Population structure of the crab *Callinectes ornatus* Ordway, 1863 (Brachyura: Portunidae) bycatch in shrimp fishery in northern Rio de Janeiro State, Brazil

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Abstract: This study provides the first data on the population structure of swimming crab *Callinectes ornatus* Ordway, 1863 bycatch from coastal shrimp fishing in northern Rio de Janeiro State, Brazil (21° 30'–21° 50' S and 41° 05'–41° 07' W). Crabs were collected monthly from April 2006 to March 2007. A total of 5,611 specimens were analyzed, of which 3,951 were males and 1,660 ovigerous and non-ovigerous females. The overall sex ratio (2:1) differ significantly from the expected 1:1 proportion, being the mature males significantly predominant as bycatch in this fishery. The specimens' carapace width and weight varied from 27 to 126 mm (mean: 77.3 ± 12.3 mm) and 1.2 to 128.2 g (mean: 31.0 ± 14.4 g) for males, and 30 to 101 mm (mean: 63.4 ± 9.3 mm) and 1.7 to 66.0 g (mean: 16.4 ± 7.4 g) for ovigerous and non-ovigerous females. Seasonal comparisons did not reveal differences between the number of specimens captured in dry and rainy periods considering both sexes and maturity stages. The size at first maturity was 79 mm for males and 65 mm for females, and the carapace width-weight relationship indicated an alometric pattern for both sexes. The bycatch swimming crabs are locally used as bait, but the capture tendency for a specific sex/age-group can affect this population structure over time.
Keywords: *crab, bycatch, shrimp fishing, southeastern Brazil, South Atlantic ocean.*

TUDESCO, C.C., FERNANDES, L.P. & DI BENEDITTO, A.P.M. **Estrutura populacional do siri *Callinectes ornatus* Ordway, 1863 (Brachyura: Portunidae) capturado incidentalmente na pesca de camarão no litoral norte do estado do Rio de Janeiro, Brasil**. Biota Neotrop. 12(1): http://www.biotaneotropica.org.br/v12n1/pt/abstract?article+bn00712012012

Resumo: Este estudo fornece os primeiros dados sobre a estrutura populacional do siri *Callinectes ornatus* Ordway, 1863 capturado incidentalmente através da pesca camaroneira realizada no litoral norte do estado do Rio de Janeiro, Brasil (21° 30'–21°50' S e 41° 05'–41° 07' O). Os siris foram coletados mensalmente entre abril de 2006 a março de 2007. Um total de 5.611 espécimes foram analisados, dos quais 3.951 eram do sexo masculino e 1.660 fêmeas ovígeras e não ovígeras. A razão sexual (2:1) diferiu significativamente da proporção 1:1 esperada, sendo os machos maduros significativamente predominantes como captura incidental nesta pescaria. A largura da carapaça e o peso dos espécimes variaram de 27 a 126 mm (média: 77,3 ± 12,3 mm) e 1,2 a 128,2 g (média: 31,0 ± 14,4 g) para machos, e 30 a 101 mm (média: 63,4 ± 9,3 mm) e 1,7 a 66,0 g (média: 16,4 ± 7,4 g) para fêmeas ovígeras e não ovígeras. As comparações sazonais não revelaram diferenças entre o número de espécimes capturados nos períodos seco e chuvoso, considerando ambos os sexos e estágios de maturidade. O tamanho de primeira maturação foi de 79 mm para machos e 65 mm para as fêmeas, e a relação largura da carapaça-peso indicou padrão alométrico para ambos os sexos. Os siris capturados incidentalmente são utilizados localmente como isca, mas a tendência de captura sobre um grupo sexual/etário específico pode afetar a estrutura dessa população ao longo do tempo.
Palavras-chave: *siri, captura incidental, pesca camaroneira, sudeste do Brasil, oceano Atlântico Sul.*

Introduction

The genus *Callinectes* consists of 14 species of swimming crabs, living in marine and estuarine areas of the American Atlantic coast (excepted *C. ornatus*, which was introduced in Europe and Japan). These animals belong to the family Portunidae and are commonly found inhabiting the shallow coastal waters (Williams 1974, Powers 1977, Ng et al. 2008). The swimming crab *Callinectes ornatus* Ordway, 1863 is distributed along the Western Atlantic, from North Carolina, USA (~34° N) to Rio Grande do Sul, Brazil (~33° S), on sandy or muddy bottoms near river mouths and bays, up to a depth of 75 m (Melo 1996). Environments with temperatures between 28-32 and 16-20 °C are preferred for males and females, respectively (Mantelatto & Martinelli 1999). This species has an opportunistic omnivore feeding habit and plays an important role in the marine food web, especially in the benthic community (Mantelatto & Christofoletti 2001, Mantelatto et al. 2002, Batista et al. 2003, Branco & Fracasso 2004).

