ABUNDANCE AND SPATIAL-TEMPORAL DISTRIBUTION OF THE FAMILY PORTUNIDAE (CRUSTACEA, DECAPODA) IN THE CURUÇÁ ESTUARY ON THE NORTHERN COAST OF BRAZIL

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ABSTRACT

Nevis, A. B.; Martinelli, J. M.; Carvalho, A. S. S. & Nahum, V. J. I. 2009. Abundance and spatial-temporal distribution of the family Portunidae (Crustacea, Decapoda) in the Curuçá estuary on the northern coast of Brazil. Braz. J. Aquat. Sci. Technol. 13(1):71-79. ISSN 1808-7035. Species composition, abundance and distribution patterns of the family Portunidae in the Curuçá estuary in the northeastern portion of the state of Pará (northern Brazil) were studied bimonthly from July 2003 to July 2004. Samples were taken with a wing trawl net during the day at ebb tide during last quarter moon. A total of 427 individuals were collected, comprising three species: *Callinectes bocourti*, *Callinectes danae* and *Callinectes ornatus*. *C. danae* was the dominant species (56%). *C. bocourti* demonstrated a preference for the rainy season and *C. ornatus* preferred the dry season. *C. danae* was present in both seasons. The results indicate that variation in salinity and pH related to season (dry and rainy) are considered determinant factors for the distribution of *C. bocourti* and *C. ornatus*.

Keywords: Composition, Brachyura, *Callinectes*, swimming crab, Amazon.

INTRODUCTION

Among the more than 300 species of Decapoda from the family Portunidae that occur in the western Atlantic (Williams, 1974), 20 are found on the Brazilian coast and 11 are found on the coast of the state of Pará (northern Brazil) (Melo, 1996; Barros *et al.*, 1997; Barros & Pimentel 2001): *Callinectes bocourti* A. Milne Edwards, 1879; *Callinectes danae* Smith, 1869; *Callinectes ornatus* Ordway, 1863; *Callinectes larvatus* Ordway, 1863; *Callinectes exasperatus* (Gerstaecker, 1856); *Cronius ruber* Lamarck, 1818; *Cronius tumidulus* Stimpson, 1818; *Portunus anceps* Saussure, 1858; *Portunus ordwayi* Stimpson, 1860; *Portunus rufiremus* Holthuis, 1959; and *Portunus spinicarpus* Stimpson, 1871. These species have a preference for estuarine environments, beaches and shallow waters (Melo, 1996).

Portunidae species have rather diversified feeding habits, including algae, vascular plants, foraminiferous species, cnidarians, mollusks, polychaetes, other crustaceans, fish and other groups (Mantelatto & Chistofoletti, 2001; Branco *et al.*, 2002). They have ecological importance in the estuarine-marine ecosystem due to their activity as predators and are voracious hunters. They also serve as a food resource for other aquatic organisms, such as fish and coastal birds (Mantelatto, 1995). At the Curuçá estuary on the coast of the state of Pará (northern Brazil), swimming crabs are an important dietary item for the fish species *Centropomus pectinatus* Poey, 1860 (Cunha, 2005), *Lutjanus jocu* (Bloch & Schneider, 1801) (Monteiro, 2005) and other fish of economic importance.

In North America, Europe and Japan, many swimming crab species have undergone intense economic exploitation (Baptista *et al.*, 2003; Branco & Fracasso, 2004). In Brazil, only the state of Santa Catarina (southern region) has a fishery targeting swimming crabs, whereas they are generally a bycatch in fish and shrimp fisheries in the most of the other regions of the country (Vieira *et al.,* 1996; Andrade, 1998; Keunecke *et al.*, 2008). On the coast of the state of Pará, swimming crabs serve as a food resource for the local human population, thereby constituting an important source of protein as well as a source of income in the for local commerce.

