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POPULATION STRUCTURE OF *HEPATUS PUDIBUNDUS* (HERBST) (CRUSTACEA, DECAPODA) CAUGHT IN TRADITIONAL FISHING FOR THE SHRIMP ON THE SOUTHEASTERN COAST OF BRAZIL

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ABSTRACT

The present study describes some population parameters for the conservation of the crab *Hepatus pudibundus* in the state of Espírito Santo, Brazil. Between January and December 2008, monthly collections were carried out (n = 12) with trawl-net fishery targeting the seabob-shrimp. In all, 514 individuals of *H. pudibundus* were captured: 209 (40.7%) males and 305 (59.3%) females. The sex ratio in the population differed from the expected 1:1, with predominance of females. The adult specimens were more numerous than juveniles. Males were larger than females, with average carapace width of 4.6 ± 0.82 cm compared with 4.1 ± 0.76 cm for females. Juveniles predominated in the class of 3.0 cm in carapace width, and ovigerous females in the class of 4.5 cm. Ovigerous females and juveniles were present throughout the year, suggesting a long period of reproduction and recruitment, reaching a peak in the summer. The size at first maturity was estimated at 3.3 cm carapace width for males and females, and 4.5 cm for all adult specimens collected. The species *H. pudibundus* is an important item in the regional shrimp fishing, coming to represent 50% of the biomass from trawling in Anchieta.

Keywords: Flecked box crab; Bycatch; Artisanal fishery; Sex-ratio; Biometry.

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ESTRUTURA POPULACIONAL DE *HEPATUS PUDIBUNDUS* (HERBST) (CRUSTACEA, DECAPODA) NA PESCA TRADICIONAL DO CAMARÃO NA COSTA SUDESTE DO BRASIL.

RESUMO

O presente estudo descreve parâmetros populacionais do caranguejo *Hepatus pudibundus*, no Sul do Estado do Espírito Santo. Entre janeiro e dezembro de 2008 foram realizadas coletas mensais (n = 12) com rede de arrasto de fundo em embarcações da pesca camaroneira local. No total, foram capturados 514 indivíduos de *H. pudibundus*: 209 (40,7%) machos e 305 (59,3%) fêmeas. A razão sexual na população diferiu do esperado 1:1 com predomínio de fêmeas. Os espécimes adultos foram mais numerosos do que os juvenis. Os machos foram maiores que as fêmeas, com médias da largura da carapaça de 4,6 ± 0,82 cm em comparação com 4,1 ± 0,76 cm para as fêmeas. Os juvenis predominaram na classe de 3,0 cm e as fêmeas ovígeras na classe de 4,5 cm de largura da carapaça. Fêmeas ovígeras e indivíduos juvenis ocorreram ao longo de todo o ano sugerindo um amplo período de reprodução e recrutamento com um pico no verão. O tamanho da primeira maturação foi estimado em 3,3cm de largura da carapaça para machos e fêmeas e a partir de 4,5cm todos os exemplares coletados foram adultos. A espécie é um importante item na pesca camaroneira regional, chegando a representar 50% da biomassa do arrasto em Anchieta.

Palavras-chave: Caranguejo baú; Fauna acompanhante; Pesca artesanal; Razão sexual; biometria.

INTRODUCTION

The artisanal fishing for the seabob shrimp *Xiphopenaeus kroyeri* (Heller1862) in Brazilian coast, affects the populations structure of benthic species. The observed bycatch fauna in artisanal fishing for the seabob is generally diversified, consisting of fish, crustaceans, mollusks, among other groups. The bycatch is always considerably more abundant than the quantity of the comercial target shrimp. Part of this capture, represented by specimens of economic importance and sufficient commercial size is landed, while another part, the largest fraction, composed of individuals with no commercial value or by commercial specimens of small size, is returned non-living to the sea (GRAÇA-LOPES et al. 2002; BRANCO 2005; BRANCO et al, 2015).

The participation of crustaceans in the bycatch of seabob shrimp is high. The diversity of crustaceans is the result of the large number of species with diverse lifestyles and reproductive strategies, which ensure a high degree of diversity and ecological importance (REIGADA; NEGREIROS-GRANSOZO, 2000; FRANSOZO et al., 2016; BARIOTO et al., 2017).

