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Population Structure of *Podocnemis expansa* (Testudines: Podocnemididae) in Southern Brazilian Amazon

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Detailed studies of the population structure of most species of turtles in the Amazon Basin are lacking throughout their range. We estimated sex ratio, size structure, relative abundance, and recapture index for the Giant South American River Turtle (*Podocnemis expansa*) in Javaés River, southern Brazilian Amazon. Field work was conducted between 2004 and 2009, and comprised a total sampling effort of 368 hours in 92 sampling days. Turtles were captured by diving and seining. A total of 645 individuals (156 adult males, 109 adult females, and 380 juveniles) were captured and marked, but only five were recaptured. Carapace length showed a unimodal pattern for males, but no clear pattern for females. The population consisted predominantly of adult males and young females, with a sex ratio of 1.4:1 (M:F). Relative abundance varied from 0–5.5 animals/h depending on the capture method employed. Most animals (73.7%) were concentrated in a single location on the river (1 km out of 40 km sampled) during the study period. Population monitoring on a long-term basis will be necessary to identify the real population structure, evaluate poaching pressure, and to support the conservation project which has been ongoing since 1985 in the area.

DECLINES in populations of *Podocnemis* in many parts of South America (Smith, 1979; Johns, 1987; Ojasti, 1995) led the governments of different countries to implement conservation programs. Among the main conservation practices are nest protection and egg translocation from natural to protected areas (IBAMA, 1989; Soini, 1997). These initiatives have been undertaken for more than three decades without evaluating the effects of these programs on sex ratio, density, and population structure (Fachín-Terán et al., 2003).

Information on turtle population ecology in Brazil is scarce for many species (Fachín-Terán et al., 2003; Vogt, 2008; Bernhard and Vogt, 2012), especially when considering the threat of human poaching practices for turtles in the Amazon (Kemenes and Pezzuti, 2007). Information about density, dispersion, population structure, and sex ratio is needed for the Amazonian turtle (*Podocnemis expansa*) in order to successfully manage this species (IBAMA, 1989). *Podocnemis expansa* is the largest freshwater turtle in South America (Pritchard and Trebbau, 1984) and represents an important food and socioeconomic resource for riverine and indigenous peoples of the Amazon Basin (Klemens and Thorbjarnarson, 1995). Lack of population data makes it difficult to determine the current status of *P. expansa,* thus limiting effective implementation of management actions and conservation practices.

Most studies that have been published on *Podocnemis* revolve around aspects of their reproductive biology (for reviews see Rueda-Almonacid et al., 2007 or Vogt, 2008, 2012). Knowledge of the conservation status of Amazonian turtle populations is still needed, not only for Brazil but for all countries included in the Amazon Basin (Vogt, 2008). Population studies have been conducted on all Amazonian species: *Podocnemis expansa* (Bataus, 1998; Hernández and Espín, 2006; Mogollones et al., 2010), *P. sextuberculata* (Fachín-Terán et al., 2003), *P. unifilis* (Fachín-Terán and Vogt, 2004; Ataídes, 2009), *P. erythrocephala* (Bernhard and Vogt, 2012), and *Peltocephalus dumerilianus* (De la Ossa and Vogt, 2011). Although there are some population studies focusing on *P. expansa*, like our study, they are restricted to a stretch of one river, and the main populations of this widely distributed species remain to be studied. In order to fill the gaps in knowledge on Amazonian turtle population ecology, the objectives of our study were to determine: (1) sex ratio, (2) relative abundance, and (3) recapture index for a population of *P. expansa* in a portion of the Javaés River in the southern Brazilian Amazon.

MATERIALS AND METHODS

Study area.—Field work was conducted in the Parque Nacional do Araguaia (Ilha do Bananal), in a 50 km (approximate) stretch of the Javaés River (Tocantins State; coordinates: 9°50′–11°10′S and 49°56′–50°30′W, Datum = SAD69) in the southern Brazilian Amazon (Fig. 1). The local ecosystem is well preserved (natural vegetation is intact and there is no evidence of pollution from cities or industry), and the area is a complex ecotone that includes elements from Cerrado, Amazon, and Pantanal (SEPLAN, 2001). The site is located between two protected areas of the Brazilian Amazon: Parque Nacional do Araguaia and Área de Proteção Ambiental da Ilha do Bananal/Cantão. The climate is tropical wet and dry (Peel et al., 2007) with two well marked seasons: a hot and wet period from November to April (rainy season) and a hot and dry period from May to October (dry season). Annual rainfall is around 1750 mm and mean annual temperature is about 24°C, remaining almost constant throughout the year (Ferreira Júnior, 2003). Mean water levels for sampling period were acquired at the nearby weather station (Barreira da Cruz, 10°34′S and 49°56′W,

