UNIVERSIDAD NACIONAL DE COLOMBIA

ACTA BIOLÓGICA COLOMBIANA
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ARTÍCULO DE INVESTIGACIÓN

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)

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Received: 24 March 2014; **Returned for revision:** 28 July 2014; **Accepted:** 23 September 2014.
Associate Editor: Alan Giraldo.

Citation / Citar este artículo como: Bermudez-Romero AL, Castelblanco-Martínez N, Bernhard R, Duque SR, Vogt CR. Nesting habitat of the 'Cupiso' *Podocnemis sextuberculata* (Testudines: Podocnemididae) in Erepecu Lake (Pará-Brazil). Acta biol. Colomb. 2015;20(2):183-191. doi: http://dx.doi.org/10.15446/abc.v20n2.42757

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.

RESUMEN

El objetivo del estudio fue identificar y explicar la influencia del hábitat sobre los nidos de la tortuga "cupiso" (*Podocnemis sextuberculata*), en el lago Erepecu ubicado en la Reserva Biológica del Río Trombetas (REBIO-Trombetas; Pará-Brasil). Inicialmente se describieron las principales características de las playas escogidas, los nidos encontrados fueron marcados y cercados para su protección contra la depredación natural. A través de regresiones lineales simples se determinó que el número de nidos por playa se correlacionó significativamente con el "área" de las playas. Los resultados muestran que la selección del lugar de nidificación en las playas del lago Erepecu por *P. sextuberculata*, podría depender en unos escenarios de compensación entre las amenazas naturales y un hábitat adecuado para anidar. Debido a la gran fluctuación hidrológica anual, es posible que el factor determinante para selección de las hembras sea el riesgo de exposición de las hembras durante la búsqueda de área de anidación, más que el tipo de hábitat en particular.
Palabras clave: Amazonas, distribución, nidos, playas, tortugas.

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 familes 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 *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* (Cornalia, 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 Rodrígues, 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, Juamir-Japurá, 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 Podocnemididae 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, Mariazinha, 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).

