ON THE POPULATION STRUCTURE OF *Callinectes danae* AND *Callinectes ornatus* (DECAPODA, PORTUNIDAE), IN GUANABARA BAY, RIO DE JANEIRO STATE, BRAZIL

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ABSTRACT

Guanabara Bay forms an estuarine ecosystem that is degraded on account of the action of several contamination sources. Despite this, it maintains an important fishery production that is mostly composed by *Callinectes danae* and *Callinectes ornatus* swimming crabs. Thirty-three trawlings were conducted from August 2002 to September 2003 in different locations in this bay, as well as visits to the Z-8 fishery colony, and cruises with fishermen. A total of 2,275 specimens were captured, of which 1,445 were *C. ornatus* and 830 *C. danae*. Their largest captures occurred in summer, being *C. ornatus* the most captured species during the season. Continuous reproductive pattern was only verified for *C. danae*. Capture of adult individuals was higher than that of juveniles for both species and sexes. The sex ratios obtained for *C. ornatus* and *C. danae* were significantly different from the expected 1:1. Growth in weight showed a very similar pattern for both species. The fishery recruitment to Guanabara Bay`s trawling fleet started in autumn for *C. danae* (35.00 mm individuals) and in spring for *C. ornatus* (30.00 mm individuals).

KEYWORDS: Swimming crabs, reproductive biology, morphometric analyses, fishery recruitment

RESUMO

Sobre a estrutura populacional de *Callinectes danae* e *Callinectes ornatus* (Decapoda, Portunidae), na Baía de Guanabara, Rio de Janeiro, Brasil

A Baía de Guanabara constitui um ecossistema estuarino que se apresenta impactado por diversas fontes de contaminação. Apesar disso, mantém uma importante produção pesqueira composta em sua maioria pelos siris *Callinectes danae* e *Callinectes ornatus*. Foram realizados 33 arrastos, de agosto de 2002 a setembro de 2003, em diferentes pontos da baía, idas à colônia de pesca Z-8 e saídas junto a pescadores. Obtiveram-se 2275 exemplares, sendo 1445 *C. ornatus* e 830 *C. danae*. As maiores capturas destas espécies ocorreram no verão e *C. ornatus* foi a espécie mais capturada durante a estação. O padrão contínuo de reprodução foi verificado apenas para *C. danae*. A captura de indivíduos adultos foi superior a de juvenis para ambas as espécies e sexos. As proporções sexuais obtidas para *C. ornatus* e *C. danae* foram significativamente diferentes do esperado de 1:1. O crescimento em peso apresentou um padrão similar para ambas as espécies. O recrutamento pesqueiro junto à frota de arrasto da Baía de Guanabara para *C. danae* iniciou-se no outono, com indivíduos de 35,0 mm, e para *C. ornatus* na primavera com indivíduos de 30,0 mm.

PALAVRAS-CHAVE: Siris, biologia reprodutiva, análises morfométricas, recrutamento pesqueiro

INTRODUCTION

Guanabara Bay is an estuarine ecosystem that practically groups the overall metropolitan region of the city of Rio de Janeiro. Despite its undeniable importance, it constitutes one of the most degraded coastal environments in the country (Amador 1997). Nonetheless, even receiving the pouring out from domestic and industrial sewages and from the non-controlled placing of solid residues, the bay is able to maintaining an important fishery production (Jablonski *et al.* 2006).

In Guanabara Bay, crustacean fishery has a prominence place and specially targets the pink-shrimps (*Farfantepenaeus brasiliensis* (Latreille, 1817) and *Farfantepenaeus paulensis* (Pérez-Farfante, 1967)). Additionally, the species belonging to the *Callinectes* genus also present high exploitation potential, especially the blue-crabs *Callinectes danae* Smith, 1869 and *Callinectes ornatus* Ordway, 1863. Inside the bay, these species are caught by liftnet and otter trawl. However, trawl fishery does not target these species that are captured as pink-shrimp fishery bycatch (Jablonski *et al.* 2006).

Despite their high fishery potential in Guanabara Bay, there are only a few investigations on the biology of these species in this ecosystem, such as the studies by Lavrado *et al.* (2000), Carvalho-Cunha (2003), Keunecke (2006) and Keunecke *et al.* (2008a, b).Therefore, the aim of this study was to produce information on the population structure of the swimming crabs C. danae and C. ornatus, aiming to improve the knowledge on their biology in Guanabara Bay.

MATERIALS AND METHODS

Guanabara Bay is characterized as a region of mixture of the saltiest waters in the Atlantic Ocean with the less salty waters from the 35 rivers of the drainage basin (Kjerve *et al.* 1997). The bay has a channel in its median portion which guarantees its self-depuration potential through the renewal of its waters due to the circulation induced by tidal currents (Villac *et al.* 1991). The regional climate is tropical humid wet with two well-

defined seasons: wet warm summers from December to April and dry cool winters from July to August. Horizontal salinity variation decreases from the bay entrance towards the most inner areas, unlike the horizontal temperature variation (Kjerve *et al.* 1997).

Biological samples were obtained by 33 trawlings during the period from August 2002 to September 2003, in different areas of Guanabara Bay. The region comprised by this study was the northeast of Rio-Niterói Bridge up to the surroundings of Ilha do Governador (Figure 1). These trawlings were carried out for commercial purposes and only fishery samples were collected.