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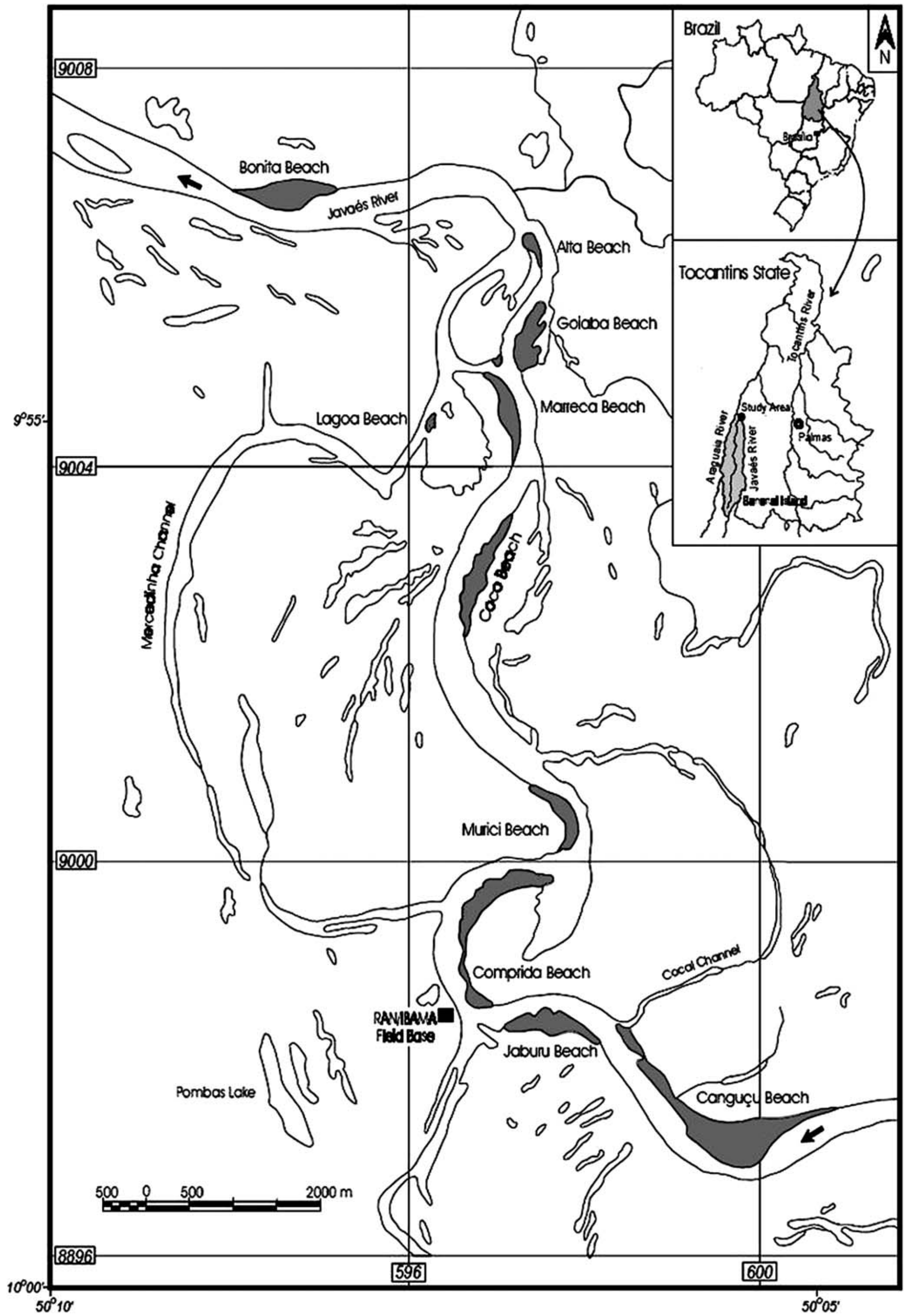

Fig. 1. Study area in the Javaés River at the northern part of Ilha do Bananal, Tocantins State, Brazil. Elaborated by P. D. Ferreiras, Jr.

Datum = SAD69) and available at the website of the National Water Agency (ANA; http://hidroweb.ana.gov.br/).

Field procedures.—Sampling was conducted from August to November (reproductive season) in 2004, 2005, 2006, 2008, and during March and June (non-reproductive season) in 2005, 2006, 2007, 2009, totaling 23 samplings (16 during reproductive season and seven during non-reproductive season) with four days per sampling. Captures were taken during daylight (between 0900 h and 1700 h) with a mean of effort of 4 hours/day. In June 2009 there was no field work.

Turtles were caught by two methods: 1) diving and actively capturing by hand in shallow parts of the river (up to 2 m deep) and 2) net seining using two boats with 25 HP outboard motors (Auricchio and Salomão, 2002; Vogt, 2012). Seines were approximately 35 m long, 3 m high, and had a 20 cm stretched mesh size. Netting was made with braided nylon (diameter #18). Capture procedures were performed by three persons in each boat (a pilot and two researchers), and sampling efforts were the same for all months during the study period. A total of 205 hours were spent capturing turtles by seining and 153 hours by diving. Animals were individually marked by drilling and affixing plastic tags in the marginal scutes (adapted from Cagle, 1939). Hatchlings were not included in the sampling, and turtles collected by net seining were limited to 20 cm of carapace width (or larger) because of the netting mesh size.

