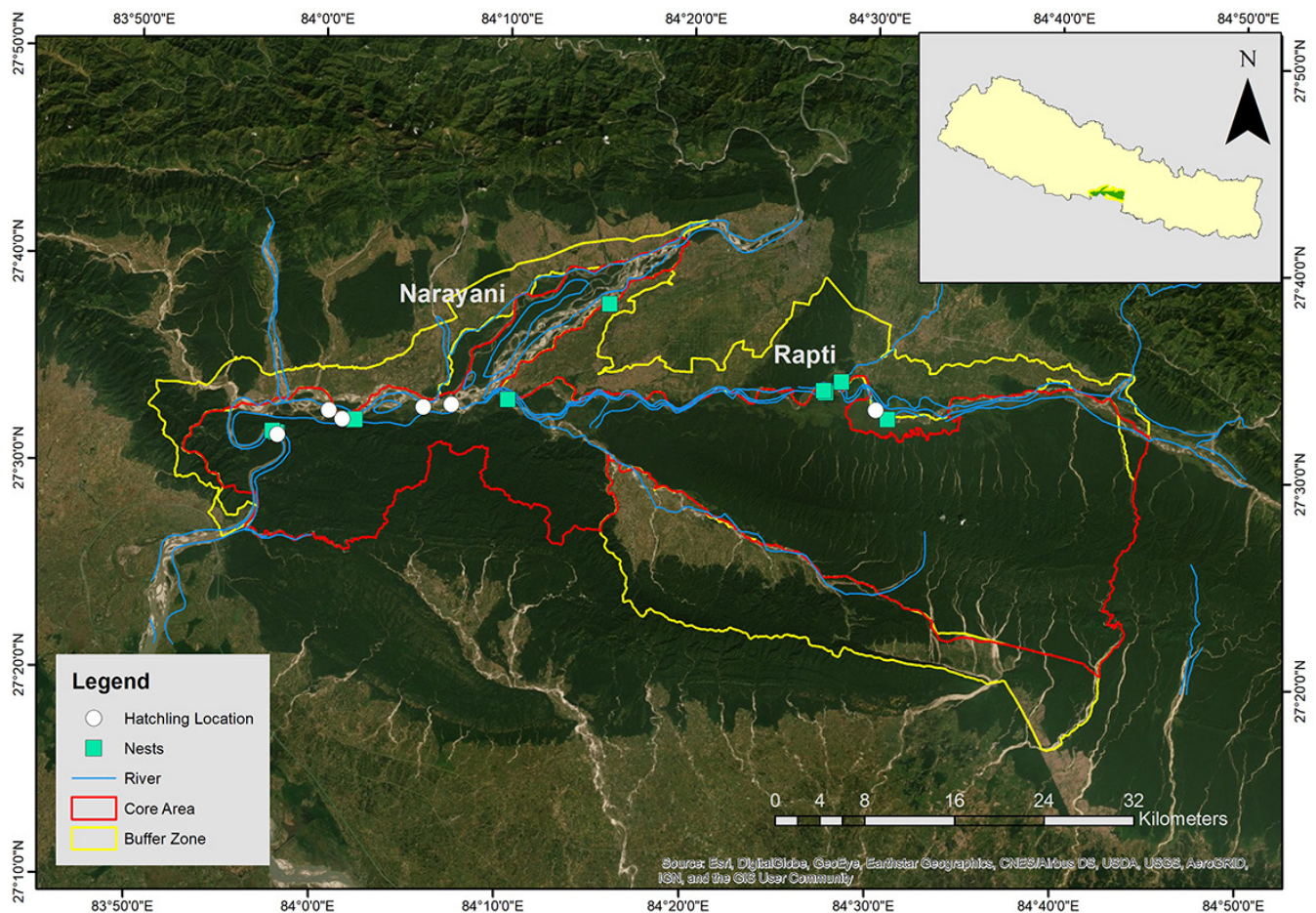


Figure 2. Locations of *in-situ* nests (green squares) and Gharial hatchlings (white circles) were sighted in January 2018, 2019 and 2020.

population increase (Acharya *et al.* 2017), a more systematic evaluation of the reintroduction program is merited.

#### Acknowledgements

I thank nest watchers and GCBC staff for their help and dedication to Gharial conservation, and Ashish Bashyal who helped with compilation and editing.

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Bed Khadka, *Gharial Conservation Breeding Center, Chitwan National Park, Chitwan, Nepal* (bed.khadka@gmail.com).

## East and Southeast Asia

### Indonesia

KALIMANTAN CROCODILE WORKSHOP. A second professional training course and workshop on medical management, conflict management and conservation of crocodiles, with special focus on *Crocodylus porosus* and *Tomistoma schlegelii*, was held in Balikpapan, Indonesia, on 15-18 November 2019. The workshop was organized by Balai

Konservasi Sumber Daya Ala (BKSDA) Kaltim, together with the Center for Wildlife Studies at the Veterinary Faculty of Syiah Kuala University Banda Aceh, and the Crocodilian Conservation Center of Florida. Members of the CSG's Veterinary Science Group and Tomistoma Task Force worked together with workshop organizers to recruit presenters and establish the lecture and practical sessions.

Funding for the workshop was provided by Syiah Kuala University Veterinary Faculty's Center for Wildlife Studies, Wildlife Reserves Singapore, Jacksonville Zoo and Gardens, the AZA's Crocodilian Advisory Group and the Mississippi Aquarium. The classroom and practical sessions of the workshop were presented by Dr. Paolo Martelli, Dr. Abraham Mathew, Bruce Shwedick, Joe Wasilewski, Dr. Adam Britton, Dadang Suryana, S. Hut.T., Oktavianus Alvanaidi Sene, S. Pi., and Dr. Christopher Stremme. Sessions were conducted in both English and Bahasa Indonesian.

The presentations included an overview of crocodilians, with special emphasis on Indonesian species, an introduction to Human-Crocodile Conflict and its management within Indonesia, an example of crocodile habitat management, an introduction to field techniques for monitoring wild crocodile populations, fundamentals of crocodilian biology, fundamentals of captive management, crocodile handling (manual and chemical restraint), diseases, clinical techniques and sampling for health assessment, nutritional, metabolic and infectious disease diagnosis, as well as prevention and treatment. Participants were provided an opportunity to share case histories, experiences and for Q&A. The two days of lectures concluded with an introduction to the CSG Step by Step Guide and Reporting Form for the Necropsy of Crocodilians.

Workshop participants represented the following organizations: BKSDA Aceh, BKSDA Jambi, BKSDA Kalimantan Barat, BKSDA Kalimantan Tengah, BKSDA Kalimantan Selatan, BKSDA Kalimantan Timur, BKSDA Kalimantan Utara, BKSDA Nusa Tenggara Timur, Tanjung Puting National Park, Gunung Palung National Park, Way Kambas National Park, Veterinary Faculty Syiah Kuala University Banda Aceh, International Animal Rescue Indonesia, Wildlife Conservation Society Indonesia, Cikananga Rescue Centre, Borneo Orangutan Survival Foundation and Java Timur Park 3.

Over the following two days, practical training was conducted at C.V. Surya Raya Crocodile Farm (SRCF) with the assistance of Joey Heung, a veterinary nurse from Hong Kong Ocean Park, and C.V. SRCF staff. The training course and workshop's 23 participants were divided into five groups, and each group participated in the capture and handling of *C. porosus* ranging from 1.8 to 2.2 m in length, each group under the direct supervision of at least one of the workshop presenters. The workshop participants were given instruction in techniques for external physical examination, collecting morphometric data, sex determination and collecting blood samples. One *C. porosus*, 3.1 m in length, was also handled in order for the participants to repeat the

above mentioned procedures with an adult specimen. A demonstration of ultrasound techniques and stomach flushing was also performed and then practiced by participants. Tail scute clipping was also demonstrated. The practical sessions concluded with participants examining juvenile *C. porosus* and *C. siamensis*, and performing necropsy procedures on *C. porosus*.



Figure 1. Participants of Kalimantan Crocodile Workshop during the practical sessions held at C.V. Surya Raya Crocodile Farm in Balikpapan.

Following the workshop, two field site visits were conducted in Central Kalimantan, at Lamandau Nature Preserve and Tanjung Puting National Park as a part of the ongoing conservation efforts of the CSG's Tomistoma Task Force. An Indonesian crocodile discussion group was created by the participants, to maintain contact and for networking purposes.

Colin Stevenson, Vice Chair, CSG Tomistoma Task Force ([coleosuchus@hotmail.com](mailto:coleosuchus@hotmail.com)).

## Australia and Oceania

### Australia

In volume 38(3) of the CSG Newsletter we reported on trials being carried with drones to identify crocodiles at swimming beaches in North Queensland. Now, we can report that drones have been applied in a more hands-on manner, to capture "problem" Saltwater crocodiles (*Crocodylus porosus*). Dr. Matt Brien and colleagues in Queensland have successfully used drones to capture Saltwater crocodiles (*Crocodylus porosus*) up to 3 m in length. The results of this work have been published in Herpetological Review (Brien *et al.* 2020).

Capture involved four stages: (1) launching of the drone and baited noose setup; (2) operating the drone so that the bait skims across the water's surface when close to the crocodile; (3) setting a noose around the top jaw of the crocodile; and, (4) capture and securing of the crocodile from a boat (4-5 m open boat, 3 people).

The drone is navigated through the live feed produced by the camera on the controller screen. A spotter, using



binoculars, provides directions on the height of the bait and its distance from the water's edge and crocodile, and reports on the crocodile's behavior. The spotter is also responsible for identifying risks and hazards such as other boats and any overhanging trees that might entangle the drone or the baited noose.

Skimming the bait along the water's surface was the most important element of using a drone to capture crocodiles, taking advantage of the innate predatory response of crocodilians to any movement at or near the water's edge and surface. Capture was relatively quick (<15 minutes).

Two of the four crocodiles reported in Brien *et al.* (2020) were problem crocodiles, which had eluded capture using traditional methods (harpoon, trap) for 3 months and 2 weeks, respectively.

This capture method is an innovative, non-lethal, humane, and efficient technique for capturing wary and hard to capture crocodiles in some situations. Like other methods, it is not considered infallible, and should be adapted and improved over time.

Brien, M., Booth, S., Beri, P., Coulson, S., Frisby, T., Perera, D. and Joyce, M. (2020). A novel method of using a drone to capture Saltwater crocodiles (*Crocodylus porosus*). *Herpetological Review* 51(1).



Figure 1. Bait skimming towards a crocodile.

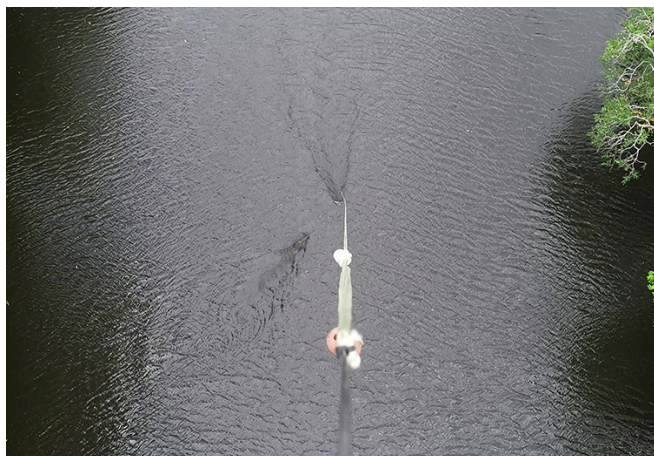


Figure 2. Crocodile pursuing skimming bait.

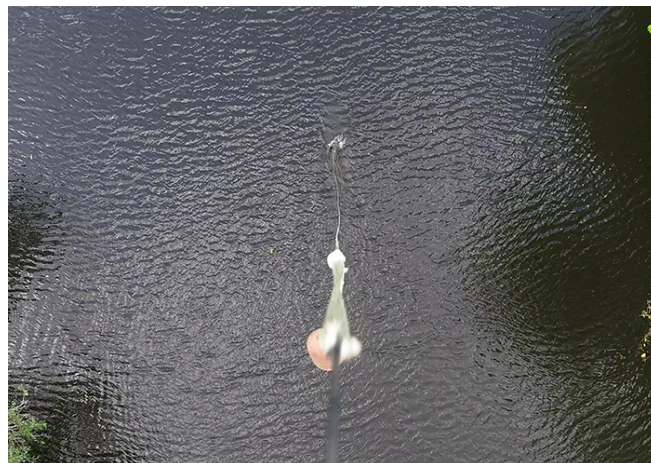


Figure 3. Crocodile grabbing baited noose.



Figure 4. Noosed crocodile being brought up to boat.

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## North America

### **USA**

**CROCODILE IN BREVARD COUNTY, FLORIDA.** American crocodiles (*Crocodylus acutus*) are increasing in numbers and extending their range in Florida. Patrick Keough submitted photographs of an American crocodile, observed on 21-22 January 2020 sunning itself on a dock on the Indian River, at Indialantic (28.119441 N, 80.590768 W), near Melbourne in Brevard County, Florida.

This location is approximately 160 km north of the reported range of the species (Lake Worth, Palm Beach County, Florida). Mr. Keough reported that the weather was cool (high 30's°F = 3-4°C). Other reports indicate that crocodiles tend to emerge and attempt to bask on very cold days, even if this may be maladaptive, while alligators remain in the water - even below ice.





Figure 1. Basking American crocodile at Brevard County.  
Photograph: Patrick Keough.

Perran Ross, CSG Deputy Chair (pross@ufl.edu). Photographs and account by Mr. Keough used with permission.