The presence of crab species as bycatch in shrimp fishing is well documented around the world (Saila 1983, Alverson et al. 1994, Svane et al. 2009). Along the Brazilian coast, many authors have already reported these bycatches, and species of genus *Callinectes* are the most affected (e.g. Graça-Lopes et al. 2002, Severino-Rodrigues et al. 2002, Branco & Fracasso 2004). In northern Rio de Janeiro State, southeastern Brazil, the species *C. ornatus* is the commonest bycatch in this fishery (Costa & Di Beneditto 2009, Di Beneditto et al. 2010), but data about its population structure are nonexistent to this region.

The northern Rio de Janeiro State is permanently influenced by Paraíba do Sul River discharge, whose plume reaches the open ocean waters in velocities ranging from 1.6 to 2.6 km.d^{-1}, carrying particle and dissolved organic matter (Souza et al. 2010). The water temperature in adjacent marine coastal areas is around 22-26 °C throughout the year and the coastal sediment is sandy-muddy, reflecting the river influence (Muehe & Valentini 1998). These characteristics favor the shrimp fishing practice (Fernandes et al. 2011) and the occurrence of many species, both estuarine and marine, which include *C. ornatus* (Di Beneditto & Lima 2003, Di Beneditto et. al. 2010).

The aim of the present study is to describe for the first time the population structure of *C. ornatus* that is continuously affected by shrimp fishing in northern Rio de Janeiro State, southeastern Brazil, providing data for population status evaluation. In the study area, the environmental conditions to the species maintenance have little changes around the year, and we hypothesized that *C. ornatus* is well distributed in all seasons. The utilization of the bycatch crabs by the local community is also discussed.

Material and Methods

This study was conducted in northern Rio de Janeiro State (21° 30'–21° 50' S and 41° 05'–41° 07' W), where the shrimp fishing is practiced in coastal areas that are influenced by the Paraíba do Sul River discharge, from less than 1 to 6 km from the coastline, in depths up to 15 m (Figure 1). The northeast wind is predominant in this