Turtles were sexed by the shape of the anal scute notch in the plastron (V-shaped in females, U-shaped in males) and size of the base of the tail, which is relatively larger and wider in males (Pritchard and Trebbau, 1984). Curved carapace length (CL), carapace width (CW), plastron length (PL), and plastron width (PW) were measured with a metric tape (to the nearest 1 mm) and body mass (BM) was determined with a Pesola scale (to the nearest 100 g). After being marked, having the mark dosed with iodine, and being measured, the turtles were released at the site of capture between two and three hours later.

Population parameters.—Sex ratio was defined as the male: female proportion in a sample. According to Gibbons (1990), functional sex ratio should be calculated based on individuals that have reached sexual maturity. For *P. expansa* this occurs at approximately 50 cm carapace length (CL) in females, based on the minimum size of nesting females in our area (Portelinha et al., 2013; IBAMA, pers. comm.) and 40 cm in males, based on mature individuals captured in the high Araguaia Basin (Bataus, 1998). Thus, we established two size structures based on CL: adults (females $\geq$ 50 cm and males $\geq$ 40 cm) and juveniles (females $<$ 50 cm and males $<$ 40 cm). To represent the size structure, we graphed the distribution of the size frequencies (based on CL) separated by intervals of 5 cm. A capture rate (based on sampling effort in hours) for each capture method was used to calculate relative abundance (Fachín-Terán et al., 2003).

To evaluate how turtles were distributed throughout the study area we performed monthly systematic focal sampling in transects covering approximately 40 km of the Javaés River between July 2008 and March 2009. Visual counts were made by two persons (pilot and a researcher) with the boat moving at a rate of 3 km/h. A total of 40 transects were surveyed every month, each consisting of 1000 m stretch of river. The visible area for counting was 50 m on each side of the boat, and the starting point was randomly chosen. Focal samplings were performed between 1600 h and 1800 h, a period with lower sunlight intensity which facilitates counts, and only the turtles that came to surface to breathe were recorded.

Statistical analysis.—We used a chi-square test (χ^2) to compare the number of turtles captured between sampling years and capture methods, size structure among sampling years, and number of turtles visualized among months with focal sampling. We performed a chi-square test (Magnusson and Mourão, 2005) for capture methods using sampling effort (number of sampling hours). Normality and homoscedasticity of data were tested with Shapiro-Wilk and Levene tests, respectively. A nonparametric Kruskall-Wallis test was used to determine differences among sampling years and between capture methods with respect to the size measurements, to test if different sized turtles were favored by one sampling method. Biomass was calculated by two methods: total summed mass (kg) of all turtles, and mean body mass of captured turtles per km of linear river (kg/km). Statistical analyses were performed using InfoStat software (Grupo InfoStat, FCA, Universidad Nacional de Córdoba; http://www.infostat.com.ar).

RESULTS

Captures.—We captured and marked 645 *P. expansa*, only five of which were recaptured (0.7% recapture rate). Of these, 534 were captured during the reproductive season (low water season, dry period) and 111 during the non-reproductive season (high water season, wet period; Table 1; Fig. 2). We captured more turtles in consecutive years of the study during the reproductive seasons but not during the non-reproductive seasons (Fig. 3). For all study periods, seining net was the best capture method (χ^2 = 105.3, df = 1, $P < 0.001$; seining: 498 turtles, diving: 147).

Most turtles (n = 450, 69.7%) were captured in deep ($\approx$3–4 m) and slow current areas with presence of riparian vegetation. However, turtles were also captured (n = 87, 13.5%) in shallow areas ($\approx$1 m) with rapid current and near nesting beaches.

Biometric data.—Mean curved carapace length (CL) for juvenile females was 30.6±9.5 cm (range: 23.2–49.1 cm; n = 270) and 64.7±7.1 cm (range: 50–77 cm; n = 109) for adults. Mean weight of juvenile females was 3.4±2.7 kg (range: 0.1–11.5 kg; n = 270) and 24.7±7.8 kg (range: 10.5–40 kg; n = 109) for adults. Mean curved carapace length (CL) for males was 41.9±5.7 cm (range: 26-55.9 cm; n = 266) and mean weight was 6.6±2.6 kg (range: 1.6–15.5 kg; n = 266). Total biomass and mean biomass per linear km for *P. expansa* in our area were 3578.6 kg and 89.4 kg/km, respectively. Carapace length of turtles captured during the reproductive season in 2005 was shorter than CL measured in the other years (H = 90.59, df = 3, $P <$ 0.001), which may reflect a higher capture rate of juveniles during the 2005 sampling year (χ^2 = 18.27, df = 3, $P <$ 0.001). On average, turtles captured by seining (45.2± 11.9 cm CL, n = 498) were larger than those captured by diving (27.0±11.7 cm CL, n = 147; H = 211.60, df = 1, $P <$ 0.001).

