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Population structure and allometry of *Podocnemis unifilis* (Testudines, Podocnemididae) in a protected area upstream Belo Monte dam in Xingu River, Brazil

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ABSTRACT

Amazon river turtles are increasingly threatened by habitat loss and alteration due to the Brazilian energy policy based on construction of hydroelectric dams, meanwhile, populational studies remain scarce. We described the population structure, and established body allometric relationships of *Podocnemis unifilis* in the Terra do Meio Ecological Station in the Iriri River, tributary of the Xingu River upstream the Belo Monte dam under construction. Turtles were captured by hand net and diving in 2012 and 2013 dry seasons, and 2013 rainy season. A total of 728 males, 296 females and four juveniles were captured. Adult sex ratio was male-biased by 9.15♂:1♀. Females were significantly larger than males. Mean straight carapace length was 268.9 ± 46.7 mm (165 – 403) for females; and 232.7 ± 24.8 mm (167 – 303) for males. The sexes were morphologically distinct in function of a proportionally larger plastron, and higher carapace, on females. Allometric relationships between straight carapace length and other morphometric traits were strong for males (R^2 *range* = 0.87 - 0.96*)* and females (R^2 *range* = 0.79 - 0.98*)*. Exploitation of *P. unifilis* in biomass extirpated from the Middle Xingu River may be estimated from body parts found post-consumption by the presented regressions.

Key words: Amazon, clear water river, length-weight relationship, sex ratio, tracajá.

INTRODUCTION

River turtles have been consumed by indigenous people as a food source since pre-colonial times in the Amazon region (Bates 1863, Johns 1987). The intense commercial consumption after European colonization has led *Podocnemis* populations to a drastic decline, especially the largest Amazon turtle *Podocnemis expansa* (Schweigger, 1812), which has increased the pressure on the smaller species *Podocnemis unifilis* (Troschel, 1848) (Mittermeier 1975, Smith 1979, Johns 1987). Since then, *P. unifilis* continues to be widely consumed and traded in the Amazon region (Rebêlo and Lugli 1996, Fachín-Terán et al. 2004, Pezzuti et al. 2010). Nowadays, besides intense poaching, turtle

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populations have been increasingly threatened by the establishment of multiple hydroelectric dam complexes in the Amazon rivers (Ferreira et al. 2013). Hydroelectric dam complexes are amongst the main causes of habitat loss and destruction of aquatic ecosystems, and are a priority for Brazilian government policies for the Amazon region. The river impoundment by dams turns natural lotic habitats into lentic ones, a habitat alteration that may affect turtle populations in many ways. Riverine habitat is flooded (Ferreira et al. 2013) and it affects the availability of nesting, nursery, and feeding areas, and may also interfere on movement patterns of migratory species and fragment river turtle populations (Moll and Moll 2004, Tucker et al. 2012). Alteration of temperature in nesting areas may influence the population structure of species whose sex is determined by the incubation temperature, such as *P. unifilis* (Souza and Vogt 1994). The Belo Monte dam hydroelectric complex is planned to be the third largest hydroelectric power station of the world regarding installed capacity and the largest entirely Brazilian one. It is more complex than only one dam in the main river since it includes a water diversion from the main channel to feed an artificial reservoir which will include another dam (ANEEL 2010). Therefore, downstream of the first dam, the river channel will keep the dry season water level all year round and will no longer be seasonally flooded as per the natural flood pulse of the Amazon rivers (Junk et al. 1989). It may severely affect the water temperature and the vegetation of the fluvial islands which are adapted to the flooding pulse. For river turtles, it implies in a drastic reduction of feeding areas and alteration of nesting sites environment. Besides the environmental effects, the establishment of large constructions usually attract more people, which increases demand on natural resources.

The Yellow-spotted Amazon River Turtle, *P. unifilis,* is a medium to large Podocnemididae species with sexual size dimorphism; male's carapace length reach up to 33.5 cm and female's carapace up to 46.5 cm (Pritchard and Trebbau 1984). It is widely distributed in the Amazon and Orinoco river basins and it is categorized as "vulnerable" by IUCN (2011), however, the Tortoise and Freshwater turtle Specialist Group (TFTSG/IUCN) has recently drafted the species as "endangered" (Van Dijk et al. 2012). Reproduction was intensely studied throughout the Amazonia (Foote 1978, Thorbjarnarson et al. 1993, Escalona and Fa 1998, Ferreira-Júnior and Castro 2006, Pignati et al. 2013), whilst some essential ecological information lacks for most populations. The size of maturity, home range, comparative analysis of population structure in distinct environments and human pressure conditions are examples of important information that is still absent. Studies on population ecology of *P. unifilis* are scarce and punctual in temporal and spatial scales (Fachín-Terán and Vogt 2004, Alcântara et al. 2013, D. Félix-Silva, unpublished data). Male and female biased populations were found. Immature individuals were always captured in small quantities and there was no consensus about the expected structure in a natural population (Vogt 2008). Therefore, there is still need for basic data collection in order to attain a complete understanding of *P. unifilis* populations' demography.