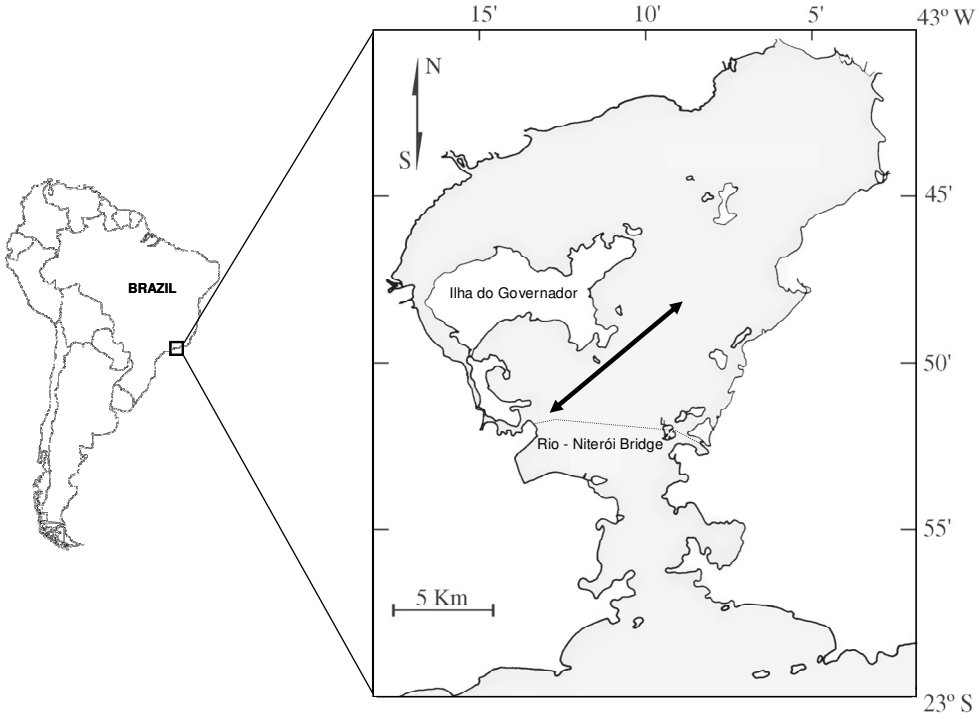

Figure 1. Map of Guanabara Bay showing the range area of the collecting sites.

The ship used was considered a standard commercial shrimp trawler. The total length of the boat was 9.5 m with 36 hp motor potency and a mesh size of 18 mm at the codend. Trawlings were carried out at dawn with a duration of approximately one hour. Visits to the Z-8 fishery colony (comprehending landing areas in Niterói - RJ and São Gonçalo - RJ) were performed, as well as cruises with the fishermen to obtain empirical data on swimming crab fishery. This survey was performed due to the scarcity of works which contemplate fishery, particularly that of swimming crabs in the bay.

Species were identified according to Williams (1974). As proposed by Williams (1974), sexual maturation of the individuals was determined through format and adherence of abdomen to thoracic sternites. Total weight (Twt-g), carapace width (including lateral spines) (Cw-mm), and total length (carapace length without the epistomial spine measurement) (Tl-mm) were measured in each individual.

The relationships between total length and carapace width and total weight and carapace width were obtained separately, for both sexes. Carapace width data were grouped in 21 classes of 5.0 mm of amplitude, and were later represented by histograms. Fishery recruitment, that is, initial size and time in which the individuals were available for capture, was assessed by the graphic analysis of frequency distribution of carapace widths. For verifying the existence of statistically significant differences in sex ratio, chi-square test was applied according to Zar (1996). The test used the absolute frequency for total period of sampling and seasonal absolute frequencies, for males and females.

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RESULTS

A total of 2,275 specimens were collected, being 1,445 *Callinectes ornatus* (63.5%) and 830 *Callinectes danae* (36.5%). Seasonal distribution showed that *C. danae* as well as *C. ornatus* were captured along the year. For both species and sexes, the highest values of capture occurred during summer. However, males of C. danae occurred in spring as well. Ovigerous females of *C. danae* were observed all year round, which did not hold true for *C. ornatus*, since no ovigerous females were recorded in autumn. (Table 1). Regarding sexual maturity, a predominance of adult individuals was recorded for both species and sexes (Figure 2).

Table 1. Seasonal occurrence of *Callinectes danae* and *Callinectes ornatus*, females, ovigerous females and males. The number between brackets represents the number of ovigerous females within the total amount of females.