Sex ratio and size structure.—Of the 645 turtles captured, 41.1% (265 individuals) were mature ($\geq$50 cm CL for females and $\geq$40 cm CL for males), including 156 males and 109 females. We observed a male-biased sex ratio of 1.4:1 (M:F; χ^2 = 8.33, df = 1, P = 0.004). Only in 2007 was the sex ratio for mature individuals female-biased (Table 2). Most turtles captured (58.9%) were juveniles (χ^2 = 20.50, df = 1, $P < 0.001$), with a female-biased sex ratio in all years (Table 2).

We found no differences between number of males and females (χ^2 = 0.03, df = 1, P = 0.857) or juveniles and adults (χ^2 = 0.12, df = 1, P = 0.719) caught by seining (Table 2). However, when sex ratio was tested according to size structure, net seining had a higher capture rate of adult males (χ^2 = 12.25, df = 1, $P < 0.001$) and juvenile females (χ^2 = 8.80, df = 1, P = 0.003). Diving showed a higher tendency to capture females (χ^2 = 80.82, df = 1, $P < 0.001$) and juveniles (χ^2 = 102.91, df = 1, $P < 0.001$).

Size structure (based on CL) presented a unimodal pattern for males. Females did not show a well-marked pattern but were often found in the 30 cm size class (Fig. 4A). Size structures for each sampling year and capture method are presented in Fig. 4. Although we used two capture methods, turtles smaller than 10 cm were not caught.

During field work conducted in the reproductive season (2004 and 2008), we found an adult-biased population (57.4 and 54.3%, respectively). Results from field work conducted

Table 1. Number of *P. expansa* captured during reproductive (August–November) and non-reproductive (March and June) seasons, date of lowest water level, and relative abundance (number of turtles per hour) related to capture method between 2004 and 2009 in the Javaés River, Brazil.

Year/Season	Sampling period (days/month)	Date of lowest water level (day/month)	Capture method: Net seining	Capture method: Diving	Total	Relative abundance: Net seining	Relative abundance: Diving
2004/Reproductive	17–20/08	11/08	1	0	1	0.2	0.0
	19–22/09	22/09	8	0	8	1.3	0.0
	25–28/10	13/10	14	1	15	2.2	0.2
	15–18/11	02/11	68	2	70	10.9	0.4
2005/Non-reproductive	22–25/03	05/03	2	4	6	0.2	0.4
	08–11/06	30/06	5	18	23	0.4	2.0
2005/Reproductive	23–26/08	31/08	0	2	2	0.0	0.4
	06–09/09	18/09	7	11	18	1.0	2.0
	24–27/10	19/10	42	50	92	6.2	9.1
	14–17/11	01/11	5	3	8	0.7	0.5
2006/Non-reproductive	27–30/03	01/03	2	0	2	0.2	0.0
	14–17/06	30/06	6	8	14	0.6	1.1
2006/Reproductive	09–12/08	09/08	9	1	10	1.4	0.2
	25–28/09	18/09	27	0	27	4.3	0.0
	21–24/10	03/10	41	2	43	6.6	0.4
	19–22/11	01/11	61	8	69	9.8	1.5
2007/Non-reproductive	18–21/03	01/03	9	2	11	0.7	0.2
	12–15/06	30/06	13	15	28	1.0	1.5
2008/Reproductive	18–21/08	30/08	32	5	37	4.0	0.9
	16–19/09	25/09	63	8	71	7.9	1.4
	07–10/10	29/10	23	2	25	2.9	0.3
	27–30/11	05/11	33	5	38	4.1	0.9
2009/Non-reproductive	16–19/03	01/03	27	0	27	1.1	0.0
Total	–	–	498	147	645	–	–

during non-reproductive season (2007 and 2009) showed a juvenile-biased population (87.2 and 92.6%, respectively). Finally, captures during reproductive and non-reproductive seasons (2005 and 2006) also showed a juvenile-biased population (77.8 and 52.7%, respectively). However, we found a common pattern for almost all years sampled (except in 2009): most males (≈80%) belonged to size classes 35, 40, and 45 cm.