Population parameters such as size structure, sex ratio and proportion of immatures, reflect the life history tracts that allowed the permanence of populations in time (Cole 1954). Monitoring such parameters is a core tool used in applied sciences of fisheries biology and wildlife management (Caughley and Sinclair 1994, Cadima 2003, Froese 2004). Population parameters of freshwater turtle species have been comparatively analyzed at temporal and spatial scales to study the effects of particular environmental conditions, habitat alteration and human pressure on the environment (Marchand and Litviatis 2004, Steen and Gibbs 2004, Dodd and Dreslik 2007). Allometric relationship is another tool used in applied sciences to monitor and evaluate the status of wild populations. The most common is the length-weight relationship (LWR), used to convert lengths into biomass, to determine fish stock status, to compare fish growth amongst areas, and also as a complement to species-specific reproduction and feeding studies (Froese 2006). Allometric relationships are useful when the collection of complete morphological data is too difficult or too expensive, such as when you have only parts of consumed animals as carapace, plastron, and head (in the case of turtles). It may also be used in participative monitoring and management programs on which a single simple morphological measurement could be gathered by trained local people.

The present paper describes the population structure and establishes the length-weight relationship and other allometric relationships of interest for a *Podocnemis unifilis* population living in a 3.3 million ha protected area, located about 450 km upstream from the future reservoir of the Belo Monte dam. The data presented may be used as a reference of a *P. unifilis* natural population in a typical clear water river in the Amazon basin, an ecosystem increasingly threatened by habitat alteration.

MATERIALS AND METHODS

STUDY AREA

The study was carried out inside the Terra do Meio Ecological Station (TMES), one of the most restrictive Protected Areas under the Brazilian environmental legislation (National System of Protected Areas – SNUC - law 9,985). TMES comprises 3,373,133.89 ha, covered mostly by pristine tropical forest and drained by Iriri River and its smaller tributaries. The Iriri River is 1,300 km long from its headwaters in the state of Mato Grosso to its mouth on the left margin of the Xingu River, about 80 km upstream Altamira city. Despite the exploitation of turtles along the Xingu basin, human pressure on turtle population inside the TMES is low as a result of its location (far away from urban centers), and to its low human density - about 17 families live sparsely along more than 300 km of the Iriri River inside the TMES. Furthermore, upstream and downstream territories are Indigenous Lands approved by law. Turtle captures were carried out between coordinates -6° 54’ 6.79” S, -53° 49’ 29.74” W and -5° 25’ 8.11” S, -54° 24’ 22.93” W (Fig. 1).

The Xingu River and its tributaries constitute a typical a clear water ecosystem in the Amazon basin. Clear water ecosystems are characterized by transparent nutrient-poor water that rapidly flows over a rocky bed. Aquatic fauna is highly adapted to that condition and to the seasonal flood pulse characteristic of Amazonian rivers (Junk et al. 1989, Goulding 1980). During the high water season the marginal forest is flooded and provides food source for the aquatic fauna, whilst in the low water season deep pools and extensive shallows remain in the river bed, and islands, sand banks and rocky rapids emerge. These ecosystems are currently threatened by gold mining activities and the construction of the Belo Monte dam (Ferreira et al. 2013).

SAMPLING METHODS

Data on the population structure of *P. unifilis* were obtained by capturing the turtles using a hand net (locally called *landuá* or *puçá*) and by diving and chasing. The hand net consists of a wooden shaft attached to a metal ring with a bag-shape net with a 10 cm size mesh attached. Both methods include active search along the river bed, pursuit and capture of animals previously viewed due to the high transparency of the Iriri River. Active search to see the turtles at surface is done by navigating on an aluminum boat with outboard motor (15 – 30 Hp) along the river bed. Pursuit consists on navigating