	Callinectes danae			***Callinectes ornatus***		
Seasons of the year	**females**	**males**	**total**	**females**	**males**	**total**
Spring	52(12)	45	97	20(11)	35	55
Summer	246(70)	42	288	123(23)	831	954
Autumn	159(41)	31	190	104(0)	142	246
Winter	229(32)	26	255	119(22)	71	190
Total	**686(155)**	**144**	**830**	**366(56)**	**1079**	**1,445**
%	**82.7(22.6)**	**17.3**	**100**	**25.3(15.3)**	**74.7**	**100**

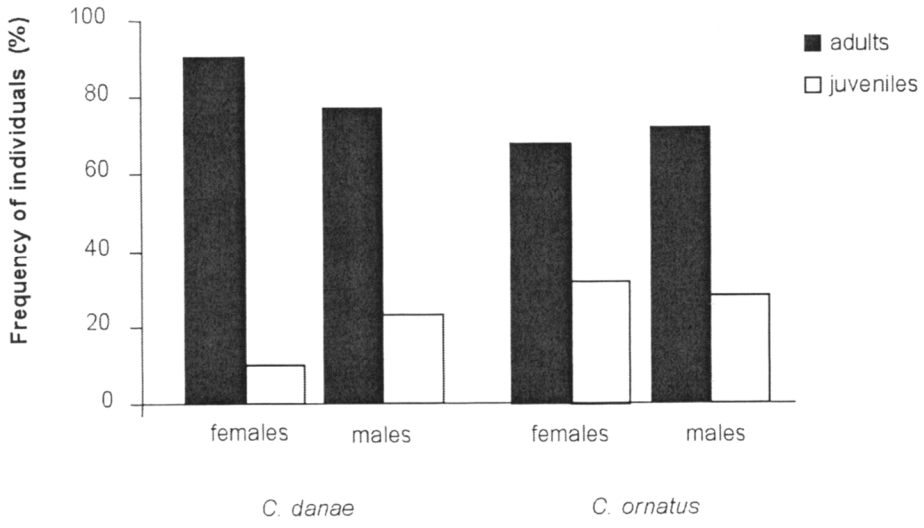

Figure 2. Percentage of adults and juveniles of *Callinectes danae* and *Callinectes ornatus* females and males.

The sex ratio found for *C. danae* (1.0M:4.8F) was significantly different from the expected ratio (χ2=353.9; p<0.01). For *C. ornatus* (3.0M:1.0F), the same pattern occurred (χ2=351.8; p<0.01).

The relationship between total length (Tl) and carapace width (Cw) for *C. danae* can be expressed by the equations Tl = 0.4192Cw + 1.8408 (females) and Tl = 0.4644Cw + 1.7575 (males), both presenting high values of the determination coefficient (R^2), 0.88 and 0.92, respectively (Figure 3).

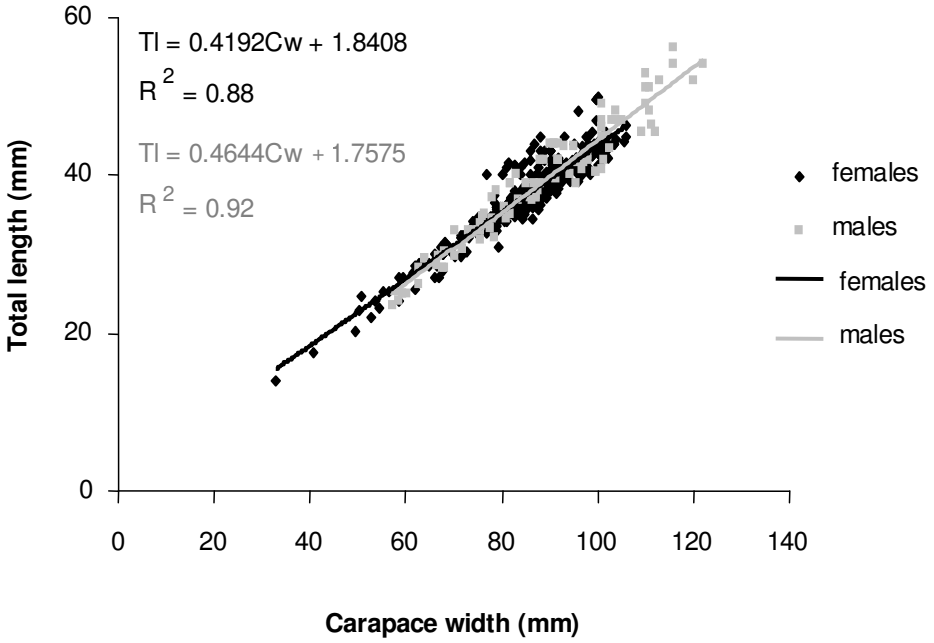

Figure 3. Morphometric relationship between total length (Tl) and carapace width (Cw) for female and male specimens of *Callinectes danae*.

For *C. ornatus*, the relationship Tl x Cw can be expressed by the equations: Tl = 0.4251Cw + 1.0689 (females) and Tl = 0.4663Cw + 1.4420 (males). Both equations present high values of the determination coefficient, 0.98 and 0.96, respectively (Figure 4).