Studies on the life cycle of Portunidae have been carried out all over the world. In Brazil as well, there is a large number of studies on the biology of these organisms, but there are as yet few studies for the coast of the state of Pará. Thus, the aim of the present study was to characterize species composition, abundance
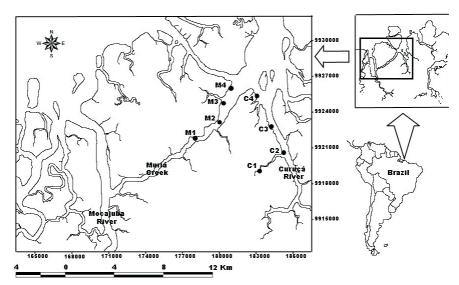
Figure 1 – Study area in the estuary or the Curuçá River, indicating the eight collection sites.

and spatial-temporal distribution of the family Portunidae in the Curuçá estuary, Pará, Brazil.

MATERIALS AND METHODS

Collections were carried out in the Curuçá estuary (Figure 1), located in the town of Curuçá in the northeastern region of the state of Pará, approximately 150 km from the state capital, Belém. This town makes up part of the Salgado micro-region and is bordered by the Atlantic Ocean to the north, the town of Terra Alta to the south, the town of Marapanim to the east and the town of São Caetano de Odivelas to the west. The center of town is located at the following geographic coordinates: 00º43'48" S and 47º51'06" W. The region has an equatorial climate, characterized by high temperatures (average of 27º C) and mean annual precipitation of 2526 mm (Pereira *et al.*, 2007).

The Curuçá estuary has two main intertidal mangrove creeks. One is denominated the Muriá Creek, which connects the Curuçá and Mocajuba rivers; the Abade Port is located on its margins. The other creek is the Curuçá River, with the town of Curuçá located on its banks. Four collection sites were selected along each of the creeks, denominated Creek C (C1, C2, C3 and C4; Curuçá River) and Creek M (M1, M2, M3 and M4; Muriá Creek); the sites were spaced approximately 2 km from one another (Figure 1). During the collections, differences in the substrate granulometry among sites were analysed using a modified method from Suguio (1973), described in Baisch *et al.* (2006) and by a visual method based on the accompanying fauna of each bottom trawl. At sites C2, M2, M3 and M4, the bottom was always muddy, unlike the other sites, where the net sack always returned with a large amount of fine

sand, silt and clay (C1), sponge (C3 and M1) and organic matter of a vegetal origin (C4).

Sampling was performed bimonthly from July 2003 to July 2004, totaling seven collections. Two trawls were carried out at the collection sites during each sampling, totaling 16 samples per month and 112 in all. Trawls were performed during the day at ebb tide during the last quarter, using a wing trawl net. The net was pulled by a wooden commercial fishing boat, 9 meters in length. Each operation lasted 5 minutes, counting from the full release of the net. On each collection, the geographic position was recorded at each minute of trawling using a Global Positioning System (GPS) for the later calculation of the distance swept by the net. At the end of each sampling, swimming crabs were collected, conserved in ice and later frozen.

Temperature, salinity, pH, dissolved oxygen (DO), suspended particulate matter (SPM) and biochemical oxygen demand (BOD) were recorded at each collection site. Temperature and salinity were measured using a conductivimeter and pH was measured using a potentiometer; these values were determined in the field. For the calculation of SPM, DO and BOD, 300 milliliters of water were collected for analysis.

Dissolved oxygen was done according Winkler, modified with the addition of sodium azide and the gathering of SPM and BOD followed procedures published by the Institute of the Millennium Project, available online on page http://www.mileniodomar.org.br. SPM, DO and BOD analyses were performed in the Hydrochemical Laboratory of the Geosciences Center of the Universidade Federal do Pará (UFPA). Data on precipitation during the collection period were obtained from the National Waters Agency (ANA, 2004). Due to the lack of information on precipitation in November 2003, May 2004 and July 2004, the mean monthly values
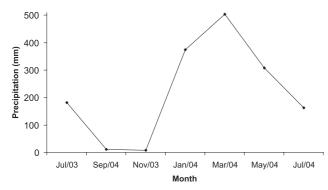
Figure 2 – Monthly precipitation for the town of Curuçá during the collection period (Source: ANA, 2005).

between 1981 and 2002 were used for the month of November 2003, whereas mean monthly values between 1981 and 2003 were used for the months of May and July 2004. The swimming crabs caught were transported to the Fishery Biology and Aquatic Resource Management Laboratory (UFPA) and kept in a freezer. After thawing, the specimens were identified to the species level using identification keys (Takeda & Okutani, 1983; Cervigón *et al.*, 1992; Melo, 1996).