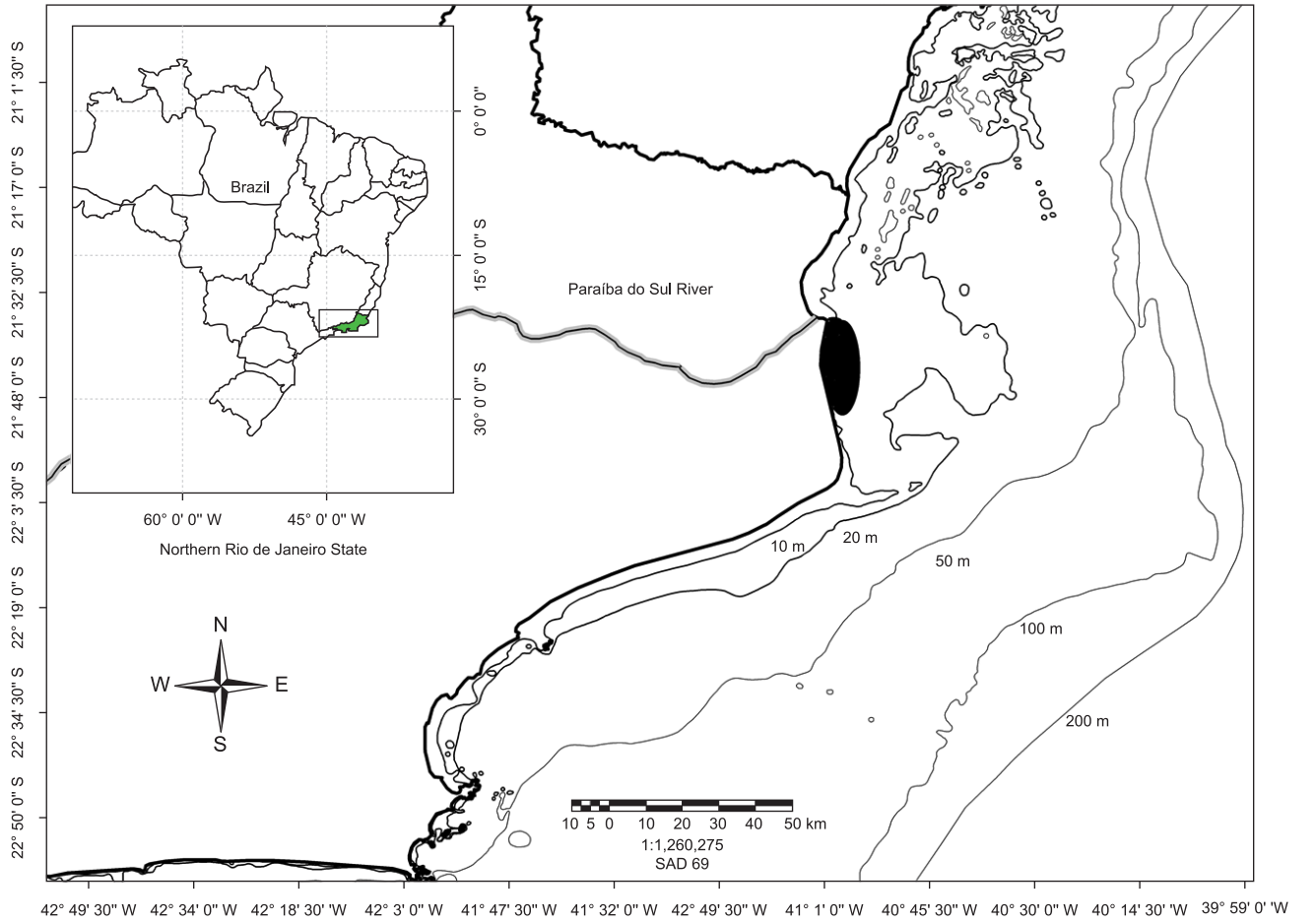

Figure 1. Northern Rio de Janeiro State indicating the fishing ground where the specimens of *Callinectes ornatus* Ordway, 1863 were bycatch (black circle).

region, and the seasons can be grouped into dry (April-September) and rainy (October-March), which are characterized by lowest and highest values of temperature and rainfall, respectively (Martins et al. 1998). From April 2006 to March 2007, monthly samples of crabs were collected from the local shrimp fishing and the fishing effort in each sampling was constant (around 3 to 4 hours). The bottom trawl net measure 10 m in length with a horizontal opening of 6 m and a cod-end mesh size of 30 mm (opposite knots).

After disembarking, *C. ornatus* was sorted out from the other bycatch crabs and then classified by gender and maturity stages by abdomen shape (females) and by moving the abdomen with a probe (males), which is possible in mature specimens (Haefner 1990). The carapace width (CW) was measured to the nearest 1 mm as the distance between the tips of the longest lateral spines using a vernier calliper (±0.1 mm accuracy), and the size class distributions of males and females (5 mm intervals) were recorded. The body weight was obtained to the nearest 0.1 g of each specimen with no pereiopods missing. Voucher specimens were deposited in the zoological collection of the Universidade Estadual do Norte Fluminense with the numbers: UENF-CO001 to UENF-CO005 for male specimens and UENF-CO006 to UENF-CO010 for female specimens.

The Chi-square test (χ^2) was applied to check the significant differences between sex ratio and maturity stages along the studied period. After verifying the assumptions of normality and homoscedasticity, the *t*-test was applied to verify differences between males and females regarding carapace width and body weight, and also between dry and rainy seasons regarding number of bycatch specimens. The statistical analysis was performed using Statistica 7.0 for Windows (StatSoft, Inc 1984-2004, USA) and a p value equal or less than 0.05 was chosen to indicate statistical significance.

The proportions of mature crabs in each size class were adjusted to a logistic model to estimate the size at first maturity ($CW_{50\%}$) for both sexes: $PM = a/1 + b\exp(-cCW)$, where PM is the percentage of mature crabs (Stearns 1992). The carapace width-weight relationships were described for each sex separately by the equation: $W = aCW$, where W is the weight (g) and CW the carapace width (mm) (Hartnoll 1982).