Relative abundance and spatial distribution.—The relative abundance of *P. expansa* (number of captured turtles/sampling hour) varied with both capture method and year

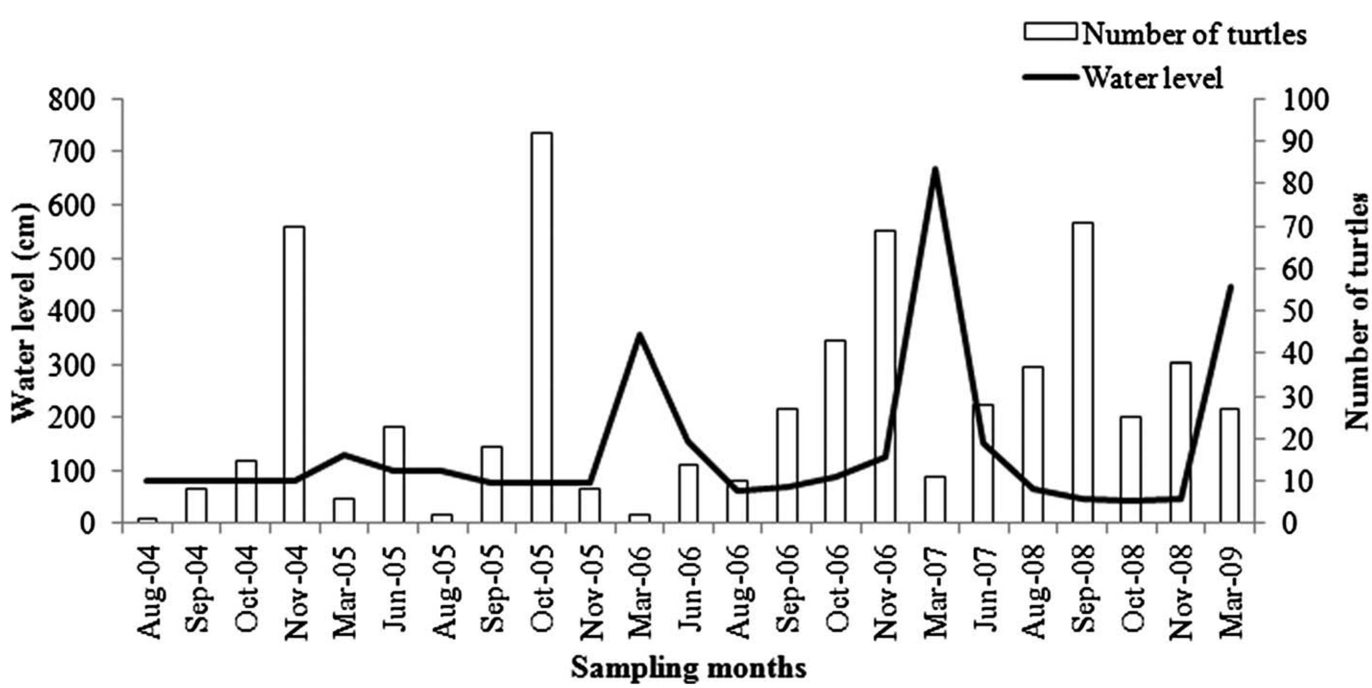

Fig. 2. Number of *P. expansa* captured and mean water level (cm) of the Javaés River (Brazil) during sampling months between 2004 and 2009.

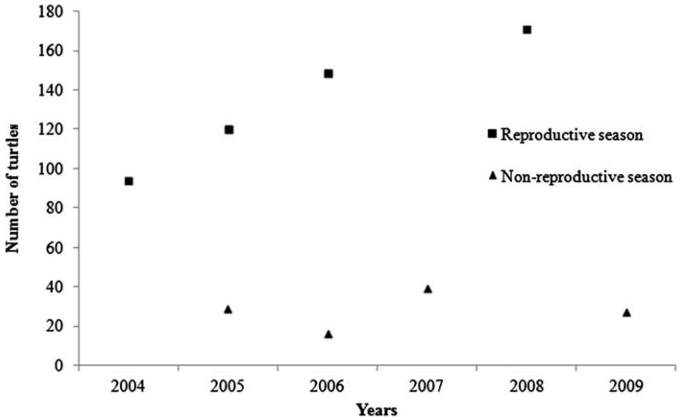

Fig. 3. Number of *P. expansa* captured in the Javaés River (Brazil) during the reproductive and non-reproductive seasons.

of capture (Table 1). The highest value for net seining was recorded during the reproductive season of 2004 (10.9 turtles per hour), and the lowest abundance rate (0 turtles per hour) was recorded during the reproductive season of 2005. For the diving method, the highest abundance was observed in the 2005 reproductive season (9.1 turtles per hour) and the lowest in the 2004 and 2006 reproductive seasons, and in the 2006 and 2009 non-reproductive seasons (0 turtles per hour).

More individuals were counted during systematic focal sampling in September and October than in the other months ($\chi^2 = 693.51$, df = 8, $P < 0.001$), and constituted as much as 54.2% of the total found in a given year. Most animals (73.7%) were concentrated in a single location on the river (1 km out of 40 km sampled). Turtles in one transect (convergence of ''Comprida'' beach; Fig. 1) always represented more than 55% of the total observed in each sample.

