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Brachyuran crustaceans from the bycatch of prawn fisheries at the mouth of the Amazon river

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ABSTRACT

The present paper is a pioneering study on the Brachyura bycatch associated with the artisan prawn fisheries at the mouth of the Amazon River. The study was conducted at four collection sites distributed along the mouth of the Amazon River between the months of January/2009 and January/2010. The animals were caught using handcrafted traps called "*matapi*", which are used by prawn fisherman in the region. Twenty matapis were used at each collection site. A total of 145 specimens were captured and six species were identified, all belonging to the Trichodactylidae family - *Sylviocarcinus maldonadoensis, S. pictus, S. devillei, Valdivia serrata, Dilocarcinus septemdentatus* and *D. pagei.* The most representative species, *S. maldonadoensis*, *S. pictus* and *S. devillei* were classified as regular. Regarding the composition of the capture, there were three specimens of *D. pagei* , only one male specimen of *D. septemdentatus,* forty-eight specimens of *S. maldonadoensis,* sixty-eight specimens of *S. pictus,* twenty-two specimens of *S. devillei* and three specimens of *V. serrata.* In all months, the brachyuran fauna showed a considerably lower biomass when compared to the prawns, representing only 5% of the catch, in a ratio of 1:0.06. For most species, the number of males was always higher than the number of females in almost all collection months.

KEYWORDS: *Macrobrachium*, prawn fishing, Crustaceans, Amazon region, Trichodactylidae

Crustáceos Brachyura da fauna acompanhante da pesca artesanal de camarões de água doce na foz do rio Amazonas

RESUMO

O presente trabalho constitui um estudo inédito sobre a fauna de Brachyura associada à pesca artesanal de camarões na foz do rio Amazonas. Este estudo foi realizado em quatro pontos de coleta distribuídos na foz do Rio Amazonas, entre os meses de janeiro/2009 e janeiro/2010. Os animais foram capturados utilizando armadilhas artesanais denominadas "matapis" usados por pescadores de camarão na região. Em cada ponto da coleta foram usados 20 matapis. Foram identificados seis espécies em um total de 145 indivíduos capturados, sendo todos pertencentes a família Trichodactylidae: *Sylviocarcinus maldonadoensis, S. pictus, S. devillei, Valdivia serrata, Dilocarcinus septemdentatus* e *D. pagei.* As espécies mais representativas *S. maldonadoensis*, *S. pictus* e *S. devillei*, foram classificadas como regulares. Quanto à composição da captura temos *D. pagei* com três exemplares, *D. septemdentatus* com apenas um exemplar macho *S. maldonadoensis* com 48 exemplares, *S. pictus* com 68 exemplares, *S. devillei* com 22 exemplares e *V. serrata* com 3 exemplares. A fauna de Brachyura apresentou, em todos os meses, uma biomassa consideravelmente menor se comparada a dos camarões, representando apenas 5% da captura, com uma proporção de 1:0,06. Para maioria das espécies a proporção de machos foi sempre superior a de fêmeas em quase todos os meses de coleta.

PALAVRAS-CHAVE: *Macrobrachium,* Pesca de camarão, Crustáceos, região Amazônica, Trichodactylidae

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INTRODUCTION

In the northern Brazilian coast, prawn fishery includes species from continental and marine waters, both having great economic and social importance (Isaac *et al*. 1992). In the continental and estuarine zones of the Amazonian states, prawn exploitation is directed towards two freshwater species, *Macrobrachium amazonicum* (Heller 1862) and *M. carcinus* (Linnaeus 1758), which are exclusively caught through artisan fishing in the states of Pará and Amapá (Odinetz-Collart and Moreira 1993; Silva *et al*. 2002a, b; Vieira and Neto 2006). However, there is no current data on the fisheries production of *M. amazonicum* and on their bycatch (Maciel and Valenti 2009).

One of the greatest problems of commercial fishing is the capture of unwanted species (Zeller and Pauy 2005), also known as bycatch, which is defined as the set of individuals of any size or species that are caught together with target species, mostly without any biological relationship between them (Graça Lopes 1996)

According to Isaac *et al.* (1992), in the north coast of Brazil, for each kilogram of tail of pink shrimp, about 7.2 kg of bycatch composed of fish, mollusks and other crustaceans are caught, resulting in about 40,000 tons/year of fishing waste.