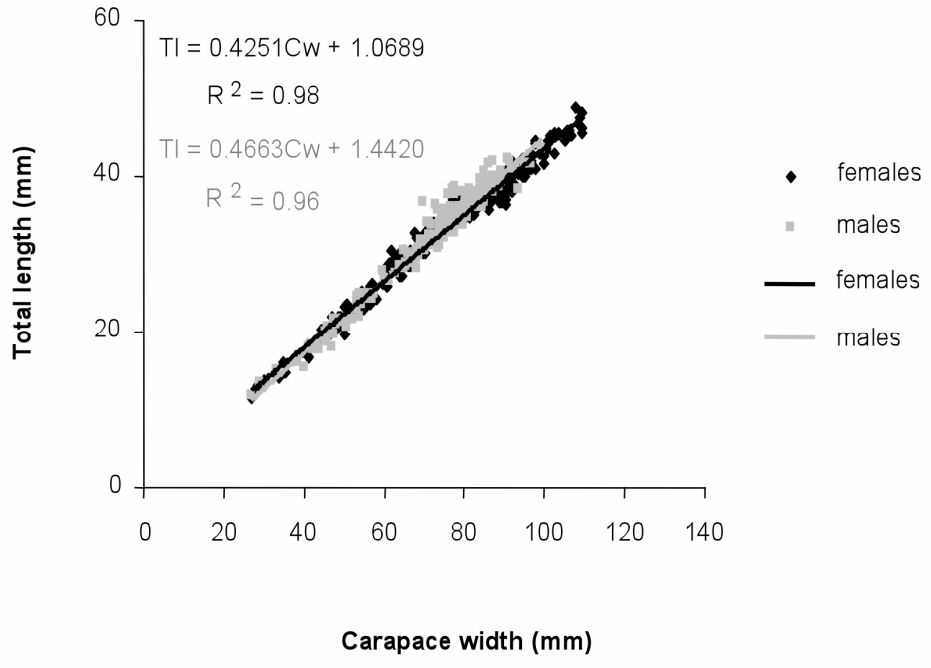

Figure 4. Morphometric relationship between total length (Tl) and carapace width (Cw) for female and male specimens of *Callinectes ornatus*.

The relationship, for *C. danae*, between total weight (Twt) and carapace width (Cw) was expressed by the equations $Twt = 0.6.10^{-4}\ Cw^{2.9937}$ (females) and $Twt = 1.10^{-4}\ Cw^{2.8706}$ (males). Both relationships presented high values of the determination coefficient (R^2), 0.92 and 0.95, respectively (Figure 5).

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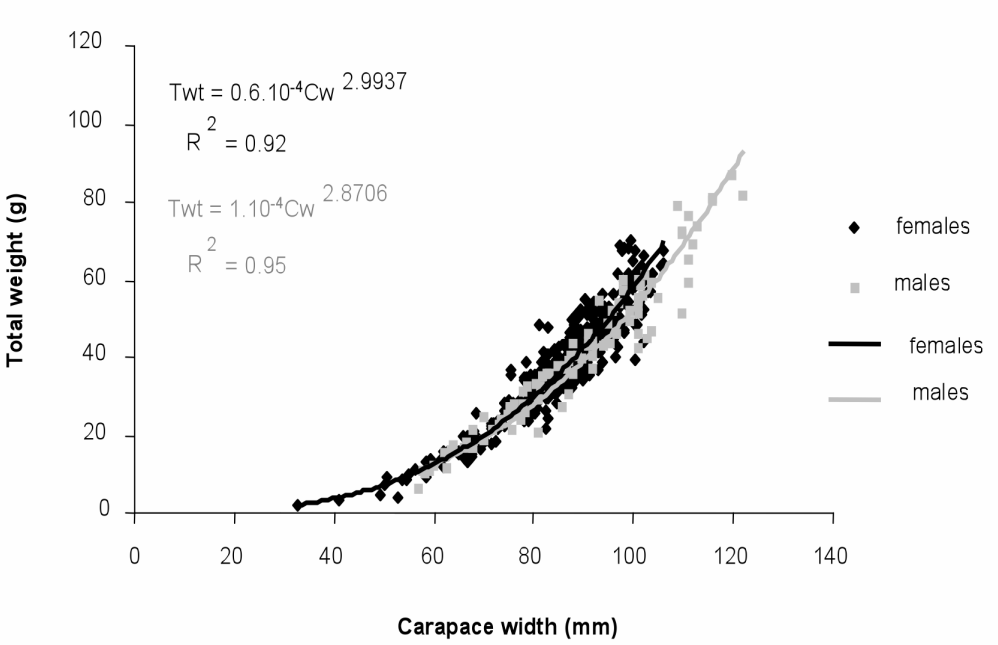

Figure 5. Morphometric relationship between total weight (Twt) and carapace width (Cw) for female and male specimens of *Callinectes danae*.

For *C. ornatus*, the estimated relationship Twt x Cw was expressed by the equations $Twt = 4.10^{-5} Cw^{3.1041}$ (females) and $Twt = 3.10^{-5} Cw^{3.1561}$ (males), with high values of the determination coefficient, 0.98 and 0.95, respectively (Figure 6).