DISCUSSION

Captures and biometric data.—We found a large difference in number of captured turtles during reproductive ($n = 534$) and non-reproductive ($n = 111$) seasons. This is probably associated with a larger concentration of turtles close to nesting beaches during the nesting season, and also the period of the lowest water level, which allowed an increase in number of captures (Fachín-Terán and Vogt, 2004; Vogt, 2008). In addition, the higher water levels during non-reproductive seasons allowed turtles to use different habitats such as adjacent lakes (Alho et al., 1979). Conducting field work during the high water level period, even though there is a reduced capture rate, should be considered because it allows researchers to access shallow parts of the river that were not accessible during the reproductive season. Field work during high water periods would allow researchers to develop different studies (i.e., diet preference) and to investigate seasonal variations in biology of *P. expansa*.

Hernández and Espín (2006) observed a decrease in the capture rate of *P. expansa* in Venezuela. Even with an increase in sampling effort, these authors reported a variation ranging from 3.7–1.2 individuals (100 m of trammel net) per year (after three years of sampling). They suggested that this capture rate reduction could be a result of differences in sampling methods and hunting activities by local inhabitants. Although we used the same sampling methods and effort throughout the years, we also found variation in number of captures. This variation in captures could be explained by migration of the turtles to other areas for feeding (Alho and Pádua, 1982).

The sampling method used can potentially generate biases in data collection (Moll and Legler, 1971). In this sense, some studies have shown that the combined use of multiple techniques during sampling can correct these deficiencies (Ream and Ream, 1966; Dunham et al., 1988). In the present study, we employed two sampling methods: net seining and diving. Net seining allowed a higher capture rate of adult males and juvenile females, while diving favored the capture of juvenile females. Other methods, such as barbless fishhooks (Bataus, 1998) or trammel nets (Vogt, 2012), could be an alternative to increase captures of adult females. The main limiting factor for the diving method is the difficulty in viewing turtles in waters deeper than 2 m (poor visibility related to the water turbidity). In addition, the use of net seining in areas shallower than 3 m is complicated because nets could become entangled in branches or trees on the river bottom.

We observed that deep areas with slow currents are the habitats preferred by *P. expansa*, although a smaller number of individuals can also be seen (and caught) in shallow areas (≈1 m) with more rapid currents close to nesting beaches, as observed for *P. unifilis* (Fachín-Terán and Vogt, 2004). Low

Table 2. Sex ratio of *P. expansa* for each studied year and capture method employed for the Javaés River, Tocantins State, Brazil. Sex ratio: number of males/number of females; *n*: number of captured turtles.

	Juveniles				Adults			
Year	♂	♀	*n*	Sex ratio	♂	♀	*n*	Sex ratio
2004[a]	13	27	40	0.5	30	24	54	1.2
2005	19	97	116	0.2	23	10	33	2.3
2006	36	51	87	0.7	40	38	78	1.1
2007[b]	8	26	34	0.3	2	3	5	0.6
2008[a]	27	51	78	0.5	60	33	93	1.8
2009[b]	7	18	25	0.4	1	1	2	1.0
Net seining	96	149	245	0.6	151	102	253	1.4
Diving	14	121	135	0.1	5	7	12	0.7
Total	110	270	380	0.4	156	109	265	1.4

[a] Captures only during reproductive season.
[b] Captures only during non-reproductive season.