## Recent Publications

Ortiz, D.A., Dueñas, J.F., Villamarin, F. and Ron, S.R. (2020). Long-term monitoring reveals population decline of Spectacled caimans (*Caiman crocodilus*) at a black-water lake in Ecuadorian Amazon. *Journal of Herpetology* 54(1): 31-38.

**Abstract:** Knowledge on long-term population trends in crocodilians is essential to assess the effectiveness of conservation areas and to guide sustainable management practices. We studied changes in population size of Spectacled (*Caiman crocodilus*) and Black caimans (*Melanosuchus niger*) over a period of 17 yr at Mateococha, a black-water lake located in Cuyabeno Wildlife Reserve, western Amazonia, Ecuador. Using standardized spotlight counts and two mark-recapture surveys, we estimated the population abundance, body size structure, and sex ratio in 1994, 2004, and 2011. The maximum number of *C. crocodilus* recorded in 1994 (147 individuals; 33 individuals/km [ind/km] of lakeshore) declined by 2004 to 94 individuals (21.1 ind/km) and by 2011 to 63 individuals (14.2 ind/km). The number of *M. niger* recorded was low but constant (5-7 individuals; 1.1-1.6 ind/km) throughout the study, suggesting that factors causing the decline in *C. crocodilus* were not related to the *M. niger* population trend. Large *C. crocodilus* adults (total length 150-220 cm) were frequent in 1994 but became rare in 2004 and 2011. The sex ratio of captured *C. crocodilus* was male-biased during all periods. The causes of the population decline are unknown, but available evidence suggests that illegal hunting and habitat degradation are likely culprits despite the protected status of the Cuyabeno Reserve. Our findings question the effectiveness of protected areas to ensure long-term survival of caiman populations

in Ecuador.

Lau, C.H., Snook, E.R., Swinford, A.K. and Bryan, L.K. (2020). *Achlya* sp. dermatitis in an American alligator (*Alligator mississippiensis*). *Journal of Comparative Pathology* 175 (<https://doi.org/10.1016/j.jcpa.2019.12.002>).

**Abstract:** Oomycetes are water moulds in the kingdom Protista and are not considered true fungi due to the structural lack of chitin and ergosterol. Many oomycetes are pathogenic, such as *Pythium* spp., and many fish are prone to *Saprolegnia* spp. infections, particularly in stressful farming situations. A juvenile American alligator (*Alligator mississippiensis*) was presented for necropsy examination with white, gelatinous, raised lesions over ulcerated regions of skin on the limbs and tail. The alligator came from a hatchery with age-divided enclosures, and several of the animals within the same enclosure showed similar lesions. Numerous hyphae with non-parallel walls and sparse, non-dichotomous branching were observed histologically on Gomori's methenamine silver staining within the ulcers. Although no organisms were detectable via polymerase chain reaction testing of fresh or formalin-fixed tissues, the organism was cultured and sequenced as an *Achlya* sp., an infrequently identified oomycete. To the author's knowledge, this is the first description of an oomycete infection within the class Reptilia.

Sinaei, M. and Loghmani, M. (2019). Plankton and aquatic insect biodiversity in the Sarbaz River, Southeastern Iran. *Indian Journal of Geo-Marine Sciences* 48(12): 1907-1915.

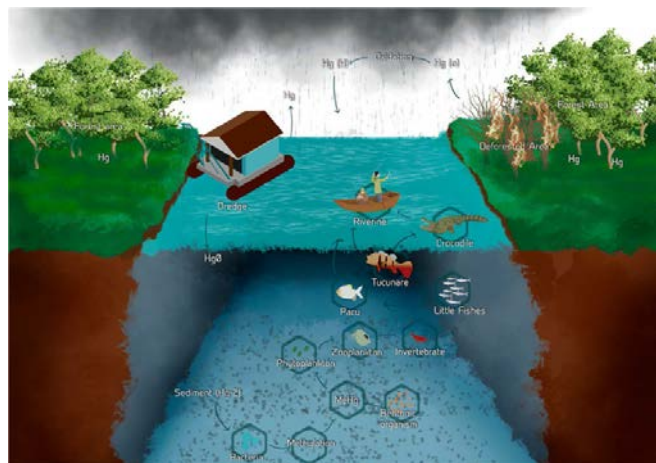
**Abstract:** Studying plankton community and determining the trends in river pollution are of great value and importance. In the present work, plankton and aquatic insect community were evaluated in 10 sites along the Sarbaz River in southeastern Iran. Among the species identified, Navicula has the highest incidence with five species. The highest frequency and density belongs to the ciliates group. Results indicate that the studied environment has a poor planktonic diversity and density. Results suggested that a decrease in plankton communities could be one of the factors influencing reductions in mugger crocodile (*C. palustris*) hatchling survival. Moreover, it was found that dominant populations of aquatic insects are susceptible to organic pollutants with tolerating levels of 0 to 4 from Diptera, Ephemeroptera, Trichoptera, Ephemerehidae, Hemiptera, Odonata orders. Moreover, an increase is noted in the Family Biotic Index (FBI) in downstream sites, suggesting a decrease in water quality compared with other sites.

Gomes, D.F., Moreira, R.A., Sanches, N.A.O., Do Vale, C.A., Daam, M.A., Gorni, G.R. and Bastos, W.R. (2020). Dynamics of (total and methyl) mercury in sediment, fish, and crocodiles in an Amazonian Lake and risk assessment of fish consumption to the local population. *Environmental Monitoring and Assessment* 192 (<https://doi.org/10.1007/s10661-020-8066-z>).

**Abstract:** Increasing concerns have been raised about the toxicity of mercury (Hg) to humans, especially for those that consume a great amount of fish. High Hg concentrations have previously been measured in Amazonian waterbodies, both resulting from natural and anthropogenic sources. However, few studies have been conducted so far in Amazonian lakes that are fished by local populations. In addition, few of those studies included methylmercury (MeHg), the most toxic and bioaccumulative Hg form, and evaluated the influence of physico-chemical conditions and season on Hg dynamics. In the present study, total Hg (THg) and MeHg concentrations were measured in bottom sediment as well as in two fish and two crocodile species of the Amazonian Cunã Lake. Bottom sediment MeHg concentrations were higher in the dry season than in the wet season, which is related to differences in physico-chemical (pH and electrical conductivity) conditions. Diet appeared to be related with animal tissue MeHg concentrations, with



the herbivorous fish having lower MeHg levels than the predatory fish and crocodiles. Based on the measured tissue concentrations and published data on local person weight and fish consumption, MeHg risk to Cuniã Lake populations was estimated. Although the MeHg fish tissue concentrations did not exceed national and international standards, a significant risk to the local population is anticipated due to their high fish consumption rates.



Gearty, W. and Payne, J.L. (2020). Physiological constraints on body size distributions in crocodyliformes. *Evolution* (<https://doi.org/10.1111/evo.13901>).

**Abstract:** At least 26 species of crocodylian populate the globe today, but this richness represents a minute fraction of the diversity and disparity of Crocodyliformes. Fossil forms are far more varied, spanning from erect, fully terrestrial species to flippered, fully marine species. To quantify the influence of a marine habitat on the directionality, rate, and variance of evolution of body size in Crocodyliformes and thereby identify underlying selective pressures, we compiled a database of body sizes for 264 fossil and modern species of crocodyliform covering terrestrial, semi-aquatic, and marine habitats. We find increases in body size coupled with increases in strength of selection and decreases in variance following invasions of marine habitats but not of semi-aquatic habitats. A model combining constraints from thermoregulation and lung capacity provides a physiological explanation for the larger minimum and average sizes of marine species. It appears that constraints on maximum size are shared across Crocodyliformes, perhaps through factors such as the allometric scaling of feeding rate versus basal metabolism with body size. These findings suggest that broad-scale patterns of body size evolution and the shapes of body size distributions within higher taxa are often determined more by physiological constraints than by ecological interactions or environmental fluctuations.

Wang, L., Cai, R., Liu, F., Lv, Y., Zhang, Y., Duan, S., Izaz, A., Zhou, J., Wang, H., Duan, R., Wu, X. and Li, T. (2020). Molecular cloning, characterization, mRNA expression changes and nucleocytoplasmic shuttling during kidney embryonic development of SOX9 in *Alligator sinensis*. *Gene* (<https://doi.org/10.1016/j.gene.2020.144334>).

**Abstract:** SOX9 plays a crucial, extensive and conservative role in the process of somatic tissue development and adult regeneration through the positive self-regulation mediated by SOM across all vertebrates. In this study, we have cloned SOX9 from the kidney of hatchling *Alligator sinensis*. The full-length of SOX9 cDNA is 3878 bp with an open reading frame encoding 494 amino acids. Amino acid alignment analyses indicated that the SOX9 exhibit highly conserved functional domains. Using the droplet digital PCR, the mRNA abundances of SOX9 during nephrogenesis in *A. sinensis* showed prominent changes in the embryonic development, suggesting that SOX9 might combines a vital role in the regulation of complex

renal development. Interestingly, we detected the nucleocytoplasmic shuttling of SOX9 protein using immunofluorescence, implying that nucleocytoplasmic shuttling is critical to the regulation of SOX9 in the renal embryonic development. Collectively, these data provide an important foundation for further studies on renal developmental biology and molecular biology of non-mammalian SOX9. Furthermore, it provides new insights into the phenomenon of SOX9 nucleocytoplasmic shuttling in *A. sinensis*, which is probably of great significance to the development of kidney metanephros embryo.

Grap, N.J., Machts, T., Essert, S. and Bleckmann, H. (2020). Stimulus discrimination and surface wave source localization in crocodilians. *Zoology* (<https://doi.org/10.1016/j.zool.2020.125743>).

**Abstract:** Juvenile Nile crocodiles (*Crocodylus niloticus*) and Spectacled caimans (*Caiman crocodilus*) use water surface waves for the detection of prey, usually insects trapped at the water surface. This prey detection relies on mechanosensors, the integumentary sensory organs. We found by go/no go conditioning that *C. niloticus* and *C. crocodilus* can discriminate surface waves that differ in frequency. On average, frequency difference thresholds were about 4-5%, eg *C. niloticus* distinguished a 40Hz surface wave from a 38.5Hz surface wave stimulus. *C. niloticus* and *C. crocodilus* also discriminated between single-frequency surface waves (15Hz and 40Hz) and surface waves that showed an abrupt frequency change (e.g. from 15 to 16.5Hz or from 40Hz to 38.5Hz). The threshold for the abrupt frequency changes averaged 3-9 %. Additionally, Nile crocodiles differentiated also between a single-frequency water surface wave and a water surface wave that was amplitude modulated. *Crocodylus niloticus* also determined the direction (mean error angle between 13.7° and 16.6°) to a surface wave stimulus. Furthermore, the distance covered by the Nile crocodiles increased slightly with increasing source distance. This was true whether a single-frequency (15Hz and 40Hz, relative distance error between 36 and 37%) or a multi-frequency (band width 1-80Hz, relative distance error 25%) surface wave stimulus was offered. Even if the rewarded stimulus (40Hz) was superimposed by an unrewarded surface wave some distance determination was observed (relative distance error between 30 and 62%).

Brocklehurst, R.J., Schachner, E.R., Codd, J.R. and Sellers, W.I. (2020). Respiratory evolution in archosaurs. *Phil. Trans. R. Soc. B* 375: 20190140 (<http://dx.doi.org/10.1098/rstb.2019.0140>).

**Abstract:** The Archosauria are a highly successful group of vertebrates, and their evolution is marked by the appearance of diverse respiratory and metabolic strategies. This review examines respiratory function in living and fossil archosaurs, focusing on the anatomy and biomechanics of the respiratory system, and their physiological consequences. The first archosaurs shared a heterogeneously partitioned parabronchial lung with unidirectional air flow; from this common ancestral lung morphology, we trace the diverging respiratory designs of bird- and crocodilian-line archosaurs. We review the latest evidence of osteological correlates for lung structure and the presence and distribution of accessory air sacs, with a focus on the evolution of the avian lung-air sac system and the functional separation of gas exchange and ventilation. In addition, we discuss the evolution of ventilation mechanics across archosaurs, citing new biomechanical data from extant taxa and how this informs our reconstructions of fossils. This improved understanding of respiratory form and function should help to reconstruct key physiological parameters in fossil taxa. We highlight key events in archosaur evolution where respiratory physiology likely played a major role, such as their radiation at a time of relative hypoxia following the Permo-Triassic mass extinction, and their evolution of elevated metabolic rates.

Clarac, F., Scheyer, T.M., Desojo, J.B., Cerda, I.A. and Sanchez, S.

(2020). The evolution of dermal shield vascularization in Testudinata and Pseudosuchia: phylogenetic constraints versus ecophysiological adaptations. *Phil. Trans. R. Soc. B* 375: 20190132 (<http://dx.doi.org/10.1098/rstb.2019.0132>).

**Abstract:** Studies on living turtles have demonstrated that shells are involved in the resistance to hypoxia during apnea via bone acidosis buffering; a process which is complemented with cutaneous respiration, transpharyngeal and cloacal gas exchanges in the soft-shell turtles. Bone acidosis buffering during apnea has also been identified in crocodylian osteoderms, which are also known to employ heat transfer when basking. Although diverse, many of these functions rely on one common trait: the vascularization of the dermal shield. Here, we test whether the above ecophysiological functions played an adaptive role in the evolutionary transitions between land and aquatic environments in both Pseudosuchia and Testudinata. To do so, we measured the bone porosity as a proxy for vascular density in a set of dermal plates before performing phylogenetic comparative analyses. For both lineages, the dermal plate porosity obviously varies depending on the animal lifestyle, but these variations prove to be highly driven by phylogenetic relationships. We argue that the complexity of multi-functional roles of the post-cranial dermal skeleton in both Pseudosuchia and Testudinata probably is the reason for a lack of obvious physiological signal, and we discuss the role of the dermal shield vascularization in the evolution of these groups.

