NESTING HABITAT OF THE ‘CUPISO’ *Podocnemis sextuberculata* (TESTUDINES: PODOCNEMIDIDAE) IN EREPECU LAKE (PARÁ-BRAZIL)

Hábitat de anidación del “cupiso” *Podocnemis sextuberculata* (Testudines: Podocnemididae) en el Lago Erepecu (Pará-Brasil)

Ana Lucía BERMUDEZ-ROMERO¹, Nataly CASTELBLANCO-MARTÍNEZ², Rafael BERNHARD³, Santiago R. DUQUE¹, Richard C. VOGT⁴.

¹ Universidad Nacional de Colombia, Sede Amazonia, Kilometro 2 via Tarapaca, Leticia, Colombia.
² Tumeffe Atoll Sustainability Association TASA, 10 North Park Street P.O. Belize City, Belize.
³ Universidade do Estado do Amazonas, Centro de Estudos Superiores de Tefé CEST. Estrada do Bexiga, 1085, Tefé, Amazonas, Brazil.
⁴ Instituto Nacional de Pesquisas da Amazônia – INPA, Avenida Efigenio Salles, 1695, Manaus, Amazonas, Brazil.

For correspondence. analubero@gmail.com

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ABSTRACT

The objective of this study was to identify and describe the nesting habitat of *Podocnemis sextuberculata* at Erepecu Lake, Trombetas River Biological Reserve, (REBIO-Trombetas; Pará-Brazil). Initially, the main features of the beaches that potentially determine the habitat selection by cupiso for nesting were described. The nests observed on the beaches were recorded, marked and fenced as protection from natural predators. Information regarding date and location was analyzed through simple linear regression for each nest in order to determine relationships between beach features and number of nests. The results showed a positive co-relationship between number of nests and area. Nest site selection by *P. sextuberculata* in the beaches of the Erepecu Lake could depend on trade-off scenarios among natural threats and a suitable nesting habitat. We also suggest that, due to the high annual hydrologic oscillations, it is possible that the driving factor for habitat selection would be the risks that the females are exposed to while searching for a nesting site, rather than a particular habitat type.

Keywords: Amazonas, beaches, distribution, nests, turtle.

INTRODUCTION

Temperature has been shown to be the main environmental variable that affects directly the sexual determination of most species of freshwater, marine, and terrestrial turtles (Bull and Vogt, 1979; Janzen and Paukstis, 1991; Ferreira-Junior, 2009). However in all the species of the families Chelidae and Trionychidae, as well as in some species of Emydidae and Kinosternidae,
the sex is genetically determined. Therefore, the nesting habitat choose is important in determining the sex of the hatchlings.

The habitat is the place where an organism, a population or a species lives, within a combination of resources and environmental factors favorable for its survival and reproduction (Gysel and Lyon, 1980; Morrison et al., 1998). Every species requires specific habitat characteristics; likewise, every habitat represents various combinations of physicochemical and biotic factors that have an effect on the species (Ojasti, 2002). For instance, in large freshwater turtles (for example genus Podocnemis) the vegetation structure, amplitude and river depth, light, sand grain size, moisture and amount of food, are positively related to their distribution and abundance, and when found together, indicate suitable habitat for the species (Flaherty and Bider, 1984; Vogt and Bull, 1984; Shively and Jackson, 1985; Morrison et al., 1998; Roosenburg and Morrison, 1984; Vogt and Bull, 1984; Shively and Jackson, 1985; Ferreira-Junior, et al., 1998; Roosenburg et al., 1999; Ferreira-Junior and Castro, 2003; Arzola, 2007; Ferreira-Junior, 2009; González-Zarate et al., 2011).

There is also variability among Podocnemis species regarding habitat requirements. For example, Podocnemis sextuberculata (Cornalía, 1849), one of the smallest species of the genus, lives in white and clear waters, in lagoons and floodplains covered by forest (Rueda-Almonacid et al., 2007), and the selection of nesting habitat is positively related to sandbanks fully exposed to the sun (Pezzuti and Vogt, 1999; Haller and Rodrigues, 2006), where the nests are located in the highest and sandy parts of the beaches (Pezzuti and Vogt, 1999; Pantoja-Lima, 2007; Ferreira-Junior and Castro, 2003). Meanwhile, Podocnemis unifilis, the second largest species of the genus, has no preferences for water type neither for the height where nest are located and is able to nest in a variety of substrates (Pantoja-Lima, 2007; Rueda-Almonacid et al., 2007). Finally, Podocnemis expansa, which is the largest species of the genus, inhabits clear, white and black waters (although less commonly in black water), and shows a preference to nest in the highest beaches with coarse grain sand (Pantoja-Lima, 2007; Rueda-Almonacid et al., 2007).