Results

A total of 5,611 specimens of *C. ornatus* were collected during sampling period, being 3,951 males (70.4%) and 1,660 ovigerous and non-ovigerous females (29.6%). A low number of ovigerous females were present (Table 1), and they were grouped with the non-ovigerous mature females for data analyses. The Chi-square test indicated a significant difference from the expected sex ratio of 1:1 ($\chi^2 = 935.42$; $p \leq 0.05$), with a male tendency (2:1). Regarding maturity, mature specimens were more frequent than immature ones for both sexes (males: $\chi^2 = 1{,}427.6$; $p \leq 0.05$ and females: $\chi^2 = 148.2$; $p \leq 0.05$).

The minimum and maximum carapace widths (*CW*) were 27 and 126 mm for males (mean: 77.3 ± 12.3 mm; median: 79.0 mm) and 30 and 101 mm for females (mean: 63.4 ± 9.3 mm; median: 63.0 mm). The size frequency distributions of both sexes are shown in Figure 2. Males presented a size-frequency distribution concentrated in the 82-86 mm interval, while females' size-frequency distribution assumed a bell-shape pattern in which the specimens are concentrated around 57-71 mm. Regarding the body weight (*W*), the values for males were 1.2 to 128.2 g (mean: 31.0 ± 14.4 g; median: 30.8 g) and for females were 1.7 to 66.0 g (mean: 16.4 ± 7.4 g; median: 15.4 g). Males were significantly larger ($t = 36.2$; $p < 0.001$) and heavier ($t = 33.3$; $p < 0.001$) than females. Seasonal comparisons did not reveal significant differences ($p > 0.05$) between the number of specimens captured in dry and rainy periods considering both sexes and maturity stages.

The size at first maturity (*CW*) was also different for both sexes, with males and females reaching sexual maturity around 79 mm and 65 mm, respectively (Figure 3). The carapace width-weight relationship is represented by $W = 0.00005CW^{3.0513}$ ($r^2 = 0.88$; n = 2,819) (males) and $W = 0.00007CW^{2.9623}$ ($r^2 = 0.89$; n = 1,097) (females), indicating alometric growth for both sexes (positive for males and negative for females).

Discussion

The presence of *C. ornatus* year-round in northern Rio de Janeiro State indicates a local resident pattern. The species occurs in marine habitats with muddy bottoms and moderate salinity, depending on estuarine areas to complete its life cycle (Pita et al. 1985, Mantelatto & Fransozo 1999, Reigada & Negreiros-Fransozo 2001, Guerra-Castro et al. 2007). Regarding to these requirements, in the study area, the marine coastal region is continuous and strongly influenced by discharge from the Paraíba do Sul River (Souza et al. 2010), which favours the species' presence. Our hypothesis of a regular distribution in all seasons was confirmed.

Table 1. Number of *Callinectes ornatus* Ordway, 1863 collected in northern Rio de Janeiro State considering sex and maturity status, and sex ratio.

Season	Date	Males			Females				Sex ratio (M:F)
		Immature	Mature	Total	Immature	Mature		Total	
						Non-ovigerous	Ovigerous		
Dry	Apr./06	141	552	693	112	127	1	240	2:1
Dry	May/06	58	310	368	83	41	4	128	2:1
Dry	June/06	9	173	182	10	46	0	56	3:1
Dry	July/07	101	235	336	101	104	0	205	2:1
Dry	Aug./06	48	100	148	18	50	3	71	2:1
Dry	Sept./06	62	219	281	8	94	0	102	3:1
Rainy	Oct./06	120	212	332	123	281	0	404	1:1
Rainy	Nov./06	50	272	322	9	47	0	56	6:1
Rainy	Dec./06	58	414	472	14	52	3	69	7:1
Rainy	Jan./06	40	124	164	31	42	0	73	2:1
Rainy	Feb./07	84	452	536	63	155	8	226	2:1
Rainy	Mar./07	17	100	117	10	20	0	30	4:1
	Total	788	3,163	3,951	582	1,059	19	1,660	2:1