To express the abundance of the organisms, the relative density (individuals/1000 m^2) was calculated for each site (C1 to C4; M1 to M4), creek (Curuçá and Muriá) and collection month. Density was also calculated for the climatic seasons of the year (rainy and dry). Collections in July, September and November were grouped and considered samples from the dry season, whereas collections from January, March and May were considered samples from the rainy season.

Relative density was calculated by dividing the number of individuals by the area swept on each trawl. The area swept was obtained from the following formula: A= NM x AC x DT, in which: NM = net mouth = 10.43m; AC = net aperture coefficient = 0.5 (Pauly, 1980); DT = distance traveled in five minutes of trawling (m). The distance traveled was calculated from the positions obtained from the GPS during the trawls, making use of georeferenced satellite imaging on the *ArcGis* 8.2$^®$ computer program (*ArcView* and *Spatial Analyst* from ESRI).

The Kruskal-Wallis test was used to determine the difference in average abundance between months, creeks, collection sites and climatic seasons for the different species, as the data did not present normal distribution, even after undergoing transformations.

Average monthly density values per species were transformed by the fourth root and the Bray-Curtis similarity coefficient was used to create a similarity matrix. Cluster analysis was applied to the matrix, with the groups linked by the simple average of their similarity values (Unweighted pair-group method with arithmetic

mean - UPGMA). Non-metric multidimensional scaling (MDS) was then performed.

The similarity of percentages (SIMPER) analysis allowed the indication of which species substantially contribute toward the formation of groups, defined by the cluster and MDS analyses. BIOENV analysis allowed the correlation of biotic and abiotic data, revealing which environmental parameters were more important to the distribution of species in the estuary. For this analysis, a Euclidean distance matrix was constructed with the abiotic data and Spearman's coefficient was used to correlate this matrix to the similarity matrix of the biotic data created using the Bray-Curtis coefficient.

RESULTS

The highest precipitation occurred in March 2004 and the lowest occurred in November 2003 (Figure 2). Table 1 displays the descriptive statistics of the environmental variables. There were significant differences for the averages of all abiotic factors between the months studied ($p < 0.05$; Table 2). The lowest temperature, salinity, DO and pH values were recorded during months with greater rainfall, whereas SPM and BOD have more expressive values in these months. Figure 3 illustrates the bimonthly variations in these environmental variables. No significant differences in environmental variables were detected between sites or creeks (Table 2).

A total of 427 individuals from the family Portunidae were found, pertaining to the following three species: *Callinectes bocourti* (39%), *Callinectes danae* (56%) and *Callinectes ornatus* (5%). Relative abundance was 1.21 ind./1000m^2 for *C. bocourti*, 1.77 ind./1000m^2 for *C. danae* and 0.15 ind./1000m^2 for *C. ornatus* Abundance of the swimming crabs varied both spatially as well as temporally (Table 3; Figures 4 to 8). *Callinectes bocourti* was more abundant in the rainy season, whereas *C. ornatus* only occurred in the dry season (Figures 4 and 6). *C. danae* occurred throughout the year, with a peak in abundance in July 2003 and another in January 2004 (Figure 4). Thus, there as a alternation in species density throughout the year,

Table 1 – Minimum, maximum, average and standard deviation (SD) values of environmental variables recorded throughout the collection periods in the Curuçá estuary.

	Minimum	Maximum	Average ± SD
Temperature (C°)	20.6	31.0	26.06 ± 2.58
Salinity	6.1	40.8	18.67 ± 10.11
pH	6.87	8.12	7.56 ± 0.36
SPM (mg/L)	13.0	98.6	39.42 ± 23.72
DO (mg/L)	3.45	8.42	5.67 ± 1.15
BOD (mg/L)	0.53	3.16	2.22 ± 0.78

Table 2 – Results of the Kruskal-Wallis test for the abiotic factors recorded in the Curuçá estuary (PA) from July 2003 to July 2004 according to month, creek and collection site.