Grosell, M., Heuer, R.M., Wu, N.C., Cramp, R.L., Wang, Y., Mager, E.M., Dwyer, R.G. and Franklin, C.E. (2020). Salt-water acclimation of the estuarine crocodile *Crocodylus porosus* involves enhanced ion transport properties of the urodaeum and rectum. *Journal of Experimental Biology* (doi: 10.1242/jeb.210732).

**Abstract:** Estuarine crocodiles *Crocodylus porosus* inhabit freshwater, estuarine and marine environments. Despite being known to undertake extensive movements throughout and between hypo- and hyperosmotic environments, little is known on the role of the cloaca in coping with changes in salinity. In addition to the well-documented functional plasticity of the lingual salt glands, we report here that the middle of the three cloacal segments (i.e. the urodaeum), responds to increased ambient salinity to enhance solute-coupled water absorption. This post-renal modification of urine serves to conserve water when exposed to hyperosmotic environments and, in conjunction with lingual salt gland secretions, enables *C. porosus* to maintain salt and water balance and thereby thrive in hyperosmotic environments. Isolated epithelia from the urodaeum of 70% seawater-acclimated *C. porosus* had a strongly enhanced short circuit current (indicator of active ion transport) compared to freshwater-acclimated crocodiles. This enhanced active ion absorption was driven by increased Na<sup>+</sup>/K<sup>+</sup>-ATPase activity, and possibly enhanced proton pump activity, and was facilitated by the apical epithelial Na<sup>+</sup> channel (ENaC) and/or the apical Na<sup>+</sup>/H<sup>+</sup> exchanger (NHE2), both of which are expressed in the urodaeum. NHE3 was expressed at very low levels in the urodaeum and likely does not contribute to solute-coupled water absorption in this cloacal segment. Since *C. porosus* does not appear to drink water of salinities above 18 ppt, observations of elevated short circuit current in the rectum as well as a trend for increased NHE2 expression in the esophagus, the anterior intestine, and the rectum, suggests that dietary salt intake may stimulate salt, and possibly water absorption by the gastro-intestinal tract of *C. porosus* living in hyperosmotic environments.

Eberle, J.J., Gottfried, M.D., Hutchison, J.H. and Brochu, C.A. (2014). First record of Eocene bony fishes and Crocodyliforms from Canada's Western Arctic. *PLoS ONE* 9(5): e96079.

**Abstract:** Discovery of Eocene non-marine vertebrates, including crocodylians, turtles, bony fishes, and mammals in Canada's High Arctic was a critical paleontological contribution of the last century because it indicated that this region of the Arctic had been mild,

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

Cherkiss, M.S., Watling, J.I., Brandt, L.A., Mazzotti, F.J., Lindsay, J., Beauchamp, J.S., Lorenz, J., Wasilewski, J.A., Fujisaki, I. and Hart, K.M. (2020). Shifts in hatching date of American crocodile (*Crocodylus acutus*) in southern Florida. *Journal of Thermal Biology* (<https://doi.org/10.1016/j.jtherbio.2020.102521>).

**Abstract:** Globally temperature of marine environments is on the rise and temperature plays an important role in the life-history of reptiles. In this study, we examined the relationship between sea surface temperature and average date of hatching for American crocodiles (*Crocodylus acutus*) over a 37-year period at two nesting sites, Everglades National Park and Florida Power and Light Turkey Point Power Plant site in southern Florida. Our results indicate that hatch dates are shifting 1.5 days earlier every two years and at half that rate for the Turkey Point site, and with every 1°C degree increase in temperature, hatching occurs about 10 days earlier in the Everglades and 6 days earlier at Turkey Point. Our results on shifting hatch dates for American crocodiles provide further details about the impacts of temperature change on crocodile life history and suggest that increased temperature may affect their phenology.

Vliet, K.A. (2020). Alligators: The Illustrated Guide to Their Biology, Behavior, and Conservation. John Hopkins University Press: Baltimore.

Fonseca, P.H.M., Martinelli, A.G., da Silva Marinho, T., Ribeiro, L.C.B., Schultz, C.L. and Soares, M.B. (2020). Morphology of the endocranial cavities of *Campinasuchus dinizi* (Crocodyliformes: Baurusuchidae) from the Upper Cretaceous of Brazil. *Geobios* (<https://doi.org/10.1016/j.geobios.2019.11.001>).

**Abstract:** Two specimens of *Campinasuchus dinizi* (CPPLIP 1319 and CPPLIP 1360) belonging to Baurusuchidae (Crocodyliformes, Notosuchia) from the Upper Cretaceous Bauru Group of Minas Gerais state (Brazil) were scanned in a Toshiba Aquilion 64 CT machine. Based on these data, it was possible to identify and reconstruct the paranasal sinuses, the nasal cavity proper, the nasopharyngeal duct, the encephalon, the paratympanic sinuses, and the semicircular canals of the inner ear. The paranasal sinuses present similar morphology to those of other mesoeucrocodylians, especially eusuchians. The nasal



cavity proper occupies the entire rostral region, with an expansion in the olfactory region. The expansion in the nasal cavity is present in other notosuchians and theropod dinosaurs (eg *Tyrannosaurus rex* Osborn, 1905), but less developed in aquatic crocodylians, which may indicate an olfactory acuity related to terrestrial habits. The encephalon is similar in shape to that of other mesoeucrocodylians. The rostral semicircular canal is smaller than the caudal one, differing from most mesoeucrocodylians. The paratympanic sinuses are more developed in *C. dinizi* than in eusuchians, being more similar to *T. rex*. *Campinasuchus dinizi* presents few variations in the internal structures of the skull in relation to taxa with different ecological niches, probably indicating that ecological factors do not strongly influence the morphology of these structures.

Lakin, R.J., Barrett, P.M., Stevenson, C., Thomas, R.J. and Wills, M.A. (2020). First evidence for a latitudinal body mass effect in extant Crocodylia and the relationships of their reproductive characters. *Biological Journal of the Linnean Society* (<https://doi.org/10.1093/biolinnean/blz208>).

**Abstract:** Relationships between distribution patterns and body size have been documented in many endothermic taxa. However, the evidence for these trends in ectotherms generally is equivocal, and there have been no studies of effects in crocodylians specifically. Here, we examine the relationship between latitudinal distribution and body mass in 20 extant species of crocodylians, as well as the relationships between seven important reproductive variables. Using phylogenetically independent contrasts to inform generalized linear models, we provide the first evidence of a latitudinal effect on adult female body mass in crocodylians. In addition, we explore the relationships between reproductive variables including egg mass, hatchling mass and clutch size. We report no correlation between egg mass and clutch size, upholding previously reported within-species trends. We also find no evidence of a correlation between measures of latitudinal range and incubation temperature, contrasting with the trends found in turtles.

Alderman, S.L., Crossley, II, D.A., Elsey, R.M and Gillis, T.E. (2020). Growing up gator: A proteomic perspective on cardiac maturation in an oviparous reptile, the American alligator (*Alligator mississippiensis*). *Journal of Comparative Physiology B* (doi: 10.1007/s00360-020-01257-6).

**Abstract:** We recently described lasting changes in the cardiac proteome of American alligators (*Alligator mississippiensis*) reared under hypoxic conditions, that resemble what embryos encounter in natural nests. While these changes were consistent with functional differences in cardiac performance induced by developmental hypoxia, the magnitude of this response was dwarfed by a much greater effect of development alone (76% of the total differentially abundant proteins). This means that substantial differences in relative steady-state protein expression occur in the hearts of alligators as they mature from egg-bound embryos to 2-year-old juveniles, and this developmental program is largely resistant to variation in nest conditions. We therefore performed functional enrichment analysis of the 412 DA proteins that were altered by development but not hypoxia, to gain insight into the mechanisms of cardiac maturation in this ectotherm. We found that the cardiac proteome of alligators at 90% of embryonic development retained a considerable capacity for transcription and translation, suggesting the heart was still primarily invested in growth even as the animal approached hatching. By contrast, the cardiac proteome of 2-year-old juveniles was weighted towards structural and energetic processes typical of a working heart. We discuss our results in the context of differences in cardiac development between ectothermic and endothermic oviparous vertebrates, and argue that the robust developmental program of the alligator heart reflects a slow-paced ontogeny, unburdened by the requirement to support the elevated peripheral oxygen demand typical of endothermic animals from a young age.

Scheyer, T.M., Hutchinson, J.R., Strauss, O., Delfino, M., Carrillo-Briceno, J.D., Sanchez, R. and Sanchez-Villagra, M.R. (2019). Giant extinct caiman breaks constraint on the axial skeleton of extant crocodylians. *eLife* 8: e49972.

**Abstract:** The number of precaudal vertebrae in all extant crocodylians is remarkably conservative, with nine cervicals, 15 dorsals and two sacrals, a pattern present also in their closest extinct relatives. The consistent vertebral count indicates a tight control of axial patterning by Hox genes during development. Here we report on a deviation from this pattern based on an associated skeleton of the giant caimanine *Purussaurus*, a member of crown Crocodylia, and several other specimens from the Neogene of the northern neotropics. *P. mirandai* is the first crown-crocodylian to have three sacrals, two true sacral vertebrae and one non-pathological and functional dorsosacral, to articulate with the ilium (pelvis). The giant body size of this caiman relates to locomotory and postural changes. The iliosacral configuration, a more vertically oriented pectoral girdle, and low torsion of the femoral head relative to the condyles are hypothesized specializations for more upright limb orientation or weight support.

Zhang, R., Nie, H., Duan, S., Yan, P., Izaz, A., Wang, R., Zhou, Y. and Wu, X. (2020). Cloning, characterization and expression profile of kisspeptin1 and the kisspeptin1 receptor at the hypothalamic-pituitary-ovarian axis (HPO) of Chinese alligator, *Alligator sinensis*, during the reproductive cycle. *Reproduction, Fertility and Development*.

**Abstract:** Kisspeptin1, as a product of the Kiss1 gene, plays an important role in the regulation of reproduction in vertebrates by activating the kisspeptin1 receptor (Kiss1R) and coexpressing in gonadotropin-releasing hormone (GnRH) neurons. The purpose of this study was to clone the Kiss1 and Kiss1R genes found in the brain of *Alligator sinensis* and to explore their relationship with reproduction. The full-length cDNA of Kiss1 is 816 bp, the open reading frame (ORF) is 417 bp, and it encodes a 138-amino acid precursor protein. The full-length cDNA of Kiss1R is 2348 bp, the ORF is 1086 bp, and it encodes a 361-amino acid protein. The results of qPCR showed that, except for Kiss1R in the hypothalamus, the expression of Kiss1 and Kiss1R in the reproductive period was higher than that in the hypothalamus, pituitary gland, and ovary in the hibernation period. The changes in GnRH2 mRNA in the hypothalamus were similar to those of GnRH1 and peaked during the reproductive period. In conclusion, we confirmed the existence of Kiss1/Kiss1R in *A. sinensis* and strongly suggest that Kiss1/Kiss1R might participate in the regulation of GnRH secretion in the hypothalamus of alligators during the reproductive stage. Furthermore, this is the first report of the full-length cDNA sequences of the Kiss1 and Kiss1R genes in reptiles.

Sosnowski, M.C. and Petrossian, G.A. (2020). Luxury Fashion Wildlife Contraband in the USA. *EcoHealth* (<https://doi.org/10.1007/s10393-020-01467-y>).

**Abstract:** The fashion industry is one of the largest markets for illegal wildlife products. This study examined US luxury fashion-related wildlife seizures made between 2003 and 2013 to better guide detection, enforcement, and policy. The findings of this study indicate that the number of incidents has increased over the 11-year period, while the number of associated items seized has decreased over this time. Of these seizures, nearly 88% were produced goods. A small proportion of genera made up the majority of seizures, with reptiles in particular accounting for 84% of incidents. Over half of all wildlife was wild-caught and was exported from eight countries. Based on these findings, it is suggested that policy be enacted relating specifically to the use of exotic leathers and furs, and that situational crime prevention alongside commitments to sustainability from fashion brands be used to reduce illegal imports and improve industry sustainability.

Sadlok, G. and Pawełczyk, K. (2020). Tetrapod swim techniques interpreted from swim trace fossils from the Lower Triassic Baranów Formation, Holy Cross Mountains, central Poland. *PalZ* (<https://doi.org/10.1007/s12542-019-00510-w>).

**Abstract:** Swimming tetrapods may leave their traces under water if their digits or limbs stir the bottom sediment. Resulting trace fossils are evidence of a swim behavior. Tetrapods swim techniques depend on the functional morphology of the swimmers. Examination of swim trace fossils may reveal the swim techniques employed and swimmers' functional morphologies behind the behaviors. The present paper analyzes swim trace fossils of tetrapods from the fluvial Lower Triassic Baranów Formation in the Holy Cross Mountains (central Poland). The examination focuses on swim techniques. An attempt is made to correlate the inferred technique with functional morphology of the swimmer. It is concluded that the two types of swim traces occur in the Baranów Formation. These record two different swim techniques - paddling with limbs and body/tail undulation. The distinct types of swim trace fossils point to two types of swimmers: fully terrestrial archosaurs paddling with their limbs and amphibious tetrapods swimming with undulatory movements - likely utilizing their laterally flattened tails.