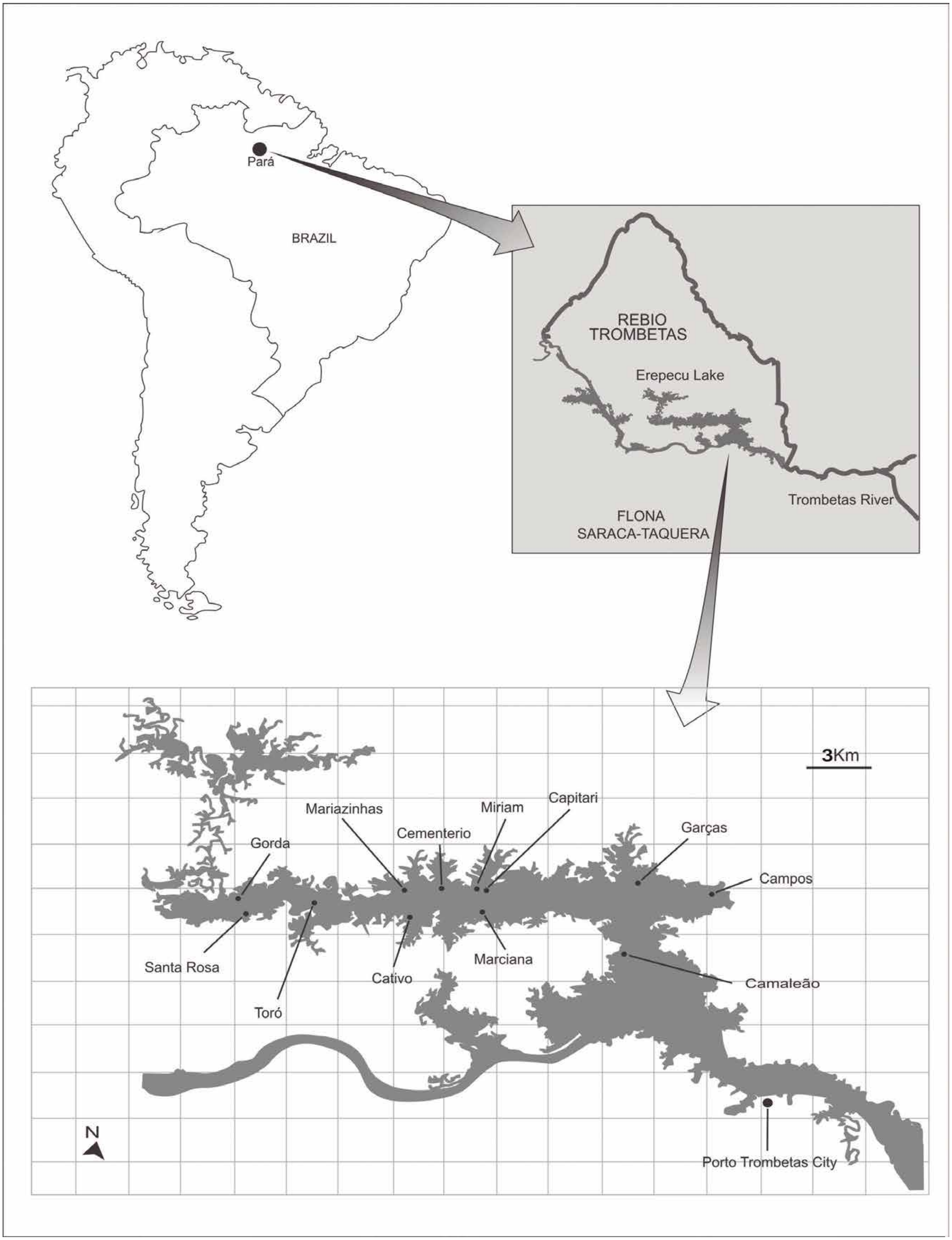

Figure 1. Study area, Trombetas Biological Reserve (REBIO-Trombetas), Erepecu lake (Pará-Brazil).

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

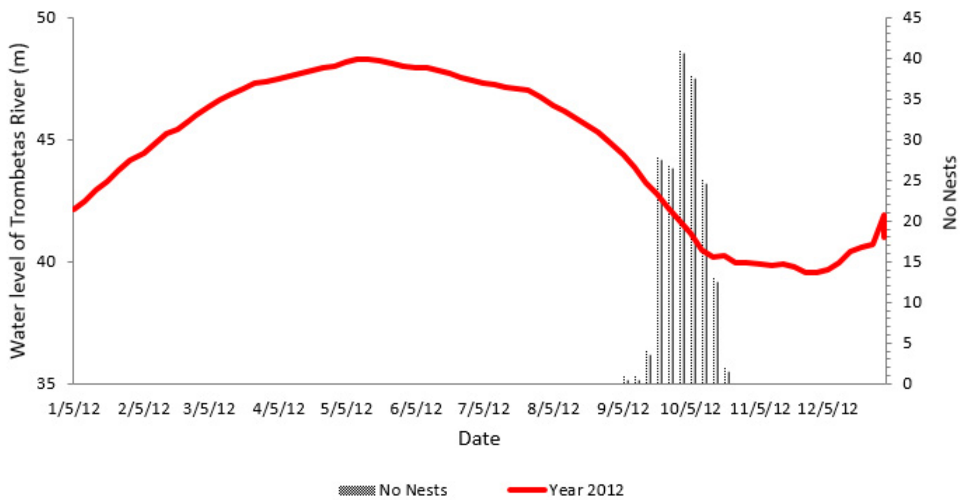

Figure 2. Water level of Trombetas River and number of nests of *P. sextuberculata* registered in Erepecu Lake.

