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**Introduction**

The decapod crustaceans of the superfamily Portunoidea, popularly known as “swimming crabs”, play a key role in the trophic web of coastal ecosystems, acting as predators of various groups of invertebrates and fishes (Branco and Lunardon-Branco, 2002). On the northern coast of São Paulo, this group is very abundant and presents one of the highest values in species richness, when compared to other brachyurans (Braga et al., 2005; Bertini et al., 2010a). Furthermore, many species of portunoids have a strong fishing potential and high commercial value, constituting an important food resource in most coastal cities. Among them, the species of the genus *Callinectes* Stimpson, 1860 are much exploited (Severino-Rodrigues et al., 2001), especially at the Western Atlantic Coast.

The swimming crab *Achelous spinicarpus* (Stimpson, 1871) has a wide geographic distribution along the Western Atlantic coast, occurring from North Carolina (United States of America) to Rio Grande do Sul (Brazil) (Melo, 1996). Since this species has no commercial value, it is discarded when captured by fishers. However, it plays a relevant ecological role in the food web by acting both as a predator and as prey and constituting an important food item for some fish species (Viana et al., 2014; Motta et al., 2016).

Studies focusing on *A. spinicarpus* are rare. In this sense it is possible to highlight only some works, such as Corbi-Corrêa and Fransozo (2002) and Pardal-Souza and Pinheiro (2013), evaluating some morphometric relationships and estimating the size at morphological maturity in southeastern Brazil, and Sanvicente-Añorve et al. (2008) on the same subject, in the Gulf of Mexico. Ogawa and D’Incao (2010) carried out a study on the growth of individuals from population collected in the northern coast of Santa Catarina. Lima et al. (2014) studied the ecological distribution of *A. spinicarpus* and *A. spinimanus* (Latreille, 1819) from Ubatuba region.

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The swimming crab *A. spinicarpus* is considered a bioindicator of cold water masses (Pires, 1992; Lima et al., 2014), such as the appearance of the South Atlantic Central Water (SACW) in southeastern coast of Brazil, which causes an increase of nutrients in the region, favoring primary production. According to Pires (1992) and Andrade et al. (2015a), this water mass may affect the dynamics of decapod crustacean assemblages, so that their population structure (Andrade et al., 2015b).

Due to SACW influence and other peculiarities of the southeastern Brazilian coast, this locality has been the target of many community studies involving species richness, abundance and diversity of decapod crustaceans, in order to better understand the dynamics of the region’s biodiversity (Fransozo et al., 2012; Bertini et al., 2010a; De Léo and Pires-Vanin, 2006; Alves et al., 2013; Furlan et al., 2013; Andrade et al., 2015a). Despite the large number of studies involving the decapod crustacean community on the north coast of São Paulo, studies at more specific ecological levels, such as populations, are necessary to understand the interactions that determine the biotic dynamics in these environments (Mantelatto et al., 1995; Braga et al., 2007). Thus, considering the importance of *A. spinicarpus* as a component of the assemblage of Portunoidea (Lima et al., 2014) this study aimed to investigate the structure of its population in a region affected by shrimp fishing in the southeast coast of Brazil, evaluating the sex ratio and frequency distribution of individuals in size classes.

**Material and methods**

**Study areas**

According to Mahiques (1995), due to its close proximity to the Serra do Mar, the southeastern Brazilian coast is characterized by a high number of coves and a cut relief, making its internal borders very irregular. These
aspects allow the formation of diverse microhabitats favoring marine biotic development and establishment (Negreiros-Franzoso et al., 1991).

The sampled regions in this study, both located on the north coast of the state of São Paulo, Brazil, differ in their hydrogeographic characteristics. The Ubatuba littoral area (23º 26’ - 23º 31’S, 44º 55’ - 45º 03’ W) presents a diverse combination of environmental variables such as texture and amount of organic matter in the sediment, temperature and salinity of the water, which favors the occurrence of many decapod crustaceans (Mantelatto and Franzoso, 1999). In contrast, the Caraguatatuba littoral area (23º 36’ - 23º 40’S, 45º 07’ - 45º 25’W) presents a more homogeneous variation of these same environmental factors, because it is sheltered from the direct action of the waves and winds by the São Sebastião Island, showing bottom morphology with slightly variations (Barros et al., 1997). These areas are influenced by three water masses that, when compared to each other, have peculiar characteristics and distinct models of distribution throughout the year (Pires, 1992): Coastal Water (Temperature > 20 ºC and Salinity < 36), Tropical Water (T > 20 ºC and S > 36), and South Atlantic Central Water (T < 18 ºC and S < 36) (Castro-Filho et al., 1987).

