

# Introduction: Reproduction in Crocodylians

Carlos I. Piña<sup>1,2,3,\*</sup>, Mark E. Merchant<sup>4</sup>, Luciano M. Verdade<sup>5</sup>

<sup>1</sup> Centro de Investigaciones Científicas y Transferencia de Tecnología a la Producción, Consejo Nacional de Investigaciones Científicas y Técnicas. Matteri y España s/n, CP E3105BWA, Diamante, ER, Argentina.

<sup>2</sup> Proyecto Yacaré, Laboratorio de Zoología Aplicada: Anexo Vertebrados (Facultad de Humanidades y Ciencias–Universidad Nacional del Litoral/ Ministerio de Aguas, Servicios Públicos y Medio Ambiente), A. del Valle 8700, CP3000, Santa Fe, Argentina.

<sup>3</sup> Facultad de Ciencias y Tecnología, Universidad Autónoma de Entre Ríos, Diamante, ER, Argentina.

<sup>4</sup> Department of Chemistry, McNeese State University, Box 90455, Lake Charles, LA 70609, USA.

<sup>5</sup> Laboratório de Ecologia Isotópica, Centro de Energia Nuclear na Agricultura, Universidade de São Paulo. Avenida Centenário, 303, Caixa Postal 96, CEP 13400–970, Piracicaba, SP, Brazil.

\* Corresponding author. Email: cidcarlos@infoaire.com.ar

Crocodylians were used for medicinal and religious purposes by the Aztecs and the Mayas in the Americas and the Egyptians in Africa. Romans printed figures of crocodiles on their coins, and images of crocodiles appear in stone on the temples of Angkor Wat in Cambodia. More recent cultures have overhunted crocodiles for their skin. As a result, by the 1970s all crocodylian species had been included in Appendix I of the Convention on International Trade in Endangered Species, with consequent banning of their international trade.

Currently, most populations have recovered and are being exploited under regulated sustainable programs. It is known that populations can be subjected to management if the number of reproductive females is not reduced (Abercrombie and Verdade, 1995), both in ranching programs based on the collection of eggs or hatchlings from wild populations of *Alligator mississippiensis* (Daudin, 1802) in the USA (Elsey et al., 2001; Elsey and Woodward, 2010), *Caiman latirostris* (Daudin, 1802) and *Caiman yacare* (Daudin, 1802) in Argentina (Larriera et al., 2008), *Crocodylus porosus* Schneider, 1801 in Australia (Webb et al., 2010), and *Crocodylus niloticus* Laurenti, 1768 in many African countries (Fergusson, 2010), and hunting programs of *Alligator mississippiensis* in the USA (Elsey and Woodward, 2010), *Caiman crocodylus* (Linnaeus, 1758) in Venezuela (Velasco and Ayarzagüena, 2010), *Caiman yacare* in Bolivia (Campos et al., 2010), and *Crocodylus niloticus* in many African countries (Fergusson, 2010). Farming operations (i.e., closed production cycle) are also carried out with crocodylians in many countries (e.g., Verdade, 2001a). In these three types of management systems (ranching, hunting, and farming) it is necessary to maintain sustainable levels of reproduction.

Since the 1970s, our understanding of reproduction in crocodylians has increased considerably. We now know that both males and females take a relatively long time to reach sexual maturity (Verdade et al., 2003, Larriera et al., 2006; Platt et al., 2008; Lance et al., 2015)—although they have significant sexual dimorphism (Verdade 2001b; Verdade, 2003; Piña et al., 2007a)—females guard nests and hatchlings (Charruau and Hénaut, 2012; Somaweera

et al., 2013), and multiple paternity appears to be common, although reproduction tends to be limited to a few dominant males (Zucoloto et al., 2006, 2009; Amavet et al., 2008; McVay et al., 2008; Lance et al., 2009b; Budd et al., 2015). So far, all extant crocodylian species studied exhibit temperature-dependent sex determination (Piña et al., 2003, 2007b; Deeming, 2004). We have also learned that weather conditions appear to influence the reproductive efforts of females (Simoncini et al., 2011; Lance et al., 2009a), and that a great portion of the reproductive energy is usually lost due to nest predation or hatchling mortality during the first year of life (Larriera and Piña, 2000; Platt et al., 2008; Somaweera et al., 2013; Mazzotti et al., 2014; Parachú-Marcó et al., 2015a).

This issue of the *South American Journal of Herpetology* is dedicated to crocodylian reproduction and is derived from a series of papers presented at the 23<sup>rd</sup> Working Meeting of the Crocodile Specialist Group, held in Lake Charles, Louisiana, USA, in May 2014. These papers include studies on diverse crocodylian species and topics, all of them related to reproduction.

Two studies (Parachú Marcó et al., 2015b; Iungman et al., 2015) are related to stress hormones (or their synthetic homologues) and their possible effects on development and sexual determination. Stress hormones do not appear to affect sexual determination (at least at the studied dosage and time of application), but the synthetic homologues increased the body size of hatchlings. Such results can be relevant in ranching and farming operations.

Two other papers provide novel information on the reproduction of crocodiles on oceanic islands, where they present a high mortality rate of hatchlings (Balaguera Reina et al., 2015). Budd et al. (2015) report that mate fidelity and high relatedness values could be a consequence of the smaller number of adult crocodiles in those populations or an indication of a small local number of dominant males.

Moore and Kelly (2015) describe the histological structure and functionality of the American alligator phallus. This study reveals that the crocodylian penis contains rigid structures in order to facilitate cloacal intromission

and that the sulcus spermaticus (i.e., the open groove that runs along the ventral aspect of the phallic shaft) is a spatially heterogeneous reproductive structure containing a complex architecture of multiple tissue types, and its morphology changes from its proximal origin between the crurae to its distal exit from the phallus tip.

Studies of reproduction in the wild are usually difficult to conduct, but new technologies can now help us understand many aspects of crocodilian reproduction that have been obscure until recently. Portelinha et al. (2015) used radio transmitters to follow reintroduced females and compared their behavior to wild females. These authors also used echographic images and hormone profiles to understand egg development. Their results show that wild and reintroduced females seem to have similar behavior, with 35–50% of females reproducing per year on average and ovulation occurring one or two months before nesting. Lance et al. (2015) describe the onset of sexual maturation of male American alligators, with males presenting a clear cycle of testosterone levels, peaking in breeding season, but varying ontogenetically.

Crocodilians comprise a group of amazing species that have faced profound environmental changes over the course of their long evolutionary history, from the effects of asteroids to the devastating impact of humans. Their reproductive biology has shown an incredibly robust adaptive capacity. Crocodilians are still used as natural resources in many regions of the world, and, thus, understanding their reproductive biology is paramount for maintaining their sustainable use. We hope this thematic issue of the *South American Journal of Herpetology* on crocodilian reproductive biology can help improve our knowledge on such an intriguing subject.

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