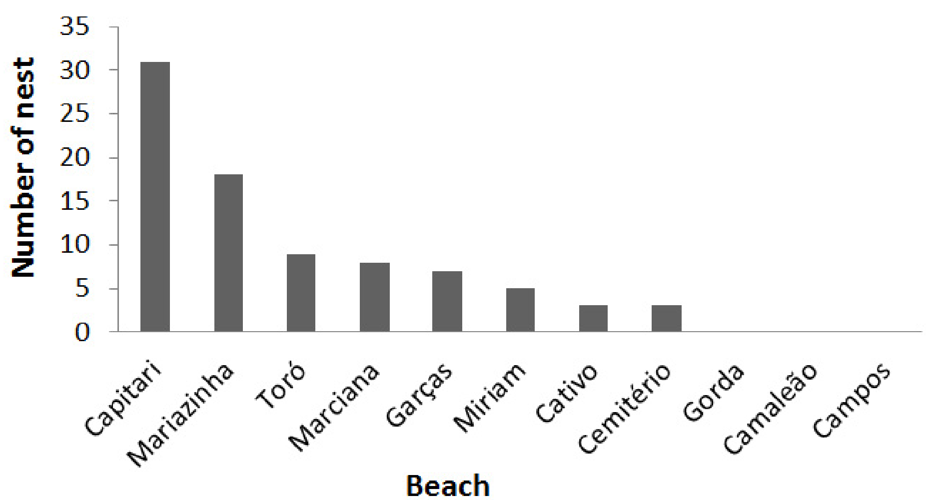

Figure 3. Number of nests of *P. sextuberculata* recorded by beach on Erepecu Lake (REBIO-Trombetas, Pará-Brasil).

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 ($\bar{X}$ = 2.35 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 *cupiso* 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 enviromental conditions as an adaptative response to increase their survival success in the different places where naturally inhabits. In the context, enviroment 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*.

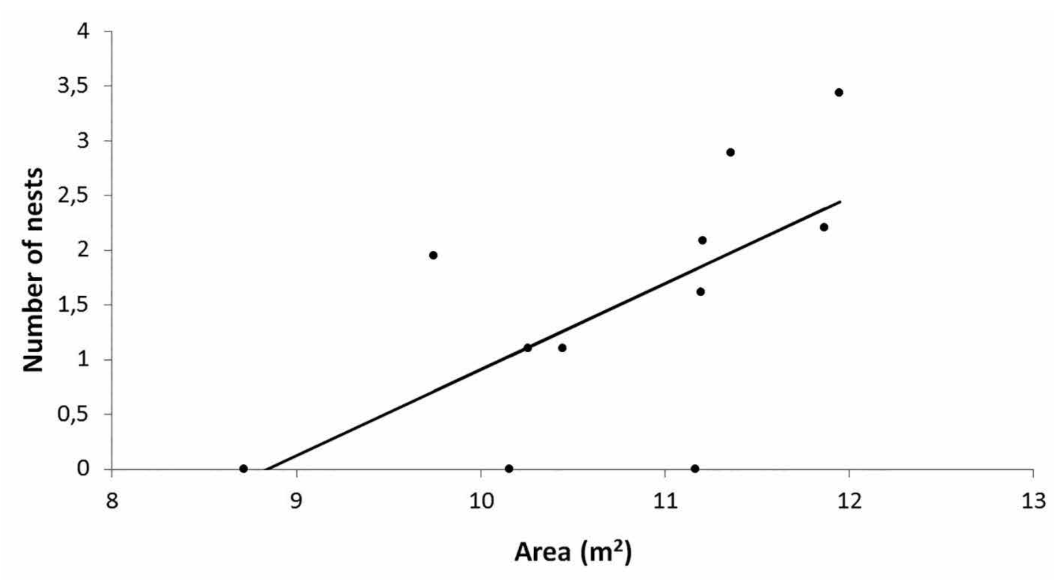

Figure 4. Correlation between the area of Erepecu Lake beaches and the number of nests of *P. sextuberculata* at Erepecu Lake (REBIO-Trombetas; Pará-Brazil).

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 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).

Beach Name	2011	2012
Gorda	1	0
Toró	12	9
Mariazinha	6	18
Cativo	0	3
Cemitério	1	3
Miriam	0	5
Marciana	20	8
Capitari	10	31
Garças	19	7
Camaleão	1	0
Campos	0	0
Total	70	84

