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POPULATION STRUCTURE, FECUNDITY AND ECOLOGICAL ASPECTS OF FRESHWATER SHRIMP SPECIES (DECAPODA, PALAEMONIDAE) OF AN URBAN FOREST FRAGMENT IN CENTRAL AMAZONIA, BRAZIL

BY

TOMAZ L. GUALBERTO[1,2]), LUANY O. DE ALMEIDA[1,2]) and MARCELO MENIN[1,2,3])

[1]) Departamento de Biologia, Instituto de Ciências Biológicas, Universidade Federal do Amazonas, Av. General Rodrigo Otávio Jordão Ramos 3000, 69077-000, Manaus, Amazonas, Brazil

[2]) Instituto Nacional de Ciência e Tecnologia de Estudos Integrados da Biodiversidade Amazônica, Ministério da Ciência e Tecnologia, Conselho Nacional de Desenvolvimento Científico e Tecnológico – INCT/CENBAM/MCT/CNPq, Brazil

ABSTRACT

Information about population structure, ecological aspects and reproductive biology of Amazonian freshwater shrimps is scarce in the scientific literature and concentrated in studies conducted in rivers. In this study we present data about species composition, population structure, abundance, fecundity and effects of abiotic factors on the distribution of freshwater shrimps in small streams at an urban forest fragment in Manaus, Central Amazonia. We collected the shrimps using minnow-traps in 12 first- and second-order streams in dry and rainy seasons. We found four species: *Macrobrachium ferreirai* Kensley & Walker, 1982, *Macrobrachium inpa* Kensley & Walker, 1982, *Macrobrachium nattereri* (Heller, 1862) and *Pseudopalaemon amazonensis* Ramos-Porto, 1979. First order streams had a higher number of species. Adults and juveniles of all species and ovigerous females were found in the majority of the sampling events. Males were more abundant and larger than females in all species of *Macrobrachium*. All species had a few, large eggs. The abundance of *M. nattereri* was affected by stream size and temperature. The population structure of the studied species was different from those in other studies on shrimp populations in Central Amazonia and other regions of Brazil, indicating effects of sampling methods and the structure and size of water bodies on the population structure in different regions. The presence of ovigerous females in all sampling periods indicates continuous reproduction.

RESUMO

Informações sobre a estrutura populacional, biologia reprodutiva e aspectos ecológicos de camarões de água doce da Amazônia são raras e concentradas em estudos realizados em grandes corpos d'água. No presente estudo, nosso objetivo foi avaliar a composição e a abundância das espécies, a estrutura populacional, a fecundidade e os efeitos de fatores abióticos sobre a distribuição de camarões em pequenos riachos de um fragmento florestal urbano em Manaus, Amazônia Central.

[3]) e-mail: menin@ufam.edu.br

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Nós coletamos os camarões em 12 riachos de primeira e segunda ordens usando armadilhas com isca, durante os períodos seco e chuvoso. Nós encontramos quatro espécies: *Macrobrachium ferreirai* Kensley & Walker, 1982, *Macrobrachium inpa* Kensley & Walker, 1982, *Macrobrachium nattereri* (Heller, 1862) e *Pseudopalaemon amazonensis* Ramos-Porto, 1979. Riachos de primeira ordem tiveram maior número de espécies. Adultos e imaturos de todas as espécies e fêmeas ovígeras foram encontrados na maioria dos períodos de amostragem. Machos foram mais abundantes e maiores que as fêmeas nas espécies de *Macrobrachium*. Todas as espécies apresentaram poucos ovos de tamanho grande. A abundância de *M. nattereri* foi afetada pelo tamanho dos riachos e pela temperatura. A estrutura populacional das espécies estudadas foi diferente da encontrada em outros estudos na Amazônia Central e em outras regiões do Brasil, indicando influência do método de amostragem e da estrutura e do tamanho dos corpos d'água sobre a estrutura das populações em diferentes regiões. A presença de fêmeas ovígeras nas amostragens indica reprodução contínua.