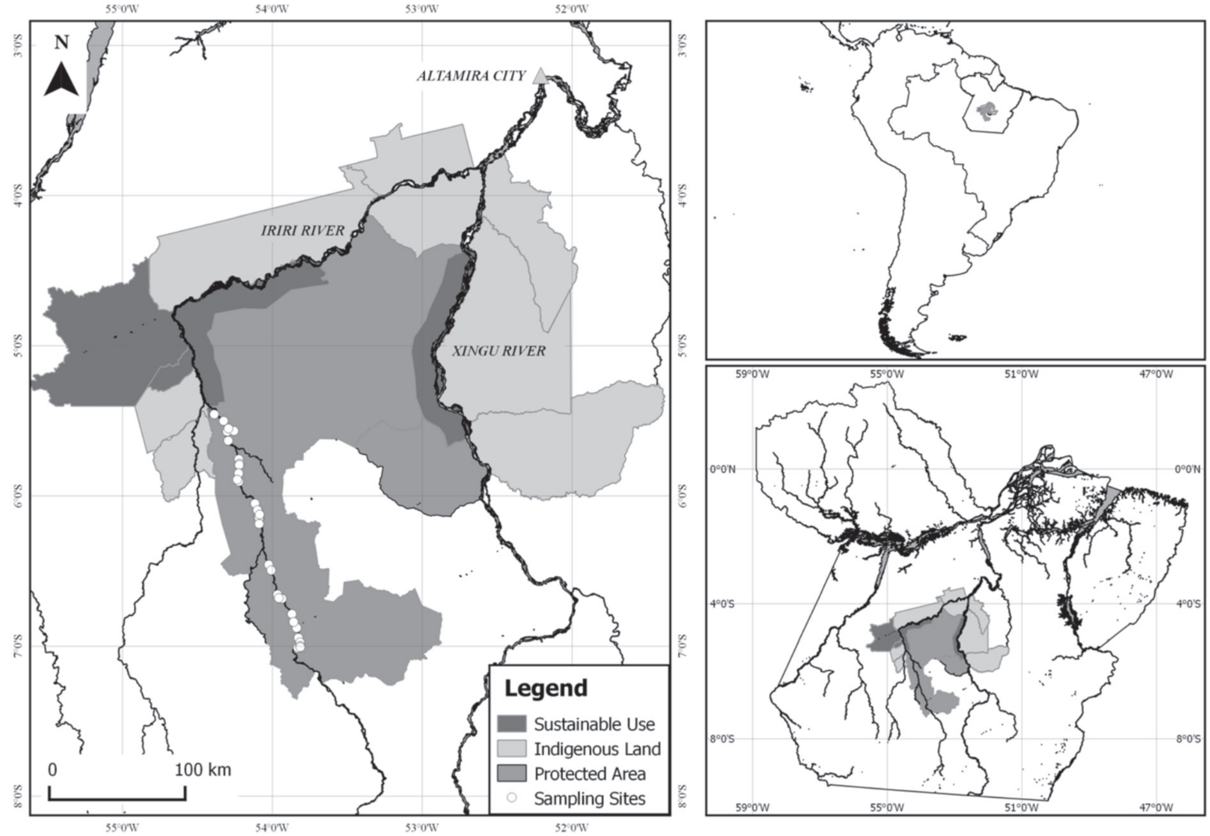

Figure 1 - Study area, Terra do Meio Ecological Station, Pará, Brazil. Circles indicate sampling sites along the Iriri River from August 2012 to October 2013.

in circles around the observed turtles with one person in the prow. The person either dives to chase the turtle underwater, or traps the turtles using the hand net. Diving must be undertaken at daylight, whilst the hand net is used with a spotlight at night. Both methods can be applied where the outboard motor is able to operate. Both methods are based on previous observations of the behavior of *P. unifilis*, that comes to surface due to the noise of the motor in the water, especially when the motorboat navigates in circles in the places turtles gather. These capture techniques are amongst the traditional methods used by local dwellers of Xingu and Iriri River to catch turtles for subsistence and commercialization (J.C.B. Pezzuti, unpublished data). The hand net was previously applied to sample *P. unifilis* in the Xingu River by Alcântara et al. (2013). In the present study, hand net was used by researchers and local people, whilst diving was performed only by the local dwellers that collaborated in the study. Both methods were applied during 20 to 25 consecutive days in all sample trips: August and October (low water season) in 2012; May (high water season), August and October (low water season) 2013.