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

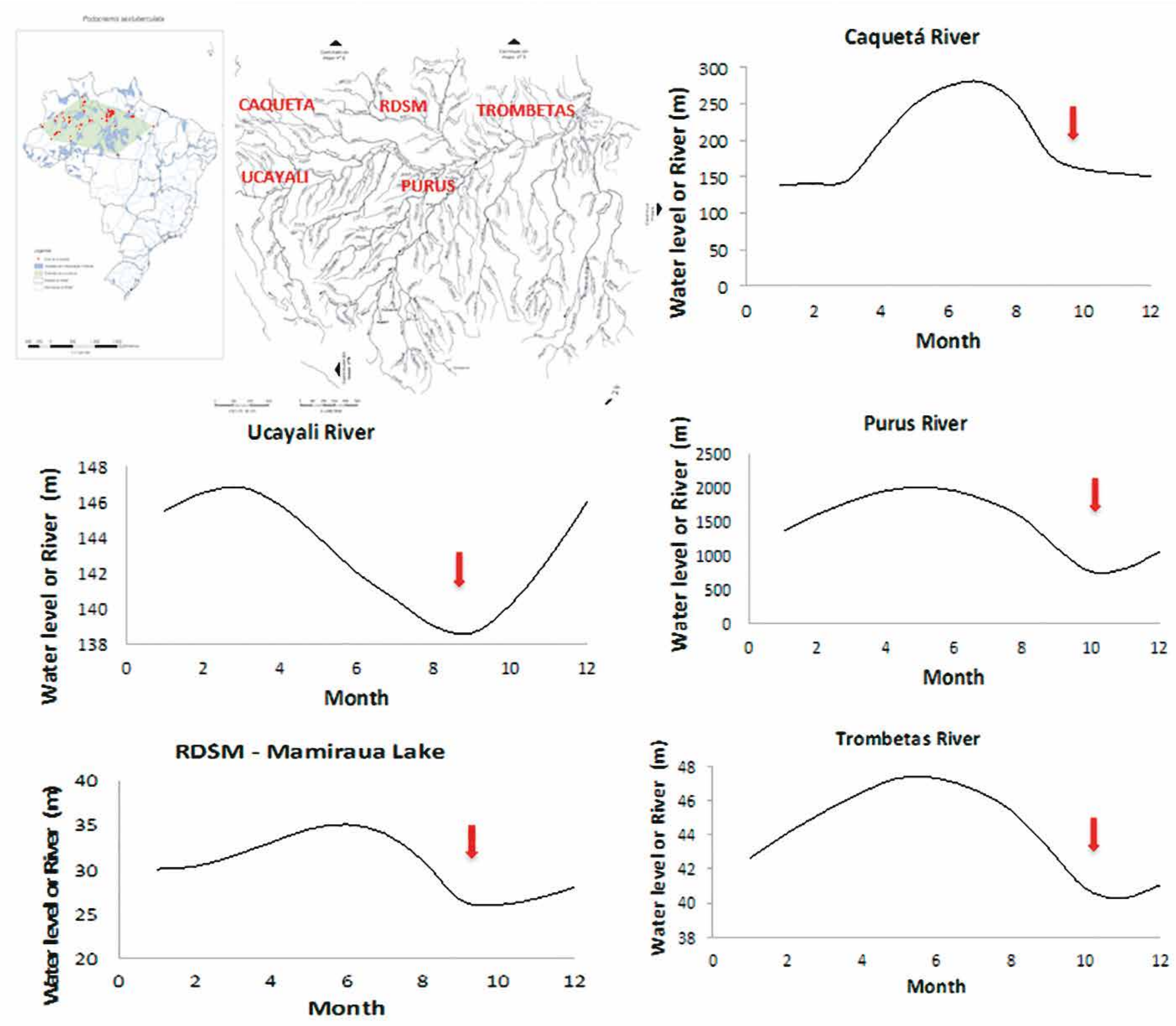

Figure 5. Flood pulse in several basins of the Amazon: Ucayali River (Vogt, 2008; CGTA-PUCALLPA, 2012); Caquetá River (Bermúdez-Romero, 2010; RDSM: Ramalho *et al*., (2009); Purús River (Pantoja-Lima, (2007) and Trombetas River (ICMBio 2012). The red arrows indicate *P. sextuberculata* nesting season.

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 leaded by local inhabitants emphasizing the proper use of natural resources, which may contribute to habitat conservation of the "cupiso" nesting sites.