INTRODUCTION

Brazilian freshwater shrimps belong to the families Atyidae, Sergestidae and Palaemonidae (cf. Melo, 2003; but see Martin & Davis, 2001 and De Grave et al., 2009 for the family status of Euryrhynchidae). The palaemonoid shrimps (families Euryrhynchidae and Palaemonidae) are represented by 32 species and six genera (*Cryphiops*, *Euryrhynchus*, *Macrobrachium*, *Palaemon*, *Palaemonetes* and *Pseudopalaemon*) in the freshwater system of Brazil, the genus *Macrobrachium* being the most diverse with 18 species (Melo, 2003).

Studies about palaemonid shrimp population structure, such as sex ratio, population recruitment period, and reproductive aspects such as reproduction period, number and size of eggs, are concentrated in the southern and southeastern regions of Brazil and were conducted with species of the genus *Macrobrachium* (cf. Bond & Buckup, 1982; Bond-Buckup & Buckup, 1989; Valenti et al., 1989; Müller et al., 1999; Lima & Oshiro, 2000, 2002; Antunes & Oshiro, 2004; Azevedo et al., 2004; Mattos & Oshiro, 2009). However, a few sets of ecological studies determining the effects of environmental characteristics on the distribution of the species in this group are available (e.g., Odinetz-Collart, 1991; Odinetz-Collart & Rabelo, 1996; Sampaio et al., 2007).

Several species of palaemonid shrimps are found in the Amazon region (Melo, 2003) but the majority of studies were conducted with *Macrobrachium amazonicum* (Heller, 1862) (e.g., Odinetz-Collart, 1993). Many studies in this region were conducted in rivers, involving systematic aspects, species description and larval development (Kensley & Walker, 1982; Magalhães, 1985, 1989; Walker & Ferreira, 1985; Walker, 1992). However, the species composition, biology, ecology and population structure from small forest streams in the Brazilian Amazon are not well determined. The shrimps occurring in small streams of terra firme forests are important elements in ecological processes of the aquatic environment because

they are present at different levels of the trophic chain, both as predators or prey (Walker & Ferreira, 1985; Walker, 1987).

Here we present data on species composition, population structure, abundance, fecundity and effects of abiotic factors on the distribution of freshwater shrimps in an urban forest fragment in Central Amazonia, Manaus.

MATERIAL AND METHODS

Study area

The study was conducted at the campus of the Universidade Federal do Amazonas — campus UFAM (03°04′34″S 59°57′30″W), municipality of Manaus, state of Amazonas, Brazil (fig. 1). The forest fragment of the campus has an area of about 600 ha of Terra Firme Forest (a not seasonally flooded forest), secondary forest, campinarana sites and deforested areas (Borges & Guilherme, 2000; Nery et al., 2004). The area has 12 first-order streams, formed by the headwaters (ten permanent and two temporary) and two second-order streams, formed by the junction of two first-order streams — following Strahler's modification of Horton's scale (Petts, 1994). The width of the streams varies from 0.6 to 1.75 m and the depth varies from 0.6 to 1.0 m. The bottoms of the streams are sandy and there are accumulations of litter. The rainy season extends from November to May, with a dry season between June and October (Marques Filho et al., 1981). The fragment isolation process began in 1971 when immigrants started a massive occupation of the area due to the attractive employment perspective of the emerging Manaus free-zone industrial district. The complete isolation of the fragment occurred about 20 years ago (Tsuji-Nishikido & Menin, 2011).

Data collection

Seven sampling events were carried out in 12 streams throughout two years (ten first order streams: all sampled in July and November 2008 and February and July 2009; two second order streams: sampled in July and November 2009 and February and July 2010) during dry (July) and rainy (February, November) periods. In each stream we determined a sample station, which consisted of a 50-m reach of stream.

Shrimps were captured using minnow-traps (Ribeiro & Zuanon, 2006; Kemenes et al., 2010) baited with sardines and sausage, during a 12-h sample period. A total of 12 traps were placed near each stream margin at each sample station, at a distance of 10 m from one another.