**Biological data**

The crabs were collected monthly from July 2001 to June 2003 in Ubatuba (UBA) and Caraguatatuba (CAR) areas, northern coast of São Paulo state. Seven sampling points were delimited in each region, at depths of 5, 10, 15, 20, 25, 30 and 35 m (Figure 1). For this, a shrimp fishing boat equipped with double-rig trawls was used. Each net has an opening of approximately, 4.5 m with distances between nodes of 20 and 15 mm, respectively, in the main net body and in the terminal cod. Each point was sampled for 30 minutes of trawling, covering an area of 18,000 m².

Collected crabs were identified according to Melo (1996), with sex determined by observing the abdominal morphology (triangular, males; rounded, females) and pleopods number (2 pairs, males; 4 pairs, females). Each swimming crab was measured using a caliper (0.01 mm) at their maximum carapace width (CW), excluding the lateral spine. All individuals were classified into demographic groups according to Haefner (1990), differentiating juveniles (immature) and adults (mature) by shape and adherence of the abdomen to thoracic sternites. Such groups are: juvenile males (JM), adult males (AM), juvenile females (JF), adult females (AF) and ovigerous females (OF).

**Data analysis**

The data were tested for normality (Shapiro Wilk test) and homoscedasticity (Levene test). Size (CW) was compared between sexes in each area (UBAmales VS. UBAfemales, CARmales VS. CARfemales) and within the same sex between areas (UBAmales VS. CARmales; UBAfemales VS. CARfemales) by Student’s t test.

The sex-ratio of the total individuals in each area was compared by the binomial test (Wilson and Hardy, 2002) to verify possible deviations from the 1:1 ratio. The population structure was evaluated based on the arbitrary distribution of individuals in size classes with a range of 2.3 mm and verification of the modal peaks.

In all analyzes, the level of significance was α = 0.05 (Zar, 2010). Peakfit software version 4.12 (Sea Solve Software Inc., 1999 - 2003) was used to verify the existence of the modal peaks of the size class distribution.

**Results**

A total of 1057 individuals were collected in the Ubatuba area, of which 598 males (525 juveniles and 73 adults) and 459 females (379 juveniles and 80 adults, including 15 ovigerous). In the Caraguatatuba area, 5112 individuals were collected, of which 3138 males (2638 juveniles and 500 adults) and 1974 females (1746 juveniles and 228 adults, including 29 ovigerous).

The mean size of male individuals in the Ubatuba area was 19.7 ± 4.8 mm (minimum = 5.5 mm, maximum = 58.3 mm) and the mean size of females was 20.2 ± 5.6 mm (minimum = 8.2 mm, maximum = 55.5 mm). There was no difference in size between male and female (t = -1.47, p = 0.14). In Caraguatatuba there was no difference between the mean male (18.3 ± 4.4 mm, minimum = 10.1 mm, maximum = 41.9 mm) and female sizes (18.4 ± 4.8 mm, minimum = 9.8 mm, maximum = 40.7 mm) (t = -0.56, p = 0.57). When comparing the mean size of the individuals between areas, it was verified that males and females had larger mean sizes in Ubatuba than in Caraguatatuba (t = 6.95, p < 0.01 and t = 7.17, p < 0.01 respectively). The mean and standard deviation values of the male and female individuals’ sizes in each area are shown in Figure 2.

The sex-ratio was significantly different from the 1:1 (male:female) pattern both in Ubatuba (1:0.7) as Caraguatatuba (1:0.6) (binomial test, p < 0.05), and thus more males were found in both areas. The frequency distribution analysis of size classes presented bimodal pattern for males and polymodal (with three peaks) for females in the Ubatuba area. In Caraguatatuba the pattern was polymodal for both sexes, with 4 and 3 peaks for males and females, respectively (Figure 2).