ACKNOWLEDGMENTS

This study was supported by the project "Tartarugas da Amazônia: Preserving for Future," of the Centro de Estúdios de Quelônios da Amazônia – CEQUA, of the Instituto Nacional de Pesquisas da Amazônia – INPA. Sponsored by Petrobras using the Petrobras Environmental Program. The Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio) provided logistical support. Thanks are due to Virginia Bernardes, Fernanda Rodrigues, Nathalia Goés, Mariel Acácio, Elis Perrone, Michele Souza, Wallace Abreu, Camila Ferrara, María Camila Díaz, Catarina Serra Gonçalves, and Jessica Ramos for help in the fieldwork. *Quilimbolas* of Erepecu Lake are thanked for allowing the development of the study and for their valuable participation.

REFERENCES

Alho CJR, Pádua LFM. Reproductive parameters and nesting behavior of the Amazon turtle *Podocnemis expansa* (Testudinata: Pelomedusidae) in Brazil. Can J Zool. 1982; 60:97-103. Doi: http://dx.doi.org/10.1139/z82-012.

Arzola JF. Humedad y temperatura en nidos naturales y artificiales de tortuga golfina *Lepidochelys olivacea* (Eschssholtz, 1829). Rev Biol Mar Oceanogr. 2007;42(3):377-383.

Bermúdez-Romero AL. Acciones para el Uso y Conservación de la Fauna Acuática Amenazada en la Amazonia Colombiana. Instituto de Investigaciones Científicas Sinchi. Informe interno. Leticia, Amazonas. Colombia; 2010. 389 p.

Bernhard R, Ferrara CR, Waldez F, Vogt RC, Souza R, Thiel RA, Bernardes VCD. Reproductive biology of *Podocnemis unifilis* and *Podocnemis sextuberculata* in Erepecu Lake, Rio Trombetas, Brasil. In: Joint Annual Meeting of the Turtle Survival Allance, Freshwater Turtle Specialist Group. R. Hudson. Tucson. 2012. p. 13.

Bernhard R. Biologia reprodutiva de *Podocnemis sextuberculata* (Testudines: Pelomedusidae) na Reserva de Desenvolvimento Sustentável, Amazonas, Brasil. Programa de Pós-Graduação em Biologia Tropical e Recursos Naturais do convênio INPA/UA, Brasil, Amazonas. Instituto Nacional de Pesquisas da Amazônia, Amazonas. 2001. 52 p.

Bernhard R. Monitoramento de praias de desova de Quelônios no lago Erepecu, Para, Brasil. ICBio. Informe interno. Porto Trombetas, Para. Brasil; 2012. 830 p.

Bull JJ, Vogt RC, Bulmer MG. Heritability of sex ratio in turtles with environmental sex determination. Evolution. 1982;36(2):333-341. Doi: http://dx.doi.org/10.2307/2408052.

Bull JJ, Vogt RC. Temperature-dependent sex determination in turtles. Science 1979; 206:1186-1188. Doi: http://dx.doi.org/10.1126/science.505003.

Ceballos C, Iverson JB, Bernhard R. *Podocnemis sextuberculata* (Cornalia 1849). In: Páez VP, Morales-Betancourt MA, Lasso CA, Castaño-Mora OV, Bock BC, editors. Biología y conservación de las tortugas continentales de Colombia. Serie Editoral Recursos Hidrobiológicos y Pesqueros Continentales de Colombia. Instituto de Investigación de Recursos Biológicos Alexander von Humboldt (IAvH), Bogotá, Colombia; 2012; p. 383-386

Ewert MA, Jackson DR, Nelson CE. Patterns of temperature-dependent sex determination in turtles. J Exp Zool. 1994;270:3-15. Doi: http://dx.doi.org/10.1002/jez.1402700103.

Fachín-Teran A, Vogt RC, Thorbjarnarson JB. Padrões de caca e uso de quelônios na Reserva de Desenvolvimento Sustentável Mamirauá, Amazonas. Brasil. In: Cabrera E, Mercolli C, Resquin R, editors. Manejo de Fauna Silvestre en Amazonia y Latinoamérica. Asunción, Paraguay; 2000. p. 323-337.

Ferreira-Junior PD. Aspectos Ecológicos da Determinação Sexual em Tartarugas. Acta Amazônica. 2009;39(1):139-154. Doi: http://dx.doi.org/10.1590/S0044-59672009000100014.