The stream size, water temperature, pH, dissolved oxygen and current velocity were measured in each station and at each sampling event. The size of the stream was determined by measuring the (a) width and (b) depth of the stream (obtained with a measuring tape within the sample station), and (c) length of the sample

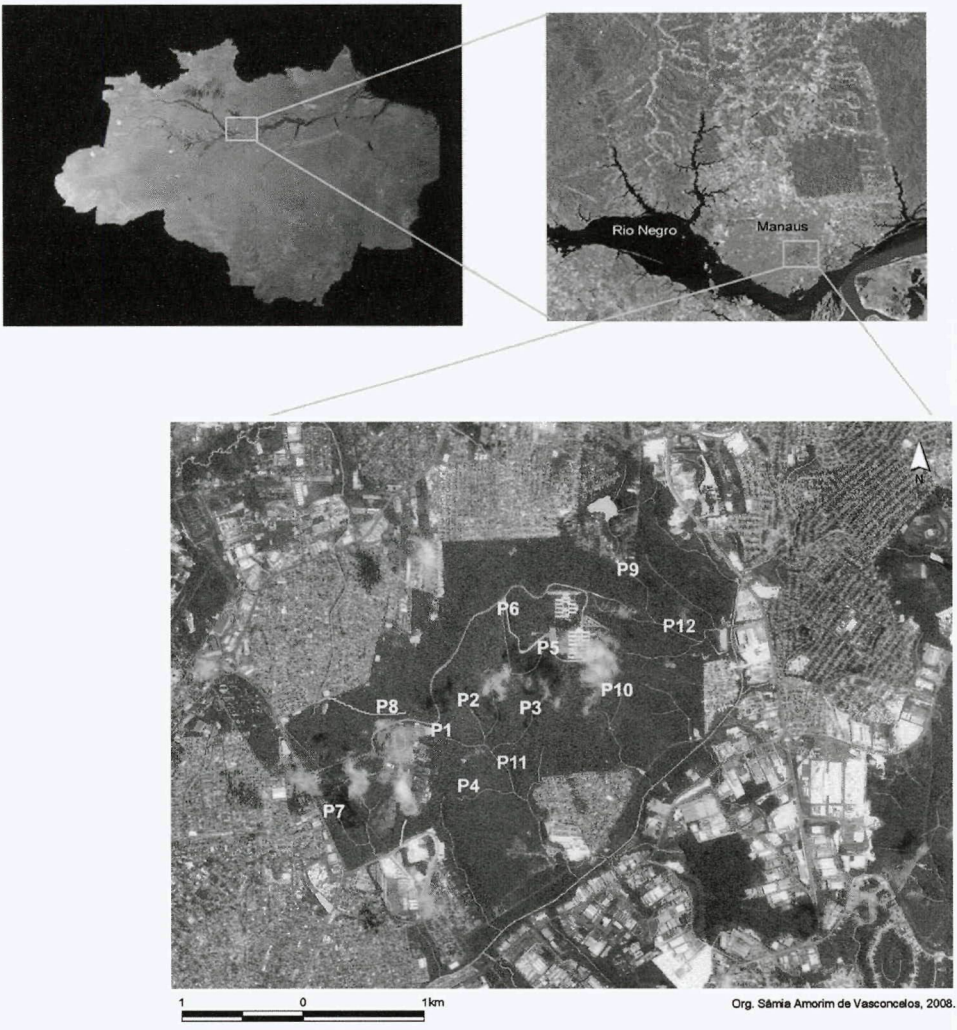

Fig. 1. Geographical location of the study area, campus of the Universidade Federal do Amazonas, Manaus, Amazonas State, Brazil. Irregular lines represent streams inside the fragment. Abbreviations (P1 to P12) represent the identification number of each plot (modified from http://earth.google.com).

station (50 m). These measurements were multiplied to obtain the size (stream size = width × depth × length). Temperature and dissolved oxygen were measured using a portable oxygen meter/thermometer (Hanna, model HI 9147). The pH was measured using a portable pH meter (Hanna, model HI 991301). Current velocity was measured at six points in each station at mid channel in the centre of the water column, using a float and marking the time it took to travel one meter downstream.

