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First Report of Female Giant South American River Turtles (*Podocnemis expansa*) Being Buried Alive During Nesting

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ABSTRACT. – *Podocnemis expansa* is the only freshwater turtle species that presents a social nesting behavior in South America, where thousands of females congregate on nesting beaches. We recorded the death of 15 females that were found fully or partially buried by other females at a gregarious nesting site from 2013 to 2017 on 2 beaches of the *Tabuleiro* of Monte Cristo, Pará, Brazil; another 2 buried females were rescued while still alive. This is the first study to quantify and record biometrical information of females' deaths not caused by predation or harvesting in a nesting area.

The Giant South American Amazon River Turtle (*Podocnemis expansa*), locally called *tartaruga-da-Amazônia*, is the largest freshwater turtle in South America and is a unique species in that it displays an elaborate social behavior during nesting activities (Alho and Pádua 1982; Ferrara et al. 2013). Females can migrate over 700 km between feeding and nesting areas in the Amazon basin and may repeatedly return to the same nesting places (Carneiro and Pezzuti 2015). Nesting behavior is composed of several phases, beginning with group formation close to nesting areas. Females spend several days coming out of the water to bask in the sun and increase their body temperature, but they do not nest on these days (Alho and Pádua 1982). Nesting is a social event, with hundreds to thousands of females using the beach at the same time to lay their eggs, an event locally called *arribação*. Gregarious nesting does not occur uniformly along the nesting site, as the females of *P. expansa* usually choose

the higher part of the beaches or sand banks (Ferreira and Castro 2005).

Turtles have a suite of coevolved life history traits that include high mortality of eggs and hatchlings, which decreases gradually as the individuals grow (Bury 1979; Crouse et al. 1987). When individuals reach adult size, mortality is mainly caused by human exploitation (Moll and Moll 2004), with natural mortality reduced to diseases and predation. Natural mortality of adults is poorly recorded and understood for Amazonian river turtle species. Females of *Podocnemis* spp. are vulnerable to predation by jaguars (*Panthera onca*), small felines, and black caimans (*Melanosuchus niger*) during nesting activity on land (Salera et al. 2009). This study presents the first records of natural mortality of *P. expansa* females found buried during nesting activities on the *Tabuleiro* of Monte Cristo, Pará, Brazil.

Methods. — The *Tabuleiro* of Monte Cristo nesting area, located in the Tapajós River, State of Pará, is one of the major reproductive sites of *P. expansa* in Brazil. It has been monitored and protected by the Instituto Brasileiro do Meio Ambiente e Recursos Naturais Renováveis (IBAMA; Brazilian Environment Agency) since 1978 through a conservation program called *Programa Quelônios da Amazônia* (PQA; Amazon Turtles Program). Until 2013, the *Tabuleiro* of Monte Cristo was composed of only the Monte Cristo beach (4°4'8.89"S, 55°38'44.24"W; WGS 84). In 2014, management measures included vegetation removal from a second nesting site, the André Beach (4°4'8.31"S, 55°38'53.70"W; WGS 84), to increase the nesting area and consequently increase the number of *P. expansa* hatchlings produced. This beach is 120 m apart from the Monte Cristo beach, separated by shrub and arboreal vegetation. Annually, it is necessary to remove the undergrowth (predominantly grasses) to make André beach suitable for nesting.

Between 2013 and 2017, reproductive monitoring carried out by IBAMA included the recording of females found buried in the nesting areas. The monitors found the buried females by walking throughout the nesting sites, carefully looking for immobile individuals and/or part of them visible in the sand. Searching was carried out usually after the nesting activity had finished. In 2017, records included biometry of the females found buried and the verification of eggs laid by them. Turtles were unburied and measured for straight carapace length (SCL), curved carapace length (CCL), carapace width (CW), plastron length (PL), and mass (kg). Measurements were taken in centimeters using a Haglof® caliper. The presence of eggs was verified by excavating the nest cavity and/or observation of oviducts by dissection of dead females. If alive, turtles were marked according to a numerical code by notches in marginal scutes to allow for individual recognition if recaptured in the future. Individual marking of captured individuals is part of the regular procedures of population monitoring carried out by the PQA.