Among the discarded catch, one of the most important species, when considering abundance,is the box crab *Hepatus pudibundus* (Herbst 1758). This is the most abundant crab of the Aethridae family (Dana1851) on the seabob shrimp, *X. kroyeri* trawl fishery (FRACASSO; BRANCO, 2005). The crab *H. pudibundus* is found in waters of the Western Atlantic from South Carolina (USA) to Rio Grande do Sul (Brazil) (NEGREIROS-FRANSOZO et al., 2008). Although without commercial value, *H. pudibundus* plays an important faunal role (FAUSTO-FILHO, 1967), but like other macrocrustaceans, it also represents the importance of coastal ecosystems because it is prey for many carnivorous organisms, either in the larval or adult form (TEIXEIRA; SÁ,1998).

Many studies provided information on relative growth, reproduction, natural diet, and population dynamics in the Brazilian coast (MIAZAKI et al, 2018; SARDÁ et al, 2013; KLÔH; DI BENEDITTO, 2010; KEUNECKE et al, 2007; FRACASSO; BRANCO, 2005; HEBLING;

RIEGER, 2003; MANTELATTO; FRANSOZO, 1994, 1992). Despite its wide distribution, high abundance and ecological role, the population biology of *H. pudibundus* is little known in the region of Espirito Santo. Thus, this paper aims to provide information about the population

structure of *H. pudibundus* as a companion item in the seabob-shrimp fishery in southeastern Brazil and to identify possible impacts on the population of *H. pudibundus*.

METHODOLOY

Study Area: The area studied consists of the Central Beach (20° 49'10" S and 40° 39'00" W) (Figure 1), a region characterized as being relatively exposed to the prevailing wind from the southeastern quadrant (NALESSO et al., 2008), with tidal amplitude 1.9 m, with a minimum of -0.2 m and a maximum of 1.7 m (DHN, 2008), with the influence of the Benevente River, an important carrier of nutrients to the beach. Precipitation is around 1,200mm/year (FERREIRA JÚNIOR et al., 2008), with a rainy summer, and the annual water temperature ranges between 23.7 °C and 27.5 °C (SÁ et al., 2007).

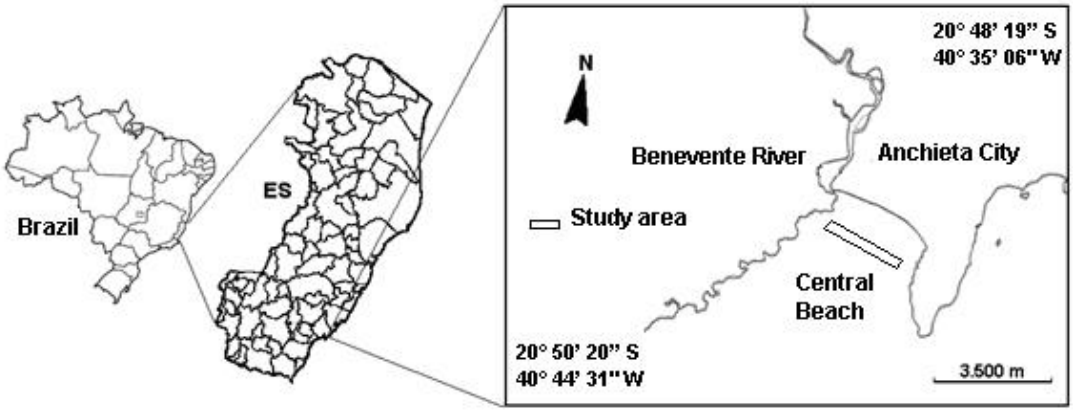

Figure 1. The study area, located in the Central Beach in Anchieta (ES). The highlighted area comprises the region from which samples were taken.

The fishing fleet of the Central Beach consists of 40 wooden boats, 8-9 meters long, vessels using a trawl net, unlike other regions of Brazil, which use two trawl nets simultaneously.

Data collection: The samples were collected monthly between January and December 2008 from the shrimping vessels along the fishing grounds in Anchieta, which has a depth of 6 to 8m. During the period closed to fishing, the samples were taken with permission from the Brazilian Institute of Environment and Natural Resources - IBAMA (Collection license number 13489-1), based on IBAMA Normative Instruction 154/2007.