Voucher specimens were deposited in the Zoological Collection Paulo Bührnheim (CZPB) of the Universidade Federal do Amazonas (*Macrobrachium ferreirai*

CZPB 003; *M. inpa* CZPB 001; *M. nattereri* CZPB 002; *Pseudopalaemon amazonensis* CZPB 004).

Data analyses

The shrimps were identified according to identification keys found in Melo (2003) and Kensley & Walker (1982). The sex was determined by the presence (male) or absence (female) of the appendix masculina on the endopod of the second pleopod.

Measurements of specimens were made using a digital calliper: total length (from the tip of the rostrum to the tip of the telson), cephalothorax length, and abdomen plus telson length. The specimens were classified as adults (males and females) or juveniles (males and females). We considered juveniles those individuals with TL smaller than or equal to that of the size of the smallest ovigerous female found for each species (Mattos & Oshiro, 2009). We did not find sexually undifferentiated individuals. Difference between the size of males and females was tested by a t-test (Zar, 1999). The adult sex ratio was checked by using the Chi-square test with Yates' Correction (Zar, 1999). The specimens were distributed in four Total Length classes of size (10 mm amplitude to each class).

The fecundity was determined by the number of eggs in an ovigerous female. The reproductive period was determined by the presence of ovigerous females (presence of eggs or distended abdominal pleura) in the population. The relationship between the fecundity and the size of ovigerous females was determined using a linear regression. The long and short axes of the eggs were measured using an optical microscope with an eyepiece scale. The egg volume was calculated by the formula $Ev = (\pi l h^2/6)$, according to Nazari et al. (2003).

The effects of the independent variables (stream size, temperature, pH, dissolved oxygen and current velocity) on the abundance of each species and on richness (data on abundance of each species is available from http://ppbio.inpa.gov.br/Port/inventarios/campusufam/camaroes) were determined using linear multiple regression. The value of abundance considered in this analyses was standardized in $\log(x + 1)$ before analyses to reduce the effect of extreme values. The collinearity between environmental variables used in the regression model was assessed by Spearman's correlation matrix.

RESULTS

Environmental parameters of streams

The sampled streams showed a small variation in the parameters measured between the dry and rainy periods; the majority of parameters were higher during

the rainy period. In the dry period, stream size varied from 4.23 to 12.25 m^3 (mean = 7.15 m^3, standard deviation (SD) = 2.56); temperature varied from 24.8 to 25.7°C (mean = 25.3°C, SD = 0.3). The water was saturated with oxygen (mean = 3.77 mg/l, SD = 0.69, range = 2.41-4.8 mg/l) and acid (mean pH = 4.79, SD = 0.32, range = 4.39-5.47). In the rainy period, stream size varied from 5.75 to 15.55 m^3 (mean = 10.07 m^3, SD = 0.94), the water was also saturated with oxygen (mean = 4.50 mg/l, SD = 0.60, range = 4.01-6.00 mg/l) and acid (mean pH = 5.32, SD = 0.75, range = 4.99-5.17); temperature varied from 24.9 to 25.0°C (mean = 25.0°C, SD = 0.1). Temperature was colinear with current velocity ($r = 0.61$). Current velocity was removed from the analysis.

Species composition, population structure and reproductive aspects

In the 12 sample stations, a total of 867 individuals were collected belonging to four species and two genera: *Macrobrachium ferreirai* Kensley & Walker, 1982, *Macrobrachium inpa* Kensley & Walker, 1982, *Macrobrachium nattereri* (Heller, 1862) and *Pseudopalaemon amazonensis* Ramos-Porto, 1979. *Macrobrachium inpa* was the most abundant species, representing 56.5% of all individuals recorded, followed by *M. nattereri* (32.2%), *M. ferreirai* (8.5%) and *P. amazonensis* (2.8%) (table I). Four species were found in the first-order streams and two species were found in second-order streams (table I).