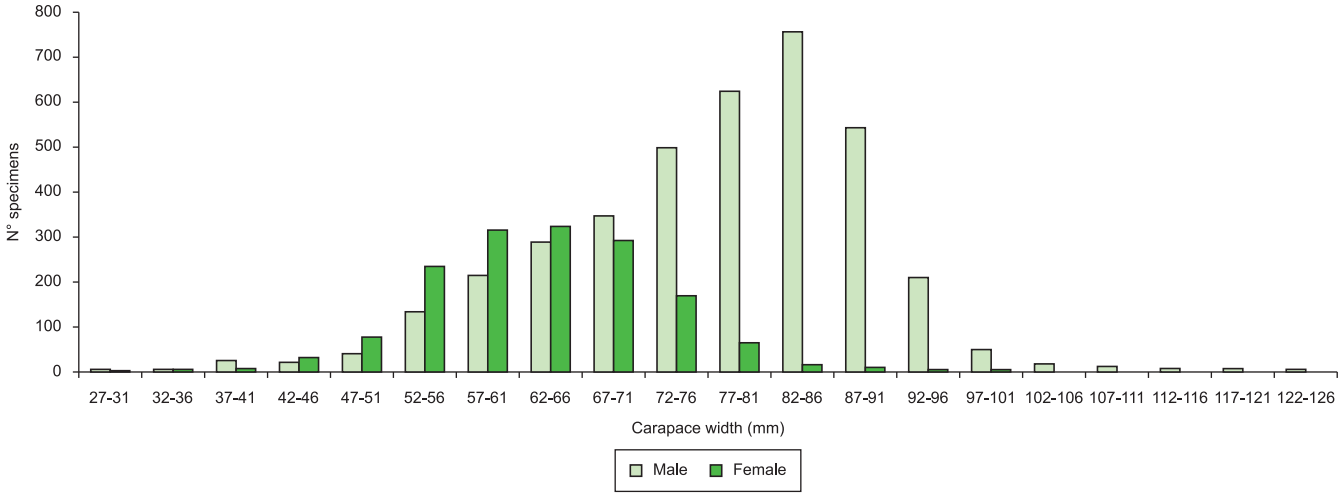

Figure 2. Size frequency distribution of males and females of *Callinectes ornatus* Ordway, 1863 in northern Rio de Janeiro State.

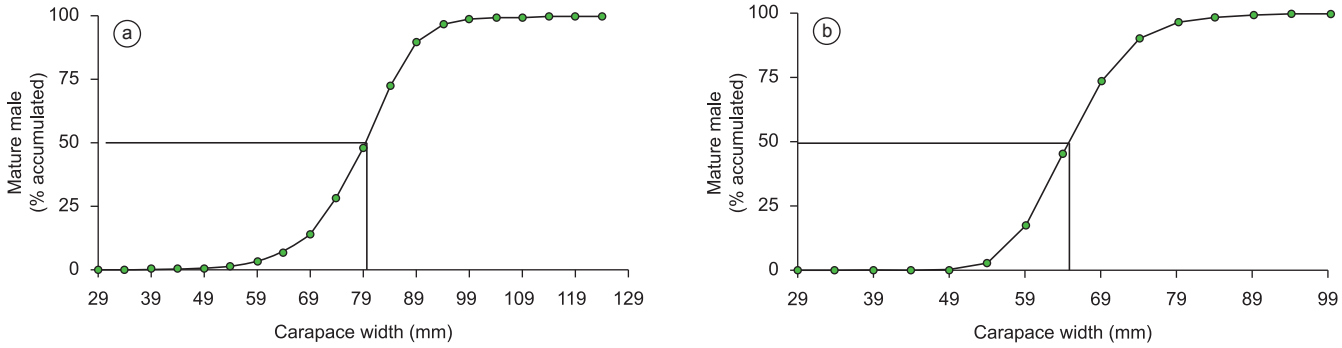

Figure 3. Size of first mature ($CW_{50\%}$) for males (a) and females (b) of *Callinectes ornatus* Ordway, 1863 in northern Rio de Janeiro State.

Previous studies on natural and bycatch populations of *C. ornatus* conducted in shallow waters have shown a male predominance in the sex ratio (e.g. Pita et al. 1985, Branco & Lunardon-Branco 1993, Mantelatto & Fransozo 1999, Baptista et al. 2003, Branco & Fracasso 2004, Keunecke et al. 2008), as also recorded in northern Rio de Janeiro State. Sexual differences in preferential habitat might explain this sex ratio. After mating, females can move offshore to high-salinity areas where the larval fluctuation is facilitated (Pita et al. 1985, Branco & Lunardon-Branco 1993), staying out of the shallow waters where the studies cited above were conducted. Moreover, females preferred lower water temperatures when compared to males, what is generally found in offshore areas (Mantelatto & Martinelli 1999).