Rubalcaba, J.G. and Olalla-Tárraga, M.A. (2020). The biogeography of thermal risk for terrestrial ectotherms: scaling of thermal tolerance with body size and latitude. *Journal of Animal Ecology* (<https://doi.org/10.1111/1365-2656.13181>).

**Abstract:** Many organisms are shrinking in size in response to global warming. However, we still lack a comprehensive understanding of the mechanisms linking body size and temperature of organisms across their geographical ranges. Here we investigate the biophysical mechanisms determining the scaling of body temperature with size across latitudes in terrestrial ectotherms. Using biophysical models, we simulated operative temperatures experienced by lizard-like ectotherms as a function of microclimatic variables, body mass and latitude and used them to generate null predictions for the effect of size on temperature across geographical gradients. We then compared model predictions against empirical data on lizards' field body temperature ( $T_b$ ), and thermal tolerance limits ( $CT_{max}$  and  $CT_{min}$ ). Our biophysical models predict that the allometric scaling of operative temperatures with body size varies with latitude, with a positive relationship at low latitudes that vanishes with increasing latitude. The analyses of thermal traits of lizards show a significant interaction of body size and latitude on  $T_b$  and  $CT_{max}$  and no effect of body mass on  $CT_{min}$ , consistent with model's predictions. The estimated scaling coefficients are within the ranges predicted by the biophysical model. The effect of body mass, however, becomes non-significant after controlling for the phylogenetic relatedness between species. We propose that large-bodied terrestrial ectotherms exhibit higher risk of overheating at low latitudes, while size differences in thermal sensitivity vanish towards higher latitudes. Our work highlights the potential of combining mechanistic models with empirical data to investigate the mechanisms underpinning broad-scale patterns and ultimately provide a null model to develop baseline expectations for further empirical research.

Duszynski, D.W., McAllister, C.T. and Tellez, M. (2020). The coccidia (Apicomplexa) of the Archosauria (Crocodylia: Eusuchia) of the world. *Journal of Parasitology* 106(1): 90-122.

**Abstract:** The order Crocodylia (suborder Eusuchia) includes 27 species of alligators, caimans, crocodiles, and gharials that are cosmopolitan in distribution, inhabiting subtropical and tropical locations. Numerous surveys (many of them trivial, with small sample sizes) have reported a wide variety of blood and intestinal apicomplexans from 17/27 (63%) crocodilian hosts, but neither a summation for the group nor a revisionary systematic approach to species evaluation has ever been provided. Herein, we summarize information on the 16 species of apicomplexans that we consider to

be valid, including 8 *Eimeria*, 1 *Haemogregarina* (that eventually may be transferred to *Hepatoozoon*), 4 *Hepatoozoon*, 2 *Isospora*, and 1 *Progarinia* species. In addition, there are 46 apicomplexan forms that we have relegated to *species inquirendae* and/or only partially identified forms that await further study. We hope this review provides a foundation for future research between parasitologists and herpetologists on parasitism of all reptiles and their relatives. Since many apicomplexans seem to be reasonably host-specific, knowledge of shared species and/or genera may assist herpetologists to better understand the phylogenetic relationships among the New World crocodilians and the direction of their dispersal in the New World.

Singh, S.K., Das, D. and Rhen, T. (2020). Embryonic temperature programs phenotype in reptiles. *Frontiers in Physiology* 11: 35.

**Abstract:** Reptiles are critically affected by temperature throughout their lifespan, but especially so during early development. Temperature-induced changes in phenotype are a specific example of a broader phenomenon called phenotypic plasticity in which a single individual is able to develop different phenotypes when exposed to different environments. With climate change occurring at an unprecedented rate, it is important to study temperature effects on reptiles. For example, the potential impact of global warming is especially pronounced in species with temperature-dependent sex determination (TSD) because temperature has a direct effect on a key phenotypic (sex) and demographic (population sex ratios) trait. Reptiles with TSD also serve as models for studying temperature effects on the development of other traits that display continuous variation. Temperature directly influences metabolic and developmental rate of embryos and can have permanent effects on phenotype that last beyond the embryonic period. For instance, incubation temperature programs post-hatching hormone production and growth physiology, which can profoundly influence fitness. Here, we review current knowledge of temperature effects on phenotypic and developmental plasticity in reptiles. First, we examine the direct effect of temperature on biophysical processes, the concept of thermal performance curves, and the process of thermal acclimation. After discussing these reversible temperature effects, we focus the bulk of the review on developmental programming of phenotype by temperature during embryogenesis (ie permanent developmental effects). We focus on oviparous species because eggs are especially susceptible to changes in ambient temperature. We then discuss recent work probing the role of epigenetic mechanisms in mediating temperature effects on phenotype. Based on phenotypic effects of temperature, we return to the potential impact of global warming on reptiles. Finally, we highlight key areas for future research, including the identification of temperature sensors and assessment of genetic variation for thermosensitivity.

Kohno, V.S., Vang, D., Ang, E., Brunell, A.M., Lowers, R.H. and Schoenfuss, H.L. (2020). Estrogen-induced ovarian development is time-limited during the temperature-dependent sex determination of the American alligator. *General and Comparative Endocrinology* (<https://doi.org/10.1016/j.ygcen.2020.113397>).

**Abstract:** Many reptiles, including the American alligator, exhibit temperature-dependent sex determination (TSD), whose thermo-sensitive period for the female alligator begins at stages-15 and ends at stage-24. Estrogen signaling plays a central role in TSD, which can be overridden by an estrogen-exposure during the thermo-sensitive period. As some environmental contaminants are estrogenic, there is growing concern about their effects on the sex ratio and reproductive health of TSD-species. It is crucial to identify the timing of gonadal commitment to either ovary or testis for a better understanding of TSD and estrogen-signals. In the current study, eggs were exposed to 5  $\mu\text{g/g}$  egg of 17 $\beta$ -estradiol (E2) or vehicle ethanol alone at three developmental stages-22, 24, and 26 at a male-promoting temperature, which produced 81% testis in all controls. E2-exposure at stages-22 and 24 induced more ovaries than the control group,



whereas the exposure at stage-26 did not induce the same outcome. These results indicated that there is a critical commitment in the testicular development between the developmental stage 24 (100% ovary in E2 Exposure) and 26 (39% ovary with E2). Based on these results, we estimated a pivotal stage as stage-25.28. Thus, a gonadal commitment to testis could be later than a known temperature-sensitive period for promoting male in TSD.

Serrano-Martínez, A., Knoll, F., Narváez, I., Lautenschlager, S. and Ortega, F. (2020). Neuroanatomical and neurosensorial analysis of the Late Cretaceous basal eusuchian *Agaresuchus fontisensis* (Cuenca, Spain). *Papers in Palaeontology* (<https://doi.org/10.1002/sp2.1296>).

**Abstract:** *Agaresuchus fontisensis* is an allodaposuchid crocodile from the Campanian-Maastrichtian (Late Cretaceous) of Lo Hueco (Cuenca, Spain). Allodaposuchidae is a clade of European basal eusuchians, which is considered a part of the stem group of Crocodylia. The holotype and paratype skulls of *A. fontisensis* were scanned on computed tomography and their internal cavities, including those of the brain, nerves and blood vessels, as well as the paratympanic sinus system and the paranasal sinuses, digitally reconstructed. The cranial endocast and pneumatic sinuses were then compared with those of other crocodyliforms. The neuroanatomy of *A. fontisensis* resembles those of other mesoeucrocodylians, sharing some morphological traits with extant crocodiles. The neurosensorial and cognitive capabilities inferred from the inner skull cavity reconstructions of *A. fontisensis* are similar to those of other eusuchians. The olfactory acuity of *A. fontisensis* is low by crocodylian standards, closer to that of the alligatoroids rather than to that of the crocodyloids. Its visual acuity is similar to that of *Lohuecosuchus megadontos*, a sympatric allodaposuchid also found in the fossil site of Lo Hueco.

Sleboda, D.A., Stover, K.K. and Roberts, T.J. (2020). Diversity of extracellular matrix morphology in vertebrate skeletal muscle. *Journal of Morphology* 281(2): 160-169.

**Abstract:** Existing data suggest the extracellular matrix (ECM) of vertebrate skeletal muscle consists of several morphologically distinct layers: an endomysium, perimysium, and epimysium surrounding muscle fibers, fascicles, and whole muscles, respectively. These ECM layers are hypothesized to serve important functional roles within muscle, influencing passive mechanics, providing avenues for force transmission, and influencing dynamic shape changes during contraction. The morphology of the skeletal muscle ECM is well described in mammals and birds; however, ECM morphology in other vertebrate groups including amphibians, fish, and reptiles remains largely unexamined. It remains unclear whether a multilayered ECM is a common feature of vertebrate skeletal muscle, and whether functional roles attributed to the ECM should be considered in mechanical analyses of non-mammalian and non-avian muscle. To explore the prevalence of a multilayered ECM, we used a cell maceration and scanning electron microscopy technique to visualize the organization of ECM collagen in muscle from six vertebrates: bullfrogs (*Lithobates catesbeianus*), turkeys (*Meleagris gallopavo*), alligators (*Alligator mississippiensis*), cane toads (*Rhinella marina*), laboratory mice (*Mus musculus*) and carp (*Cyprinus carpio*). All muscles studied contained a collagen-reinforced ECM with multiple morphologically distinct layers. An endomysium surrounding muscle fibers was apparent in all samples. A perimysium surrounding groups of muscle fibers was apparent in all but carp epaxial muscle; a muscle anatomically, functionally, and phylogenetically distinct from the others studied. An epimysium was apparent in all samples taken at the muscle periphery. These findings show that a multilayered ECM is a common feature of vertebrate muscle and suggest that a functionally relevant ECM should be considered in mechanical models of vertebrate muscle generally. It remains unclear whether cross-species variations in ECM architecture are the result of phylogenetic, anatomical, or

functional differences, but understanding the influence of such variation on muscle mechanics may prove a fruitful area for future research.

Surf, A., Nordengren, K., Tumilson, C.R. and Irwin, K. (2019) Observations of an alligator (*Alligator mississippiensis*) nest and behavior of hatchlings in Clark County, with anecdotal observations of other alligator nests in Arkansas. *Journal of the Arkansas Academy of Science* 73: 123-128.

Billings, B.K., Behroozi, M., Helluy, X., Bhagwandin, A., Manger, P.R., Güntürkün, O. and Ströckens, F. (2020). A three-dimensional digital atlas of the Nile crocodile (*Crocodylus niloticus*) forebrain. *Brain Structure and Function* (<https://doi.org/10.1007/s00429-020-02028-3>).

**Abstract:** The phylogenetic position of crocodilians in relation to birds and mammals makes them an interesting animal model for investigating the evolution of the nervous system in amniote vertebrates. A few neuroanatomical atlases are available for reptiles, but with a growing interest in these animals within the comparative neurosciences, a need for these anatomical reference templates is becoming apparent. With the advent of MRI being used more frequently in comparative neuroscience, the aim of this study was to create a three-dimensional MRI-based atlas of the Nile crocodile (*Crocodylus niloticus*) brain to provide a common reference template for the interpretation of the crocodilian, and more broadly reptilian, brain. *Ex vivo* MRI acquisitions in combination with histological data were used to delineate crocodilian brain areas at telencephalic, diencephalic, mesencephalic, and rhombencephalic levels. A total of 50 anatomical structures were successfully identified and outlined to create a 3-D model of the Nile crocodile brain. The majority of structures were more readily discerned within the forebrain of the crocodile with the methods used to produce this atlas. The anatomy outlined herein corresponds with both classical and recent crocodilian anatomical analyses, barring a few areas of contention predominantly related to a lack of functional data and conflicting nomenclature.

Barnas, A., Chabot, D., Hodgson, A., Johnston, D.W., Bird, D.M., and Ellis-Felege, S.N. (2019). A standardized protocol for reporting methods when using drones for wildlife research. *Journal of Unmanned Vehicle Systems* (<https://doi.org/10.1139/juvs-2019-0011>).

**Abstract:** Drones are increasingly popular tools for wildlife research, but it is important that the use of these tools does not overshadow reporting of methodological details required for evaluation of study designs. The diversity in drone platforms, sensors, and applications necessitates the reporting of specific details for replication, but there is little guidance available on how to detail drone use in peer-reviewed articles. Here, we present a standardized protocol to assist researchers in reporting of their drone use in wildlife research. The protocol is delivered in six sections: 1) Project Overview, 2) Drone System and Operation Details, 3) Payload, Sensor, and Data Collection, 4) Field Operation Details, 5) Data Post-Processing, and 6) Permits, Regulations, Training, and Logistics. Each section outlines the details that should be included, along with justifications for their inclusion. To facilitate ease of use, we have provided two example protocols, retroactively produced for published drone-based studies by the authors of this protocol. Our hopes are that the current version of this protocol should assist with the communication, dissemination, and adoption of drone technology for wildlife research and management.

Wöss, C., Unterberger, S.H., Degenhart, G., Akolkard, A., R.Traxl, R., Kuhn, V., Schirmer, M., Pallua, A.K., Tapperti, R. and Pallua, J.D. (2020). Comparison of structure and composition of a fossil

*Champsosaurus* vertebra with modern Crocodylidae vertebrae: A multi-instrumental approach. Materials 104: (<https://doi.org/10.1016/j.jmbbm.2020.103668>).