Each sample consisted of a drag with a duration of 1 hour. Samples were collected by a boat from the local fleet, using trawl nets with approximate dimensions of 5m long and 5m wide. The mouth of the trawl was about 3m long and 3m wide. The mesh sleeve was 30 mm in diameter, and in the terminal portion (bagger) it was 25mm in diameter between opposite knots. The average speed of the vessel was 2 knots.

Specimens of *H. pudibundus* were separated from the other species and were numerically quantified and assessed for their total weight, average carapace length (CL) and width (CW). The biometric and weight analyses were performed by sex, with the aid of calipers in millimeters (greater carapace width) and a precision scale in grams. The identification of males and females was based on Marochi et al. (2016)

Statistical analysis: The chi-squared test (x^2), to the significance level of 5% and n-1 degrees of freedom (n = 2), was applied to verify the possible difference between the sex ratio during the months (ZAR, 2010). To check the influence of traditional Seven-whisker shrimp fishing on the *H. pudibundus* population, analyses were done on the frequency distributions by size classes with age threshold for identification of juveniles, based on size at first maturity (BRANCO et al., 1999) Regression analysis was performed to investigate the relationship between growth length and width of the carapace.

Significant differences among the biometric data, such as width and carapace length and weight of organisms throughout the month of collection, were analyzed by single-factor ANOVA with Tukey test *a posteriori* ($p < 0.05$). The significant differences between the biometric data for males and females were analyzed by Student's *t*-test ($p < 0.05$) (ZAR, 2010).

RESULTS AND DISCUSSION

Carcinofauna is an important item in the fishing for seabob shrimp (*Xiphopenaeus kroyeri*), coming to represent 50% of the trawl net catch in Anchieta (in the months of March and April). The representation of *H. pudibundus* in the carcinofauna varied from 1% (January) to 10% (April) (Figure 2).

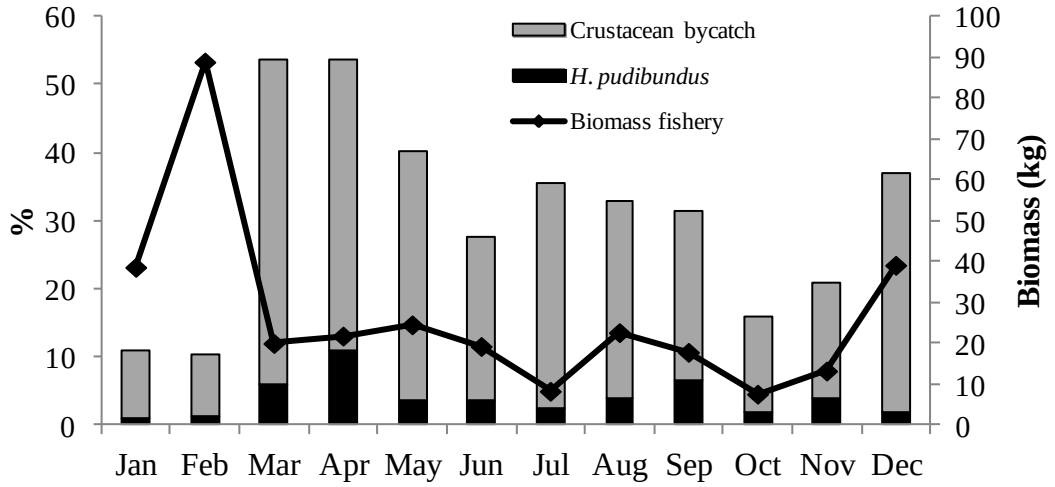

Figure 2. Relative share (%) of crustaceans and *H. pudibundus* from the drag and the total biomass in the period from January to December 2008.

Hepatus pudibundus can be considered as a typical species of bycatch carcinofauna of seabob shrimp in shallow waters of the southeastern coast. As a result, its population is more likely at risk of imbalance as a result of incidental capture (SEVERINO-RODRIGUES et al., 2002).

