Acta Scientiarum

http://www.periodicos.uem.br/ojs/
ISSN on-line: 1807-863X
Doi: 10.4025/actascibiolsci.v46i1.69922

Analysis of the influence of tourism on nesting beaches for the Amazon turtle (*Podocnemis expansa*) on the Crixás-Açu river

Lívia Schroder Memória Paiva[1], Tairone Paiva Leão[1], Paulo Lopes Ribeiro[2], Leo Caetano Fernandes da Silva[2], Mariana Pastori Lara[2] and Rodrigo Diana Navarro[1]*

[1]Laboratório de Aquicultura e de Biotecnologia em Organismos Aquáticos, Faculdade de Agronomia e Medicina Veterinária, Universidade de Brasília, Campus Universitário Darcy Ribeiro, 70910-900, Brasília, Distrito Federal, Brazil. [2]Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis, Goiânia, Goiás, Brazil. *Author for correspondence. E-mail: navarrounb@gmail.com

ABSTRACT. Freshwater turtles play an important ecological and social role, with *Podocnemis expansa* (arrau turtle) being the largest freshwater Testudine in Latin America. The overexploitation of this species for the meat and egg by-products trade has significantly reduced *P. expansa* populations, which makes conservation actions necessary. The reproductive success of the species is essential for its permanence, and one of the most important stages of reproduction is the nesting process. Amazon tortoises can be demanding in the selection of spawning sites, evaluating substrate, ambient temperature, vegetation, safety against predators, among other factors that affect nests. Tourism on turtle nesting beaches can be interpreted as a threat to breeding turtles, which therefore may avoid busy places, being left with limited options. With this subject in mind, this work aimed to discuss factors that interfere in the nesting process and to evaluate the possible influence of tourism on the number of spawnings of *P. expansa* in the Crixás-Açu river (Goiás State, Brazil), one of its natural habitats. Data were obtained on the number of nests and the presence or absence of camping/tourism on 24 beaches along the river in September and October 2020, from which a boxplot graph was produced using the R software. No correlation was found between the selection of the beaches by turtles and the presence or absence of tourism, requiring further studies on the multiple factors that influence spawning in the Crixás-Açu river. The information published here can complement the database of future studies and corroborate the knowledge necessary for the adequate protection of these animals.

Keywords: tortoise; spawning; freshwater turtle.

Received on October 13, 2023
Accepted on August 22, 2024

Introdution

Podocnemis expansa, popularly known as the Amazon turtle, belongs to the order Testudines, suborder Pleurodira, family Podocnemididae (Navarro & Alves, 2021; Ribeiro, Balbino, & Navarro, 2023; Ribeiro & Navarro, 2020). The species is widely distributed in Brazil, occupying the Amazon, Orinoco River and Araguaia-Tocantins River basins. These chelonians are also found in Peru, Venezuela, Bolivia, Colombia and the Guianas (Guimarães et al., 2023; Navarro, Souza, & Navarro, 2023). They are animals whose reproductive cycle depends on the ebb and flow of rivers. Consequently, floodplain and igapó forests, which occupy floodplains, are present in the territories of *P. expansa* (Lacava & Balestra, 2019). During periods of flooding, adult Amazon turtles remain in lagoons, meanders and flooded forests, where there is a supply of food and protection from predators. Females return to the rivers during the low-water period, in the dry season, to nest (Lacava & Balestra, 2019).

The use of turtles for the subsistence of riverside communities and indigenous groups did not present a threat to the species until the involvement of the European market: in Colonial Brazil, the consumption of this species extended to mercantilist extractivism, in the large-scale commercialization of oil and butter extracted from eggs, these products being used both for lighting and frying food (Navarro &Alves, 2021) which may be one of the main causes of the decline in *Podocnemis* populations. This exploratory activity affected not only *P. expansa* but also others of the genus, which became an alternative source of raw materials in the low supply of Amazon turtles (Lacava & Balestra, 2019).

In addition to overexploitation through illegal trade, the decline of these populations is also attributed to the loss and fragmentation of habitats, caused, for example, by the construction of hydroelectric plants, agricultural occupation and human occupation (Lacava & Balestra, 2019). Tourism is another anthropic factor that can influence the behavior of females during nesting: breeding females can avoid laying eggs on beaches with ideal conditions due to the presence of humans on the popular "river beaches" (Bom & Barberi, 2021). This work aims to analyze the influence of tourism on the spawning of *Podocnemis expansa* on beaches of the Crixás-Açu river and discuss other variables that can affect the nesting of these animals.