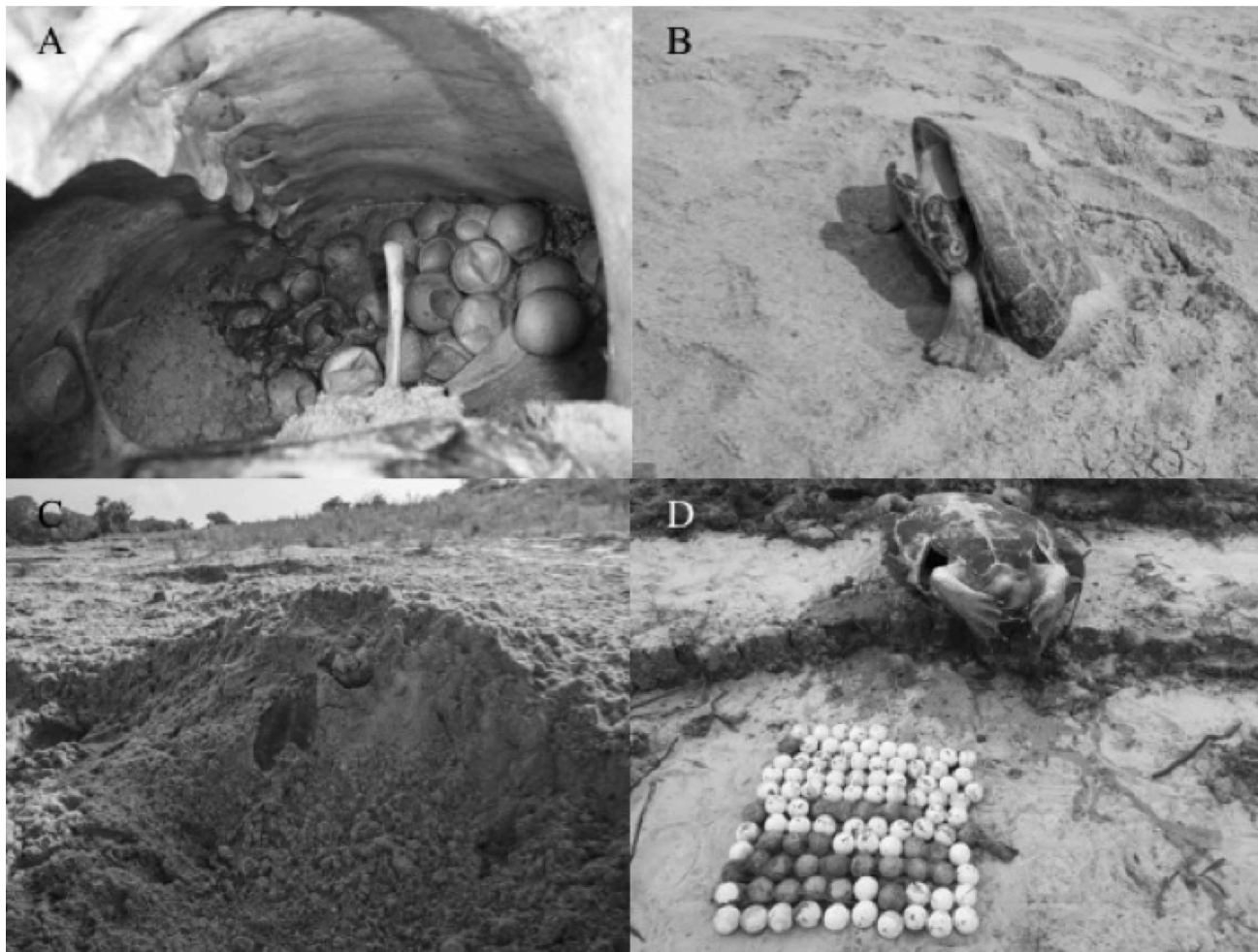


Figure 1. Females buried in the Tabuleiro of Monte Cristo, State of Pará, Brazil. (A) Dead female buried in 2013 and found in the next reproductive season. Photo by Paulo Lopes. (B) Female with the posterior half of the body buried in the nest, 2017. Photo by R. Lacava. (C) Completely buried female, 2017. Photo by R. Lacava. (D) Dead female with eggs removed from her oviducts, 2017. Photo by R. Lacava.

Results. — In 2013, 9 females were found buried and dead on the Monte Cristo beach. The following year, 1 dead turtle was found with the eggs preserved inside the carapace (Fig. 1A). In the following years, with the inclusion of André Beach, only 1 dead buried female was found in 2014 at André Beach, whereas in 2015 and 2016 there was no record of buried dead females. In 2017, the nesting season began on 29 September and lasted until 21 November. Buried females were found at both nesting areas from 22 to 29 October, when a great gregarious nesting occurred. During this period, 7 females were found buried during egg laying activities, 6 of which were dead (Table 1). The females were found in a vertical position, totally buried ($n = 1$) or with the posterior half of the body buried in the nest hole (Fig. 1B–C). Two of them were rescued still alive and, after time to rest and recover, they were released into the river. However, one of these was found dead on André Beach 3 d later.