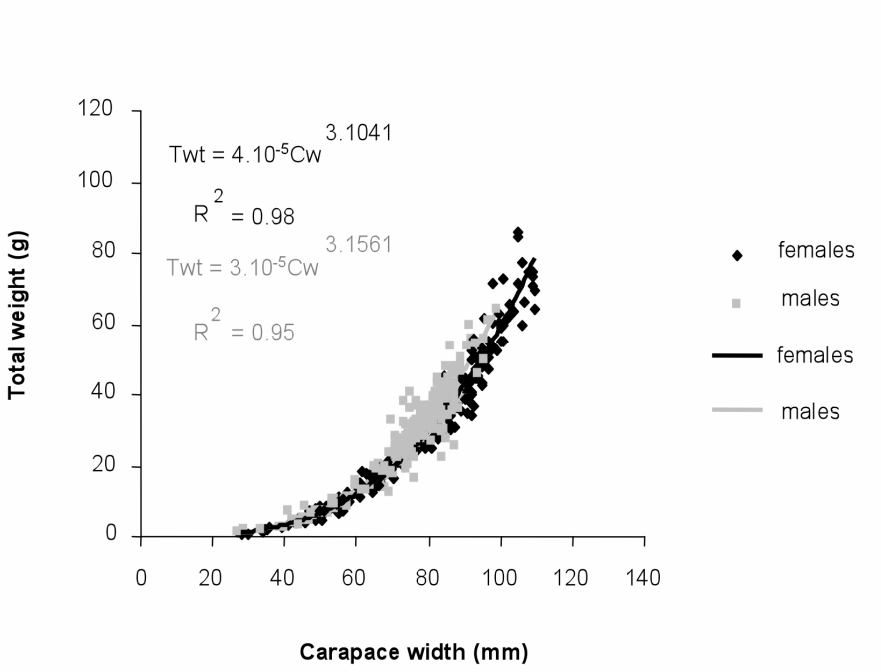

Figure 6. Morphometric relationship between total weight (Twt) and carapace width (Cw) for female and male specimens of *Callinectes ornatus*.

By superposing the curves of *C. danae* and *C. ornatus* males and females, it was observed that there was a partial overlap among females, being *C. ornatus* females a little wider and heavier. Among males, the overlap was not so marked, being *C. ornatus* males proportionally heavier, although less wide than *C. danae* specimens (Figure 7).

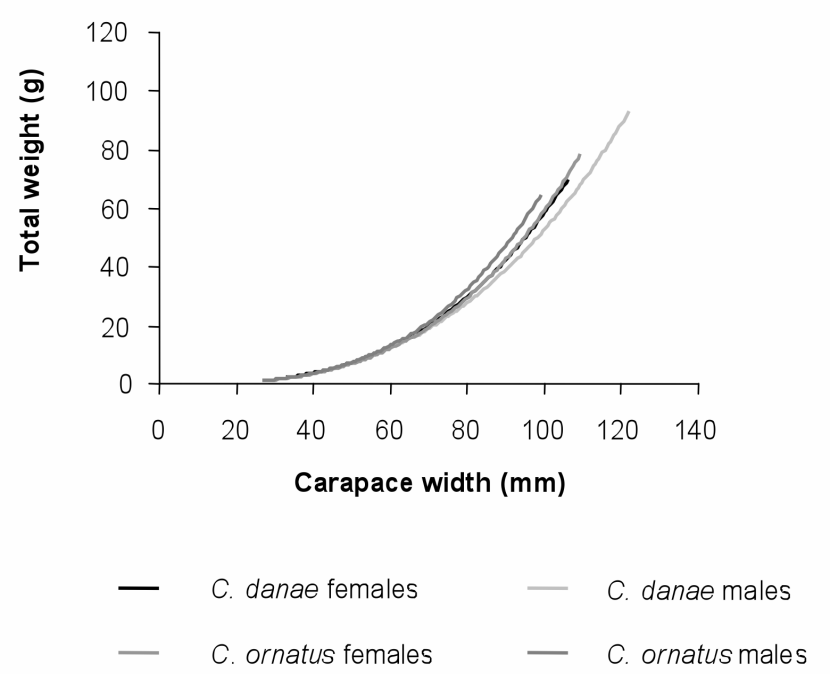

Figure 7. Comparison of the curves of the relationship between total weight (Twt) and carapace width (Cw) for female and male specimens of *Callinectes danae* and *Callinectes ornatus*.

Frequency distribution of carapace width evidenced the capture of *C. danae* females with amplitude between 32.85 and 116.20 mm with a modal value of 90.00 mm. For males, variation was from 40.14 to 122.00 mm with two modal peaks; the first in 80.00, and the second in 105.00 mm (Figure 8).

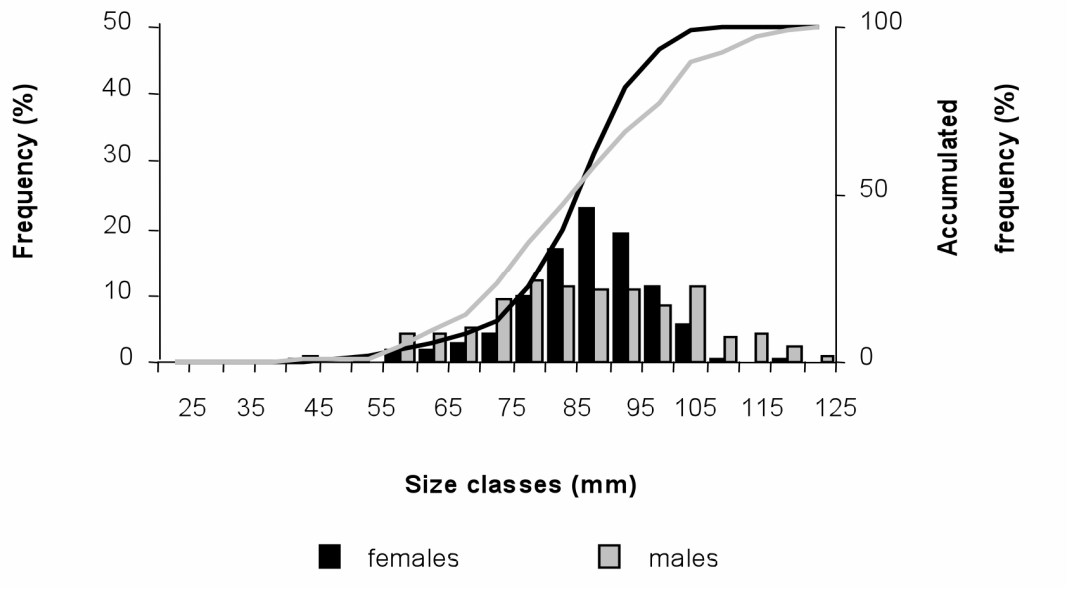

Figure 8. Relative frequency of carapace size for female and male specimens of *Callinectes danae*.