The sampling area comprised marine coastal waters, where crab adult specimens were more numerous than the juveniles. The specimens capture was biased by the mesh size that excludes most of the crabs with carapace width lower than 30 mm (mesh size). However, the size groups of *C. ornatus* can be spatially segregated in accordance with environmental features. Studies concerning *Callinectes* spp. have revealed that juveniles preferred calm and shallow waters with more organic material and low salinity (Negreiros-Fransozo & Fransozo 1995, Mantelatto 2000, Chazaro-Olvera & Peterson 2004, Posey et al. 2005, Fernandes et al. 2006). It is likely that the juveniles would be distributed inside the estuary, where trawlers do not operate. The spatial segregation between size groups can favour the juveniles' protection because the preferred habitat is outside of the trawlers' fishing grounds. The low number of ovigerous females recorded in the present study can also indicate a spatial segregation, as explained above, which can reflect behavioural differences between them and the non-ovigerous ones (Pita et al. 1985, Branco & Lunardon-Branco 1993).

The size class distribution in the study area showed differences between males and females, with incidental capture tendency towards specimens that have already reached the sexual maturity. In crustaceans, growth differences between sexes are verified (Hartnoll 1982). In the genus *Callinectes*, males are larger than females, as shown in Table 2. This difference is related to reproductive and somatic investments. The female's growth slows after the puberty moult because they expend more energy during gametogenesis. The male has a longer growth period, expending more energy for this, as a larger size represents a competitive advantage over other males, in addition to facilitating the mating process (Mantelatto & Fransozo 1999, Baptista et al. 2003). The alometric growth in length-weight relationship verified in the present study is expected in crustaceans (Hartnoll 1982). Similar results were reported by Baptista et al. (2003) and Branco & Fracasso (2004) for *C. ornatus* specimens from southern Brazil, and the alometric coefficients considering the three studies had little variation: 3.0513 to 3.1649 (males) and 2.9626 to 3.1047 (females).

According to the local fishermen, the biomass of bycatch crabs can represent up to 50% of the total shrimp production in a fishery operation. Di Beneditto et al. (2010) recorded eight crab species from shrimp fishing in the study area, with *C. ornatus* being the most representative species, totaling 82% of the bycatch crabs. Locally, the specimens of *C. ornatus* can be used as bait in Balistidae (triggerfishes) fishing and, despite its low commercial value, around R$ 1.50 per kg (or U$ 0.85), it is not discarded as other bycatch species

Table 2. Comparison between maximum carapace width of males (M) and females (F) of genus *Callinectes* in Brazil.

Local	Species	Carapace Width (mm)		References
		M	F	
Espírito Santo (20° 18' S)	*C. ornatus*	78.3	67.3	Fernandes et al. (2006)[1]
Rio de Janeiro (21° 30' and 21° 50' S)		126	101	Present study[2]
Rio de Janeiro (~22°S)	*C. ornatus*	110	94	Keunecke et al. (2008)[2]
	C. danae	120	113	
São Paulo (23° 20' and 23° 35' S)	*C. ornatus*	84.6	74.8	Negreiros-Fransozo et al. (1999)[1]
São Paulo-Paraná (25° 51' S)	*C. sapidus*	112	106	Mendonça et al. (2010)[2]
Paraná (25° 37' S)	*C. ornatus*	62.6	51	Baptista et al. (2003)[2]
Santa Catarina (26° 02' and 26° 28' S)	*C. danae*	130	110	Pereira et al. (2009)[1]
	C. sapidus	160	130	
Santa Catarina (27° 30' S)	*C. danae*	135	115	Branco & Masunari (1992)[1]

[1]Specimens collected from natural populations; [2]Specimens collected from fisheries.

are. The commercial use of the bycatch crabs is a way to reduce the waste associated with the shrimp fishing. However, the capture tendency for a specific sex/age-group (as the mature males verified in the present study) may represent a risk to population maintenance over time. Thus we recommend the regular evaluation of this fishing impact on the *C. ornatus* population structure.

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