Ferreira-Junior PD, Castro PTA. Geological control of *Podocnemis expansa* and *Podocnemis unifilis* nesting areas in Rio Javaés, Bananal Island, Brazil. Acta Amazônica 2003;33(3):445-468. Doi: http://dx.doi.org/10.1590/S0044-59672003000300010.

Ferronato B, Morales V. Biology and Conservation of the Freshwater Turtles and Tortoises of Perú. Ircf Reptiles Amphibians. 2012;19(2):103-116.

Flaherty N, Bider JR. Physical structures and the social factor as determinants of habitat use by *Graptemys geographica* in southwestern Quebec. Am Midl Nat. 1984;111:259-266. Doi: http://dx.doi.org/10.2307/2425320.

Folk RL. Petrology of Sedimentary rocks. Hemphill Publication. Auistin, USA; 1974. 182 p.

García N. Biología reproductiva y conservación de las tortugas charapa *Podocnemis expansa*, cupiso *Podocnemis sextuberculata* y taricaya *Podocnemis unifilis* en las playas aledañas al municipio de Puerto Nariño, Amazonas: (Tesis de pregarado). Facultad de Estudios Ambientales y Rurales, Pontificia Universidad Javeriana. 2005. 209 p.

García M. Fatores ambientais relacionados a nidificação de *Podocnemis expansa,* no rio Javaés, entorno do Parque Nacional do Araguaia, Tocantins. Curso de Pós-Graduação em Ciências do Ambiente, Universidade Federal do Tocantins, Universidade Federal do Tocantins, rio Javaés, entorno do Parque Nacional do Araguaia, Tocantins; 2006. 66 p.

González-Zarate A, Montenegro OL, Castaño-Mora OV. Caracterización del hábitat de la tortuga de río *Podocnemis* *lewyana,* en el Río Prado Aguas abajo del embalse de Hidro Prado, Tolima, Colombia. Caldasia. 2011;33(2):471-493.

Goulding M, Barthen R, Ferreira EJG, editors. The Smithsonian Atlas of the Amazon. Smithsonian Institution Press, Washington; 2003. 253 p.

Guisande C. Editor. Tratamiento de datos. Universidad de Vigo. Edición Díaz de Santos edn. Pontevedra, España. 2006. 353 p.

Gysel LW, Lyon LJ. Análisis y Evaluación de Hábitat. In: Manual de Técnicas de Gestión de Vida Silvestre Wildlife Society. Marlyland; 1980. 703 p.

Haller EC, Rodrigues MT. Reproductive Biology of the Six-Tubercled Amazon River Turtle *Podocnemis sextuberculata* (Testudines: Podocnemididae), in the Biological Reserve of Rio Trombetas, Pará, Brazil. Chelonian Conserv Biol. 2006;5(2):1-4. Doi: http://dx.doi.org/10.2744/1071-8443(2006)5[280:RBOTSA]2.0.CO;2.

Ibama. Plano de Manejo, Reserva Biológica do Rio Trombetas, Pará; 2004. 4185 p.

Janzen FJ, Paukstis GL. Environmental sex determination in reptiles. Ecology, evolution, and experimental design. Q Rev Biol. 1991;66:149-179. Doi: http://dx.doi.org/10.1086/417143.

Köppen W. Editor. Climatología. Un estudio de los climas de la tierra. Fondo de Cultura Económica Ciudad de México, Distrito Federal. México. 1984. 366 p.

Mcarthur R, Pianka E. Optimal use of a patchy environment. Am Nat. 1966;100:603-609. Doi: http://dx.doi.org/10.1086/282454.

Morrison ML, Marcot BG, Mannan RW. Wildlife – Habitat relationships. Concepts and Applications, Second edn. The University of Wisconsin. Press, Madison, Wisconsin, Estados Unidos. 1998. 670 p.

Novelle SMH. Caracterização do micro-habitat dos ninhos e predação dos ovos de *Podocnemis erythrocephala* em áreas de desova no rio Ayuanã, Manaus: Programa de Pós-Graduação em Biologia Tropical e Recursos Naturais do convênio INPA/UA, Instituto Nacional de Pesquisas da Amazônia, Amazonas. 2006. 80 p.