**Abstract:** Information on the adaptation of bone structures during evolution is rare since histological data are limited. Micro- and nano-computed tomography of a fossilized vertebra from *Champsosaurus* sp., which has an estimated age of 70-73 million years, revealed lower porosity and higher bone density compared to modern Crocodylidae vertebrae. Mid-infrared reflectance and energy dispersive X-ray mapping excluded a petrification process, and demonstrated a typical carbonate apatite distribution, confirming histology in light- and electron microscopy of the preserved vertebra. As a consequence of this evolutionary process, the two vertebrae of modern Crocodylidae show reduced overall stiffness in the finite element analysis simulation compared to the fossilized *Champsosaurus* sp. vertebra, with predominant stiffness along the longitudinal z-axes.

Habarugira, G., Moran, J., Colmant, A.M.G., Davis, S.S., O'Brien, C.A., Hall-Mendelin, S., McMahon, J., Hewitson, G., Nair, N., Barcelon, J., Suen, W.W., Melville, L., Hobson-Peters, J., Hall, R.A., Isberg, S.R. and Bielefeldt-Ohmann, H. (2020). Mosquito-independent transmission of West Nile virus in farmed Saltwater crocodiles (*Crocodylus porosus*). Viruses 12: 198.

**Abstract:** West Nile virus, Kunjin strain (WNVKUN) is endemic in Northern Australia, but rarely causes clinical disease in humans and horses. Recently, WNVKUN genomic material was detected in cutaneous lesions of farmed saltwater crocodiles (*Crocodylus porosus*), but live virus could not be isolated, begging the question of the pathogenesis of these lesions. Crocodile hatchlings were experimentally infected with either 105 (n= 10) or 104 (n= 11) TCID50-doses of WNVKUN and each group co-housed with six uninfected hatchlings in a mosquito-free facility. Seven hatchlings were mock-infected and housed separately. Each crocodile was rotationally examined and blood-sampled every third day over a 3-week period. Eleven animals, including three crocodiles developing typical skin lesions, were culled and sampled 21 days post-infection (dpi). The remaining hatchlings were blood-sampled fortnightly until experimental endpoint 87 dpi. All hatchlings remained free of overt clinical disease, apart from skin lesions, throughout the experiment. Viremia was detected by qRT-PCR in infected animals during 2-17 dpi and in-contact animals 11-21 dpi, indicating horizontal mosquito-independent transmission. Detection of viral genome in tank-water as well as oral and cloacal swabs, collected on multiple days, suggests that shedding into pen-water and subsequent mucosal infection is the most likely route. All inoculated animals and some in-contact animals developed virus-neutralizing antibodies detectable from 17 dpi. Virus-neutralizing antibody titers continued to increase in exposed animals until the experimental endpoint, suggestive of persisting viral antigen. However, no viral antigen was detected by immunohistochemistry in any tissue sample, including from skin and intestine. While this study confirmed that infection of saltwater crocodiles with WNVKUN was associated with the formation of skin lesions, we were unable to elucidate the pathogenesis of these lesions or the nidus of viral persistence. Our results nevertheless suggest that prevention of WNVKUN infection and induction of skin lesions in farmed crocodiles may require management of both mosquito-borne and water-borne viral transmission in addition to vaccination strategies.

Souron, A., Napias, A., Lavidalie, T., Santos, F., Ledevin, R., Castel, J.C., Costamagno, S., Cusimano, D., Drumheller, S., Parkinson, J., Rozada, L. and Cochard, D. (2019). A new geometric morphometrics-based shape and size analysis discriminating anthropogenic and non-anthropogenic bone surface modifications of an experimental data set. In 2019 IMEKO TC-4 International Conference on Metrology for Archaeology and Cultural Heritage, Florence, Italy, 4-6 December 2019.

**Abstract:** Reliable discrimination of anthropogenic and non-anthropogenic bone surface modifications (BSM) is crucial to reconstructing the taphonomic history of bone assemblages and past behaviors of hominids and other animals. This discrimination is hindered by equifinality, i.e., BSM with similar morphologies that were produced by different agents. Here we propose a new method to identify the taphonomic agents responsible for BSM and apply it to an experimental data set containing 177 BSM produced by anthropogenic (stone tool-induced cut marks) and non-anthropogenic agents (carnivoran and crocodylian bite marks, and trampling marks). We used 3D topographic models of BSM built from confocal microscopy and applied geometric morphometrics-based shape and size analyses to cross-sectional profiles extracted from the BSM. The new method considers both average profiles and intra-mark variability of profiles. Multivariate analyses of several shape and size variables result in a new synthetic morphospace where anthropogenic and non-anthropogenic BSM show very little overlap.

Cadena, E.-A., Scheyer, T.M., Carrillo-Briceño, J.D., Sánchez, R., Aguilera-Socorro, O.A., Vanegas, A., Pardo, M., Hansen, D.M., Sánchez-Villagra, M.R. (2020). The anatomy, paleobiology, and evolutionary relationships of the largest extinct side-necked turtle. Science Advances 6: eaay4593.

**Abstract:** Despite being among the largest turtles that ever lived, the biology and systematics of *Stupendemys geographicus* remain largely unknown because of scant, fragmentary finds. We describe exceptional specimens and new localities of *S. geographicus* from the Miocene of Venezuela and Colombia. We document the largest shell reported for any extant or extinct turtle, with a carapace length of 2.40 m and estimated mass of 1.145 kg, almost 100 times the size of its closest living relative, the Amazon river turtle *Peltecephalus dumerilianus*, and twice that of the largest extant turtle, the marine leatherback *Dermochelys coriacea*. The new specimens greatly increase knowledge of the biology and evolution of this iconic species. Our findings suggest the existence of a single giant turtle species across the northern Neotropics, but with two shell morphotypes, suggestive of sexual dimorphism. Bite marks and punctured bones indicate interactions with large caimans that also inhabited the northern Neotropics.

Mascarenhas-Júnior, P.B., Maranhão dos Santos, E., Barbosa de Moura, G.J., Diniz, G.T.N. and de Sousa Correia, J.M. (2020). Space-time distribution of *Caiman latirostris* (Alligatoridae) in lentic area of Atlantic Forest, northeast of Brazil. Herpetology Notes 13: 129-137.

**Abstract:** This study aimed to estimate the abundance and the spatial-temporal distribution of a population of *Caiman latirostris*, characterizing its age structure and microenvironmental specificity related to abiotic and anthropogenic factors. Between April 2015 and May 2016, we carried out field expeditions at the Tapacurá River dam (8.043856°S; 35.195710°W), Pernambuco district, Brazil, counting animals by the light reflected by their eyeballs. For statistical analyses, chi-square tests were used for the evaluation of microenvironmental specificity, linear regressions for environmental variables and Student t-test for relations with the anthropogenic influence and the presence of marginal Atlantic Forest vegetation, at a confidence level of  $p < 0.05$ . A total of 996 individuals (0.78 ind/km) were recorded, 326 juveniles, 207 sub-adults and 164 adults. From all sighted animals, 299 could not be identified because they submerged before the observer approached. Among the animals identified by age group, 458 were sighted in margin areas and 239 in central areas of the reservoir. From the total of animals sighted, 702 were associated with floating aquatic vegetation. Juveniles preferred marginal areas, adults were at the central regions of the reservoir, and sub-adults had no microenvironmental preference. Reservoir volume, water temperature and precipitation were the environmental variables with the greatest explanatory power for the variation in



the number of sightings (61.5%, 46.1% and 24.5%, respectively). The animals sighted preferred open areas without native marginal Atlantic Forest vegetation ( $p=0.0098$ ) associated with an intensified human activity, near houses, fishing nets and caiman traps ( $p=0.0258$ ).

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Raudhatin, R., Abdullah, A., Rahmatan, H., Safrida, S. and Syafrianti, D. (2020). Public actions toward the Saltwater crocodile conflict (*Crocodylus porosus*) with the human In Kilangan Village Aceh Singkil District. JIMPBio 5(1).

**Abstract:** This study aims to determine the differences in the actions of people who have been exposed to conflicts with communities that have never been exposed to the conflict between the Crocodile and Crocodile shaft with humans. The study was conducted in August 2019. This type of research is a descriptive study with a quantitative approach. Data collection by questionnaire and interview. Data analysis with Chi-squared. Respondents in this study are people who have been exposed to conflicts and who have never been exposed to estuarine crocodile conflicts with humans. The results of this study indicate that there are differences in community actions that have experienced conflicts with those who have never experienced estuarine crocodile conflicts with humans and there are no differences in community actions that have been affected by human-crocodile conflicts in Aceh Singkil Regency in terms of education, sex and ethnicity. The conclusions are (1) There are differences in the actions of the people who have been affected by conflict with those who have never been affected by a crocodile-human conflict in Aceh Singkil District (2) There is no difference in the actions of the people who have been affected by a human-crocodile conflict in Aceh Singkil Regency based on the type of education, gender and ethnicity.

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Saputro, M.B., Rifanjani, S. and Siahaan, S. (2020). Studi habitat buaya senyulong (*Tomistoma schlegelii*) di Sungai Sekonyer Taman Nasional Tanjung Puting Kalimantan Tengah. Jurnal Hutan Lestari 8(1): 145-155.

**Abstract:** Senyulong (*Tomistoma schlegelii*) are crocodiles that have a unique morphology with shape of the snout in its mouth. This species based on IUCN Red List classified by endangered category (IUCN 2004). This study aim to determine characteristics of Senyulong Habitat in Sekonyer River, Tanjung Puting National Park, Central Kalimantan using by Purposive Sampling in discovery spot or ex crocodile nest, Parameter analyzed by important value index (INP), dominance index (C), index species diversity (H), species abundance index (e), and species similarity index. The results showed the abiotic water habitats in the river water pH 6 which indicated normal, an average of depth 4.5 meters and a water temperature 23.90°C. Biotically False Gharial likes the habitat of aquatic plants such as Rasau (*Pandanus tectorious*), water lily (*Hanguana malayana*) for sheltering. False gharial aquatic food habitats such as Toman fish (*Channa gachua*), Gabus (*Channa striata*) and Runtuk (*Channa luchi*) Baung (*Mystus wyckii*), Lais (*Lais hexamena*). Abiotically terrestrial habitats contain sandy clay texture and histosol soil types with 6 soil acidity, with 78% air humidity and the average temperature of 29°C. Biologically, Senyulong terrestrial habitat formed by buffer zone with large tree with wide canopy and several types of terrestrial animals Senyulong food such as long-tailed monkeys, orangutans, and wild pigs. The terrestrial habitat of False Gharial is an important place to spawning ground by placing its eggs under a large buttress tree and covering the nest with leaf litter to keep it warm to camouflage egg predators such as to monitor lizards.

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Fago, A., Natarajan, C., Pettinati, M., Hoffmann, F.G., Wang, T., Weber, R.E., Drusin, S.I., Issoglio, F.M., Marti, M.A., Estrin, D.A. and Storz, J.F. (2020). Structure and function of crocodilian hemoglobins and allosteric regulation by chloride, ATP and

CO<sub>2</sub>. American Journal of Physiology (<https://doi.org/10.1152/ajpregu.00342.2019>).

**Abstract:** Hemoglobins (Hbs) of crocodilians are reportedly characterized by unique mechanisms of allosteric regulatory control, but there are conflicting reports regarding the importance of different effectors such as chloride ions, organic phosphates, and CO<sub>2</sub>. Progress in understanding the unusual properties of crocodilian Hbs has also been hindered by a dearth of structural information. Here we present the first comparative analysis of blood properties and Hb structure and function in a phylogenetically diverse set of crocodilian species. We examine mechanisms of allosteric regulation in the Hbs of 13 crocodilian species belonging to the families Crocodylidae and Alligatoridae. We also report new amino acid sequences for the  $\alpha$ - and  $\beta$ -globins of these taxa which, in combination with structural analyses, provide insights into molecular mechanisms of allosteric regulation. All crocodilian Hbs exhibited a remarkably strong sensitivity to CO<sub>2</sub>, which would permit effective O<sub>2</sub> unloading to tissues in response to an increase in metabolism during intense activity and diving. Although the Hbs of all crocodilians exhibit similar intrinsic O<sub>2</sub>-affinities, there is considerable variation in sensitivity to Cl<sup>-</sup> ions and ATP, which appears to be at least partly attributable to variation in the extent of N-terminal acetylation. Whereas chloride appears to be a potent allosteric effector of all crocodile Hbs, ATP has a strong, chloride-independent effect on Hb-O<sub>2</sub> affinity only in caimans. Modeling suggests that allosteric ATP-binding has a somewhat different structural basis in crocodilian and mammalian Hbs.

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Hale, A., Merchant, M. and White, M. (2020). Detection and analysis of autophagy in the American alligator (*Alligator mississippiensis*). JEZ-B (<https://publons.com/publon/10.1002/jez.b.22936>).

**Abstract:** In response to environmental temperature depression in the fall and winter, American alligators (*Alligator mississippiensis*) brumate. Brumation is characterized by lethargy, fasting, decreased metabolism, and decreased body temperature. During brumation, alligators will periodically emerge for basking or other encounters when environmental conditions permit. This sporadic activity and lack of nutrient intake may place strain on nutrient reserves. Nutrient scarcity, at the cellular and/or organismal level, promotes autophagy, a well-conserved subcellular catabolic process used to maintain energy homeostasis during periods of metabolic or hypoxic stress. An analysis of the putative alligator autophagy-related proteins has been conducted, and the results will be used to investigate the physiological role of autophagy during the brumation period. Using published genomic data, we have determined that autophagy is highly conserved, and alligator amino acid sequences exhibit a high percentage of identity with human homologs. Transcriptome analysis conducted using liver tissue derived from alligators confirmed the expression of one or more isoforms of each of the 34 autophagy initiation and elongation genes assayed. Five autophagy-related proteins (ATG5, ATG9A, BECN1, ATG16L1, and MAP1-LC3B), with functions spanning the major stages of autophagy, have been detected in alligator liver tissue by western blot analysis. In addition, ATG5 was detected in alligator liver tissue by immunohistochemistry. This is the first characterization of autophagy in crocodylians, and the first description of autophagy-related protein expression in whole blood.