There were differences in the abundance of each species between sampling periods. Adults and juveniles of all species and ovigerous females were found in the majority of the sampling events. A higher number of individuals and ovigerous females were found in the dry period.

Forty males (54.66%) and 34 females (45.33%; two juveniles) of *M. ferreirai* were captured. The sex ratio was 1.2 : 1. There was no significant difference in the number of males and females ($\chi^2 = 0.50$, df = 1, $P = 0.99$). Males (table II) were significantly larger than females (total length: $t = -7.609$, $P < 0.0001$). Four ovigerous females produced between 26 and 37 eggs (mean = 31.50, SD = 5.80); another three females had distended abdominal pleura. Ovigerous females ranged in total length between 36.2 to 43.3 mm. Most individuals measured between 30 and 40 mm in total length (fig. 2A).

For *M. inpa* 394 males (80.4%; 373 adults and 21 juveniles) were found and 96 females (19.6%; 86 adults and 10 juveniles), 23 of which had eggs or distended abdominal pleura (23.9%). The adult sex ratio was 3.7 : 1 (males/females). The number of males was significantly higher than females ($\chi^2 = 192.53$, df = 1, $P = 0.001$). Males (table II) were significantly larger than females (total length: $t = -18.822$, $P < 0.0001$). Eighteen females produced between six and 21 eggs (mean = 10.78, SD = 3.75). Five females had distended abdominal pleura.

TABLE I

Number of individuals of each species of shrimp collected at the campus of the Universidade Federal do Amazonas, Manaus, Amazonas, Brazil, in first- and second-order streams

Species	July 2008	November 2008	February 2009	July 2009	November 2009	February 2010	July 2010	Total
First-order streams								
Macrobrachium inpa Kensley & Walker	172/56/10/19	58/24/4/10	62/4/1/0	81/8/4/0				465
Macrobrachium nattereri (Heller)	31/21/1/3	15/12/1/3	18/16/1/1	6/8/5/0				127
Macrobrachium ferreirai Kensley & Walker	6/2/2/0	10/10/1/2	9/7/1/0	15/15/3/0				74
Pseudopalaemon amazonensis Ramos-Porto	0/5/1/0	0/12/1/3	0/4/1/0	0/3/1/0				24
Total	293	141	120	136				
Second-order streams								
Macrobrachium inpa				–	2/0/1/0	5/0/2/1	14/4/1/0	25
Macrobrachium nattereri				21/21/2/0	15/11/1/0	27/13/2/0	22/22/1/0	152
Total				42	26	40	44	

The numbers represent: male total/female total/ovigerous females/juveniles.

TABLE II

Measurement (in mm) of males and females of four species of freshwater shrimps from the campus of the Universidade Federal do Amazonas, collected in July and November 2008, February, June, July and November 2009, and February and June 2010, Manaus, Amazonas, Brazil

Species	Total length		Cephalothorax length		Abdomen + telson length	
	Males	Females	Males	Females	Males	Females
Macrobrachium ferreirai	48.0 ± 6.4 37.3-61.0	37.7 ± 5.0 25.0-50.5	13.7 ± 2.0 9.9-18.2	10.6 ± 1.5 6.7-14.1	26.5 ± 3.7 20.3-33.9	21.0 ± 3.0 13.4-29.0
Macrobrachium inpa	37.8 ± 4.9 23.3-53.0	27.9 ± 3.3 20.0-38.4	10.9 ± 1.6 6.0-15.4	7.9 ± 1.1 5.0-11.5	21.6 ± 3.1 10.7-30.4	16.5 ± 2.1 12.3-21.6
Macrobrachium nattereri	54.4 ± 10.5 32.0-80.0	42.8 ± 6.4 26.1-59.9	15.9 ± 3.5 8.6-24.8	12.3 ± 2.7 6.6-32.6	29.8 ± 6.2 17.0-48.3	23.4 ± 4.0 13.1-35.2
Pseudopalaemon amazonensis	–	28.9 ± 3.0 22.4-33.3	–	5.7 ± 0.8 4.2-7.0	–	16.3 ± 3.6 11.4-2.70

Values are means ± standard deviation and range.