Carapace width, for *C. ornatus* females, ranged from 26.74 to 109.30 mm with two modal peaks; in 65.00 mm and 95.00 mm. For males, it ranged from 26.96 to 99.13 mm with the occurrence of two modal peaks; the first in 85.00, and the second in 65.00 mm (Figure 9).

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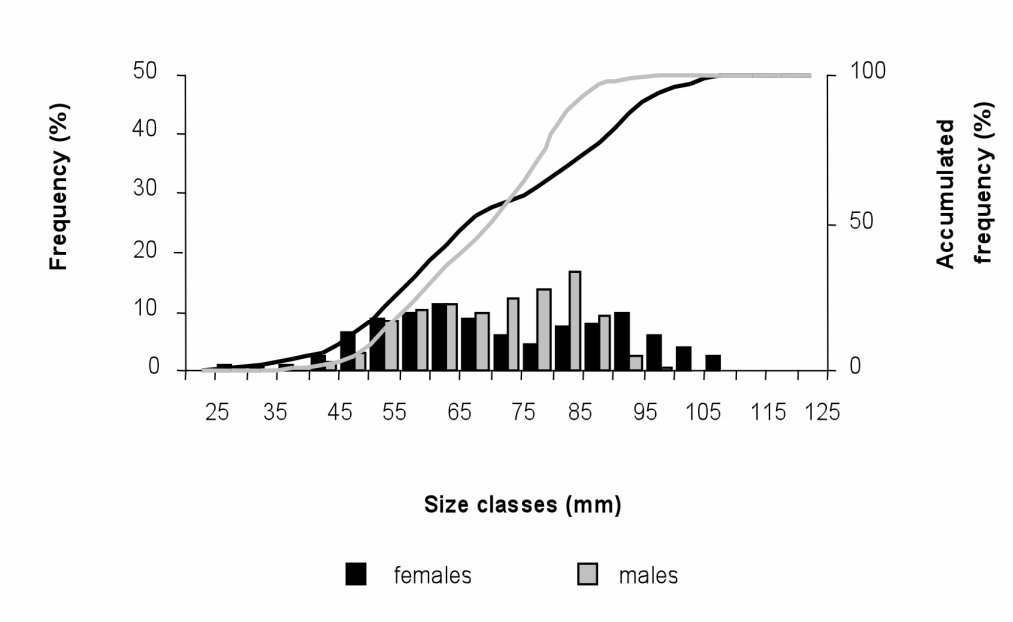

Figure 9. Relative frequency of carapace size for female and male specimens of *Callinectes ornatus*.

Fishery recruitment observed for *C. danae* started in autumn with individuals larger than 35.00 mm. The recruitment observed for *C. ornatus* fishery started in spring with individuals over 30.00 mm (Figures 10 and 11).

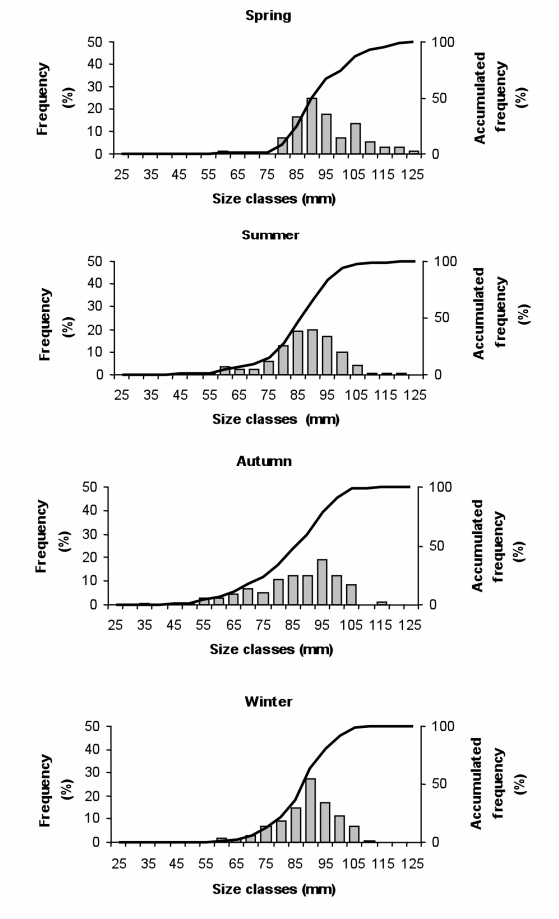

Figure 10. Seasonal relative frequency of carapace size for female and male specimens of *Callinectes danae*.