Between January and December 2008, 514 specimens of *H. pudibundus* were collected: 209 males (40.7%) and 305 females (59.3%). The sex ratio differed from the expected 1:1 (x^2 = 17,930, gl = 1, p = 0.0001), which was also evident in the monthly analysis of the data, revealing a significant difference in favor of females in February (x^2 = 9,308, gl = 1, p = 0.002), March (x^2 = 8,191, gl = 1, p = 0.004), and September (x^2 = 4,446, gl = 1, p = 0.035) (Figure 3).

In Anchieta, *H. pudibundus* represented 10% of bycatch carcinofauna, corroborating the data of Severino-Rodrigues et al. (2002) for the shores of Guarujá (São Paulo). The sex ratio for *H. pudibundus* in Anchieta differs from the expected (1:1), with a greater abundance of females, a result similar to that found by Fracasso and Branco (2005) in Armação Itapocoroy, where the proportion found also differed from the expected (1:1). The differences in sex ratio occur due to mortality by sex, migration, differential use of habitats, food resources and reproductive periods (CASTILHO et al., 2008, YAMADA et al., 2007). Moreover, Klôh and Di Beneditto (2010) and Lima et al (2014b) mention that the populations of the species *H. pudibundus* along the Brazilian

coast point to the predominance of females in relation to males. Miazaki et l (2018) on the southern coast of São Paulo state colected a total of 1650 specimens were 551 males and 1099 females and the males were larger than females.

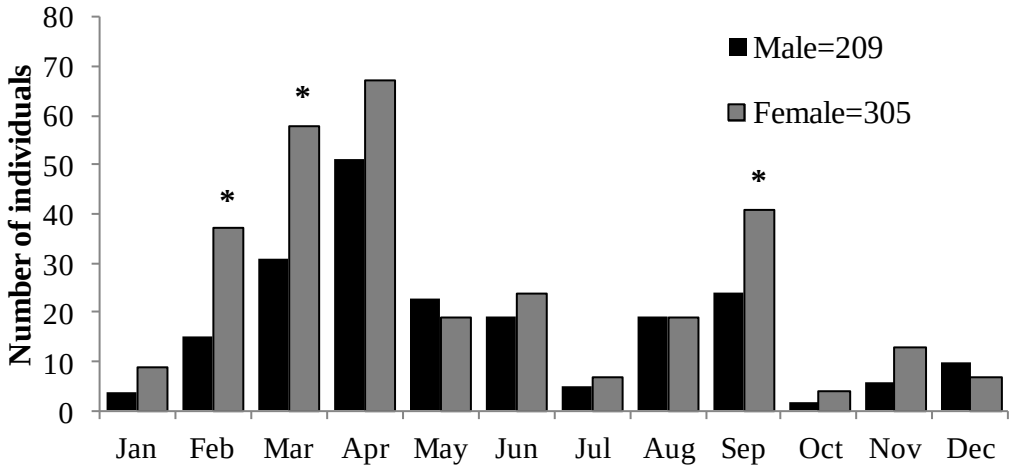

Figure 3. Monthly number of males and females of *H. pudibundus* in the period from January to December 2008. (*) Significant difference by x^2 test.

The carapace width ranged from 2.0 to 6.6 cm with a predominance of females in grades between 3.5 and 4.5 cm for males and between 4.0 and 5.0 cm. Males (LC = 4.6 ± 0.82 cm) had a carapace width significantly larger than females (CL = 4.1 ± 0.76 cm) (t = -6.76381, gl = 512, p = 0, 00001) (Figure 4).