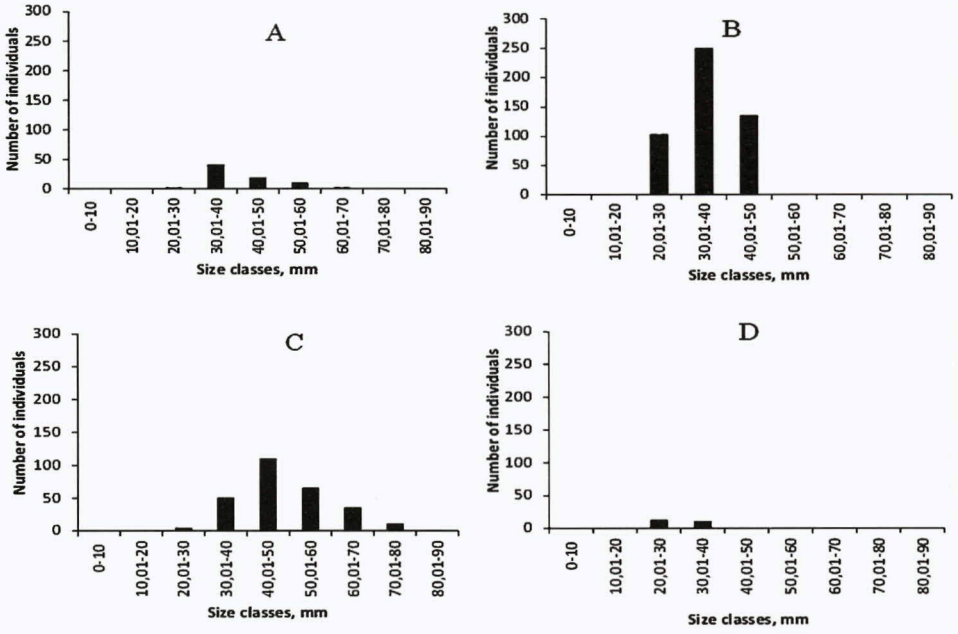

Fig. 2. Number of individuals of freshwater shrimps distributed in total length classes (10 mm amplitude) at the campus of the Universidade Federal do Amazonas, Manaus, Amazonas, Brazil. A, *Macrobrachium ferreirai* Kensley & Walker, 1982; B, *Macrobrachium inpa* Kensley & Walker, 1982; C, *Macrobrachium nattereri* (Heller, 1862); and D, *Pseudopalaemon amazonensis* Ramos-Porto, 1979.

The total length of ovigerous females ranged from 25.8 to 32.8 mm. There was no relationship between the total length of the females and the number of eggs ($R^2 = 0.013$, $F_{1,16} = 0.209$, $P = 0.654$). Individuals found ranged in size from 30 to 40 mm (fig. 2B).

For *M. nattereri* 155 males (55.6%; five juveniles) were captured, and 124 females (44.4%; two juveniles). The adult sex ratio was 1.27 : 1. There were no significant differences in the number of males and females ($\chi^2 = 3.49$, df = 1, $P = 0.99$). Males (table II) were significantly larger than females (total length: $t = -11.355$, $P < 0.0001$). Four ovigerous females produced between 34 and 118 eggs (mean = 77.25, SD = 36.05). The other 10 females had distended abdominal pleura. The total length of ovigerous females ranged from 37.2 to 50.2 mm. The size of individuals of this species was greater than that of other species of this study, with specimens ranging in size from 50 to 60 mm (fig. 2C).

Only 24 females of *P. amazonensis* were captured, three of these were immature. Four females produced between three and 12 eggs (mean = 8.00, SD = 3.74) and two females had distended abdominal pleura. The total length of ovigerous females varied between 28.6 and 32.4 mm. The total length of most individuals ranged from 20 to 30 mm (fig. 2D).