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Drumheller, S.K., Nestler, J.H., Hackett Farris, C.E., Farris, S.C. and Mazzotti, F.J. (2020). *Crocodylus acutus* (American crocodile) bite marks on a nest data logger. PeerJ 8:e8577.

**Abstract:** Several data loggers deployed to monitor temperature and humidity of *Crocodylus acutus* (American crocodile) nests in South Florida could not be located after hatching. One badly damaged data logger was retrieved, providing insight into the possible fate of the others. Using a taphonomic approach, we identified numerous indentations, consistent with crocodylian bite marks, and

inconsistent with potential mammalian or squamate bites. It seems most likely that the data logger was damaged by the nesting *C. acutus* rather than during attempted nest predation. Estimated bite forces for reproductive age, female *C. acutus* exceed the predicted material properties of the data logger's housing, suggesting that the bites were exploratory in nature. We suggest that data loggers be removed prior to hatching or permit remote data storage.

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Berruyer, C., Porcier, S.M. and Tafforeau, P. (2020). Synchrotron "virtual archaeozoology" reveals how Ancient Egyptians prepared a decaying crocodile cadaver for mummification. PLoS ONE 15(2): e0229140.

**Abstract:** Although Ancient Egyptians mummified millions of animals over the course of one millennium, many details of these mummification protocols remain unknown. Multi-scale propagation phase-contrast X-ray synchrotron microtomography was used to visualise an ancient Egyptian crocodile mummy housed at the Musée des Confluences (Lyon, France). This state-of-the-art non-destructive imaging technique revealed the complete interior anatomy of the mummy in three dimensions. Here, we present detailed insight into the complex post-mortem treatment of a decaying crocodile cadaver in preparation for mummification. Except for the head and the extremities of the limbs, everything beneath the skin of the crocodile (ie organs, muscles, and even most of the skeleton) was removed to cease further putrefaction. This unexpected finding demonstrates that earlier knowledge obtained from textual and other archaeological sources does not sufficiently reflect the diversity of mummification protocols implemented by Ancient Egyptians.

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Gorza, L.L., Nóbrega, Y.C., Santos, R.V., Flecher, M.C., Sena, F.P., Neves, D.N.S., Souza, L.M., Paz, J.S., Souza, T.D. and Santos, M.R.D. (2020). Combined metabolic bone diseases, medullary aplasia and bacterial pneumonia in broad-snouted caiman (*Caiman latirostris*).

**Abstract:** Seven juvenile Broad-snouted caiman (*Caiman latirostris*), bred in captivity and subjected to a diet deficient in minerals and vitamins during the first months of life, developed intense cachexia and generalized loss of bone stiffness. In a histopathological evaluation, the proliferation of stellate elongated cells with scarce and eosinophilic cytoplasm in the middle of a loose fibrillar and eosinophilic extracellular matrix was observed, especially in the long bones, which was compatible with fibrous osteodystrophy. Diffuse disorganization of the chondrocyte columns of the endochondral ossification zones with a light multifocal presence of dilated blood capillaries characterized rickets. The bone marrow of the animals revealed intense replacement of active myeloid tissue with adipose tissue and rare promyelocytes, which were compatible with marrow aplasia. Additionally, caseous lesions were evident in the lungs of three animals and the histopathological findings and microbiological analysis were compatible with a bacterial pneumonia. The present work gives a detailed anatomopathological description of the case.

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Strickland, B.A., Gastrich, K., Mazzotti, F.J., Massie, J.A., Paz, V., Viadero, N., Rehage, J.S. and Heithaus, M.R. (2020). Variation in movement behavior of alligators after a major hurricane. Animal Biotelemetry 8: 7.

**Abstract:** Hurricanes can have catastrophic effects on coastal ecosystems. To minimize negative impacts of storms, animals may seek shelter in place, move to a nearby refuge, or evacuate long-distances. Crocodilians can be important predators in estuarine habitats, but little is known about how they respond to extreme weather events. We investigated the movement behaviors of eight acoustically tracked American alligators (*Alligator mississippiensis*) before, during, and after Hurricane Irma in 2017 within the Shark River Estuary of Everglades National Park, USA. Using tracking data, we compared their movements and habitat use before and after

the hurricane to similar timeframes in other years without major storms. We observed considerable variation in movement tactics and responses to the hurricane. Of eight animals that we tracked, two showed no changes in movement or habitat use throughout the study. Two animals ceased upstream excursions that they were regularly making before the hurricane with one of these animals reducing the distance ranged across the river system. Another animal moved upstream from the lower river to the mid-estuary immediately after the hurricane despite having not done this in the 60 days prior. Two other animals moved from the marsh and mangrove forest habitats to river channels several days after the hurricane. One animal shifted to commuting downstream from its upstream habitat shortly before the storm and continued this behavior for the rest of the 2017 and 2018 wet seasons. We found considerable variability in behavioral responses to the hurricane, ranging from no discernable changes in movements to one animal exhibiting a complete shift in movement tactics not observed by any animal in the long-term tracking of this population. Our research provides insight into alligator movement behavior and ecology in the context of a major hurricane disturbance.

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Lee, H.W., Esteve-Altava, B. and Abzhanov, A. (2020). Phylogenetic and ontogenetic changes of the anatomical organization and modularity in the skull of archosaurs. bioRxiv (doi: <https://doi.org/10.1101/2020.02.21.960435>).

**Abstract:** Comparative anatomy studies of the skull of archosaurs provide insights on the mechanisms of evolution for the morphologically and functionally diverse species of crocodiles and birds. One of the key attributes of skull evolution is the anatomical changes associated with the physical arrangement of cranial bones. Here, we compare the changes in anatomical organization and modularity of the skull of extinct and extant archosaurs using an Anatomical Network Analysis approach. We show that the number of bones, their topological arrangement, and modular organization can discriminate between birds, non-avian dinosaurs, and crurotarsans, and between extant and extinct species. By comparing within the same framework juveniles and adults for crown birds and alligator (*Alligator mississippiensis*), we find that adult and juvenile alligator skulls are topologically similar, whereas juvenile bird skulls have a morphological complexity and anisomerism more similar to that of non-avian dinosaurs and crurotarsans than to their adult forms. Clade-specific ontogenetic differences in skull organization, such as extensive postnatal fusion of cranial bones in crown birds, can explain this pattern. The fact that juvenile and adult skulls in birds do share a similar anatomical integration suggests the presence of specific constraint in their ontogenetic growth.

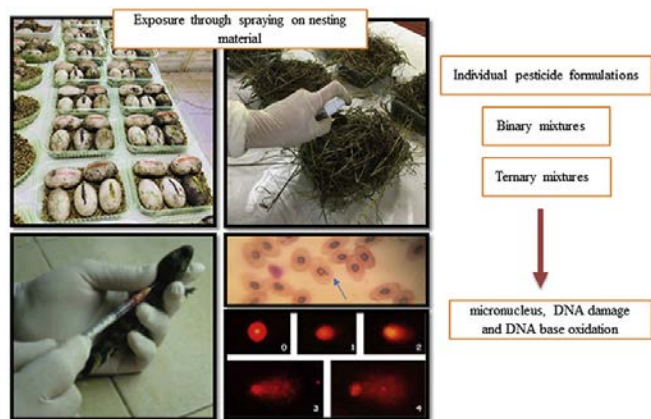
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Odetti, L.M., López González, E.C., Romito, M.L., Simoniello, M.F. and Poletta, G.L. (2020). Genotoxicity and oxidative stress in *Caiman latirostris* hatchlings exposed to pesticide formulations and their mixtures during incubation period. Exotoxicology and Environmental Safety (<https://doi.org/10.1016/j.ecoenv.2020.110312>).

**Abstract:** Agricultural expansion and the consequent use of pesticides lead to the loss and fragmentation of natural habitats of several wild species. Then, many species are inevitably exposed to a wide amount of pesticide formulations. Glyphosate (GLY)-based formulations are the most used herbicide, whereas two of the most employed insecticides are chlorpyrifos (CPF) and cypermethrin (CYP). The aim of this study was to evaluate genotoxicity, oxidative damage, and the modulation of antioxidants defenses in peripheral blood of *Caiman latirostris* after embryonic exposure to pesticide formulations and their mixtures. Pesticides concentrations employed were equivalent to those recommended in agricultural practices for application in soybean crops and a half of them: GLY: 2% and 1%; CYP: 0.12% and 0.06%; CPF: 0.8% and 0.4%. Two similar experiments (E1 and E2) were carried out in consecutive years, where *C. latirostris* eggs were exposed to pesticide formulations separately and in different mixtures through application on the incubation



material. After hatching, blood samples were taken and genotoxicity and oxidative stress was evaluated through the micronucleus (MN) test, the modified comet assay, the lipid peroxidation (LPO) levels and the activities of catalase (CAT) and superoxide dismutase (SOD) antioxidant enzymes. The results indicated the presence of DNA damage, oxidation of purines and pyrimidines, and increased frequency of micronucleus (FMN) in the case of GLY, CYP, and CPF formulations exposure, as well as in all the mixtures tested, with respect to the control groups. Specifically, the results observed for the mixtures would indicate independent action or antagonism of the components for DNA damage and base oxidation (purines and pyrimidines) and a possible potentiation interaction for the FMN in two binary mixtures. However, there were not differences regarding lipid peroxidation, the activity of antioxidant enzymes and growth parameters. This study proved that the use of pesticide formulations at concentrations used in the field generate deleterious genetic effects on this species, then, exposure to them could threaten its survival and health status.



Cao, R., Somaweera, R., Brittain, K., FitzSimmons, N.N., Georges, A. and Gongora, J. (2020). Genetic structure and diversity of Australian freshwater crocodiles (*Crocodylus johnstoni*) from the Kimberley, Western Australia. Conservation Genetics (<https://doi.org/10.1007/s10592-020-01259-5>).

**Abstract:** The Australian freshwater crocodile (*Crocodylus johnstoni*) is endemic to the northern mainland tropics of Australia and is widespread across the Kimberley region in the northwest Australia. Currently, there is limited understanding of the genetic structure and diversity of these populations, which impacts on our ability to evaluate the conservation status of the species. Population genetic analyses of 173 freshwater crocodiles from the Ord River, Fitzroy River, and Lennard River basins were conducted using single-nucleotide polymorphisms (SNPs). After filtering, 1185 SNPs were retained for downstream population genetic analysis. STRUCTURE and principal component analyses identified three clusters consistent with the three river basins. Population differentiation gave an FST of 0.15 between western and eastern Kimberley and the pairwise FST range was 0.06–0.18 among the three river basins. Assignment tests identified three migration events between the adjacent Fitzroy River and Lennard River basins, which may be explained by possible overland movement across these river basins. The population structure found here indicates that delimitation of management units should be based on river basins with the proximity of adjacent river basins taken into consideration when gene flow exists. Estimates of effective population size showing a low ratio of effective population size to census size in Lake Argyle may raise the concern of future monitoring in this area. Further population genetic studies across the species' full range are required to better understand the extent of river basins acting as discrete population units, gene flow, population dynamics, and demographic history.

Brien, M., Booth, S., Beri, P., Coulson, S., Frisby, T., Perera, D.

and Joyce, M. (2020). A novel method of using a drone to capture Saltwater crocodiles (*Crocodylus porosus*). Herpetological Review 51(1).

Ouedraogo, I., Oueda, A., Kangoye, N.M., Thiam, M., Kabore, J. and Kabre, G.B. (2020). Traditional beliefs and conservation of *Crocodylus suchus* (Étienne Geoffroy Saint-Hilaire 1807) in the sacred ponds of Bazoule and Sabou (Burkina Faso). European Scientific Journal 16(6): 188-205.

**Abstract:** From January 2016 to May 2017, *C. suchus* from two sacred ponds in the villages of Bazoule and Sabou were monitored. The objective of this study was to highlight the local perceptions and beliefs of the populations, then capitalize on endogenous conservation measures. The local attitudes, beliefs and perceptions of the population about the crocodile were studied using an ethno-zoological approach based on interviews using a questionnaire. Diurnal and nocturnal inventories have been conducted to determine the crocodile population structure. The results of this study suggest that traditional beliefs play a very important role in the protection and conservation of *C. suchus* in Bazoule and Sabou villages. A total of 268 crocodile individuals have been counted in Bazoule: 25% of hatchlings; 17% of juveniles; 12% of subadults and 10% of adults. In Sabou out of a total of 249 individuals counted, 22% are hatchlings; 12% juveniles; 12% of sub-adults and 14% of adults. Despite traditional perceptions and beliefs that provide some protection for crocodiles in these ponds, pressures from anthropogenic activities could influence their abundance.

Runa, S. (2019). Chromosome preparation of peripheral blood cells of Chinese alligator and chromosomal location of polymorphic microsatellite loci. MSc thesis, Zhejiang University, Hangzhou, China.