Buried females' size varied from 50.0 to 71.5 cm SCL and weighed from 11.9 to 33.8 kg (Table 1). Nests of the females found alive were not found, but we counted 41

eggs in the oviducts of the female found dead 3 d later (Table 1). We found eggs in the oviducts of 3 other dead females, indicating that they died before nesting (Fig. 1D). The nests of 2 dead females were not found and these turtles were not checked for eggs in the oviducts. These turtles were found at the gregarious nesting site in the same inclined position as the other ones.

Discussion. — This is the first study that quantifies and records biometrical information of mortality of females not caused by predation in nesting areas. To our knowledge, this is the first scientific record of this kind of natural mortality of adult female turtles of any species. A local resident who participates every year in the reproductive monitoring affirmed that female deaths had happened before monitoring began in 2013 on Monte Cristo beach, but no information was taken about the quantity and status of turtles prior to 2013.

Reproduction, including the nesting phase, is an activity that demands a great amount of energy from female turtles (Congdon et al. 1982). It is common to observe exhaustion in females of *P. expansa* as they slowly

Table 1. Morphometric measures of females found buried in the Monte Cristo (MC) and André (AN) beaches, State of Pará, Brazil, in 2017. Weight (kg); SCL = straight carapace length (cm); CCC = curved carapace length (cm); CW = carapace width (cm); PL = plastron length (cm); *n* eggs = number of eggs verified either by nest or oviduct observation.

Day	Beach	Burial	Weight	SCL	CCC	CW	PL	<i>n</i> eggs
22 Oct ^a	AN	Partial	29.2	67.0	70.0	51.5	59.0	—
24 Oct	MC	Partial	33.8	71.5	74.6	57.0	61.2	—
25 Oct	AN	Partial	24.1	63.2	66.0	47.5	55.0	105
25 Oct	AN	Partial	32.0	67.0	70.0	50.5	59.2	105
27 Oct ^b	AN	Total	15.7	60.3	63.0	46.0	51.4	41
27 Oct	AN	Partial	11.9	50.0	50.3	38.6	44.6	63
29 Oct	MC	Partial	—	62.5	—	45.0	—	—

^a Female rescued alive.

^b Female rescued alive and found dead 3 d later.

return to the water after nesting. However, there is no record of dead females found either on the way to the water or at the nest, which would be expected in nesting areas throughout the Amazon if thermal stress or nesting exhaustion was the cause of death of females of *P. expansa*. Despite the fact that we did not perform a necropsy, and the causes cited above (thermal stress and exhaustion) cannot be ruled out, the respiration physiology of turtles and the position in which we found them lead us to believe they died by asphyxiation.

Respiration in turtles requires the retraction of the head and hind legs to create a pressure difference and allow air to enter the lungs; this is because of the limitations of the capacity of the thoracic cavity caused by the presence of a rigid carapace (Duncker 2004). Because the dead turtles described here were found with their hind legs buried in a motionless position, we believe the burial made the breathing difficult and likely caused their death. In addition, the 2 live females found buried in 2017 began an intense exhalation and inspiration cycle when they were unburied and placed in the usual horizontal position.

The digging activity of many females nesting together may cause some of them to be buried by the others digging in the vicinity. Despite the cause of these deaths not being conclusive, evidence suggests that burial caused the deaths and that they were not buried after being dead. The main evidence for this was the fully buried female found alive with no sign of lesion/predation, which would not be expected if the females died for another reason and then were subsequently buried. The case of the buried females would be one of a density-dependent mortality likely occurring where there is a great number of female turtles nesting. Density-dependent mortality is commonly recorded for turtle eggs, when a nesting female promotes partial destruction of nests laid previously in the nesting season. This occurs with *P. expansa* in Tabuleiro of Monte Cristo (P.S.M., R.V.L., and R.A.F., *pers. obs.*) and also in other turtle species that present gregarious nesting, such as the sea turtle species *Chelonia mydas* (Bustard and Tognetti 1969), *Lepidochelys olivacea* (Cornelius 1991; Honarvar et al. 2008), and *Dermochelys coriacea* (Girondot et al. 2002).

Population modeling for *P. expansa* indicates that removal of adult individuals has a major effect on population dynamics, unlike the mortality of eggs and hatchlings which have a naturally high mortality (Mogollones et al. 2010), and the same population dynamic pattern has been estimated for other turtle species (Crouse et al. 1987; Crouse 1999). As relatively small and large adult females were found dead, apparently these mortalities were not size related. For the estimated 10,000 nesting females at the Monte Cristo nesting area in 2015 (R.A.F., *pers. obs.*), nesting mortality affected 0.06% of adult females of this population in 2017. Because this rate of mortality is more likely to occur in areas where a great number of females nest together in a short period of time, conservation programs may prevent natural mortality caused by burial by making larger areas suitable for *P. expansa* nests as well as by visually examining the nesting areas looking for buried females as soon as possible after the gregarious nesting events.

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