Podocnemis sextuberculata is known as cupiso in Colombia and iaçá or pitiu in Brazil. The species is distributed in the Amazon Basin of Colombia (Amazonas, Caquetá and Putumayo rivers; Ceballos et al., 2012), Peru (Loreto y Ucayali Rivers; Ferronato and Morales, 2012) and Brazil (Juruá, Jurumirim-Japurâ, Purus, Solimões, Trombetas and Tapajós Rivers (Ceballos et al., 2012). The Trombetas River Biological Reserve (REBIO-Trombetas), located in the north of the state of Pará (Brazil), encompasses numerous beaches used as nesting areas by P. sextuberculata, including those of the Erepecu Lake. Turtles in the lake are threatened by high levels of female capture and egg poaching and the species is currently considered as the most exploited within this ecosystem. The species faces the same conservation scenario in larger rivers such as Solimões, Purus, Madeira and Amazonas (Fachín-Terán, 2000; Bernhard, 2001; Pantoja-Lima, 2007).

Due to the wide geographic and climatic variability reported for Podocnemisididae habitat (Ewert et al., 1994), it is expected that the reproductive dynamics will vary on a local geographic scale. In the main large breeding beaches (known as ‘tabuleiros’) of the Trombetas River, studies addressing reproductive biology (Haller and Rodrigues, 2006) and genetics (Silva, 2002; Silva et al., 2011) have already been conducted. However, for Erepecu Lake, there is no quantitative biological information of the local reproductive dynamics of the cupiso to assess the current conservation state, and therefore, to develop management strategies aimed towards local species’ conservation.

The overall objective of the study was to identify and describe the habitat, distribution and abundance of P. sextuberculata nests on the beaches of Erepecu Lake, Trombetas River Biological Reserve, (REBIO-Trombetas; Pará-Brazil). Abundance and distribution are relevant to assess the current species’ conservation state, which is expected to contribute in the design of plans and strategies that allow the proper in-situ management of this species.

METHODS AND MATERIALS

Study Area

The study was conducted at the REBIO-Trombetas, State of Pará, in northern Brazil (01° 19’ 54” Lat S, 56° 36’ 20.44” Lon W), between September 12th and December 12th, 2012. The Erepecu Lake is located in the Igapó floodplain, and is about 40 km in length (IBAMA, 2004). The area is considered climate category Af, characterized by Tropicak rainy climate without seasons, with equatorial rainfall regime, and temperatures exceeding 18 ºC (Köppen, 1984). The lake is under the hydrological influence of the Trombetas River, tributary of the Amazon River, with two well-defined hydroclimatic periods in the yearly cycle: high-waters from March to August and low-waters from September to February (Goulding et al., 2003). The vegetation consists mainly of ‘ombrófilos’ (upland forests), ‘igapó’ (floodplain forest), ‘várzea’ (floodplain forest), and secondary vegetation (IBAMA, 2004).

Methods

The study was conducted at 11 sand beaches: Gorda, Toró, Marazinha, Cemitério, Cativo, Miriam, Marciana, Capitari, Garças, Camaleão and Campos (Fig. 1). The area and the mean height of the water level were measured and recorded for each beach. The water level was determined with a handcrafted ruler installed in the central part of the lake. Four samples of substrate were collected at the ends of each beach for classification by granulometric analysis according to Folk (1974; NTC1522, 1979; NTC77, 2007).
Figure 1. Study area, Trombetas Biological Reserve (REBIO-Trombetas), Erepecu lake (Pará-Brazil).
The beaches were visited between 5:00 am and 10:00 am in order to detect *cupiso* nests by following the trails left by females during the nesting events (Pezzuti and Vogt, 1999). For each nest, information on nest number, nesting date, nesting locality, density and geographical coordinates was recorded.

Basic statistics were determined for each of the variables (mean, standard deviation, minimum and maximum value). The Shapiro-Wilk normality test and linear regressions were performed to detect relations between the variables (Guisande, 2006). The analysis was conducted with the statistical software SPSS 17.0 Base Statistic.

**RESULTS**

The nesting of *cupiso* in Erepecu Lake occurred between September 12th and October 18th of 2012, when the level of Trombetas River was the lowest of the year (Fig. 2). In total, 84 nests were recorded on eight beaches. The beaches with the highest relative abundance (number of nests per beach) were Capitari (31) and Mariazinha (18); while the lowest relative abundance occurred at Miriam (5), Cativo (3), and Cemitério (3). At Gorda, Camaleão and Campos beaches, no nests were recorded (Fig. 3).