FACTORS	Month		Creek		Site	
	H	p	H	p	H	p
Temperature (C°)	33.138	<0.0001	1.060	0.303	2.892	0.894
Salinity	50.097	<0.0001	0.233	0.628	1.968	0.961
pH	37.700	<0.0001	0.507	0.082	9.719	0.2051
SPM (mg/L)	51.155	<0.0001	0.006	0.934	0.720	0.998
DO (mg/L)	46.525	<0.0001	0.275	0.600	3.437	0.841
BOD (mg/L)	46.708	<0.0001	0.249	0.617	8.366	0.301

beginning with *C. danae* in July 2003, followed by *C. ornatus* in the second semester of the year and, lastly, *C. bocourti,* which occurred in greater density in the first semester of 2004 (Figure 4). *Callinectes bocourti* was more abundant in the Curuçá creek (Figure 5A). *C. danae* density increased in the more external sites of the estuary in both creeks (Figure 5B).

Cluster analysis based on the abundance of each species revealed that the samples could be divided into three groups, with a cutoff point of 87% similarity (Figure 7). Group I included the months of January 2004 and
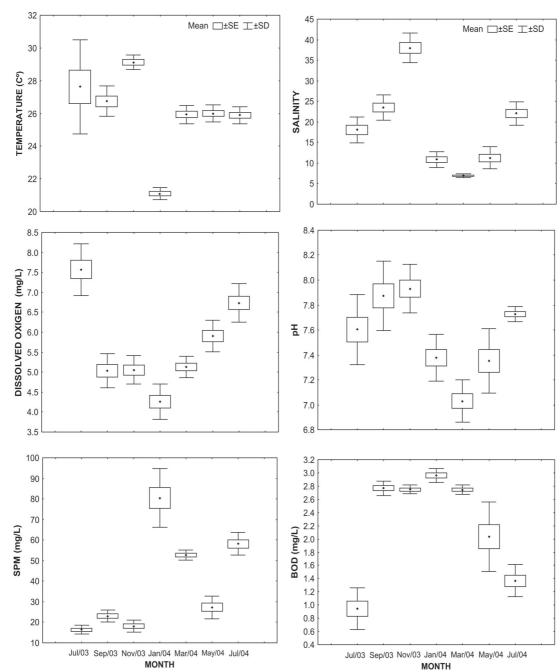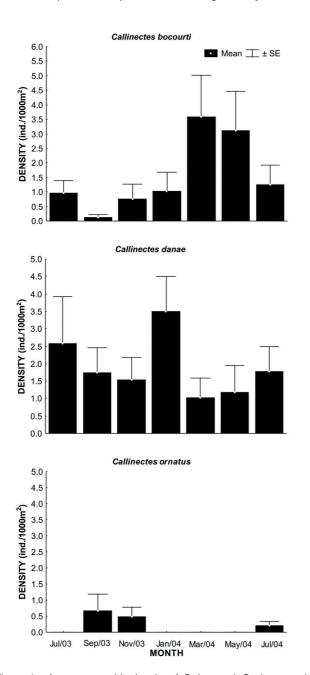

Figure 3 – Average bimonthly values, standard error (SE) and standard deviation (SD) of abiotic factors collected in the Curuçá estuary (PA) from July 2003 to July 2004.

Table 3 – Results of the Kruskal-Wallis test for density regarding the different factors analyzed in the Curuçá estuary (PA) from July 2003 to July 2004.

Species	Month	Site	Creek	Season
C. bocourti	**	ns	*	**
C. danae	ns	*	ns	ns
C. ornatus	*	ns	ns	**

* = p<0,05; ** = p<0,01; ns = not significantly

Figure 4 – Average monthly density of *C. bocourti*, *C. danae* and *C. ornatus* throughout the collection period in the Curuçá estuary (PA). Density is represented in different scales for the different species. SE=standard error.

July 2003, in which greater densities of *C. danae* were found. Group II was made up of March 2004 and May 2004, with a greater density of *C. bocourti*. Group III was formed by September 2003, November 2003 and July 2004, which were the only months in which there was the appearance of all three species (*C. bocourti*, *C. danae* and *C. ornatus*). The groups defined by cluster analysis (months) were also confirmed on the two-dimensional plotting of the MDS and interpreted by the climatic season of the year: Group I occurred in both seasons (dry and rainy); Group II only occurred in the rainy season; and Group III only occurred in the dry season (Figure 8).