The participation of the bycath in the fishery of prawn *Macrobrachium amazonicum* and *M. carcinus* is often high, considerably exceeding the biomass of the target species, especially when the fishing instrument used is the trawl net. It can reach up to 70% of the biomass produced by this fishing area in the state of Amapá (Vieira 2003). Juveniles of croakers (*Pachypops* sp) and hake (*Plagioscion surinamensis* and *P. squamosissimus*), species with high local economic value, have been a target of these catches with nets and often discarded as bycath (Vieira 2003).

This overfishing and discard of large amount of bycatch will contribute to the loss of food and biodiversity, biomass reduction, dangerous menace for fish stocks, changes of the relationships predator/prey and therefore modifying the structure and the function of trophic communities that support fishing environment. Moreover, the most obvious consequence of the excessive capture of the bycatch fauna is a decrease of populations found there (Lewison *et al*. 2004; Eayrs 2007).

Although the problem of the bycatch is globally concerned, the impact on the composition and abundance of the species varies according to the fishing area and time of the year. However, knowledge of the potential ramifications of their removal on the aquatic ecosystem is still incipient (Eutrópio 2009). Unfortunately, decapod crustaceans (crabs and shrimps) perform the second position in abundance and biomass among animal groups that compose the bycatch fauna (Eutrópio 2009).

Among decapod crustaceans, the brachyurans are composed of the highest number of species: 6,793 species belonging to 1,271 genera and 93 families (Ng *et al.* 2008). Most of them have marine life, but there are also freshwater species and terrestrial and semiterrestrial species with wide distribution, occurring in all oceans and continents at varied depths.

Freshwater prawn fishing is an artisan activity of great economic importance in the Amazonian rivers, especially in the states of Amapá, Pará and Amazonas; there are very few evaluative studies of fisheries, especially those concerning to the bycatch fauna, including the brachyurans. This study aimed to describe and characterize the brachyuran fauna of the bycatch of the freshwater prawns *Macrobrachium amazonicum* and *M. carcinus* caught through artisan fishing at the mouth of Amazon River.

MATERIALS AND METHODS

Area of study

The study area comprised the regions of Santana Island (00º03'40.9"S and 051º08'46.6"W), Rasa Island (00º16'08.1"S and 051º07'25.9"W), Pequena Island (00º15'20.0"S and 051º18'10.6"W) and Mazagão Velho (00º15'39.9"S and 051º20' 42.3'W), located at the mouth of the Amazon River, between in the states Pará and Amapá (Figure 1). The areas studied are relatively similar and important to artisanal prawn fishing. All study area presents various drainage channels, with varying sizes and depths, allowing the daily flooding and the formation of a wide diversity of micro-habitats. In the site of Santana island, the

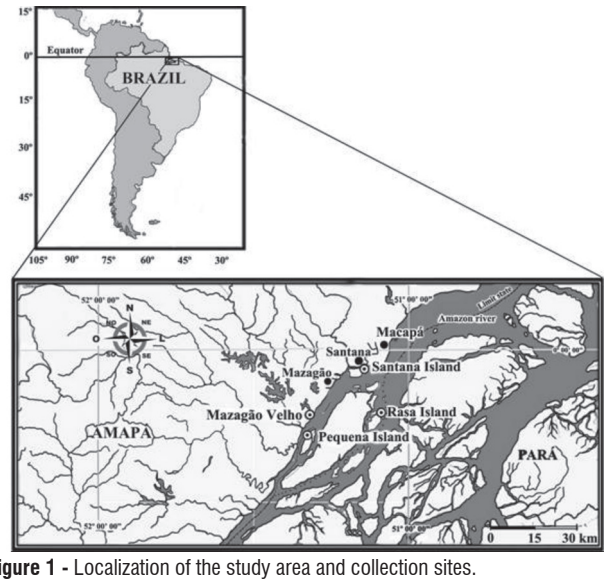

Figure 1 - Localization of the study area and collection sites.

"*várzea*" *vegetation* is open and sparely, with the presence of a narrow border of macrophytes. In Pequena and Rasa islands, the "*várzea*" vegetation is moderately dense with some wide bands of macrophytes occupying its edge. In the Mazagão Velho, the "*várzea*" vegetation is strongly dense with great and wide bands of macrophytes along of the river.