Material and methods

Study area

Data were collected on beaches along a stretch of approximately 105 km of the Crixás-Açu river, a tributary of the Araguaia river, in the state of Goiás, Brazil (Figure 1). The study area extends from Brandão beach (13°40′46.3753″ S, 50°4′32.3680″ W) to Santo Antônio 2 beach (13°26′36.5100″ S, 50°32′41.0292″ W), and is under monitoring by the Amazonian Chelonians Program of the Brazilian Institute of the Environment and Renewable Natural Resources (PQA/IBAMA). Twenty-four beaches (n = 24) were observed from 09/23/2020 to 10/01/2020.

Figure 1. Section covered during data collection on the Crixás-Açu river (Goiás State, Brazil) with yellow markers indicating the registered beaches. The number of nests on each beach is reported in parentheses. Source: PQA, 2020

Data collection

The Amazon Chelonians Program (PQA/IBAMA), which has been collecting data from the region since 1985, provided the coordinates of the observed beaches, the number of nests on each beach and the presence or absence of camps. On beaches with few nestings, the PQA team carried out individual nest counts (Balestra, 2016). On beaches with high spawning rates (>100 nests), an estimate of the number of nests was made, as in these cases there is overlapping of burrows.

Data analysis

The geographic coordinates provided were entered in the Google Earth Pro program for visual analysis of the beaches and their surroundings (Table 1).

First, a logarithmic transformation was performed on the data, which did not present a normal distribution and presented high variability (from 0 to 1,500 nests per beach), to enable graph representation. After this, a boxplot was produced comparing the number of nests in two groups: beaches with camping and beaches without camping. For this purpose, the R software (version 4.2.1) was used.

Table1. Location of beaches, date of observation, presence (yes) or absence (no) of tourism per and number of nests per beach in 2020.

Beaches	Coordinates UTM		Date	Camping	Nests
	Latitude (S)	Longitude (W)			
Brandão	13°40′46.3753″	50°4′32.3680″	23/09/2020	No	0
Brandão 2	13°41′15.8046″	50°4′45.3844″	23/09/2020	No	1
Praia da Anta	13°39′32.7497″	50°6′8.1866″	23/09/2020	No	3
Volta grande	13°41′13.2214″	50°6′54.4903″	23/09/2020	Yes	1
Capivara	13°39′29.3752″	50°9′11.0605″	24/09/2020	No	7
Japonês	13°38′27.7448″	50°11′23.0945″	24/09/2020	No	1
Draguinha	13°38′58.0500″	50°11′42.1013″	24/09/2020	No	2
Draga	13°39′12.6135″	50°11′49.0158″	24/09/2020	Yes	3
Falsa Moreira	13°37′49.0822″	50°14′18.3250″	01/10/2020	No	50
Moreirinha	13°37′43.0100″	50°14′26.4594″	01/10/2020	No	15
Moreira	13°37′12.9726″	50°14′5.6093″	01/10/2020	No	1500*
Moreira Alta	13°36′51.3800″	50°14′17.0800″	01/10/2020	No	200
Ariranha	13°34′29.8611″	50°22′41.8799″	26/09/2020	No	2
Santa Fe 4	13°32′32.5084″	50°24′52.9506″	26/09/2020	No	28
Santa Fe 1	13°33′7.1500″	50°25′39.0964″	26/09/2020	Yes	1
Santa Fe 3	13°32′56.4963″	50°26′11.0994″	26/09/2020	No	1
Santa Fe 2	13°32′40.7800″	50°26′39.2200″	28/09/2020	No	17
Santa Fe 5	13°33′23.6379″	50°27′14.1257″	28/09/2020	No	4
Santa Fe 6	13°33′37.3564″	50°27′23.4097″	28/09/2020	No	27
Coroinha	13°31′1.2876″	50°31′42.3660″	28/09/2020	Yes	28
Coroinha 4	13°28′48.7900″	50°31′29.5918″	29/09/2020	No	11
Santo Antônio	13°27′38.1800″	50°31′58.4901″	29/09/2020	No	5
Santo Antônio 3	13°27′32.4100″	50°32′18.8791″	29/09/2020	No	12
Santo Antônio 2	13°26′36.5100″	50°32′41.0292″	29/09/2020	No	9

*Estimated value due to possible nest overlap. Source: PQA/IBAMA (2020).