The SIMPER analysis revealed that Groups I and III had a greater contribution from *C. danae* and Group II had a greater contribution from *C. bocourti* (Table 4). Analyzing the individual or combined influence of the environmental variables on species distribution, correlation values no greater than 0.7 were found. Nonetheless, the variables that appear to best explain the pattern of species occurrence in the estuary are precipitation, salinity, pH and the interaction of these factors (Table 5).

DISCUSSION

The swimming crab community in the Curuçá estuary was represented by just three species. Studying swimming crabs in other estuaries in the northeast of the state of Pará, Cintra & Silva (2002) also found the same three species, with *C. bocourti* as the most abundant species. This differs from the findings of the present study, in which *C. danae* was the most abundant species. Both studies found *C. ornatus* to be the least abundant species. Melo (1996) reports that *C. ornatus* occurs in areas with depths as great as 75 m and Cintra *et al.* (2003) collected the species on the coast of Pará at a depth of 65 m. In the present study, collections were carried out in an estuarine area with shallow depths (under 5 m), which may explain the low occurrence of this species throughout the study period.

Studies on distribution patterns for brachyurans in relation to the dynamics of abiotic factors stress the temperature and salinity of the water, which are considered extremely important for a better understanding of the dynamics of these crustaceans (Pinheiro, 1991). Variations in temperature and salinity have been cited by a number of authors as important factors for the occurrence of particular species from the genus *Callinectes*. The greatest catches of *C. danae* in eastern Porto Rico (Buchanan & Stoner, 1988) and the city of Ubatuba (southeastern Brazil) (Chacur & Negrei-ros-Fransozo, 2001) occur in waters with higher temperatures (27 to 28 °C). Under laboratory conditions,
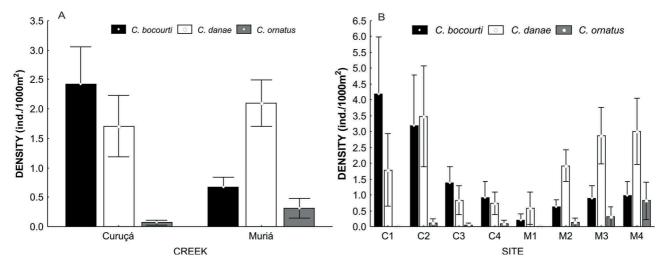
Figure 5 – Average density (± standard error) of *C. bocourti*, *C. danae* and *C. ornatus* in relation to creeks and collection sites (**A** and **B**, respectively) from July 2003 to July 2004 in the Curuçá estuary (PA).

an increase in mortality rate was observed for *Callinectes sapidus* Rathbun, 1896 with a decrease in temperature and salinity (Rome *et al.*, 2005). Salinity was found to be favorable to the abundance of *Callinectes bellicosus* Stimpson, 1859 in a coastal lake in Mexico (Arreola-Lizárraga *et al.*, 2003); *Callinectes simillis* Williams, 1966 exhibits a better growth rate in high salinity (Guerin & Stickle, 1997). Róman-Contreras (1986) found that the entrance of *C. sapidus*, *C. danae* and *C. ornatus* in Términos Lake (México) tended to be greater when salinity increased.

In the present study, the factors that best explained the distribution of the swimming crabs in the estuary were precipitation, salinity and pH. Oscillations in these environmental variables are related to the climatic season. An increase in salinity and pH is characteristic of the dry season, when the sea water penetrates the estuary in a greater volume as a result of reduced rainfall. Seasonal variations for the Curuçá estuary have also been described by Rosa Filho *et al.* (2007) that found a greater density of macrofauna from benthonic associations in the rainy period and a greater density of meiofauna in the dry season.

The difference in density between months, creeks and collection sites is explained by the ecological preferences of each species. *Callinectes ornatus* prefers more saline environments (Muriá Creek, Site M4) and, therefore, occurs in greater abundance in the dry season. *Callinectes bocourti* was more abundant in the rainy season, especially in the Curuçá Creek at the innermost site of the estuary (C1). These results are in agreement with findings described by Teixeira & Sá (1998), who, in studying the abundance of decapod macrocrustaceans in shallow waters of the Mundaú Lake complex (state of Alagoas, northeastern Brazil), report that *C. bocourti* was more abundant in low salinity (values below 14), whereas *C. ornatus* was found in salinity values above

20. *C. bocourti* tolerates waters with low salinity, whereas *C. ornatus* more commonly occurs in waters with moderate salinity (18 to 35) (Mantelatto, 1995; Melo, 1996).