Samples were collected monthly from January 2009 to January 2010, using a handcrafted trap called *matapi* (30 cm in diameter and 50 cm in length) (Figure 02), baited with flour of babaçu (*Orbignya speciosa.*) fruit. The *matapi* consists of a cylinder made of fibers of palm trees *jupati* (*Raphia vinifer*), *bacaba* (*Oenocarpus bacaba*) or *miriti* (*Mauritia flexuosa*) and open in both ends in which a pair of cone made of sticks is inserted (Simonian 2006). Twenty *matapis* were used at each collection site. Traps were set at depths of 1 to 2 meters, during an average of 12 hours of immersion. This sampling is equivalent to the capture performed by artisanal fishermen, which takes place every tidal cycle (12h, twice daily). All captures occurred at daybreak. The caught specimens were properly labeled and preserved in plastic bags containing solution of 4% formalin + 70% ethanol (1:1).

At the laboratory, the brachyuran fauna was sorted from the bycatch of the target species and stored in a container with 80% ethanol where they remained until the start of screening. The identification of the specimens was done according to Melo (2003) and the sex recognition according to instructions provided by Mota-Alves (1975) and Nascimento (1993). Specimens of each species will be deposited in the collection of crustaceans from the Zoology Museum of USP-MZUSP.

Biometries were performed using a digital caliper (accuracy 0.01 mm) and digital scale (precision 0.01g). The following biometric measurements were taken: carapace width (CW) (taken at the largest dimension), carapace length (CL) (taken from the anterior margin of the forehead to the posterior margin of the carapace) (Ivo *et al.* 1999). According to their occurrence, the caught species were classified into three categories: occasional (1 to 5 months); seasonal (6 to 8 months) and regular (9 to 12 months) (Anzari *et al.* 1995).

The biometric data was tabulated and submitted to descriptive statistical analysis to determine average, minimum, maximum and standard deviation of carapace length, carapace width and the weight of the dominant species. A student's t-test (Beiguelman 2002) was performed for the most abundant species in order to identify possible differences in width, length and weight between sexes.

Differences between sex ratios were verified using chi-square test (x^2), at asignificance level of 5% and n-1 degrees of freedom (Beiguelman 2002). General aspects of population structures of the most abundant crabs caught are briefly presented and discussed.

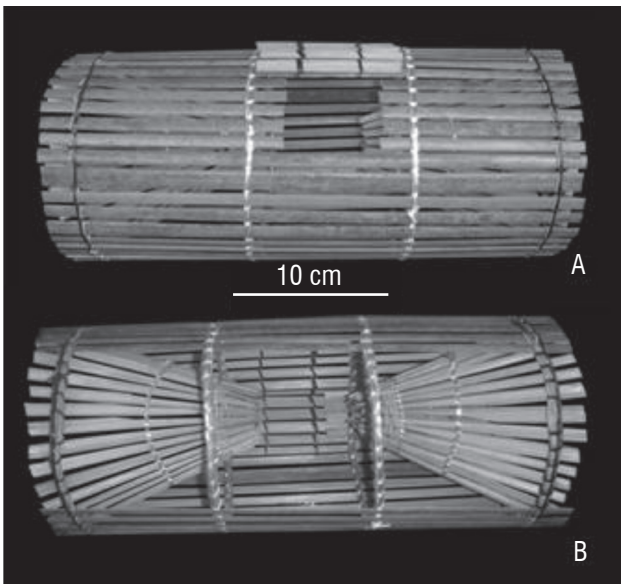

Figure 2 - Matapi an artisanal trap of prawn fisheries at the mouth of the Amazon. A – External view; B – internal view.

RESULTS AND DISCUSSION

Species composition

Throughout the study, 145 crabs belonging to the Trichodactylidae family (H. Milne-Edwards 1853) were caught. There were 100 males (69%) and 45 females (31%), distributed in three genera and six species (Table 1, Figure 3). The most abundant species were *Sylviocarcinus maldonadoensis* (Pretzmann 1978), *S. pictus* (H. Milne-Edwards 1853) and *S. devillei* (H. Milne-Edwards 1853), all classified as regular occurrence in the sampling. *Dilocarcinus pagei* (Stimpson 1861), *D. septemdentatus* (Herbst 1783) and *Valdivia serrata* (White 1847) were the least abundant and frequent, being considered as occasional species. According to Severino-Rodrigues *et al.* (2002), species classified as regular in fisheries are strongly related to the environment of the target species and therefore may be considered typical of bycatch of the referred fishery.