The beaches had a mean area of 64,821 m²; ranging from 6,134 m² (Campos) to 154-322 m² (Capitari). The mean

![Figure 2. Water level of Trombetas River and number of nests of *P. sextuberculata* registered in Erepecu Lake.](image)

![Figure 3. Number of nests of *P. sextuberculata* recorded by beach on Erepecu Lake (REBIO-Trombetas, Pará-Brasil).](image)
nest density was 1.18 nests/ha. The average beach height in relation to the water levels, varied from 1.56 m in Campos to 4.09 m in Camaleão \( (X = 2.35 \text{ m}) \). The type of beach substrate varied between “too coarse sand” and “fine sand”; 55% of the beaches showed higher values for the “mid-sized sand” substrate, 27% showed higher values for the “too coarse sand”, and 18% showed “coarse sand” substrate.

Simple linear regressions only showed a significant relationship between the water level of Erepecu Lake and the Trombetas River \( (r^2=0.40; F_{1,90}=8.673; p=0.005) \); and between nest abundance and the size of the beach \( (r^2=0.42; F_{1,7}=7.798; p=0.031) \) (Fig. 4).

**DISCUSSION**

**Nest Distribution and Abundance**

The beaches used for nesting by *cupido* in Erepecu Lake have been recognized since 1979 as important nesting areas not only for this species, but also for *P. unifilis*. However, the area and height of these beaches vary significantly between years due to the annual oscillation of Erepecu Lake, which is directly influenced by the Trombetas River hydrologic cycle (IBAMA, 2004).

The synchrony between the water level and the nesting period of *P. expansa* starts when the Trombetas River experiences its lowest levels (Alho and Pádua, 1982). The nesting period of *P. sextuberculata* in the Purus River starts before the lowest levels are recorded (Pantoja-Lima, 2007), the same as occurs with Erepecu Lake.

Information about nest density for *P. sextuberculata* exists only for the Japurá River, more specifically, for the Mamirauá Sustainable Development Reserve (Pezzuti and Vogt, 1999), and for Abafuri Biological Reserve (Pantoja-Lima, 2007). Pezzuti and Vogt (1999) reported high values (3.47 nests/ha), in comparison to the ones recorded for Erepecu Lake (1.18 nests/ha), while Pantoja-Lima (2007) reported lower densities (0.62 nests/ha). These differences that can be explained by the geographical variation reported for Podocnemididae. According to Ewert *et al.*, (1994) *Podocnemis* species that show a widespread geographical distribution, adjust to the different environmental conditions as an adaptive response to increase their survival success in the different places where naturally inhabits. In the context, environment variations can hence be related to the number of individuals present in an area as it has been described by other authors (García, 2005).

The nesting period of *P. sextuberculata* in Erepecu Lake began in the inner part of the lake where the first beaches were recorded. Towards the outer part of the lake, beaches emerged a couple of days later, when the first nests were also detected. This emergence pattern can be associated with the hydrologic dynamics of the lake, which in the inner part shows more influence of the Mungubal Stream, while in its outer parts it is directly influenced by the Trombetas River (IBAMA, 2004). Considering that the Amazon flooding pulse and drying dynamics are determined by precipitation variation in the upper reaches of the rivers, it is suggested that the rain pattern would have an indirect effect on the reproductive dynamic of the species, as it has been argued by other authors (Soini, 1996). Therefore, it is possible that the mixed influence of the two sources (Mungubal Stream and Trombetas River) is the determining factor for nesting of *P. sextuberculata*.

![Figure 4. Correlation between the area of Erepecu Lake beaches and the number of nests of *P. sextuberculata* at Erepecu Lake (REBIO-Trombetas; Pará-Brazil).](image-url)
The total number of nests for 2012 was 84, similar to the results obtained by the local people in 2011, when 70 nests of this species were recorded on eight beaches of Erepecu Lake. Even though the data was not statistically analyzed, it is possible to see differences between the nest abundance per beach (Table 1). Interannual variation may be the result of different methodologies, and/or may be associated with interannual changes in capture pressure. Whatever, differences of this type might be tied to the annual variation of the hydrologic cycles, which can create changes in the beaches morphologies, altering the access conditions, and forcing females to seek new nesting areas (Ferreira-Junior and Castro 2003).

Podocnemididae species (Alho and Pádua, 1982), and more specifically P. sextuberculata (Bernhard, 2001), depend on the water level for nesting. The environmental variability of Erepecu Lake could affect and modify the distribution and abundance of “cupiso” nests, especially since this species specifically nests on sandy beaches totally exposed to sunlight (Pezzuti and Vogt, 1999; Haller and Rodrigues, 2006).

Due to the water level influence on the begin of the nesting season in Podocnemididae, the dates vary geographically in the Amazon Basin (Fig. 5) according to regional differences in the low water and high water periods (Vogt, 2008). In the case of P. sextuberculata, the nesting period occurs between late June and September in the Ucayali River, Peru (Vogt, 2008), between October and March in the Caquetá River, Colombia (Bermúdez-Romero, 2010), between August and October in the Mamirauá Sustainable Development Reserve, Brazil (Bernhard, 2001), and between August and September in the lower Purus River, Brazil (Pantoja-Lima, 2007).