Captured turtles were weighed on Pesola® spring scales (±10.0 to ±100.0 g) and measured on maximum sizes (mm): straight carapace length (SCL), carapace height (CH), carapace width (CW), plastron length (PL), and head width (HW), with calipers Haglöf® (±1 mm) or Mitutoyo® (±0.1 mm). Curved carapace length (CCL) was obtained using a plastic metric tape with milimetric scale. Captured animals were marked with a circular incision in the marginal shields following a coding system that allowed for individual recognition. Sex was identified according to the secondary sexual characteristics of head color, pre-cloacae distance and length and thickness of the tail (Pritchard and Trebbau 1984). Males are smaller and maintain on their heads the yellow spots typical of hatchlings, and present a thicker and longer tail. Individuals on which secondary sexual characteristics were not evident were considered juveniles. Males were considered sexually mature (adult) with SCL $\geq$ 18 cm; and females with SCL $\geq$ 30 cm. Males and females smaller than the size of sexual maturity were considered subadult (sexually immature). The sizes of sexual maturity were elucidated from morphological and histological analyses of 32 males' and 38 females' gonads from the same area (P.S. Miorando, unpublished data).

All procedures with animals were carried out according to the international practices and care under the control of the internal ethical committee of the Universidade Federal do Pará (Process 211-14).

DATA ANALYSIS

Data on size distribution (SCL and weight) of males and females were described by mean, minimum and maximum standard deviation. Size (SCL) and weight were compared between the sexes and methods by the non parametric Mann-Whitney *U*-test, after verification that the data were not normally distributed. The sex ratio was compared between methods of capture by Pearson Chi-Square test (Zar 2010). Measurements of SCL, CW, CH, PL and HW of individuals captured in 2013, in which complete biometrics were taken, were used to perform a Principal Components Analysis (PCA) to verify morphological variation between the sexes (sex as a fixed factor, 2 levels). Values of measurements were standardized by the maximum (SCL) to avoid size effect. Morphological difference based on a resemblance matrix (Euclidean distance) amongst individuals was statistically tested by Permutation Multivariate Analysis of Variance (PERMANOVA) to an α-of-significance = 0.05 (Clarke 1993). PCA and PERMANOVA were performed on PRIMER® v.6 (Clarke and Gorley 2006). Allometric relationships were performed on morphometric data measured from individuals captured in August 2012 and 2013. Allometric relationships CCL-SCL, PL-SCL and HW-SCL were estimated by simple linear regression model. LWR was estimated by the equation $W = aL^b$ (W: weight; L: length) (Froese 2006). length and weight values were log-transformed to linearize the equation to a simple linear model, $\ln(W) = \ln(a) + b*\ln(L)$ (Froese 2006). Parameter b of regressions was compared between sexes by the Welch-T test (Zar 2010).

RESULTS

A total of 1,028 individuals of *P. unifilis* were captured: 728 males, 296 females and four immature individuals without the secondary sexual characteristics (SCL range = 51.6 - 117 mm). Captures occurred mostly (89%) in August, during the low water season (Table I). Hand net captured 839 individuals; whilst 191 were caught by diving (five captures were occasional by locals). Methods did not differ either in the sex ratio (Pearson chi-square = 2.411, df = 1, P = 0.120) nor in the SCL of captured turtles (U = 75318.3, N = 1022, P = 0.353). Therefore, data from individuals captured with hand net and diving were pooled to express the population structure. Population was dominated by adult males, which accounted for 68.7% of all individuals captured (Fig. 2). Considering only sexually mature individuals, sex ratio was strongly male-biased by 9.15♂:1♀ (705 males, 77 females); and it was still male-biased by 2.45:1 when all

TABLE I
Captures of *Podocnemis unifilis* in the Terra do Meio Ecological Station, Pará, Brazil, carried out in 2012 and 2013.

	2012		2013			N individuals
	August	October	May	August	October	
Males	433	32	11	222	30	728
Females	182	8	7	83	16	296
Juveniles	1	0	3	0	0	4
SUM	616	40	21	305	46	1028