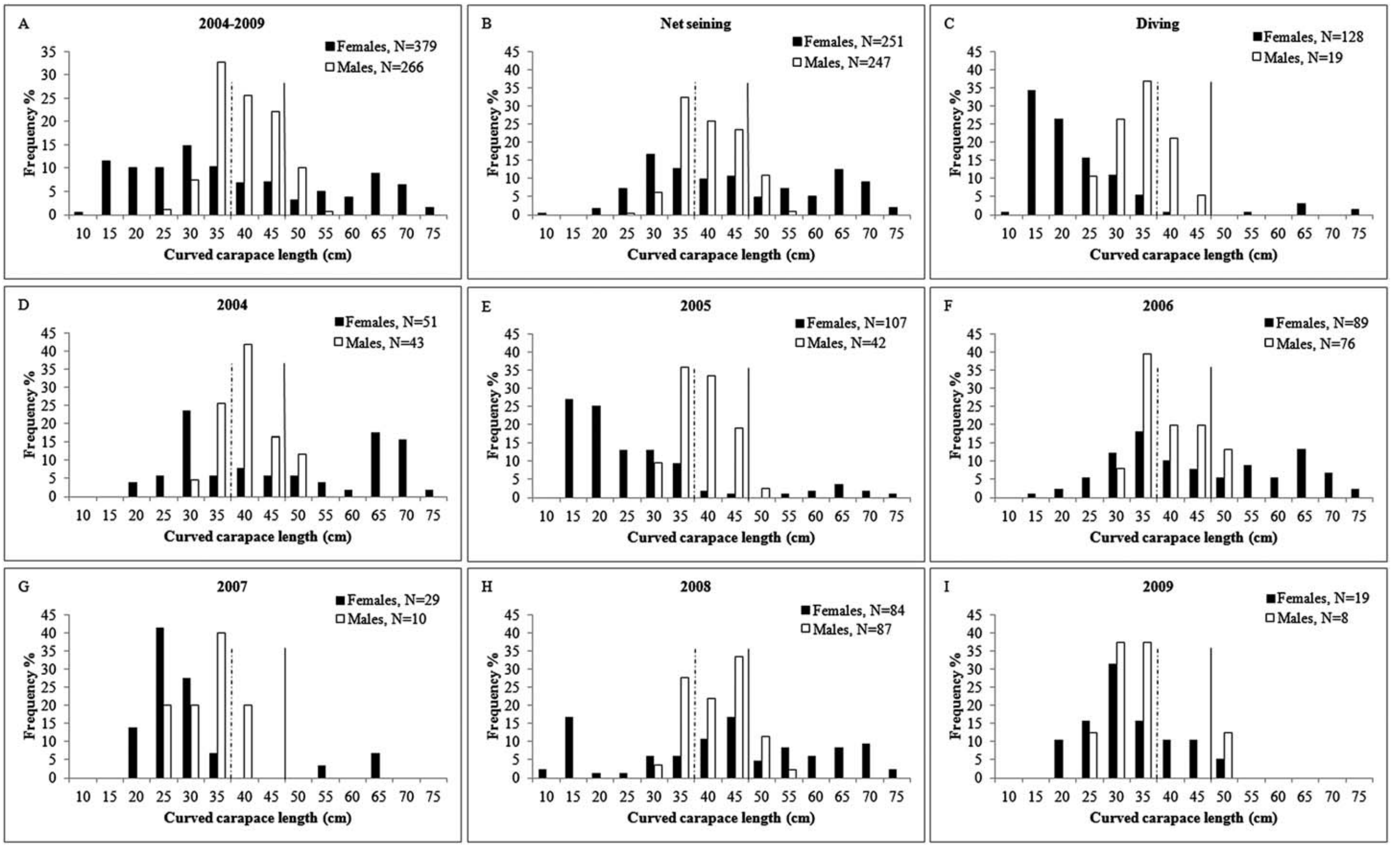

Fig. 4. Curved carapace length of *P. expansa* captured in the Javaés River in southern Brazil. (A) All sampled years; (B) net seining; (C) diving; (D) 2004; (E) 2005; (F) 2006; (G) 2007; (H) 2008; (I) 2009; dashed lines show the beginning of sexual maturity for males and continuous lines for females.

number of recaptures was probably associated with wide migratory routes of this species (Vogt, 2008) or could indicate that we captured a small amount of individuals in relation to the total population size. A similar pattern has been reported for other Amazonian species with a recapture rate of less than 9% (Fachín-Terán et al., 2003; Fachín-Terán and Vogt, 2004; Ataídes, 2009). However, for a sample of 4432 turtles, Bernhard and Vogt (2012) showed higher recapture rates (between 6.2 and 21.3%) for a population of *P. erythrocephala* captured mainly with trammel nets on the Negro River Basin.

In the present study, mean CL for adult females (64.7±7.1 cm) was similar to results reported by Alho and Pádua (1982) and Cantarelli (2006) (66.0±3.0 cm and 64.0±3.9 cm, respectively), and smaller than that observed by Soares (2000; 73.4±3.6 cm). However, mean CL for males in our study (41.9±5.7) was similar to results obtained by Bataus (1998; 39.6±4.1 cm). Differences in mean CL for adult females compared to that presented by Soares (2000) could reflect a simple variation in body size between two distinct populations (i.e., latitudinal variation; Litzgus and Mousseau, 2006) or be due to hunting pressure (Velasco and Ayarzaguena, 1995).

Sex ratio and size structure.—Some studies have described a female-biased sex ratio for *P. expansa* in the Brazilian (Danni and Alho, 1985), Colombian (Valenzuela et al., 1997), and Venezuelan Amazon (Hernández and Espín, 2006; Mogollones et al., 2010; Peñaloza et al., 2013). However, we observed a functional male-biased sex ratio (based only on mature turtles; χ^2 = 8.33, df = 1, P = 0.004). Sex ratio deviations found in turtle populations could be explained by differential sex ratio at hatching due to temperature controlled sex determination, physical characteristics of nests, movement and migration between genders, poaching, and variation in mortality and survivorship rates of males and females (Gibbons, 1990; Lovich and Gibbons, 1990). Therefore, besides the factors mentioned above, for comparison and interpretation of such results, the capture method, season, sampling location, and effort should always be considered because all of these variables could also influence the calculated sex ratios.

Populations with high hatchling mortality and high fecundity, as in the case of turtles, should present a stable demographic structure consisting of a large number of adults (Pielou, 1977). As suggested by Gibbs and Amato (2000), we observed a population composed predominantly by juveniles in the present study (58.9%). A higher rate of juveniles of *P. expansa* was also observed by Hernández and Espín (2006) and Mogollones et al. (2010) in Venezuela. However, it should be considered that Hernández and Espín (2006) evaluated the effects of a conservation program after the release of more than 86,000 juveniles bred in captivity, which could explain the bias for this size group.