**Discussion**

Usually, males of the Brachyura species, which inhabit the marine environment, reach a larger body size than females, thus defining the competitive ability to access
receive females, as well as protecting them during copulation (Hartnoll, 1969). Thus, males invest more energy in somatic growth than females (Hartnoll, 1982). However, the absence of difference between the mean males and females sizes reveals that, for A. spinicarpus, size cannot be considered as an indication of sexual dimorphism. Such pattern is not common for Brachyura, since size difference has already been related in Southeastern Brazilian coast (Bertini et al., 2010b; Almeida et al., 2013; Fransozo et al., 2013; Silva et al., 2014; Andrade et al., 2015c). However, a different pattern was also observed by Ogawa and D’Incao (2010) for A. spinicarpus, who collected samples from 10 to 100 m in depth and described females with mean sizes larger than males. The results described by Sanvicente-Añorve et al. (2008), who collected this species in the Gulf of Mexico (unspecified depths), indicate similar mean size between males and females.

In nature, populations in which males and females do not present major morphological differences are those in which males do not undergo intraspecific competitions for females. This is common in populations with very high densities, such as A. spinicarpus, which was the second most abundant Brachyura species in Ubatuba and the first in Caraguatatuba (Braga et al., 2005). Populations of this species can occur at so high densities in some depths that, according to a study by Pires (1992), in the Ubatuba

![Figure 2. Achelous spinicarpus (Stimpson, 1871). Frequency distribution in size classes for males and females with indication of modal peaks (*) in the Ubatuba and Caraguatatuba areas, São Paulo northern coast, Brazil.](image-url)
region, *A. spinicarpus* comprised about 90% of the megafauna in areas affected by the water mass South Atlantic Central Water.

Although the abundance of *A. spinicarpus* was higher in Caraguatatuba, the mean size of the individuals at this site was lower than in Ubatuba. According to Braga et al. (2005), Ubatuba presents a high abundance of other species of portunids (possible competitors), more than in Caraguatatuba. Therefore, the fact that Ubatuba presents a greater number of possible competitors may have affected the occurrence of larger individuals in this area.

Just after the birth, the sex-ratio tends to be close to 1:1. Nevertheless, along the ontogenetic development, factors such as longevity, mortality and differential growth between the sexes can affect this relation (Wenner, 1972; Hartnoll, 1982). In addition, differential behavior among demographic groups can also cause deviations in Mendelian patterns. Pinheiro et al. (1996) verified a pattern of differential distribution by demographic groups of the swimming crab *A. cribrarius*, in which juveniles and adult males occupied shallower areas, whereas adult and ovigerous females were found in deeper areas. According to Pinheiro and Fransozo (1999), this fact occurs because females in reproductive activity migrate to deeper regions, which are more susceptible to the influence of water masses, so that a more efficient dispersion of the larvae occurs after spawning. Thus, demographic groups are susceptible to be captured in different abundances, according to their distribution.

The differential occupation of space by demographic groups of *A. spinicarpus* was confirmed by Silva (2015), in Ubatuba and Caraguatatuba, whose study suggests that abiotic factors such as temperature, salinity and sediment characteristics influence the distribution of the demographic groups of this species. This feature may represent an ontogenetic ecological niche strategy, in that individuals occupy different spaces throughout development, reducing intra-specific competition by resources (in this case, space). Therefore, the deviation from the 1:1 pattern of sex-ratio for *A. spinicarpus* found in the present study could be caused by the differential occupation by demographic groups at the sampling points. In addition, the collections may have covered only the main occupation area of the juveniles, since this species extends its distribution to 500 m (Melo, 1996). This also explains the high number of juvenile individuals found during the collections and the low number of ovigerous females, since these would be in deeper areas (Ogawa and D’Incao, 2010; Pardal-Souza and Pinheiro, 2013).

According to Diaz and Conde (1989), bimodality or polymodality are usually reflections of recruiting pulses, differential or catastrophic mortality, or behavioral differences. The possibility of behavioral differences, mainly related to the occupation of non-sampled areas in this study, cannot be ruled out, since groups of individuals of different sizes, mainly ovigerous females, can be spatially segregated, occupying deeper and non-sampled areas in this study, as suggested by Negreiros-Fransozo and Fransozo (1995) and Negreiros-Fransozo et al. (1999) for *C. ornatus*, in the Fortaleza and Ubatuba coves, Ubatuba area.

The importance of the studied areas as places of juvenile development of *A. spinicarpus* is evident. This is justified by the high number of captured juvenile individuals. The lack of information about this species hinders the clarification of some questions suggested in this paper, for instance, if differential distribution occurs among demographic groups. Studies aiming at characterize the spatio-temporal distribution, reproduction features and juvenile recruitment can serve as important tools that may help to understand such aspects, especially in areas such as Ubatuba and Caraguatatuba, where the growing expansion of tourism and fishing activity can cause environmental impacts.

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