COMPOSITION AND ABUNDANCE OF SHRIMP SPECIES (PENAEIDEA AND CARIDEA) IN FORTALEZA BAY, UBATUBA, SÃO PAULO, BRAZIL

Adilson Fransozo, Rogério C. Costa, Fernando L. M. Mantelatto, Marcelo A. A. Pinheiro and Sandro Santos

NEBECC.Group of Studies on Crustacean Biology, Ecology and Culture
AF & RCC. Depto. de Zoologia. IBB. UNESP. s/n. 18618-000. Botucatu. SP. Brasil

fransozo@ibb.unesp.br

FLMM. Depto. de Biologia – FFCLRP - Universidade de São Paulo (USP) -
Av. Bandeirantes. 3900 - 14040-901. Riberão Preto. SP. Brasil
MAAP. Depto de Biologia Aplicada – FCAV – UNESP – 14870-000. Jaboticabal. SP. Brasil
SS. Depto de Biologia – CCNE – Universidade Federal de Santa Maria. 97119-900.
Santa Maria. RS. Brasil

ABSTRACT

The abundance and spatio-temporal distribution of the caridean and penaeid fauna from Fortaleza Bay, Ubatuba, São Paulo, Brazil, were analyzed. Seven transects were sampled over a one year period from November 1988 to October 1989. A total of 17047 shrimps were captured, representing 13 species belonging to 5 families. The interaction of temperature and type of sediment was fundamental in determining the presence and abundance of shrimp species in the area.

I. INTRODUCTION

Since human populations are growing along coastlines and their resultant anthropogenic impact thus increasing, gathering accurate information on benthic communities is urgently needed for proper management and conservation of coastal ecosystems (Alongi 1989).

Along the Brazilian coast, the shrimp fauna is represented by 61 species of Dendrobranchiata (D'Incao 1995), 38 species of Alpheoidea (Holthuis 1993) and 48 species of Palaemonoidea (Ramos-Porto 1986). In São Paulo State, dendrobranchiates, palaemonoids and alpheoids comprise 19, 14, and 23 species, respectively (Christoffersen 1982, Holthuis 1993, D'Incao 1995, Costa et al. 2000).

In spite of their economic importance, only a few studies have been conducted so far on the shrimp fauna of São Paulo, namely those on their taxonomy (Christoffersen 1982, D'Incao 1995, Costa et al. 2000), abundance (Pires 1992, Nakagaki et al. 1995) and population biology (Rodrigues et al. 1993, Chacur and Negreiros-Fransozo 1998, Nakagaki and Negreiros-Fransozo 1998, Costa and Fransozo 1999).

The aim of the present paper is to characterize the caridean and penaeid fauna from Fortaleza Bay, Ubatuba (SP) Brazil with emphasis on their abundance and spatio-temporal distribution as a function of the most relevant environmental factors, i.e. temperature, salinity, depth, organic matter contents and sediment grain-size composition.

II. MATERIALS AND METHODS

Fortaleza Bay is located in the northern coast of the State of São Paulo (23° 29'30" to 23° 32'30" S and 45° 06'30" to 45° 10'30" W). According to Castro-Filho et al. (1987) this region is affected by three water masses with different distribution patterns in summer and winter. The Coastal Water (CW) mass is characterized by a high temperature and low salinity, the Tropical Water (TW) mass by a high temperature and high salinity, and the South Atlantic Central Water (SACW) mass by a low temperature and salinity following an annual cycle.

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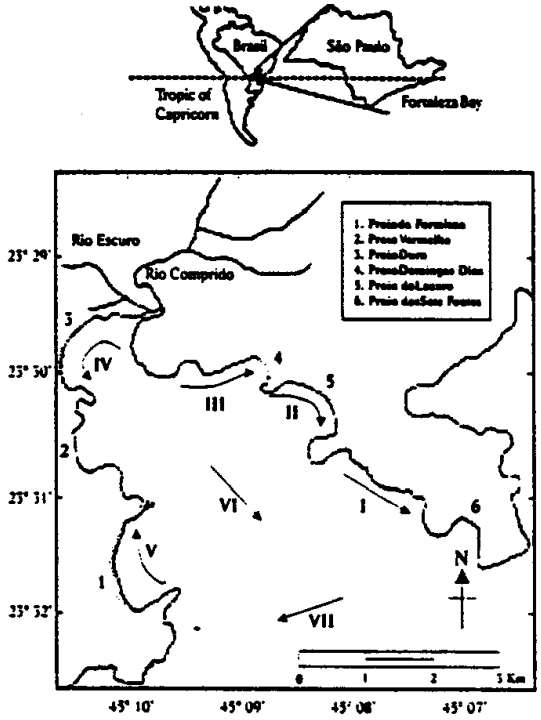

Figure 1. *Map of the Fortaleza Bay.*

Shrimps were sampled in Fortaleza Bay, using a 7.5 m long double-rig net with a 10 mm mesh size cod end. Samplings were performed monthly over a year, from November 1988 to October 1989. During the monthly samplings, 7 trawls (transects) of 1 km each (Fig. 1) were performed.