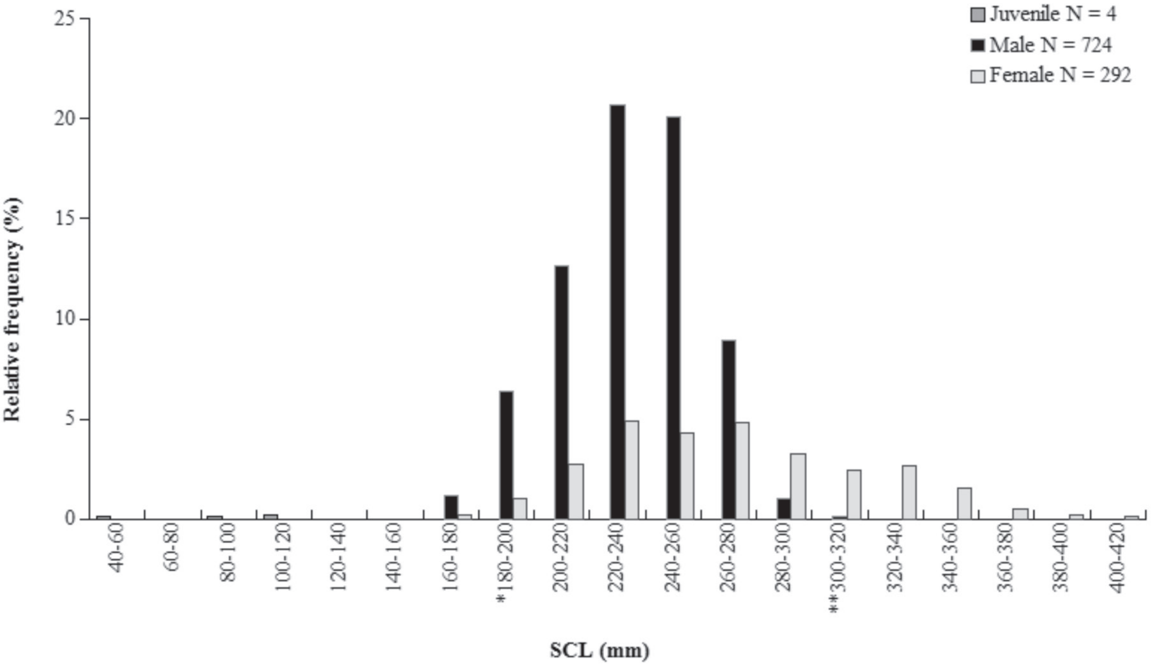

Figure 2 - Population structure (SCL, straight carapace length) of *Podocnemis unifilis* captured in Terra do Meio Ecological Station, Iriri River, 2012-2013. Size of sexual maturity for *males and **females.

sexed individuals were accounted for. Sexually immature individuals accounted for only 2.7% of males, and for 73.8% of females.

Females were larger (U = 154994, N = 1016, $P < 0.0001$) and heavier (U = 161440, N = 1009, $P < 0.0001$) than males. Males measured on average SCL 232.7 ± 24.8 mm (167–303 mm, N = 724) and weighed 1357 ± 363 g (450–2450 g, N = 721). Size structure was normally distributed with higher proportion in the classes between 220 and 260 mm SCL. Females mean SCL and weight were 268.9 ± 46.7 mm (165–403 mm, N = 292) and 2329 ± 1184 g (540–6900 g; N = 288), respectively. Despite the significant difference, the most frequent size classes for females were similar to those for males, from 220 to 280 cm SCL (Fig. 2). There was significant difference between males' and females' morphology (PERMANOVA, pseudo-F = 320.09, P = 0.001), explained mainly by a longer plastron, and higher carapace in females (Fig. 3). PCA explained in two axes, 90.6% of morphological variation between males and females (PC1 = 65.6% and PC2 = 25%). Variation was mainly driven by PC1, based on PL (eigenvector coefficient = 0.939) and CH (eigenvector coefficient = 0.343). PC2 was based on CW (eigenvector coefficient = 0.982) and on CH (eigenvector coefficient = 0.141), and had minor contribution to explain morphological variation between sexes, since males and females showed similar distribution along this axis (Fig. 3). HW had the least contribution to compose both axes.

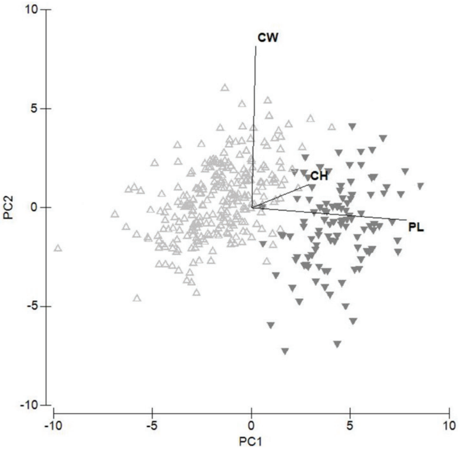

Figure 3 - Principal Component Analysis (PCA) of morphometric measures of *Podocnemis unifilis* males (Δ, light gray) and females (▼, dark gray) from Terra do Meio Ecological Station, PA, 2013. PL = plastron length; CH = carapace height; CW = carapace width.

Allometric regressions were all statistically significant to P= 0.0001, and SCL was better estimated by CCL and PL (Table II). Amongst females, regressions made considering all individuals (adults and subadults) resulted in higher coefficients of determination and narrower confidence limits. In contrast, regressions performed for adult females had lower sample sizes and more variability, which led to a wider confidence interval (Table II). Adult females had higher values of *b* parameter than adult males (Wt = 26.043, df = 56, P = 0.0001), and subadult females (Wt = 8.935, df = 60, P = 0.0001), and subadult females also had higher *b* parameter than adult males (Wt = 78.381, df = 235, P = 0.0001) (Table II).