Table 1 - List of brachyuran species caught from January/2009 to January/2010. Occurrence (O) is represented by (<) occasional, (+) seasonal and (>) regular.

Taxon	2009 – 2010		
	N	%	O
Trichodactylidae (H. Milne-Edwards, 1853)			
Sylviocarcinus pictus (H. Milne-Edwards, 1853)	68	46.90	>
Sylviocarcinus maldonadoensis (Pretzmann, 1978)	48	33.10	>
Sylviocarcinus devillei (H. Milne-Edwards, 1853)	22	15.17	>
Dilocarcinus pagei (Stimpson, 1861)	3	2.07	<
Valdivia serrata (White, 1847)	3	2.07	<
Dilocarcinus septemdentatus (Herbst, 1783)	1	0.69	<
Total	145	100	

In the study of bycatch of marine shrimp, Branco and Fracasso (2004) conjectured that the occasional occurrence of some species may be related to migratory processes occurring in the fishing area. Although *D. pagei, D. septemdentatus* and *V. serrata* have been considered as occasional species, their occurrence cannot be explained by migration events, since they are gregarious and territorial in adulthood, performing only short and/or casual movements, similar to other freshwater crabs (Dobson *et a.* 2007a, b). Actually, their actual distributions between the continental and the estuarine environment depend on not only their movements (migration) but also on environmental fluctuations as tides and floods, caused by seasonal and lunar cycles (dispersion mechanisms) (Collins *et al.* 2011).

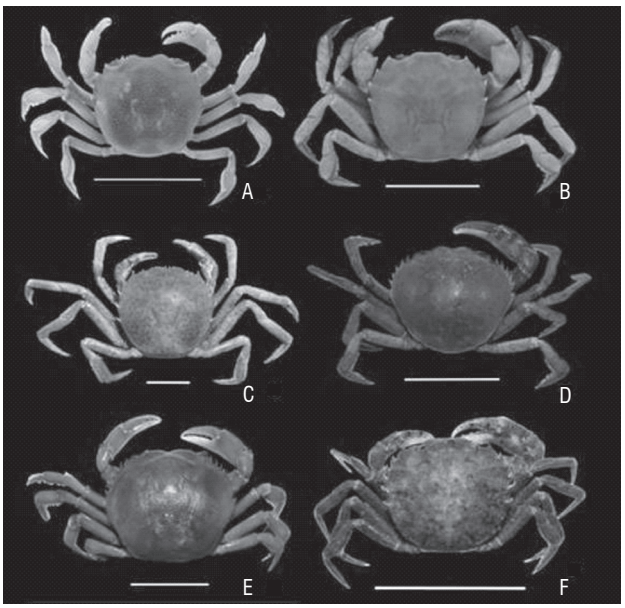

Figure 3 - Dorsal view of brachyurans caught at the mouth of the Amazon River. A) *Sylviocarcinus pictus* (H. Milne-Edwards 1853), B) *Sylviocarcinus maldonadoensis* (Pretzmann, 1978), C) *Sylviocarcinus devillei* (H. Milne-Edwards 1853), D) *Dilocarcinus septemdentatus* (Herbst 1783) E) *Dilocarcinus pagei* (Stimpson 1861) and F) *Valdivia serrata* (White 1847). Scale: 3 cm.

In the Amazon estuary, the connection between continental and estuarine rivers is done through floods that frequently occur during the rainy season. Our observation reveals that this event favors the occurrence of typically continental species such as the ones belonging to the genus *Dilocarcinus* and *Valdivia* in the estuary, as well as the occurrence of estuarine species of genus *Armases* (Rathbun 1897) (Decapoda, Sesarmidae) such as *A. benedicti* and *A. rubripes* in freshwater rivers connecting to the Amazon. According of Schubart and Diesel (1998), some species of the genus *Armases* tolerates large variations in salinity (from 0 to 45 ppt), allowing its survival when they are eventually taken up the river or freshwater lakes during the rainy season.

Species occurrence and abundance

Among the six species found in this study, four were also reported by Vieira (2003): *S. devillei*, *S. maldonadoensis, S. pictus* and *D. pagei*, which confirms their regularity in the bycath of the prawn *M. amazonicum*.