Callinectes danae appears to have a greater tolerance for variations in salinity, but prefers muddy substrates, such as those at sites C2, M2, M3 and M4. This fact has been cited by Melo (1996), who reports that the species has a great tolerance for salinity and may occupy estuaries, especially those with muddy sediments. Teixeira & Sá (1998) found the same species related to the type of substrate in the Mundaú Lake complex (Alagoas). Thus, the inclusion of sediment type in future studies could be a valuable aspect in explaining the distribution of this species.

The three species have different ecological preferences. This is reinforced by the alternation in species over the months studied. The fact that the
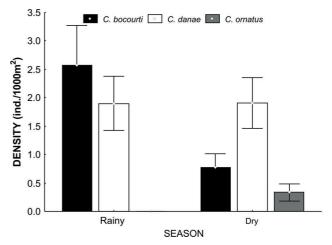

Figure 6 – Average density (± standard error) of *C. bocourti*, *C. danae* and *C. ornatus* in relation to climatic season from July 2003 to July 2004 in the Curuçá estuary (PA).

A

Bray-Curtis Similarity (%)
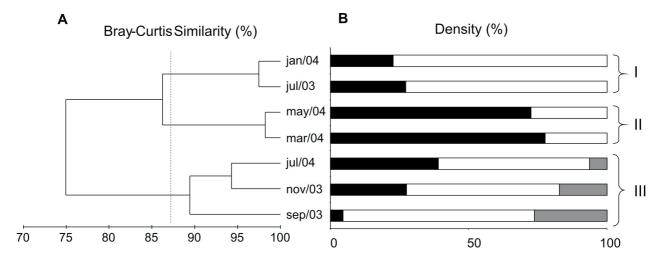
B

Density (%)

Figure 7 – A: Dendrogram of the cluster analysis on swimming crab species density in the Curuçá estuary (PA) from July 2003 to July 2004; B: Percentage of species density. Black = *C. bocourti*; White = *C. danae* and Grey= *C. ornatus.*
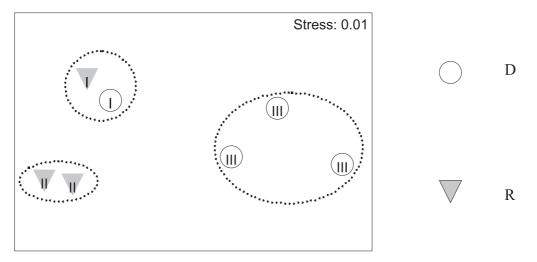

Figure 8 – Multidimensional scaling based on swimming crab species density in the Curuçá estuary (PA) from July 2003 to July 2004. D = Dry season; R = Rainy season.

Table 4 – Results of the SIMPER analysis indicating the percentage (%) contribution of swimming crab species for the three groups formed in the cluster analysis. ASWG = average similarity within groups.

Species	Group I	Group II	Group III
ASWG (%)	87,84	93,00	93,00
C. bocourti	27,16	**75,25**	14,50
C. danae	**72,84**	24,75	**71,96**
C. ornatus	-	-	13,54

Table 5 – Correlation between environmental variables and species density obtained through BIOENV analysis.

Variables	Correlation
Precipitation, pH	0.695
Salinity, precipitation	0.688
Salinity, pH, precipitation	0.688
Precipitation	0.681
pH	0.664
Salinity	0.571
Salinity, pH	0.569

species occupy the estuary in different seasons may be a strategy to avoid competition for food, as all three species are carnivorous and have basically the same food items in their diets (Branco, 1996; Mantelatto & Chistofoletti, 2001; Branco *et al.*, 2002).

The results of the present study demonstrate that variation in salinity and pH related to changes in precipitation may be considered determinants in the distribution of *C. bocourti* and *C. ornatus.* Moreover, the association of *C. danae* with sediment type should be studied further in order to explain its distribution in the Curuçá estuary.

ACKNOWLEDGEMENTS

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