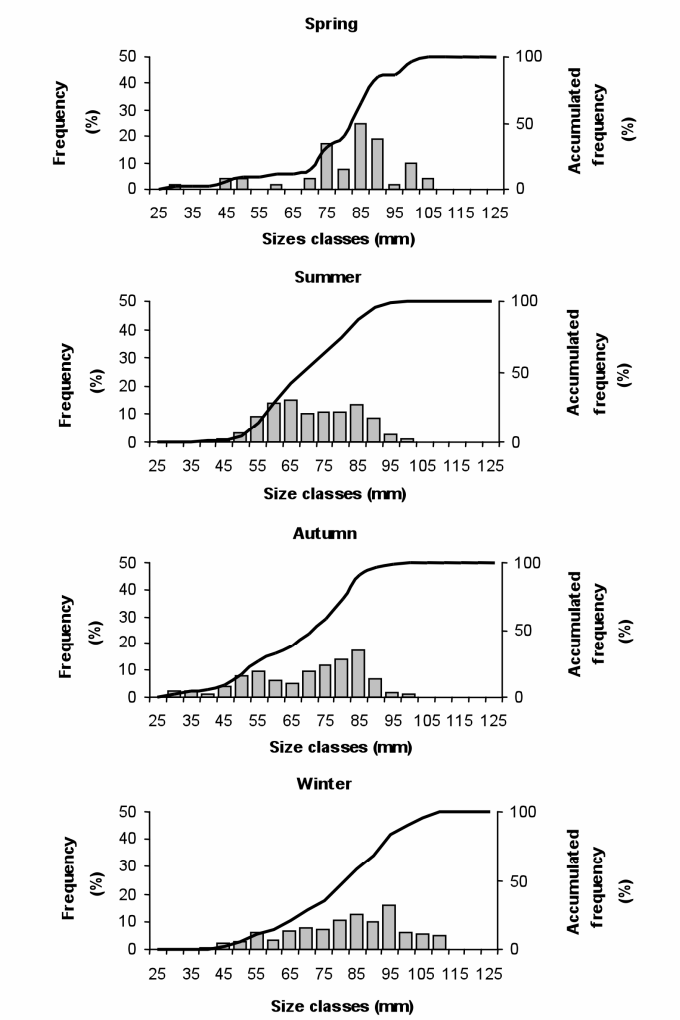

Figure 11. Seasonal relative frequency of carapace size for female and male specimens of *Callinectes ornatus*.

In the swimming crab fishery in Guanabara Bay, the largest capture, as described by the community, occurs in the end of spring, and it extends through the middle of summer in two fishing modalities: (1) trawling, following the largest period of shrimp fishery which occurs in the regions closer to the central channel, and (2) liftnet which occurs in the inner areas next to mangroves. During the pink-shrimp closed season (from March to May), fishermen change the fishing methods from liftnets to trawling, resulting in a decrease in the incidental catch of swimming crabs. However, during the crab (*Ucides cordatus*, Linnaeus, 1763) closed season (from October to December), part of these collectors targets the swimming crabs, a fact which would explain the increase in liftnet fishery during the period of the largest capture of these species.

DISCUSSION

In past studies on the spatial distribution of *Callinectes danae* and *Callinectes ornatus* in Ubatuba, it was verified habitat partition between these two species (Negreiros-Fransozo & Fransozo 1995). In our study, as well as in that of Lavrado *et al.* (2000) and Carvalho-Cunha (2003), which were also carried out in Guanabara Bay, this pattern was not observed, since both species were captured in the study area.

In agreement with the present study, the highest abundance of *C. ornatus* was also observed by Negreiros-Fransozo & Fransozo (1995), Pinheiro *et al.* (1997), Reigada & Negreiros-Fransozo (2001) in Ubatuba (SP) and by Lavrado *et al.* (2000) and Carvalho-Cunha (2003) in Guanabara Bay. According to Pinheiro *et al.* (1997) in their work in Ubatuba, *C. omatus* presented a wide ecological niche which overlapped that

of other species of portunids, thus being considered a generalist species. Taking this into consideration, we assume that *C. omatus*, in Guanabara Bay, shows the same behavior described above.

The largest captures of *C. ornatus* and *C. danae* for both sexes followed a seasonal variation, with the highest values occurring in summer, whereas for *C. danae* males, a similar pattern was observed in spring. It is during this period of the year, in Guanabara Bay, that the fishing effort targeting shrimp increases (Jablonski *et al.* 2006). The swimming crabs, captured as bycatch of shrimp fishery, follow this same trend. It is worth to notice that 22 trawlings, out of a total of 33, were done during summer.

In tropical and subtropical regions it is known that swimming crab reproduction is a continuous process since environmental conditions are permanently favorable for feeding, gonadal development, and larval hatching (Costa & Negreiros-Fransozo 1998 and Negreiros-Fransozo *et al.* 1999). In the present study, a continuous reproductive pattern was observed for C. danae, which is in agreement with investigations performed in similar habitats (e.g. Ubatuba (23°S, 45°W)) (Costa & Negreiros-Fransozo,1998; Chacur *et al.*, 2000; Chacur & Negreiros-Fransozo, 2001). However, for C. ornatus, this pattern was not observed since (1) no ovigerous female was captured during autumn and (2) no juvenile individual was continuously captured along the period of this study. Hence, in Guanabara Bay, the absence of this pattern may indicate that ovigerous females were not captured because they occupy areas not covered by the trawlings, as observed in the work by Carvalho-Cunha (2003) who reported that the presence of ovigerous females was only verified at the bay mouth. Besides, Keunecke (2006) in Guanabara Bay observed that both species presented a continuous reproductive pattern.