Results

There was overlapping distributions in the boxplot, which intuitively indicates that the data between the two groups might not present significant differences. But it was also possible to observe that beaches without camping showed greater variability in the number of nests, especially in the upper tail. In the same group, it is observed that the outlier is in a higher position (Figure 2).

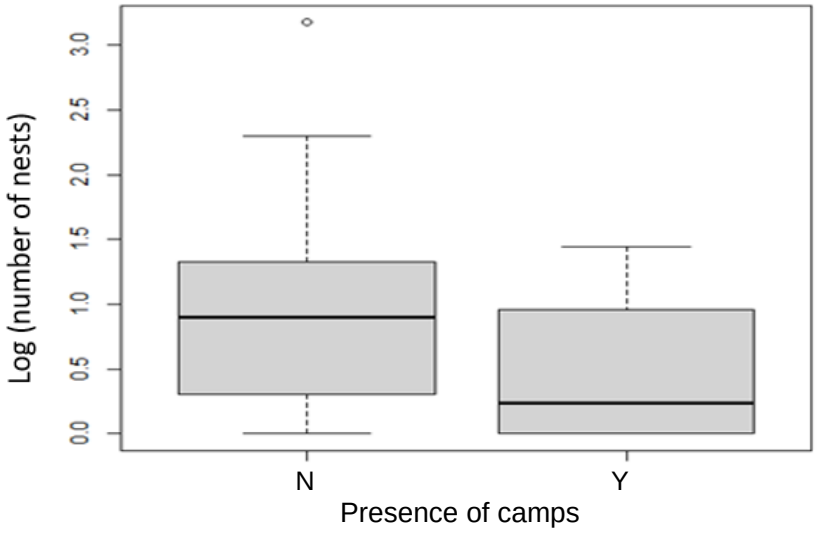

Figure 2. Boxplot of the median number of nests on beaches without (N) and with (Y) camps. Source: The authors

Even when excluding the outlier, the variability in the number of nests is extreme, and the number of beaches with camping (n = 4/24) is small to be able to be compared with beaches without camping (n = 20/24).

Although the boxplot did not indicate an influence of tourism on *P. expansa* spawnings, it can be observed that the beaches that had the most spawnings did not have camps (Moreira, Moreira Alta and Falsa Moreira (Figure 3). Tourism may be one of the factors limiting spawning sites (Bom & Barberi, 2021), and the high concentration of nests on just one beach generates very similar embryonic conditions in each burrow, which

can generate a biased sex ratio (due to temperature) and limit genetic variability (Ferreira Júnior & Castro, 2006). Factors such as incubation period, amount of clay in the sand and percentage of riverine vegetation may also be possible predictors of reproductive success in turtles (Ribeiro et al., 2024).

Figure 3. Falsa Moreira, Moreirinha, Moreira, and Moreira Alta beaches. Number of nests in parentheses. Source: PQA (2020).

Discussion

It is known that sea turtles are reluctant to nest in places with anthropogenic disturbances (Taylor & Cozens, 2010; Esperanza, Martínez, Tuz, & Pérez-Collazos, 2016). Light pollution influences the female's choice of spawning site and disorients the newly hatched, which head towards the light to reach the sea. The change in environment caused by adjacent buildings limits space and compacts the sand of spawning sites. These factors have been shown to reduce the reproductive success of these animals (Taylor & Cozens, 2010; Esperanza et al., 2016), and it is possible that this influence is repeated with freshwater Testudines.

It is important to highlight that the choice of nesting beaches for turtles is multifactorial, and with the present data alone it is not possible to state that tourism was a determining factor in nesting sites. As seen in the Google Earth image (Figure 1), the river is surrounded by farms, often with a narrow strip of vegetation protecting its banks, and there may be disturbances in the environment caused by domestic animals and water contamination by pesticides (Navarro & Alves, 2021, Ribeiro et al, 2024).

Conclusion

Although the analysis of the present data did not show a correlation between tourism and the number of nests on freshwater beaches, it is possible to observe that the beaches with the most nesting did not have camps. Currently, the species *Podocnemis expansa* is classified by the International Union for Conservation of Nature [IUCN] (2013) as a species at low risk of extinction, but dependent on conservation programs. The advancement of research into the natural habitats of freshwater Testudines is important for the development of better conservation strategies and to support socio-environmental actions that protect not only the Amazon turtles, but the entire ecosystem in which they are present.

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