**Abstract:** Alligator *sinensis* is an endemic freshwater crocodile in China, and is listed as a critically endangered species by IUCN. With the efforts of scientific research and staff, the number of alligators in the reserve has been increasing. Relatively few studies have focused on the structure and function of chromosomes and the location of molecular markers. The morphological structure of chromosomes carries the unique information of species and is an essential part of cell biology research. Molecular markers have also been applied to many biological fields with their unique advantages. The research contents are mainly divided into two parts: First, the peripheral blood cells of Chinese alligator were used to prepare metaphase chromosome specimens. Making animal chromosome specimens is the most basic technique of cytogenetics, and it is a prerequisite for experiments such as studying chromosomes and performing gene mapping. There are four main methods based on materials. Among them, peripheral blood preparation is convenient, the damage to the research object is small, and the division is more. Therefore, this study is the first time to use the peripheral blood cells of Chinese alligator to prepare chromosome specimens. Scientific experiments related to chromosomes provide a practical method. 2. Locate the alligator microsatellite locus on the chromosome. Microsatellites are a class of genetic markers with a high degree of polymorphism. Locating them is helpful for the selection of a set of alligator microsatellites with no obvious linkage and uniform distribution, which is helpful to make up for the deviation of the conventional molecular genetic map. In this study, *A. sinensis* in the Yinjiabian alligator sanctuary in Changxing, Zhejiang Province, was used as the object. The peripheral blood cells were used to prepare metaphase chromosome slides. On this basis, Giemsa staining was performed on the chromosome by trypsin treatment, and the chromosome of *A. sinensis* was measured and analyzed using ImageJ software, and the slides with good split phase were selected. Dots are located on the chromosomes of Chinese alligators. The main results are as follows: (1) Chromosome slides were prepared from *A. sinensis* peripheral blood cells, and 200 well-dispersed and complete chromosomal alligator metaphase chromosomes were obtained. (2) The arm

ratio and relative length data of five pairs of Chinese alligator macrochromosomes were obtained. Analysis showed that they belonged to the centromere chromosome. (3) Using fluorescence *in situ* hybridization, the Chinese alligator microsatellite locus CXA-138 was mapped to a pair of homologous chromosomes. In this study, peripheral blood cells were used to prepare metaphase chromosomal specimens, and the fluorescence *in situ* hybridization method was used to successfully locate the Chinese alligator microsatellite loci on the chromosome.

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Hamilton, D.W. (2020). Waste Management for Alligator Farming and Ranching. Oklahoma Cooperative Extension Fact Sheet BAE-1771. Oklahoma Cooperative Extension Service: Oklahoma, USA.

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Simá-Pantí, D.E., Contreras-Moreno, F.M., Coutiño-Cal y Mayor, C., Zúñiga-Morales, J.A., Méndez-Saint Martin, G. and Reyna-Hurtado, R.A. (2020). Morelet's crocodile predation by jaguar in the Calakmul Biosphere Reserve in southeastern México. *Therya Notes* 1(1): 8-10.

**Abstract:** *Panthera onca* is the largest feline in America. Its diet has been studied in several countries, and reptiles have been identified as part of it. Despite being one of the most studied felines in Mexico, the depredation of *P. onca* towards crocodiles had not been documented with photographic evidence until now. This note documents for the first time with a photograph, a *Crocodylus moreletii* depredated by a *P. onca*, in southeastern Mexico.

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Cissell, J.R. and Steinberg, M.K. (2020). Human landscape modification in Placencia, Stann Creek District, Belize: Possible implications for crocodile hybridization. *Journal of Latin American Geography* (<https://muse.jhu.edu/article/751161/summary>).

**Abstract:** Habitat destruction and degradation represent the most significant contemporary threats to populations of American crocodiles (*Crocodylus acutus*) and Morelet's crocodiles (*Crocodylus moreletii*) throughout their respective ranges. In addition to destroying nesting sites, escalating inter- and intra-specific competition, and increasing instances of human-crocodile conflict, it has been suggested that habitat decline may also be contributing to recent hybridization that could threaten each species' genetic integrity. In this paper, we use the Placencia Peninsula in southern Belize as a case study, synthesizing remote-sensing based quantification of historical land use / land cover (LULC) change in the study area with insights from literature to demonstrate the potential role of LULC change as a driver of crocodile hybridization in the area. Using visual interpretation and supervised classification of satellite imagery, we found that, between 1976 and 2017, built-up land, agriculture, and aquaculture expanded dramatically in the study area at the expense of mangrove and littoral forests, evergreen broadleaf forests, and savanna. The widespread conversion of traditional crocodile habitat to anthropogenic land uses likely increased the concentration of suitable American and Morelet's crocodile habitat within a diminished sympatric zone, making Placencia's increasingly human-modified landscape more conducive to crocodile hybridization in 2017 than it was four decades prior. With similar landscape conversions taking place throughout the crocodiles' overlapping zones in North and Central America, hybridization may soon represent an increasingly substantial threat to both species' conservation statuses.

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Somaweera, R., Nifong, J., Rosenblatt, A., Brien, M.L., Combrink, X., Elsey, R.M., Grigg, G., Magnusson, W.E., Mazzotti, F.J., Percy, A., Platt, S.G., Shirley, M.H., Tellez, M., Van der Ploeg, J., Webb, G., Whitaker, R. and Webber, B.L. (2020). The ecological importance of crocodylians: Towards evidence-based justification for their conservation. *Biological Reviews* (<https://doi.org/10.1111/brv.12594>).

**Abstract:** Large-bodied predators are well represented among the world's threatened and endangered species. A significant body of literature shows that in terrestrial and marine ecosystems large predators can play important roles in ecosystem structure and functioning. By contrast, the ecological roles and importance of large predators within freshwater ecosystems are poorly understood, constraining the design and implementation of optimal conservation strategies for freshwater ecosystems. Conservationists and environmentalists frequently promulgate ecological roles that crocodylians are assumed to fulfil, but often with limited evidence supporting those claims. Here, we review the available information on the ecological importance of crocodylians, a widely distributed group of predominantly freshwater-dwelling, large-bodied predators. We synthesise information regarding the role of crocodylians under five criteria within the context of modern ecological concepts: as indicators of ecological health, as ecosystem engineers, apex predators, keystone species, and as contributors to nutrient and energy translocation across ecosystems. Some crocodylians play a role as indicators of ecosystem health, but this is largely untested across the order Crocodylia. By contrast, the role of crocodylian activities in ecosystem engineering is largely anecdotal, and information supporting their assumed role as apex predators is currently limited to only a few species. Whether crocodylians contribute significantly to nutrient and energy translocation through cross-ecosystem movements is unknown. We conclude that most claims regarding the importance of crocodylians as apex predators, keystone species, ecosystem engineers, and as contributors to nutrient and energy translocation across ecosystems are mostly unsubstantiated speculation, drawn from anecdotal observations made during research carried out primarily for other purposes. There is a paucity of biological research targeted directly at: understanding population dynamics; trophic interactions within their ecological communities; and quantifying the short- and long-term ecological impacts of crocodylian population declines, extirpations, and recoveries. Conservation practices ideally need evidence-based planning, decision making and justification. Addressing the knowledge gaps identified here will be important for achieving effective conservation of crocodylians.

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Gutiérrez-Ibáñez, C., Dannish, M.R., Kohl, T., Kettler, L., Carr, C.E., Tisdale, R.K., Iwaniuk, A.N., Luksch, H. and Wylie, D.R. (2020). Zebrin expression in the cerebellum of two crocodilian species. *Brain, Behavior and Evolution* (<https://doi.org/10.1159/000505897>).

**Abstract:** While in birds and mammals the cerebellum is a highly convoluted structure that consists of numerous transverse lobules, in most amphibians and reptiles it consists of only a single unfolded sheet. Orthogonal to the lobules, the cerebellum is comprised of sagittal zones that are revealed in the pattern of afferent inputs, the projection patterns of Purkinje cells, and Purkinje cell response properties, among other features. The expression of several molecular markers, such as aldolase C, is also parasagittally organized. Aldolase C, also known as zebrin II (ZII), is a glycolytic enzyme expressed in the cerebellar Purkinje cells of the vertebrate cerebellum. In birds, mammals, and some lizards (*Ctenophores* spp.), ZII is expressed in a heterogenous fashion of alternating sagittal bands of high (ZII+) and low (ZII-) expression Purkinje cells. In contrast, turtles and snakes express ZII homogeneously (ZII+) in their cerebella, but the pattern in crocodilians is unknown. Here, we examined the expression of ZII in two crocodilian species (*Crocodylus niloticus* and *Alligator mississippiensis*) to help determine the evolutionary origin of striped ZII expression in vertebrates. We expected crocodilians to express ZII in a striped (ZII+/ZII-) manner because of their close phylogenetic relationship to birds and their larger and more folded cerebellum compared to that of snakes and turtles. Contrary to our prediction, all Purkinje cells in the crocodilian cerebellum had a generally homogenous expression of ZII (ZII+) rather than clear ZII+/- stripes. Our results suggest that either ZII stripes were lost in three groups (snakes, turtles, and crocodilians) or ZII stripes evolved independently three times (lizards, birds, and mammals).



Moore, B.C., Fitri, W-N. and Augustine, L. (2020). Crocodylian conservation and evolution insights from an anatomical and histological examination of phalli from male false gharial (*Tomistoma schlegelii*). *Anatomia, Histologia, Embryologia* (<https://doi.org/10.1111/ahel.12542>).

**Abstract:** As wild population threats for the endangered false gharial (*Tomistoma schlegelii*) persist, conservation breeding programs, including developing semen collection techniques for subsequent artificial insemination, are becoming important species conservation measures. Developing reproductive biology understanding of a species is important to developing best practices and hopefully maximizing reproductive successes. However, information on crocodylians functional copulatory anatomy in general is lacking. To that end, zoological facilities and conservation centres have the exceptional opportunity to contribute new understandings that may not otherwise be attainable regarding crocodylian reproductive anatomy, particularly during routine physical examinations or post-mortem necropsies. Therefore, to better understand *T. schlegelii* reproductive biology, to contribute knowledge in support of zoo breeding conservation efforts and to contribute to what is known overall about crocodylian reproduction, we investigated phallic anatomy of adult male *Tomistoma* from two zoological populations, the St. Louis Zoo, USA and Sungai Dusun Wildlife Reserve, Peninsular Malaysia. Here, we present the gross anatomical features and histological analysis of underlying tissue-level details in pursuit of a better understanding of copulatory function and associated gamete transfer mechanisms. While much of the overall *Tomistoma* phallic morphology and inferred function corresponds to that of other crocodylian species and speaks to conserved aspects of functional anatomy across taxa, species-specific aspects of glans and glans tip morphology are also identified. These novelties are discussed in a general function and overall broader evolutionary contexts.

Strand, J., Thomsen, H., Jensen, J.B., Marcussen, C., Nicolajsen, T.B., Skriver, M.B., Sogaard, I.M., Ezaz, T., Purup, S., Callesen, H. and Pertoldi, C. (2020). Biobanking in amphibian and reptilian conservation and management: opportunities and challenges. *Conservation Genetic Resources* (<https://doi.org/10.1007/s12686-020-01142-y>).

**Abstract:** Numerous species from the classes Amphibia and Reptilia are facing extinction as a result of habitat loss and increasing anthropogenic impact on the environment; to be more specific, 32% amphibian and 20% reptilian species are either threatened or endangered. The aim of this review is to highlight the status of biobanking as one of the many tools within conservation of amphibians and reptilians. Moreover, we discuss opportunities and challenges as well as provide recommendations for future conservation and management strategies for saving vulnerable species from the two taxa. Previous studies have reported production of viable offspring from cryopreserved amphibian germplasm and in reptiles from cooled spermatozoa. However, further research is needed to improve the efficiency of cryopreserved germplasms for future use in biobanks. More advanced research directions include culture of fibroblast cell lines coupled with appropriate pluripotent stem cells and advanced reproductive technologies as this will represent one further unique and invaluable resource in species conservation and management.

Finger Jr., J.W., Goetz, S.M., Kelley, M.D., Horne, L.M., Piccolomini, S., Elsey, R.M. and Mendonça, M.T. (2020). American alligator (*Alligator mississippiensis*) serum inhibits Pitviper venom metalloproteinases. *Journal of Herpetology* 54(2): 151-154.

**Abstract:** American alligators (*Alligator mississippiensis*) are known to consume venomous Pit Viper snakes, apparently with no ill effects. Alligators handle venomous and nonvenomous snakes similarly during consumption, indicating that alligators may possess a physiological resistance to venom. In our study, we tested the

ability of alligator blood sera to inhibit the activity of two of the primary toxins in Eastern Copperhead (*Agkistrodon contortrix*) venom, hemolytic toxins and snake venom metalloproteinases (SVMP). Specifically, we compared relative venom activity following incubation with alligator sera to a venom-only control as well as venom incubated with serum from a species lacking venom resistance (House mouse; *Mus musculus*). In comparison to controls, alligator sera significantly reduced SVMP activity, although we observed no effect of alligator sera on hemolytic activity. Interestingly, we detected individual variation with respect to hemolytic activity such that inhibition was positively related with both alligator length and body condition. Our results provide evidence that alligator serum is capable of inhibiting at least one of the primary toxins present in pit viper venom

Singh, Y. and Rao, R.J. (2020). Status and conservation of Mugger in protected area and unprotected area in Shivpuri, Madhya Pradesh, India. *Studies in Indian Place Names* 40(50): 2626-2633.

**Abstract:** Crocodile species were greatly depleted worldwide and India is no exception. There are three crocodilians species found in India, fresh water crocodile Mugger (*Crocodylus palustris*), Gharial (*Gavialis gangeticus*), and the Saltwater crocodile (*Crocodylus porosus*). Mugger is a medium-sized crocodile that mostly inhabits freshwater lakes, ponds, sluggish rivers, swamps and marshes. Under Indian Crocodile Project, launched during 1975, about 24 Crocodiles Sanctuaries have been established where crocodile reintroduction programmed have been taken up. Due to conservation management populations of crocodiles especially mugger has been increased in different states of India. The crocodiles are also living in unprotected water bodies, sometimes near urban areas which lead to conflicts between humans and crocodiles. This study is generated a very useful data on conservation requirements of crocodiles in urban areas both in protected and unprotected areas.