All species had a few, large eggs, but the eggs of *M. ferreirai* were the largest, followed by those of *P. amazonensis*, *M. inpa* and *M. nattereri* (table III).

Effects of environmental variables on the abundance and richness of the species

The effects of environmental variables were evaluated only for *M. inpa* and *M. nattereri*, which were found in 80% and 50% of the sampled stations, respectively. *Macrobrachium ferreirai* and *P. amazonensis* were found in 21% and 15% of the sampled stations, respectively, and no analysis was performed for these species.

TABLE III

Mean, standard deviation and range of egg measurements and volume for shrimp species at the campus of the Universidade Federal do Amazonas, collected in July and November 2008, February, June, July and November 2009, and February and June 2010, Manaus, Amazonas, Brazil

Species	Short axis (mm)	Long axis (mm)	Volume of the eggs (mm^3)
Macrobrachium ferreirai	1.95 ± 0.08	2.64 ± 0.13	7.17 ± 0.96
Kensley & Walker	1.75-2.00	2.45-2.90	5.50-8.80
Macrobrachium inpa	1.70 ± 0.07	2.46 ± 0.04	5.41 ± 0.32
Kensley & Walker	1.55-1.75	2.40-2.50	4.87-5.72
Macrobrachium nattereri	1.47 ± 0.05	2.05 ± 0.09	3.27 ± 0.36
(Heller)	1.40-1.60	1.85-2.25	2.51-3.97
Pseudopalaemon amazonensis	1.77 ± 0.03	2.57 ± 0.03	6.16 ± 0.04
Ramos-Porto	1.75-1.80	2.55-2.60	6.13-6.19

The model explained about 6.4% of the variation in the abundance of *M. inpa* ($R^2 = 0.064$, $F_{4,43} = 0.739$, $P = 0.571$), but no variables were related to this variation.

The abundance of *M. nattereri* ($R^2 = 0.396$, $F_{4,43} = 7.043$, $P < 0.0001$) was significantly and positively related to stream size ($t = 4.073$, $P < 0.0001$), and negatively related to water temperature ($t = -3.2567$, $P = 0.02$).

The richness was not related to environmental variables ($R^2 = 0.077$, $F_{4,43} = 0.891$, $P = 0.478$).

DISCUSSION

The four species reported in the study area have already been recorded in other areas in central Amazonia, such as the Ducke Forest Reserve, Tarumã-Mirim River and its tributaries, Jaú river basin, and in the small streams around Manaus (Walker & Ferreira, 1985; Henderson & Walker, 1986; Magalhães & Walker, 1988; Walker, 1994; Cleto-Filho & Walker, 2001; Magalhães, 2009; Kemenes et al., 2010).

In our study, the more abundant species were *Macrobrachium inpa* and *M. nattereri*, similar to the findings of Walker (1992) and Walker & Ferreira (1985) at Tarumã-Mirim River, a Negro River tributary. This fact might be indicating that these species are habitat generalists, occurring both in small rivers linked to greater Amazonian rivers and in small forest streams, being common species in the aquatic fauna of this region. On the other hand, the abundance of *M. ferreirai* was small in the present study, differing form the data by Kemenes et al. (2010), who reported a greater number of individuals of this species in samples made with hand dip nets and traps, taken in headwater streams of the Jaú river basin in Central Amazonia. The same study also verified the lower abundance of *Pseudopalaemon* species, similar to that found in the present study, in spite of the differences in the collection methods.

The total number of individuals of all species was greater in months during the dry period than in months during the rainy period. During the rainy period the volume of water of the streams overflows and invades their marginal areas, facilitating the dispersion of species to colonize other microhabitats, while in the dry period there is a decrease in volume of water in streams, restricting the individuals to the main streambed, which can facilitate the capture of the shrimps by traps. Similar observations are made by Walker (1987) in samples made with hand nets at Tarumãzinho River (Manaus), where the number of shrimps collected was greater in September, when the water retreats to the riverbed and the organisms are forced to follow it.