Most specimens (61%) were caught during the rainy season (December-June) in the present study. This result corroborates Silva's study (2010) about population structure of the crabs *S. devillei* and *S. pictus* in the municipally of Belém, inside the same Amazon estuary, who recorded highest number of specimens in the rainy period. This may be related to the increased activity caused by the expansion of floodplain areas where feeding and reproduction take place by trichodactylid crabs (Mansur and Hebling 2002; Rocha and Bueno 2004). On the other hand, they tend to stay hidden, reducing their vulnerability to fishing gear, in dry seasons. The highest abundance were in Pequena island with 45 specimens (31.04% of sampling), followed by Santana island with 43 specimens (29.64%), Rasa island with 40 specimens (27.59%) and Magazão Velho with 17 specimens (11.73%). On the other hand, Santana island had the highest species richness (six species) and Magazão Velho, the lowest (two species) (Figure 4). The occurrence and abundance of these species may be related to the distribution of macrophyte vegetation in the different collection sites, because these areas show similar environmental characteristics due to the large volume of water of the Amazon River (Hu *et al.* 2004). The macrophytes, and are important sources of food, provide shelter for juvenile and adult crabs when threatened by predation (Rosa *et al.* 2009).

Ratio between the target species biomass and the brachyuran fauna biomass

The total biomass of prawn was considerably higher than the biomass of the brachyuran fauna in the bycatch, reaching a ratio of 1:0.06 (Figure 5). Similar results were obtained by Vieira (2003), who recorded the expressively higher biomass

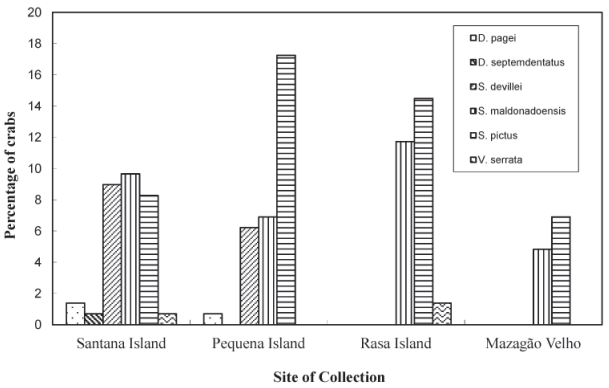

Figure 4 - Percentage of brachyuran species caught between January/2009 and January/2010 and their areas of occurrence.

of *M. amazonicum* than the biomass of the bycatch fauna. This indicates that the *matapi* is above all, a selective instrument, performing lower impact that the trawl nets, whose bycath biomass of crustacean is often greater than the target species biomass, as it can be seen in the studies carried out by Branco and Fracasso (2004) and Branco and Verani (2006).

Population structure of the trichodactylid crabs

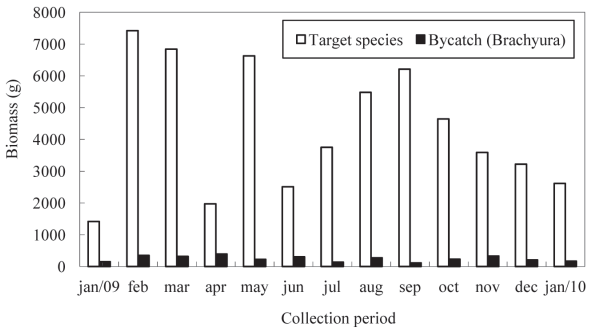

Figure 5 - Ratio between the biomass of prawn (*Macrobrachium amazonicum* and *M. carcinus*) and the brachyuran accompanying fauna caught at the mouth of the Amazon River between January/2009 and January/2010.

Sylviocarcinus maldonadoensis

We caught 48 specimens of *Sylviocarcinus maldonadoensis*, being 33 males (68.75%) and 15 females (31.25%), with a sex ratio of 1:2,2 (x^2= 6.75) and a significant difference level of 5% (Figure 6).

There is no available literature on the sex ratio of *S. madonadoensis*. However, Mansur *et al.* (2005) observed a contrasting dominance of females over males (1:4) for the congeneric species *Sylviocarcinus australis.* For the freshwater crab *Trichodactylus borellianus* Nobili 1896, Collins *et al.* (2006) also reported a dominance of females. On the other hand, Mansur *et al.* (2005) mentioned that for *Dilocarcinus pagei,* the ratio between males and females in the population remained in a balance of 1:1. These differences may be related to the methods of collection and the period of capture on both studies – with sieves during the day in the mentioned authors, while in the present study the traps were set at night, when the territorial males are more vulnerable for capture.