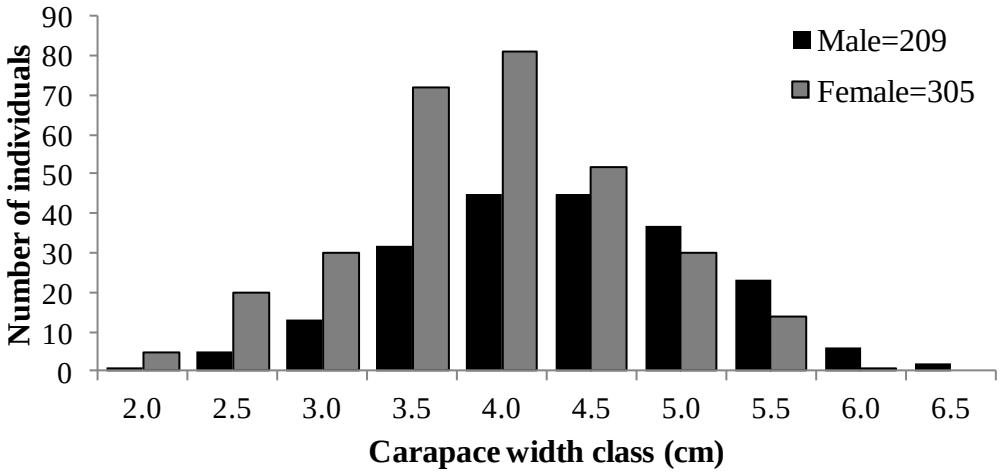

Figure 4. Number of males and females of *H. pudibundus* by class of carapace width (cm) in the period from January to December 2008.

The carapace width of juveniles ranged from 2.0 to 4.0 cm, with predominance of the class of 3.0 cm. The carapace width of adults ranged from 3.5 to 6.0 cm, with predominance among the classes from 3.5 to 4.5 cm. As for ovigerous females, the carapace width ranged between 3.0 and 6.0 cm, with predominance of individuals in the class of 4.5 cm (Figure 5).

The carapace width for *H. pudibundus* in Anchieta ranged from 2.0 to 6.6 cm for males and females, and in ovigerous females, the carapace width ranged between 3.0 and 6.0 cm. Klôh and Di Beneditto (2010), in Rio de Janeiro, found a variation of carapace width (2.3 to 6.8 cm) similar to that in Anchieta. Fracasso and Branco (2005), in Armação Tapocoroy (SC), registered a variation of the carapace of males and females (1.0 to 8.0 cm) and of ovigerous females (3.0 to 7.0 cm), greater than that in the present study. Populations of crustaceans that are distributed in lower latitudes and higher temperatures consist of individuals of smaller body size compared to those at higher latitudes and, consequently, lower temperatures (HARTNOLL, 1982).

Ovigerous females were observed in the months from February to May and from August to November, except in October. Juveniles of *H. pudibundus* occurred throughout the year, except in January. There was an increase of juveniles in the summer months, which is probably the peak period of recruitment (Figure 6).

Ovigerous females were recorded in Anchieta in the months from February to May and from August to November, except in the month of October. According to Fracasso and Branco

(2005), ovigerous females occurred from December to May and in July. The low representation of ovigerous females in the sample batch may be related to migration to sheltered areas due to constant fishing pressure or differential preference in depth, temperature, and texture of the sediment (KLÔH; DI BENEDITTO, 2010).

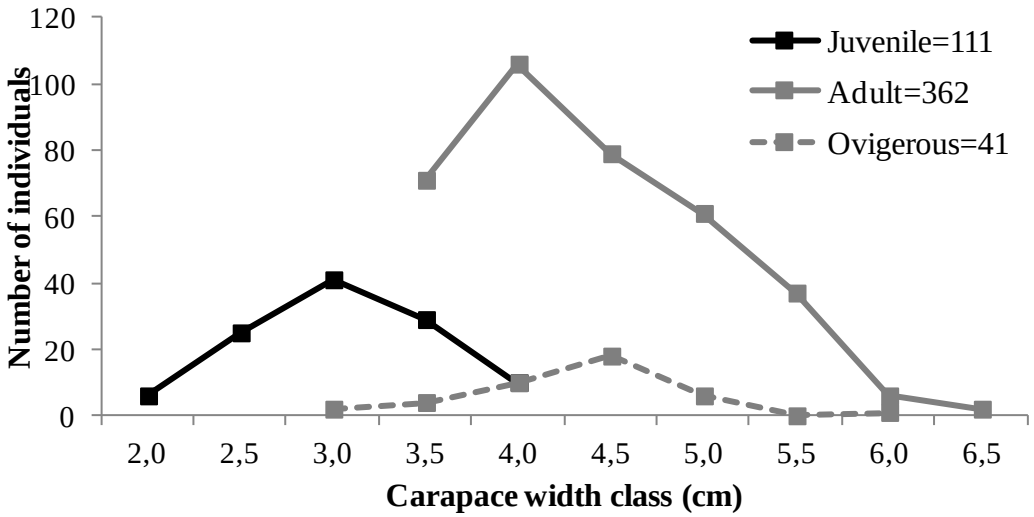

Figure 5. Number of juveniles, adults, and ovigerous females of *H. pudibundus* by class of carapace width (cm) in the period from January to December 2008.