For species of the genus *Macrobrachium* the number of males was larger than the number of females, contradicting the majority of the studies with prawns of

Macrobrachium and other palaemonid species, which found a great number of females or equality in the sex ratio (Odinetz-Collart, 1988; Odinetz-Collart & Enriconi, 1993; Odinetz-Collart & Magalhães, 1994; García-Dávilla et al., 2000; Lima & Oshiro, 2002; Sampaio et al., 2007). A greater number of males in the samples can be explained by effect of the collection method (baited traps), considering that *Macrobrachium* individuals are usually territorialists (García-Dávila et al., 2000). Adult males are more competitive than females, and would be the first ones to have access to the bait traps. In contrast, the predominance of males was also observed for other species of freshwater shrimps (*Macrobrachium olfersii* (Wiegmann, 1836), and *Potimirim potimirim* (Müller, 1881)) both in the southeastern region of Brazil (Ammar et al., 2001; Lima et al., 2006).

We found only females of *P. amazonensis* in the studied area. However, in studies conducted at large water bodies in the Manaus region, both males and females were found (Walker, 1994). The low number of individuals collected and the absence of males for this species may be related to sampling method. According to Kensley & Walker (1982), *P. amazonensis* is characteristic of shallow waters on sandy substrate. In our study, traps were placed randomly on the stretches of streams selected without regard to substrate, so the sample may not have favoured collection of this species. For this species the total length of ovigerous females was smaller than that found by Magalhães & Medeiros (1998).

Males were larger than females for the three species of the genus *Macrobrachium* indicating sexual dimorphism in size similar to that found in other studies (Mantelatto & Barbosa, 2005 for *Macrobrachium brasiliense* (Heller, 1862) and Fransozo et al. (2004) for *Macrobrachium iheringi* (Ortmann, 1897)). *Macrobrachium nattereri* was the largest species sampled in the study area. The mean total length was 54.2 mm for males and 42.4 mm for females. However, larger individuals were found in streams in Colombia (71.5 mm for males and 43.6 mm for females; Valencia & Campos, 2007).

The low number of eggs found in ovigerous females in the present study is similar to that observed in other species of palaemonid shrimps of continental waters (Kensley & Walker, 1982; Magalhães & Walker, 1988; Pereira & Garcia, 1995), which produce large eggs with a reduction in the number of larval stages (Magalhães, 1989). The presence of ovigerous females in all sampling periods indicates continuous reproduction, as found for other or the same species in the Amazon region (Walker & Ferreira, 1985; Walker, 1992; Odinetz-Collart & Enriconi, 1993; García-Dávila et al., 2000).

The population structure of the studied species was different from other studies on shrimp populations in Central Amazonia and other regions of Brazil. These differences can be related to sampling methods and structure and size of water

bodies. The reproduction and distribution of *M. inpa*, *M. nattereri* and *P. amazonensis* were strongly affected by the annual hydrological cycle in Tarumã-Mirim River (Walker & Ferreira, 1985). For *Macrobrachium potiuna* (Müller, 1880) the temperature affected the number of juveniles (Mattos & Oshiro, 2009), and water temperature and rainfall influenced the number of juveniles of *M. iheringi* in a first order stream in southeastern Brazil (Fransozo et al., 2004).

No significant relationships were found between abundance of the most common species (*M. inpa*) or the species richness and the environmental variables measured. The abundance of the second most abundant species (*M. nattereri*) was related to stream size and water temperature. However, there was a small variation in the water temperature in our study and the influence on the abundance of this species may be an artefact. In subtropical regions, the water temperature has been detected to influence the size of the population and reproductive cycle of palaemonid shrimps (Bond & Buckup, 1982; Müller & Carpes, 1991; Müller & Prazeres, 1992; Mattos & Oshiro, 2009). Kemenes et al. (2010) also verified relationships between stream size (width and depth) and *M. nattereri* abundance, and suggested that this species uses the entire water column for feeding.

The richness found in the studied area, an urban forest fragment, indicates the importance of the preservation of small streams in forest fragments in the region and, mainly, the forest fragment as the studied area.

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