<table>
<thead>
<tr>
<th>Beach Name</th>
<th>Number of nests of P. sextuberculata 2011</th>
<th>Number of nests of P. sextuberculata 2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gorda</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Toró</td>
<td>12</td>
<td>9</td>
</tr>
<tr>
<td>Mariazinha</td>
<td>6</td>
<td>18</td>
</tr>
<tr>
<td>Cativo</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Cemitério</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Miriam</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Marciana</td>
<td>20</td>
<td>8</td>
</tr>
<tr>
<td>Capitari</td>
<td>10</td>
<td>31</td>
</tr>
<tr>
<td>Garças</td>
<td>19</td>
<td>7</td>
</tr>
<tr>
<td>Camaleão</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Campos</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>70</td>
<td>84</td>
</tr>
</tbody>
</table>

**Table 1. Number of nests of P. sextuberculata by beach for 2011 and 2012 at Erepecu Lake (REBIO-Trombetas). Data for 2011 were recorded by local people (Bernhard et al., 2012).**

**Habitat Effects on Nest Distribution and Abundance**

On Erepecu Lake beaches, the area was the only variable significantly related to nest abundance, probably due to a greater availability of nesting sites.

Weisrock and Janzen, (2000) affirm that the environmental characteristics of the nests can have a strong effect in the development of the Podocnemis embryos. However, this study did not show significant relations between any other environmental variable and nests abundance, suggesting that nesting selection is a product of a group of environmental variables, as it has been argued in different studies (Bull and Vogt, 1979; Bull et al., 1982).

Pezzuti and Vogt (1999), and Pantoja-Lima (2007), stated that the “cupiso” nesting selection is mainly influenced by the beach topography. In this study, more nests were recorded in higher areas. Nevertheless, it is important to say that these authors recorded the preference for higher areas at the same beach, and do not contrast the height differences among the other places, as occurred in this study. In the highest beach (4.06 m Camaleão), and the lowest (Campos 1.5 m), no nest was recorded.

Likewise, the statistical analysis did not reveal any important influence of height on nesting selection. This might indicate that in Erepecu Lake, the species prefers to nest in beaches where flooding or humidity excess, and where dry conditions cannot affect the embryo development (Alho and Pádua, 1982).

Podocnemis expansa and P. unifilis have a clear preference by specific nesting substrates (Ferreira-Junior, 2009). Although no significant relationship was found between the number of nests and the type of substrate, it was noticeable that beaches with coarser grained substrates (large-sand grain) did not contain nests, while beaches with mid-sized sand grain substrate recorded more nests. This might indicate that this type of substrate allows for sufficient oxygen distribution between interstitial spaces of the sand and the eggs in the nest, and impeaches the eggs to become too dry, positively influencing the development of embryos (Ferreira-Júnior and Castro, 2003; García, 2006; Arzola, 2007).

As no significant relations where found between the physical variables of the beaches and the number of nests, it is likely that P. sextuberculata may adopt strategies that offer more benefits for a lower energetic inversion, choosing the simplest path that contributes to an optimal scenario. This cost-benefit analysis takes into account all the different factors and limitations that a species has, according to ‘optimization theory’ by McArthur and Pianka (1966). Therefore, the selection of P. sextuberculata nesting place in the beaches of the Erepecu Lake, could be a result of a balance between the risk of predation at the time of nesting, and the physiological stress affecting the turtle when it is moving to the beach (Novelle, 2006) and it is not solely because of the environmental characteristics of the beaches.
and the nests, as described in previous studies (Bull and Vogt, 1979; Bull et al., 1982).

CONCLUSIONS
This is the first attempt to investigate the Brazilian cupiso in Erepecu Lake. While we did not find evidence that nest site selection is driven by environmental factors of the beaches, our results are an interesting contribution toward the protection of the nesting areas.

The main reason for the decrease of turtle populations is human predation (IBAMA, 2004). The Trombetas River Biological Reserve is currently affected by bauxite exploitation, which has facilitated the increase of boat traffic near Erepecu Lake. The rapid growth of the human population inside the reserve has been tracked, which according to IBAMA showed in 1987 the population did not exceed 22 families, but now it is more than 6,000 people. This population trend points to an increase in the use of natural resources present in the area, affecting turtle populations as one of the most heavily demanded products in the region.

A major problem is the lacking of active presence of environmental agents and analysts, in charge of controlling and monitoring the area. It is necessary the implementation
of environmental education programs led by local inhabitants emphasizing the proper use of natural resources, which may contribute to habitat conservation of the “cupiso” nesting sites.

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