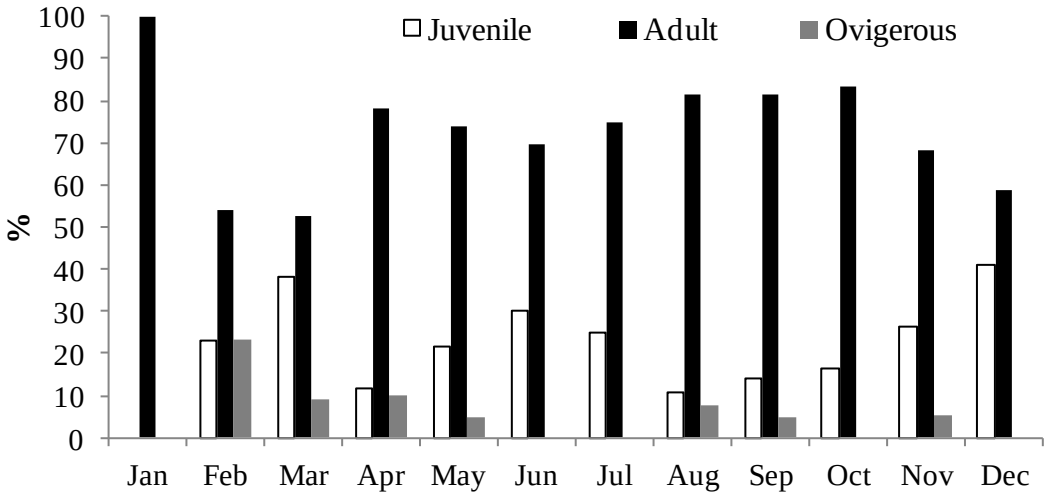

Figure 6. Frequency of occurrence per month for youth, adults, and ovigerous females of *H. pudibundus* in the period from January to December 2008.

The size at first maturity was estimated at 3.3 cm carapace width for males and females, and starting at 4.5 cm, all specimens collected were adults (Figure 7). Looking at the classes of

carapace width as a function of size at first maturity, it is evident that the fishing in Anchieta has caused a greater impact on adult specimens (males = 82.78%, females = 74.4%) than on juveniles (male = 17.22%, female = 25.6%) (Figure 8).

The size at first maturity of *H. pudibundus* in Anchieta was estimated at 3.3 cm carapace width for males and females. Mantelatto et al. (1994), and Reigada and Negreiros-Fransozo (2000), on the coast of São Paulo, and Fracasso and Branco (2005), in Armação Tapocoroy (SC), found the size of *H. pudibundus* at first maturation ranging from 3.4 to 3.6 cm carapace width for males and females, respectively. Lima et al (2014a) found the size of *H. pudibundus* at first maturation ranging from 3.2 cm carapace width for males and females.

Analyzing the classes of carapace width as a function of size at first maturity, it is evident that the traditional fishing in Anchieta has had a greater impact on adult specimens than on juveniles, confirming the data reported by Keunecke et al. (2007) and Klôh and Di Beneditto (2010).