The capture of adult individuals, in our study, was higher than that of juveniles, both for *C. danae* and *C. ornatus*, in both sexes. This result may be related to the different site occupation, according to size or age. Partition of habitats was already verified by Buchanan & Stoner (1988) in Porto Rico and in Brazil by Negreiros-Fransozo & Fransozo (1995), Negreiros-Fransozo *et al.* (1999) and Chacur & Negreiros-Fransozo (2001) in Ubatuba (SP), and by Severino-Rodrigues *et al.* (2001) in Santos and São Vicente (SP). According to Buchanan & Stoner (1988), adult swimming crabs may choose most desirable areas in terms of physical parameters and food supply, while juvenile individuals will better survive in sites where there are fewer predators and more protection, namely shallower areas and mangroves.

The sex ratio obtained for *C. ornatus* differed from the expected, revealing the male dominance in the studied area. This result was also verified by Mantelatto & Fransozo (1996) and Negreiros-Fransozo *et al.* (1999) in studies performed in Ubatuba and by Carvalho-Cunha (2003) and Keunecke (2006) in Guanabara Bay. A hypothesis for the explanation of this pattern may be the fact that a single female may copulate with many males during the same reproductive period (Negreiros-Fransozo *et al.* 1999) and adult females may shift to off-coast areas where temperature and/or salinity conditions may be favorable to spawning (Negreiros-Fransozo & Fransozo 1995). Another possible hypothesis is the spatial stratification between sexes, with males preferentially occupying environments more easily sampled by trawl net, as this was the instrument used in the capture of the specimens in all the studies cited. The stratified behavior regarding sex and individual size for C. ornatus was verified by Pita *et al.* (1985) in a study in the Bay-Estuary complex of Santos (SP).

Concerning *C. danae*, an evident dominance of females was observed.

This result was also verified by Branco & Thives (1991) in Itacorubi Mangrove (SC) and by Carvalho-Cunha (2003) and Keunecke (2006) in Guanabara Bay. As stated by Branco & Thives, (1991) that pattern may indicate the migration of ovigerous females to areas of a higher salinity for spawning and male permanence in waters of low salinity, which are areas of growth and copulation, as rivers and mangroves. In a study performed by Severino-Rodrigues *et al.* (2001) in rivers of the estuarine region of Santos and São Vicente, a higher proportion of males over females was found (2.0M:1.0F). This result reinforces the idea of male permanence in low salinity waters. In Guanabara Bay, this same pattern seems to be occurring between males and females.

The equations obtained through the relationship

between total weight and carapace width showed a very similar pattern for both sexes and species, but particularly among females. This similarity indicates that both species do not show sexual dimorphism related to weight, as suggested for *Arenaeus cribarius* (Lamarck, 1818) in a study in Ubatuba (Pinheiro & Fransozo 1993). Similarity in shape of both species is highly supported by phylogenetic studies where it is stated that they are the closest among the *Callinectes* genus (Weber et. al. 2003).

Frequency distribution of carapace width for both species and sexes revealed that Guanabara Bay is occupied by different population strata. As observed by Keunecke (2006), *C. ornatus* and *C. danae* presented a continuous reproductive pattern. Taking this into account, it was possible to infer that the populations of *C. ornatus* and *C. danae* in Guanabara Bay were represented by many cohorts, as it was demonstrated in our results.

The fishery recruitment observed for *C. danae* started in the beginning of autumn with individuals over 35.00 mm, whereas for *C. ornatus* it started in spring with individuals over 30.00 mm, which indicates that trawling fishery in Guanabara Bay is targeting juveniles of both species considering the size data at the first sexual maturation obtained in previous studies performed in Santa Catarina, São Paulo and Rio de Janeiro (Branco & Thives 1991, Branco & Lunardon-Branco 1993, Mantelatto & Fransozo 1996, Keunecke, 2006).

The constant presence of *C. danae* and *C. ornatus* in trawlings carried out at Guanabara Bay demonstrates that these species are important bycatch fauna components of the pink-shrimp fishery (*F. brasiliensis* and *F. paulensis*). Actually, in the south and southeast regions of Brazil, the closed season of the pink-shrimp species are regulated by a governmental decree (IN 189, September 23th, 2008) that prohibits the capture of these species between March and May. This closed season aims to preserve the population of those species but ignores the bycatch fauna captured in that fishery. This fact may be extremely harmful for *C. danae* and *C. ornatus* populations inhabiting Guanabara Bay since ovigerous females and juveniles of both species were caught in the shrimp fishery.

Despite that *C. danae* and *C. ornatus* possess a great fishery potential in Guanabara Bay, their fisheries are not regulated. More studies are necessary on the fishery potential of these species in other regions of the country in order to regulate their fishery. The permanent maintenance of a collection system of fishery statistics is important as subsidy for policies of fomentation to fishery, organization of the fishery sector, and for quantification of eventual losses due to environmental accidents.

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