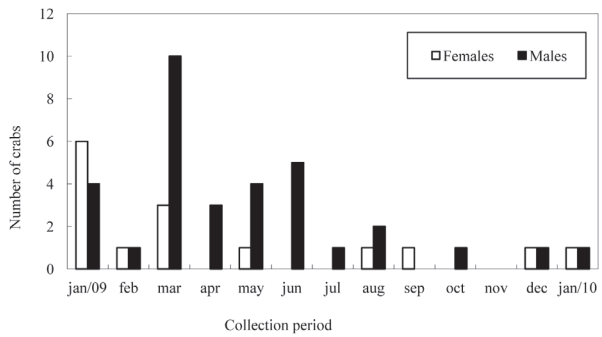

Figure 6 - Monthly distribution of the occurrence of males and females of *Sylviocarcinus maldonadoensis* (Pretzmann 1978) caught between January/2009 and January/2010.

The total biomass of the bycatch brachyuran fauna was of 3,081.4 g and *S. maldonadoensis* accounted for 23.97% (=738.6 g). The weight of the male specimens ranged from 5.59 g to 22.4 g, averaging 14.54 g, while the females', from 5.93 g to 55.67 g, averaging 18.33 g. However, there was no significant difference between the sexes when the *t*-test was applied. Regarding to the size of carapace, similar results were observed (Table 2).

In the same way, in the study of the growth of the trichodactylid crab *Dilocarcinus pagei*, Taddei and Herrera (2010) found significant differences in the weight and in the carapace length between females and males, having female's higher values. Differences in weight and length between the sexes may be attributed to the females' need for space in the cephalothorax for the development of the gonads (Hines 1982). In addition, because eggs of freshwater crabs have a higher amount of yolk and the embryonic development till juvenile stage occurs in the female's pleopods, space for this harboring is essential for theses crabs (Beck and Cowell 1976).

Table 2 - Biometrics of *Sylviocarcinus maldonadoensis* (Pretzmann, 1978), caught at the mouth of the Amazon River.

	Male			Female		
	CW (mm)	CL (mm)	Weight (g)	CW (mm)	CL (mm)	Weight (g)
Minimum	26.61	24.61	5.59	25.66	23.84	5.93
Maximum	37.46	35.62	22.40	49.55	48.29	55.67
Average	31.51	29.21	14.54	34.55	31.76	18.33
Standard Deviation	2.72	2.23	3.68	6.67	6.41	12.15

Sylviocarcinus pictus

We caught 68 specimens of *Sylviocarcinus pictus*, being 51 males (75%) and 17 females (25%), with a sex ratio of 1:3 (x^2: 17, G.L: 1; P<0.05), with a significant predominance of males in April and October (Figure 7). The disparity in the sex ratio is common in crustaceans and it may be related to their reproductive strategies (Wenner 1972). According to Haley (1979), the deviation in the sex ratio of crustaceans may be due to several causes, usually attributed to their dispersion pattern, to periods of food restriction for one gender, migration, mortality and growth rates differentiated between the sexes.

The biomass of *S. pictus* was 1,449.51 g, accounting for 48% of the total biomass of bycatch. The average weight was 20.61 g, ranging from 3.32 g to 41.5 g. The weight of the male specimens ranged from 10.03 g to 34.52 g, averaging 21.56 g, while the females', from 3.32 g to 41.5 g, averaging 17.80 g. However, there was no significant difference between the

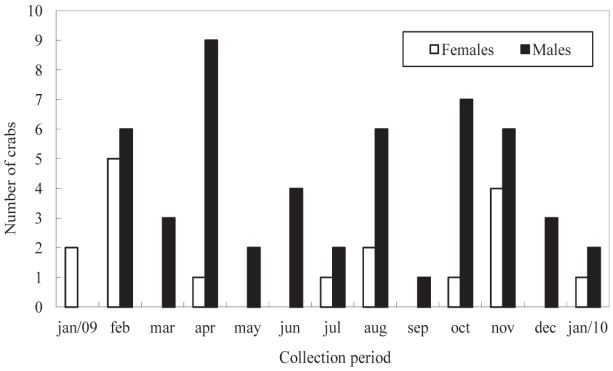

Figure 7 - Monthly distribution of the occurrence of males and females of *Sylviocarcinus pictus* (H. Milne-Edwards 1853) caught between January/2009 and January/2010.