NTC77. Norma Técnica Colombiana. In: Método de ensayo para el análisis por tamizado de los agregados finos y gruesos. Editada por el Instituto Colombiano de Normas Técnicas y Certificación (ICONTEC). Bogotá, Colombia; 2007. p. 9-29.

NTC1522. Norma Técnica Colombiana. In: Ensayo para determinar la granulometría por tamizado. Editada por el Instituto Colombiano de Normas Técnicas y Certificación (ICONTEC). Bogotá, Colombia; 1979. p. 45.

Ojasti J. Manejo de fauna Silvestre Neotropical.SIMAB Series No 5. Dalmeier F, editor. Smithsonian Institution/MAB. Washington, DC. EEUU; 2002. 290 p.

Pantoja-Lima J. Aspectos da Biologia Reprodutiva de *Podocnemis expansa* Schweigger, 1812, *Podocnemis sextuberculata* Cornalia, 1849 e *Podocnemis unifilis* Troschel, 1848 (Testudines: Podocnemididae) na Reserva Biológica do Abufari, Amazonas, Brasil. Manaus: Programa de Pós-Graduação em Biologia Tropical e Recursos Naturais do convênio INPA/UA, Instituto Nacional de Pesquisas da Amazônia, Amazonas; 2007. 74 p.

Pezzuti JCB, Vogt RC. Nesting ecology of *Podocnemis sextuberculata* (Testudines, Pelomedusidae) in the Japurá River, Amazonas, Brazil. Chelonian Conserv Biol. 1999;3(3):419-424.

Ramalho EE, Macedo J, Vieira TM, Valsecchi J, Calvimontes J, Marmontel M, *et al*. Ciclo hidrológico nos Ambientes de Várzea da reserva de Desenvolvimento Sustentável Mamirauá–Mádio rio Solimoes, Período de 1990 a 2008. UAKARI. 2009;5(1):61-87.

Roosenburg WM, Haley KL, Mcguire S. Habitat selection and movements of Diamondback Terrapins, *Malaclemys terrapin*, in Maryland Estuary. Chelonian Conserv Biol. 1999;3:425-429.

Rueda-Almonacid JV, Carr JL, Mittermeier RA, Rodríguez-Mahecha JV, Mast RB, Vogt RC, *et al*. Las tortugas y los cocodrilos de los países andinos el trópico, Editorial Panamericana ed. Formas e impresos, Bogotá, Colombia; 2007. 537 p.

Shively SH, Jackson DR. Factors limiting the upstream distribution of the Sabine Map Turtle. Amer Midl Nat. 1985;114:292-303. Doi: http://dx.doi.org/10.2307/2425604.

Silva TJ. Genética da conservação de *Podocnemis sextuberculata* (Testudines, Pelomedusidae, Cornalia, 1849) utilizando a região ND1 do DNA Mitocondrial. Manaus: Curso de pos-graduacao em Genética e Evolução do Centro de Ciências Biológicas e da saúde, Universidade Federal De São Carlos. São Carlos, São Paulo, Brasil 2002. 63 p.

Silva TJ, Monjeló LAS; Viana MNS, Pezzuti JC, Andrade PCM.; Vogt RC, *et al*. Population genetics analysis of *Podocnemis sextuberculata* (Testudines, Podocnemidae): lack of population structure in the central Amazon Basin. Genet Mol Res. 2011;10(3):1393-1402. Doi: http://dx.doi.org/10.4238/vol10-3gmr1163.

Soini P. Reproducción, abundancia y anidación de quelonios acuáticos en La Reserva Nacional Pacaya-Samiria, Perú. Folia amazónica. 1996;8:147-161.

Vogt RC, editor. Tartarugas da Amazônia, Edição geral Walter H edn. Wust. Lima, Peru. 2008. 104 p.

Vogt RC, Bull J. Ecology of hatchling sex ratio in map turtles. Ecology. 1984;65:582-587. Doi: http://dx.doi.org/10.2307/1941420.

Weisrock DW, Janzen FJ. Thermal and fitness-related consequences of nest location in Painted Turtles (*Chrysemys picta*). Funct Ecol. 2000;34(3):94-101.