The only demographic data sets for *P. expansa* are the studies conducted by Bataus (1998) in Brazil and by Hernández and Espín (2006) and Mogollones et al. (2010) in Venezuela. This lack of knowledge about the conservation status of this species, not only in Brazil but for its entire distribution, makes management activities difficult. Therefore, we emphasize the importance of studies like ours and encourage similar studies in other locations in the Amazon. Such studies should access the current conservation status of populations of *P. expansa* and infer the effectiveness of conservation projects, as in the case of the ''Projeto Quelônios da Amazônia,'' which has been ongoing for more than three decades in the Brazilian Amazon (IBAMA, 1989).

In years when sampling occurred only during the reproductive season (2004 and 2008), the population was characterized by a high number of adults, and in years with sampling only during the non-reproductive season (2007 and 2009), the data reflect a higher proportion of juveniles. As mentioned previously, this variation can be explained by the fact that adults leave the river and go to lakes and flooded areas to feed during the non-reproductive season (Alho et al., 1979; Vogt, 2008), and at the beginning of the reproductive season they migrate back to the river searching for nesting areas (Fachín-Terán et al., 2003). The absence of males in the 10–25 cm size classes may be evidence that these animals are using different habitats than the rest of the population, as observed by Fachín-Terán and Vogt (2004) for another species of *Podocnemis*.

During field sampling, some local fishermen mentioned a change in the turtle poaching behaviour that is currently practiced in the region. They reported that in the last few years (starting ≈2005) there was a change in preference from adult females (≥50 cm CL) to juveniles (between 20 and 35 cm CL), as these individuals are easier for trading and transporting inside the riverine cities. However, it should be mentioned that the turtle poachers are catching the size classes that are most abundant in the population at our study site (juveniles), and it could mean that they are catching whatever they can easily catch. Although our results did not show a population reduction, this information should be considered by environmental organizations during enforcement activities. Pantoja-Lima et al. (2014) reported interesting and useful information about the chain commercialization of *Podocnemis* spp. turtles in the Purus River (Amazon basin), showing the consumption in urban areas and the importance of those animals for subsistence of riverine people (economy and food). A preference for consuming juveniles of *P. expansa* (between 14 and 32 cm CL) was also observed by Hernández and Espín (2003) and Peñaloza et al. (2013) in Venezuela. Hernández and Espín (2003) reported that 94.5% (218 individuals) of harvested turtles were juveniles.

Changes in the poaching habits of *P. expansa* are of great ecological importance for medium and long-term population stability. Higher extraction rates of juveniles compromise an entire generation and recruitment of individuals in the future, which will lead to a population decline. This is even more critical in turtles, as they are long-lived animals requiring several years to reach sexual maturity, especially in the case of *P. expansa*, which takes 11–28 years (Mogollones et al., 2010). Therefore, a greater pressure on juveniles could lead to a long-term population decline for *P. expansa* in Javaés River, and possibly within a few years, one could find remarkably different results from those described here.

Relative abundance and spatial distribution.—As reported by Alho et al. (1979) and Bataus (1998), we found higher relative abundance rates in the river during months with the lowest water level (reproductive season). During non-reproductive season, relative abundance rates were lower (reaching 0 turtles/hour), showing that an increase in the water level could interfere with captures or reduce the number of animals in the river, allowing them to access other areas, as previously reported (Fachín-Terán and Vogt, 2004). During the visual counts, we also observed more turtles during the reproductive season (September, $n = 261$ and October, $n = 186$) than during the non-reproductive season (March, $n = 7$ and April, $n = 13$). Seasonal variation in abundance rates was also observed by Ataídes (2009) and Norris et al. (2011) for *P. unifilis*.

The fact that most turtles (73.7%) were observed in only one transect (convergence of ''Comprida'' beach; Fig. 1) represents a reproductive congregation of *P. expansa* where they copulate, ovulate, nest, and wait for hatchling emergence (IBAMA, 1989). Turtles concentrate in areas with similar characteristics (slow stream and deep waters near nesting beaches) during nesting throughout the range of this species in Brazil for mating and protection via group behavior. A clumped distribution was also described by Restrepo et al. (2008) after observing individuals of *Podocnemis lewyana* basking on shorelines of the Magdalena River (Colombia).

Diurnal counts (systematic focal sampling) of turtles that come to the surface to breathe should work as a simple and low-cost method for quick surveys of populations of *Podocnemis* because the highest values found in sampling can be considered as the minimum size of the population (Townsend et al., 2005). The fact that we were able to capture 645 individuals with only five recaptures suggests that counting turtles from the boat clearly underestimated population size. Protection and conservation of new areas considering the entire habitat heterogeneity (i.e., river, surrounding lakes, riparian vegetation, and nesting beaches) are extremely important for the long-term stable persistence of this species. Moreover, attention should also be given to protect areas with the characteristics mentioned above because large concentrations of *P. expansa* remain for long periods (almost six months) in these places, and these habitats are therefore a potential target for poaching.

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