DISCUSSION

Seasonal variation of capture rates has been widely described for *Podocnemis* spp. (Fachin-Terán and Vogt 2004, Fachín-Terán et al. 2003, Bernhard and Vogt 2012, Alcântara et al. 2013). During the high water season, the aquatic fauna is sparsely distributed over the extensive floodplain, but when the water recedes, turtles and aquatic fauna in general are forced to concentrate in the remaining habitats (Goulding 1980, Junk et al. 1989). In the present study, 89% of captures occurred in the low water season, when turtles were captured mainly in the deeper pools along the river bed. It is important to note that the difference in the number of captures between August, 2012 and 2013 was a result of variation in capture effort and do not reflect a population decline in the study area. The number of captures diminished in October because lower areas became flooded and offered new shallow areas (<50 cm) for turtles, where neither the hand net nor diving were efficient.

The strongly male-biased sex ratio observed in the present study (9.15♂:1♀) was similar to the sex ratio of 9.8♂:1♀ observed for adult *P. unifilis* in the Guaporé River, despite different methods of capture were used (Fachín-Terán and Vogt 2004). Our study and Fachín-Terán and Vogt (2004) are the only studies on *P. unifilis* that considered adult individuals alone to calculate the sex ratio, as was indicated by Bury (1979) and Lovich and Gibbons (1990). The absence of data about the size at maturity one of main barriers to describe the correct sex ratio of populations of *Podocnemis* spp. Alcântara et al. (2013) observed a sex ratio of 1.89♂:1♀ capturing *P. unifilis* using hand net in the area of the future reservoir of Belo Monte dam in the Xingu River. An even sex ratio of 1.12♂:1♀ was observed for

TABLE II
Allometric regressions of *P. unifilis* from Terra do Meio Ecological Station on August 2012 and August 2013. LWR: length-weight relationship. Parameters of simple linear regression ($Y = a + b*X$) are given. N: sample size; CI: confidence interval; R^2: coefficient of determination (all relationships significant at $P < 0.0001$). SCL straight carapace length (mm); W: weight (g); CCL: curved carapace length (mm); PL: plastron length (mm); HW: head width (mm).

				LWR ($\ln(W) = \ln(a) + b*\ln(SCL)$)				
		X		Y				
Group	N	min	max	min	max	*a*	*b* (95% CI)	R^2
Female; all	245	179	430	680	6900	-8.37	2.87 (2.81-2.93)	0.974
Female; subadult	186	179	299	680	3100	-7.71	2.75 (2.65-2.85)	0.942
Female; adult	59	300	430	2800	6900	-8.60	2.91 (2.63-3.19)	0.883
Male; adult	598	180	303	630	2450	-6.11	2.44 (2.38-2.50)	0.900
				SCL = *a* + *bCCL**				
Female; all	245	195	434	179	430	-5.61	0.94 (0.92-0.95)	0.986
Female; subadult	186	195	340	179	299	-8.73	0.95 (0.92-0.97)	0.964
Female; adult	59	322	434	300	430	16.09	0.87 (0.82-0.93)	0.938
Male; adult	598	200	320	180	303	-13.12	0.96 (0.95-0.98)	0.956
				SCL = *a* + *bPL**				
Female; all	245	158	354	179	430	2.78	1.12 (1.10-1.14)	0.985
Female; subadult	186	158	274	179	299	9.65	1.08 (1.05-1.12)	0.964
Female; adult	59	261	354	300	430	6.87	1.11 (1.02-1.19)	0.924
Male; adult	598	150	242	180	303	-9.92	1.25 (1.23-1.28)	0.952
				SCL = *a* + *bHW**				
Female; all	245	30.5	58.1	179	430	-56.72	8.09 (7.85-8.32)	0.949
Female; subadult	186	30.5	47.1	179	299	-58.74	8.12 (7.73-8.51)	0.901
Female; adult	59	41.4	58.1	300	430	67.84	5.53 (4.78-6.29)	0.790
Male; adult	598	28.4	45.4	180	303	-13.09	6.88 (6.67-7.09)	0.870