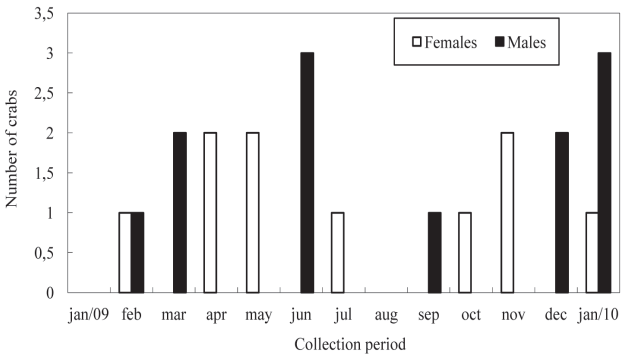

Figure 8 - Monthly distribution of the occurrence of males and females of *Sylviocarcinus devillei* (H. Milne-Edwards 1853), caught at the mouth of the Amazon River from January/2009 to January/2010.

sexes when the *t*-test was applied. The carapace width ranged from 19.24 mm to 45.75 mm for females and from 25.27 mm to 45.52 mm for males. There was no significant difference between the sexes when the *t*-test was applied (Table 3).

During the study, 22 specimens were obtained, being 12 males (54.55%) and 10 females (45.45%), with a sex ratio of 1:0,8 (x^2: 0.18; G.L: 1; P>0.05), with no significant difference during the study (Figure 8). According to Goés and Fransozo (2000), the sex ratio can vary greatly within the brachyuran family. These authors also state that environmental pressure, food availability and reproductive strategy may affect the sexes in different extents, thereby promoting differentiated or non differentiated sex ratios along their lifecycle.

The biomass produced by *S. devillei* was 800 g, with an average weight of 36.36 g. Curiously, Vieira (2003) did not mention the biomass of this specie in his study. The carapace width ranged from 27.59 mm to 60.48 mm for females and from 21.36 mm to 61.84 mm for males, significant difference between the sexes when the *t*-test was applied. The weight of the male specimens ranged from 4.08 g to 83.8 g, averaging 27.47 g, while the females', from 8.05 g to 112.69 g, averaging 47.04 g. Significant difference between the sexes when the *t*-test was applied.

Table 3 - Biometrics of *Sylviocarcinus pictus* (H. Milne-Edwards, 1853), caught at the mouth of the Amazon River.

	Male			Female		
	CW (mm)	CL (mm)	Weight (g)	CW (mm)	CL (mm)	Weight (g)
Minimum	25.27	25.13	10.03	19.24	17.68	3.32
Maximum	42.52	38.87	34.52	45.75	40.82	41.50
Average	35.68	32.69	21.56	33.69	30.57	17.80
Standard Deviation	2.91	2.71	5.52	7.32	6.87	10.11

Table 4 - Biometrics of *Sylviocarcinus devillei* (H. Milne-Edwards, 1853), caught at the mouth of the Amazon River.

	Male			Female		
	CW (mm)	CL (mm)	Weight (g)	CW (mm)	CL (mm)	Weight (g)
Minimum	21.36	19.94	4.08	27.39	26.18	8.05
Maximum	61.84	50.67	83.80	60.48	59.63	112.69
Average	38.10	35.76	27.47	46.33	55.84	47.69
Standard Deviation	10.33	10.10	21.14	8.84	8.84	26.99

CONCLUSIONS

Sylviocarcinus pictus is the most abundant freshwater crab in the Amazon estuary as it was the dominant species both in biomass and in the number of specimens in all studies areas.

Sylviocarcinus maldonadoensis and *S. pictus* have diversified habits as they were found in all collection sites.

Males of *Sylviocarcinus maldonadoensis* and *S. pictus* are more vulnerable for capture with *matapi,* as they have strong dominance when compared to females' abundance, with unbalanced sex ratio.

The *matapi* is an efficient fishing trap for the capture of decapods crustaceans when compared to other devices such as the trawl net, because the biomass of brachyuran fauna in the bycatch was satisfactorily lower than the biomass of the target species.

ACKNOWLEDGEMENTS

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