Keul, A. (2018). Consuming the king of the swamp: materiality and morality in South Louisiana alligator tourism. Pp. 179-192 in *Tourism Experiences and Animal Consumption: Contested Values, Morality and Ethics*, edited by C. Kline. Routledge: London.

Qunhua, H. (2019). Molecular Mechanism of Alligator Reproductive Ecology and Spouse Selection Strategy. PhD thesis, Zhejiang University, Hangzhou, China.

**Abstract:** *Alligator sinensis* is an endangered and rare reptile endemic to China. According to historical records, the Chinese alligator has been widely distributed in the middle and lower reaches of the Yangtze River. Due to environmental damage, habitat loss and human hunting, the Chinese alligator population has declined rapidly and is endangered. However, after nearly forty years of efforts, the population restoration work of alligator sinensis has achieved remarkable results and the population has increased significantly. Therefore, strengthening the research on the alligator's reproduction, ecology and behavior mechanism is necessary for the scientific management and sustainable development of Chinese alligator populations. In order to cope with the changes in the external complex environment and improve the genetic quality of the population, reptiles usually respond in behavior, which is reflected in nest selection characteristics and mate selection strategies. However, the relationship between the nest environment factors and reproduction of Chinese alligators, and the molecular mechanism of spouse selection are unknown. Based on this, relevant research is carried out on Chinese alligators in the Changxing Alligator Nature Reserve. The main tasks are: (1) observing the behavioral spectrum of Chinese alligators; (2) investigating and counting the environmental parameters, temperature and reproduction index of the nests in the protected area to find the impact The potential factors of Chinese alligator breeding; (3) paternity test and analysis of multiple mating of Chinese alligator;

(4) molecular mechanism of Chinese alligator selection from MHC gene and microsatellite (SSR) perspective. The main research results are as follows: (1) Observing the behavioral activities of Chinese alligators, the behaviors mainly include temperature regulation behavior, reproduction behavior, communication behavior, sports behavior, feeding behavior, conflict behavior, homosexual behavior and other behaviors. (2) The comparison of nest environment factors in different habitats shows that the average closest tree distance in the core area is 0.99 m. The average water source distance was 2.47 m, and 82% of the nest depressions were above 0.8. In the wild area, the average distance between the nest and the nearest tree was 0.69 m, and the average water source distance was 4.59 m. Only 32% of the nests were closed above 0.8. There was no significant difference in hatching success rate between the core area and the wild area ( $P=0.817$ ). The body weight and body length of newborn crocodiles were significantly different in different living environments (birth weight:  $P<0.001$ ; birth body length:  $P=0.005$ ). In addition, the female crocodile body length in the core area was significantly positively related to nest spawning and young crocodile weight ( $P<0.05$ ), and the female crocodile body length in the wild area was significantly positively related to the young crocodile body length ( $P<0.05$ ). There was a significant negative correlation between the nest temperature fluctuations of Chinese alligator and hatching success rate ( $P<0.01$ ); in multiple linear regression analysis, The parameters of the optimal model are canopy closure and closest tree distance, which are closely related to the average nest temperature. (3) Parental identification of breeding offspring from 2015 to 2017. In this study, 13 microsatellite loci were used to perform paternity testing on 31 offspring of known mothers in the core area. As a result, 12 offsprings were successfully identified. Paternity tests were performed on the offspring of the 35 nests of mother and father who were unknown, and the true mothers of 28 and 30 fathers were successfully identified. In addition, there are 69 pedigrees in the core and wild areas, of which 94.2% of the offspring are single fathers, and only 5.8% of the offspring are two fathers. The double-parent phenomenon only appeared in the core area, and the wild-field areas all showed single-parent conditions. (4) Random sampling results show that the heterozygosity rate of the MHC class I gene I1327e3 locus in the breeding male is outside the 95% confidence interval, and is significantly higher than that in the random sampling male ( $P=0.001$ ); meanwhile, the amino acid of the male actual mate pair Distance and amino acid functional distance are outside the randomly sampled spouse pair and significantly higher than the randomly sampled spouse pair (amino acid distance:  $P=0.031$ ; amino acid functional distance:  $P=0.031$ ), which indicates that female Chinese alligators support heterozygous advantage in spouse selection Hypothesis and genetic compatibility hypothesis. At the same time, the number of offspring of heterozygous males is significantly higher than that of homozygous males, which can prove the heterozygote dominance hypothesis. In addition, the kinship coefficient of the actual breeding spouse pair is within the confidence interval of the randomly sampled spouse pair, indicating that the Chinese alligator population does not evade inbreeding in its spouse selection strategy. Conclusion: This study establishes the behavior profile of Chinese alligator for the first time, and reports suspected homosexual behavior. Secondly, the degree of canopy closure, the closest tree distance, and the average nest temperature have a significant effect on the hatching rate; again, the patriarchal identification results show that the Chinese alligator offspring About 95% are single-parents. Finally, the mating of female Chinese alligators supports the heterozygous dominance hypothesis and gene compatibility hypothesis, and Chinese alligators do not avoid inbreeding. The results of this study will be of great significance for the further improvement and management of artificially restored populations. The wild areas are all single fathers. (4) Random sampling results show that the heterozygosity rate of the MHC class I gene I1327e3 locus in the breeding male is outside the 95% confidence interval, and is significantly higher than that in the random sampling male ( $P=0.001$ ); meanwhile, the amino acid of the male actual mate pair Distance and amino acid functional distance are outside the randomly sampled spouse pair and significantly higher than the randomly sampled spouse pair (amino acid distance:  $P=0.031$ ; amino acid functional distance:  $P=0.031$ ),

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Abas, S., Nartey, E.N. and Asmah, A.E. (2020). The myth about crocodiles in Sisala tradition (an inspiration for textile design). *International Journal of Innovative Research and Advanced Studies* 7(3): 19-27.

**Abstract:** This paper seeks to develop motifs and textures for textile design by taking inspiration from the popular myth surrounding the crocodile in the Sisala tradition of the Upper West Region. A myth is a traditional story, especially one concerning the early history of a people, or explaining a natural or social phenomenon, and typically involving supernatural beings or events. In this context the popular concept of the myth and its taboo surrounding the crocodile among the Sisala's, translated in motifs for fabric design was the focus. Nevertheless, textile design is a highly creative branch of art that involves the process of creating designs that are printed on woven, knitted or other types of fabrics. Hence the study, therefore, employed both the description and the narrative research methods and informal interview was organised to validate the facts gathered. Five motifs were developed during the idea development processes, the crocodile was the focused element used to develop the motifs. The study explored the use of mercerized cotton, khaki, reactive dyes and vat dyes to design and produce fashionable fabrics via the



screen printing and batik techniques. Discussions were based on historical, cultural and artistic context. The fabrics produced can be adopted as an educational tool to educate and encourage incoming textile designers from all parts of the country specifically from the upper west region to breath out a new way of activating their artistic skills and talents. More importantly, the paper proved that oral tradition translated into motifs has enormous impact on textile design and Ghanaian traditional textile.

Block, C. (2019). Don't Touch Me Like That: Masculinity, Touch, and the Role Of Affect in Media Representations of Animal Attacks. PhD thesis, The University of Memphis, Tennessee, USA.

**Abstract:** This dissertation analyzes masculinity and touch in three highly publicized cases where men intentionally interacted with wild animals and were harmed in the process. I focus predominately on the first week of media coverage following Steve "The Crocodile Hunter" Irwin who was killed by a massive stingray while filming for a television series off the Great Barrier Reef, Roy Horn of the famed Las Vegas magician duo Siegfried and Roy who was mauled by one of his performing tigers in front of a live audience, and Antoine Yates, an African American man bitten by the pet tiger he kept in his Harlem apartment. Drawing from studies of masculinity, gender performance, and affect, I argue that the manner in which the media represented touch as an indicator of normative masculinity influenced whether the event was portrayed as something tragic, deserved, or criminal. I contend the representation of Irwin as a white, heterosexual man privileged his status and behavior so that the loss of his life was viewed as a world-wide tragedy. Conversely, the representations of Horn and Yates constructed them as masculine failures who deserved their injuries and endangered others. These conflicting emotional elements of sadness, blame, and fear are, as Massumi (2002) argued the effect of affect and, as I argue, an affect related to representations of their masculinity. As such, the men viewed as outside the cultural norm were not only discouraged from participating in and performing manhood acts associated with white, straight men, they were also culpable for any injuries they (or others) incurred while attempting to do so.

Helm, C.W., Cawthra, H.C., Combrink, X., Helm, C.J.Z., Rust, R., Steer, W. and van den Heever, A. (2020). Pleistocene large reptile tracks and probable swim traces on South Africa's Cape south coast. *South African Journal of Science* 116(3-4) (<https://doi.org/10.17159/sajs.2020/6542>).

**Abstract:** The Cape south coast of South Africa contains a wealth of Pleistocene vertebrate trace fossil sites in aeolianites and cemented foreshore deposits. Published studies have described mammal and avian tracksites identified along this coastline. We report here on a number of Pleistocene palaeosurfaces within the Garden Route National Park that exhibit tracks of large reptiles, including probable swim traces. The tracks were probably made by more than one species, and may include a crocodylian. There are no extant reptiles in this coastal region capable of making such tracks and traces, which probably represent an indication of a previously more extensive range for the Nile crocodile and a monitor lizard. These findings demonstrate the potential for ichnology to complement the traditional body fossil record. Two Middle Stone Age stone artifacts were found embedded in one palaeosurface containing multiple reptile trackways. These discoveries have implications for the understanding of Pleistocene palaeoenvironment and palaeoclimate - in an area which is important in the study of modern human origins.

Martín D Ezcurra, M.D., Jones, A.S., Gentil, A.R. and Butler, R.J. (2020). Early Archosauromorphs: The crocodile and dinosaur precursors. *Reference Module in Earth Systems and Environmental Sciences* (<https://doi.org/10.1016/B978-0-12-409548-9.12439-X>).

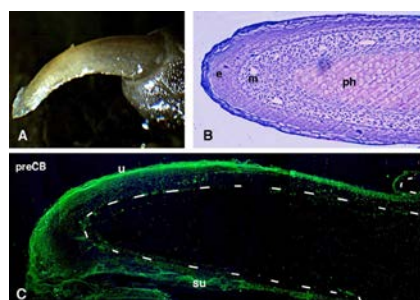
**Abstract:** The archosauromorphs include crocodiles, dinosaurs

(containing birds) and all reptiles more closely related to them than to lepidosaurs (tuataras, snakes, lizards). The oldest archosauromorphs have been collected in middle-upper Permian rocks of Europe and Africa, and the group survived the Permo-Triassic mass extinction (c. 252 million years ago), the deadliest biotic crisis documented in the fossil record. After this mass extinction, archosauromorphs diversified and became the dominant tetrapods of continental ecosystems and dispersed across the entire planet during the Triassic Period. The evolution of archosauromorphs during the Triassic is considered an example of adaptive radiation in geologic time. The non-archosaurian archosauromorphs (a group that excludes modern forms, namely crocodiles and birds, and all descendants from their most recent common ancestor) were eclipsed by the archosaur radiation in the Late Triassic, and no groups survived the Triassic-Jurassic mass extinction (c. 201 million years ago). The last decade has witnessed a renewed interest in the paleobiology of non-archosaurian archosauromorphs, and multiple advances have been made in our knowledge of these fossil reptiles. Here, we provide an updated review of the diversity, distribution, phylogeny, ecology and long-term evolution of the important but underappreciated early archosauromorph groups that flourished before the dominance of dinosaurs.

Baynes-Rock, M. (2020). *Crocodile Undone: The Domestication of Australia's Fauna*. The Pennsylvania State University Press: University Park, PA, USA.

Alibardi, L. (2020). Immunolocalization of corneous beta proteins of the epidermal differentiation complex in the developing claw of the alligator. *Annals of Anatomy - Anatomischer Anzeiger* (<https://doi.org/10.1016/j.aanat.2020.151513>).

**Abstract:** Knowledge on the sharpness, mechanical and hydration resistance of the corneous material of claws requires information on its constituent proteins. The present immunohistochemical study has localized some of the main corneous beta proteins (CBPs, formerly termed beta-keratins) indicated to be present in alligator claws only by genomic data. Using specific antibodies we show the immunolocalization of representative claws CBPs of the Epidermal Differentiation Complex (Beta A1 group) during late stages of claw development in alligator. Intense but asymmetric proliferation, revealed by 5BrdU-immunolabeling, determines the formation of a curved dorsal part (unguis) and a linear ventral part (sub-unguis). The large beta-cells generated in the unguis and their packing into a solid corneous layer occur before thinner beta-cells appear in the sub-unguis. In the latter, CBPs are also immune-detected but with less intensity compared to the unguis, and corneocytes remain separated and desquamate. It is suggested that at the tip of the developing claw beta-corneocytes move downward into the initial part of the sub-unguis. This circular movement contributes to sharpen the claw as these cells fully cornify and are desquamated from the sub-unguis. Corneocytes of the unguis contain 10-16kDa proline-serine-rich proteins that also possess high percentages of glycine, cysteine, tyrosine, valine and leucine. Cysteines likely give rise to numerous -S-S- bonds in the constituent hard horny material, tyrosine contribute to packing proteins into a dense horny material while glycine, valine and leucine increase the hydrophobic property of claws in these water-adapted predators.



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