P. unifilis only in the Tucuruí dam reservoir using gill nets and traps (D. Félix-Silva, unpublished data). However, those sex ratios were calculated based on all sexed individuals, and not on adults alone. A male-biased sex ratio was observed for *P. sextuberculata* (1.94♂:1♀) captured by trammel nets at Mamirauá Reserve in the middle Solimões River (Fachín-Terán et al. 2003). In contrast, female-biased sex ratio was observed for *P. erythrocephala* (0.49♂:1♀) captured by trammel nets and diving in the Negro River, state of Amazonas (Bernhard and Vogt 2012). A sex ratio different than 1:1 in turtle populations should not be expected when sample sizes are not smaller than 100 (Gibbons 1970, Bury 1979). However, in spite of a greater sample size, numerous studies have reported biased sex ratios. Differential mortality, distinct behavior, temperature of incubation, different age/size at maturity, sampling methods and microhabitats sampled, are the most mentioned factors to explain a skewed sex ratio (Ream and Ream 1966, Gibbons 1990, Lovich and Gibbons 1990, Steen et al. 2006). The male-biased sex ratio commonly reported for *Podocnemis* spp. populations is usually attributable to disproportionate mortality of females (Ramo 1982, Fachín-Terán and Vogt 2004). It is well known that Amazonian dwellers traditionally prefer to consume and trade large females, mainly during the nesting season (Bates 1863, Smith 1979, Pezzuti et al. 2010). Nesting females are also more prone to predation by jaguars and alligators in pristine areas of the Amazon region (Salera-Jr et al. 2009). In the United States, differential mortality of females on roads during nesting migration caused a skewed sex ratio towards males on freshwater turtle populations (e.g. Steen et al. 2006). The male-biased sex ratio of *P. unifilis* in the Guaporé River was also attributed to the lower incubation temperatures and to higher human predation of nests in open, warmer areas, which would produce primarily females (Fachín-Terán and Vogt 2004). Temperature of incubation may be a natural cause to skewed primary sex ratio in species in which sex determination is temperature-dependent, as the *Podocnemis* spp. (Souza and Vogt 1994). Differences in age or size at maturity may also unbalance the sex ratio towards the sex that matures before (Lovich and Gibbons 1990), and mistakes on determination of sexual maturity can also lead to an incorrect biased sex ratio and to an incorrect proportion of juveniles when describing a population (Gibbons 1970). Moreover, the influence of methods of capture on sex ratio and size frequency distribution should not be overlooked in studies on turtle population structure (Ream and Ream 1966, Gibbons 1970, Lovich and Gibbons 1990). For amazonian species, this aspect was better discussed in Bernhard and Vogt (2012), who showed that diving and trammel nets, including variation of the mesh size, had significant effects on the sex ratio and the proportion of juveniles of *P. erythrocephala* captured in the Negro River.

In the present study, the size of sexual maturity of *P. unifilis* was elucidated as part of a wider project (P.S. Miorando, unpublished data). Histological analyses provided us security about the sizes of sexual maturity for males and females, and thus the sex ratio is unlikely to be biased due to mistakes in maturity determination. We consider that differential mortality is a possible cause to explain the sex ratio strongly skewed towards male. Although the Terra do Meio Ecological Station is currently one of the most restrictive Protected Areas under Brazilian legislation, human settlements were denser before the creation of the protected area about 10 years ago and the pressure on turtle was probably much greater than nowadays. In addition to human pressure, nesting females are naturally predated by jaguar (*Panthera onca*) (pers. obs.).

There are natural factors that should not be overlooked in the discussion of the population structure observed in the present study. Lower incubation temperature in the Iriri region and the earlier maturity of males are natural factors that are likely to influence the higher proportion of adult males in the population. The first hypothesis should be tested by estimation of the threshold temperature for specific areas in the Amazon basin, as this parameter is probably subject to geographic variation along the large distribution of *P. unifilis*. The second hypothesis is based on the pattern observed in freshwater species that the age and size of maturity determines the sexual dimorphism, with the smaller sex maturing earlier and at a smaller size than the larger sex (Moll and Moll 2004). Differential maturity may be the most important influence on sex ratio in the absence of other factors that result either in differential mortality or skewed primary sex ratio (Gibbons 1990, Lovich and Gibbons 1990). The sex that matures earlier with smaller size will outnumber the sex that matures with larger size (Lovich and Gibbons 1990). Since in *Podocnemis* species there is sexual size dimorphism with males reaching smaller size and also maturing at smaller sizes than females (Rueda-Almonacid et al. 2007), it is expected that mature males outnumber mature females in *Podocnemis* populations. In the present study, we consider that the strongly male-biased sex ratio observed to *P. unifilis* may be due to a combination of three possible factors: higher pressure on larger females by humans and jaguars, a primary sex ratio that may be male-biased due to the temperature regime in the study area, and the natural trend due to differential maturity size.