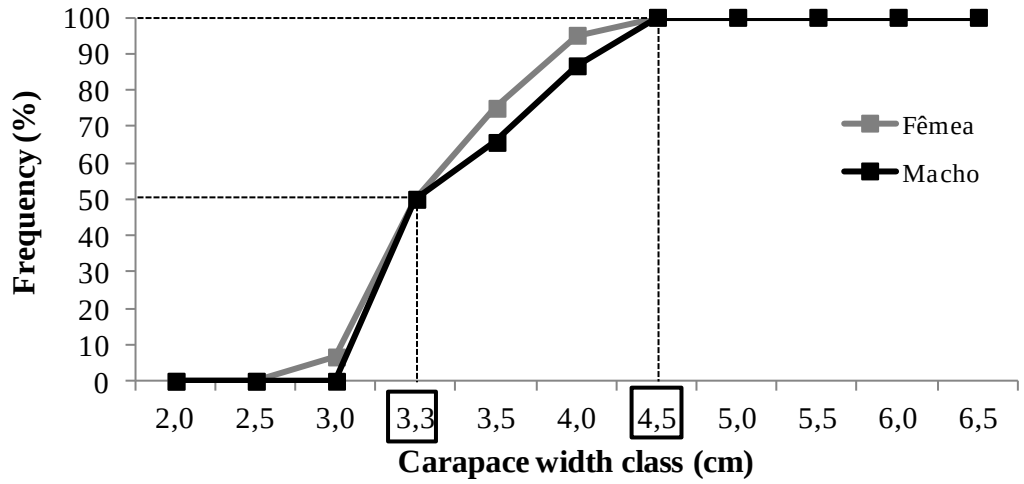

Figure 7. Frequency distribution of males and females, by class of carapace width (cm) in the period from January to December 2008. The highlighted figures indicate the size for males and females that are 50% and 100% mature.

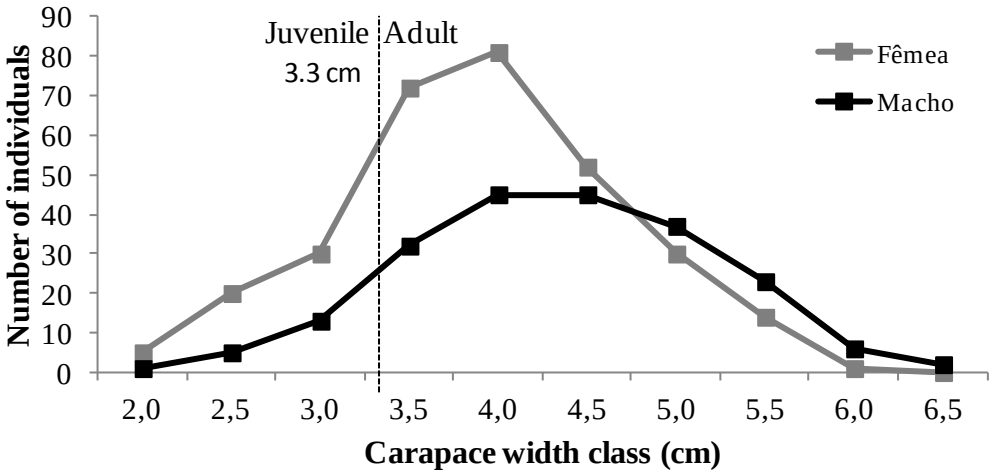

Figure 8. Number of specimens of *H. pudibundus* by class of carapace width (cm) in the period from January to December 2008.

CONCLUSION

The present study reveals a regularly occurring pattern for *H. pudibundus* in the region, confirming its preference for coastal waters with deep mud, or sand and mud, which characterize the study area. Males showed larger body size than females, which agrees with the pattern described in the literature for most brachyurans. Several factors can explain this difference in *H. pudibundus*: i) chelipeds of males being larger and heavier, ii) pressure of reproductive selection acting favorably with regard to larger males, which in turn would leave more descendants, and iii) the females, after sexual maturity, investing more in reproduction and metabolism in the maturation of the gonads than in their growth.

The low representation of ovigerous females in the sample batch may be related to their move to sheltered areas due to constant fishing pressure constant and / or differing preferences with regard to depth, temperature, and texture of the sediment. In the case of juveniles, the low selectivity of the mesh of the trawl may explain their scarcity in the sample. This same feature was observed in other areas of the Brazilian coast where the species *H. pudibundus* was evaluated, always with a higher percentage of adults. However, the spatial segregation of youth

and adults of the species cannot be excluded, and specific studies are needed to elucidate this condition.

The low representation of *H. pudibundus* regarding brachyuran species seems to indicate that the continuous action of shrimp fishing activities in coastal areas can influence the size and structure of populations of brachyuran due to the systematic withdrawal of individuals, leading to changes in recruitment rate and size population. Therefore, the continuation of such samples is recommended in order to assess the impact of fishing activity on the populations of *H. pudibundus* and other brachyuran in their areas of occurrence.

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