We could also consider the possibility that adult females were in shallow areas near nesting beaches and thus sub-sampled by the capture method, as Fachín-Terán et al. (2003) stated for *P. sextuberculata* in the Mamirauá Reserve. However, it is unlikely because no adult female was observed neither breathing on water surface nor wandering underwater in shallow areas near beach shores during the whole sampling period. On the other hand, small juveniles were occasionally found amongst rocks at shallow sites that were not sampled in this study. It was clear, by the low number of unsexed juveniles, that the methods did not work well to capture them, and it is explained by the fact that they use microhabitats that could not be sampled by the adopted methods of capture. Small juveniles are commonly sub-sampled in turtle populations due to their distinct behavior and habitat use (Bury 1979); and low proportion of smaller individuals (<150 mm) can be observed in all studies of population structure mentioned in this discussion. A proportional capture of the actual percent of juveniles in the population consists in a major challenge to demographic studies of *Podocnemis* spp. populations.

Comparisons of morphometric measures confirmed the sexual size dimorphism of the species (Pritchard and Trebbau 1984) for this population. Besides the size difference, PCA and PERMANOVA analyses showed morphological differences between the sexes mainly due to a larger plastron and higher carapace on females. A complete analysis on morphological differences between the sexes is scarce in the literature for Podocnemidids. Bernhard and Vogt (2012) compared morphometric measures, one by one, between sexes for *P. erythrocephala,* and found that females had significantly longer plastron and higher carapace, the same morphological characteristic most relevant to the *P. unifilis* sexual differences found in the present study. Males captured in the Iriri River reached similar maximum size (≈ 300 mm) as recorded in the Xingu River (Alcântara et al. 2013), Guaporé River and Mamirauá Reserve (Fachín-Terán and Vogt 2004). Females from Iriri reached similar maximum size (≈ 400 mm) as those recorded in the Xingu River (Alcântara et al. 2013), but were smaller than females from Guaporé River and Mamirauá Reserve, where females reached ≈ 460 mm (Fachín-Terán and Vogt 2004). This is the first study to establish allometric regressions of body measures, especially the LWR, to amazon turtle species. Regressions were performed separately for males and females to account for morphological differences between sexes. The *b* parameter of LWR was higher for adult females, intermediary for subadult females, and lower for adult males, which indicate that females accumulate more biomass per unit of SCL growth than males. It was expected that regressions for adult females had a higher value of *b* parameter, a lower value of coefficient of determination and a wider confidence limits as a result of natural variation among individuals that contained shell eggs in oviducts and individuals that had already nested. We may consider that the weight of an individual varies along the year, and thus the presented LWR is more precise to estimate the weight of turtles in the low water season. Morphometric measures of bony structures do not suffer seasonal variation, and thus they can be applied year round with the same precision. Regressions of curved carapace length, plastron length and head width related to straight carapace length may be applied to estimate the size structure, and LWR the biomass of consumed individuals in the region of Middle Xingu River. Morphological variation among populations is likely to occur, and so the regressions here presented should be cautiously applied to other areas of the geographical distribution of *P. unifilis*.

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RESUMO

Os quelônios dos rios amazônicos estão crescentemente ameaçados pela perda e alteração do habitat em função da política energética brasileira baseada na construção de barragens hidroelétricas, enquanto estudos populacionais continuam escassos. Nós descrevemos a estrutura da população e estabelecemos relações alométricas corpóreas de *Podocnemis unifilis* na Estação Ecológica Terra do Meio no Rio Iriri, tributário do rio Xingu a montante da contrução da barragem de Belo Monte. Os quelônios foram capturados por puçá de mão e mergulho nas estações seca de 2012 e 2013 e na estação cheia de 2013. Foi capturado o total de 728 machos, 296 fêmeas e quatro juvenis. A razão sexual dos adultos foi desviada para os machos por 9.15♂:1♀. As fêmeas foram significativamente maiores que os machos. O comprimento retilíneo médio da carapaça foi de 268.9 ± 46.7 mm (165 – 403) para as fêmeas, e de 232.7 ± 24.8 mm (167 – 303) para os machos. Os sexos foram morfologicamente distintos em função do plastrão e altura da carapaça proporcionalmente maiores nas fêmeas. As relações alométricas entre o comprimento reto da carapaça e as demais características morfométricas foram fortes para machos (R^2 *range* = 0.87 – 0.96) e fêmeas (R^2 *range* = 0.79 – 0.98). A exploração de *P. unifilis* em biomassa retirada do médio Rio Xingu pode ser estimada a partir de partes do corpo encontradas pós-consumo através das regressões apresentadas.

Palavras-chave: Amazônia, rio de água clara, relação peso-comprimento, razão sexual, tracajá.

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