Average depth at Fortaleza Bay is 9 m (range 4.4 - 13.3 m). The mean annual values for temperature and salinity were 23.5°C (range 21 - 28.1°C) and 34.4‰ (range 32.4 - 35.6‰). The mean value of organic matter content for the whole sampled year was 4.07% (range 2.3 - 6.6%) and the sediment grain-size composition, expressed in Phi values (ϕ) (Suguio 1973), showed a predominance of fine and very fine sand fractions for most transects (Table 1). A detailed description of sampling methods and the analysis of environmental factors at Fortaleza Bay, during the same period, are available elsewhere (Negreiros-Fransozo et al. 1991).

The relationship between species abundance and the variation of studied abiotic factors was assessed by means of examining Pearson's correlation coeffficients at the 5% significance level (Zar 1996).

The species constancy index (C) was calculated according to Dajoz (1983): C=px100/P, where "p" is the number of samples in which a given species was recorded, and "P" the total number of samples analyzed. Species were classified in three different categories: constant (C > 50%), accessory (25% < C < 50%), and accidental (C < 25%). For diversity analyses, the Shannon-Wiener (H') and equitability (J') indices were calculated as indicated by Krebs (1989).

Table 1. *Average values of abiotic factors obtained in each transect during the period from November 1988 to October 1989. Sediment grain composition is expressed as Phi (ϕ) values.*

Transect	Depth (m)	Phi ϕ	Salinity (‰)	Organic Matter (%)
I	11.2 ± 0.9	2.9	34.8 ± 0.8	4.4 ± 2.5
II	7.0 ± 0.9	2.5	34.3 ± 1.3	6.7 ± 2.4
III	8.5 ± 0.9	3.8	34.4 ± 1.1	2.3 ± 1.3
IV	4.4 ± 0.6	3.3	33.3 ± 1.3	1.8 ± 1.3
V	7.1 ± 0.8	2.7	34.4 ± 1.1	3.5 ± 1.4
VI	11.1 ± 1.2	3.4	34.4 ± 1.1	5.1 ± 1.8
VII	13.3 ± 1.6	3.5	34.9 ± 1.7	4.6 ± 3.6

III. RESULTS

A total of 17047 specimens was obtained comprising 13 species belonging to 5 families: Penaeidae, Solenoceridae, Sicyoniidae, Palaemonidae, and Hippolytidae. The family Penaeidae showed the highest species richness (6 species) and abundance (16610 individuals).

Xiphopenaeus kroyeri (Heller, 1862) was a constant species (78%), followed by the accessory species *Artemesia longinaris* Bate, 1888 (18.1%). The species *Farfantepenaeus brasiliensis* (Latreille, 1817), *Farfantepenaeus paulensis* (Pérez Farfante, 1967), *Litopenaeus schmitti* (Burkenroad, 1936), *Rimapenaeus constrictus* (Stimpson, 1874), *Pleoticus muelleri* (Bate, 1888), *Sicyonia dorsalis* Kingsley, 1878, *Sicyonia typica* (Boeck, 1864), *Sicyonia laevigata* Stimpson, 1871, *Nematopalaemon schmitti* (Holthuis, 1950), *Palaemon pandaliformis* (Stimpson, 1871) and *Exhippolysmata oplophoroides* (Holthuis, 1948) were considered as accidental contributing with only 3.9% of the total abundance (Table 2).

With the exception of *X. kroyeri*, recorded throughout the year, the occurrence of shrimp species varied throughout the sampling period (Table 3). *Farfantepenaeus brasilensis* and *F. paulensis* were present in samples from

Table 2. Species composition and number of shrimps each transect in Fortaleza bay. (C=constancy; Co=consant; Ac=accessory and Ad=accidental).

Families/Species	Transects							Total	C
	I	II	III	IV	V	VI	VII		
PENAEIDAE									
Xiphopenaeus kroyeri	2263	434	2224	1160	394	2378	4445	13298	Co
Farfantepenaeus brasiliensis	9	61	4	0	0	1	5	80	Ad
Farfantepenaeus paulensis	7	47	1	0	1	1	0	57	Ad
Litopenaeus schmitti	12	6	7	16	4	4	3	52	Ad
Rimapenaeus constrictus	1	3	0	0	1	3	27	35	Ad
Artemesia longinaris	1151	5	276	172	0	435	1049	3088	Ac
Subtotal	3443	556	2512	1348	400	2822	5529	16610	
SOLENOCERIDAE									
Pleocicus muelleri	9	21	1	0	5	10	105	151	Ad
Subtotal	9	21	1	0	5	10	105	151	
SICYONIIDAE									
Sicyonia dorsalis	6	8	2	0	0	9	26	51	Ad
Sicyonia typica	3	5	0	0	0	4	2	16	Ad
Sicyonia laevigata	0	0	0	0	1	0	0	1	Ad
Subtotal	11	13	2	0	1	13	28	68	
PALAEOMONIDAE									
Nannopalaemon schmitti	0	0	4	0	0	0	1	5	Ad
Palaemon pandaliformes	0	1	0	0	0	0	0	1	Ad
Subtotal	0	1	4	0	0	0	1	6	
HIPPOLYTIDAE									
Exhippolysmata oplophoroides	52	3	60	0	1	8	88	212	Ad
Subtotal	52	3	60	0	1	8	88	212	
TOTAL	3515	594	2579	1348	407	2853	5771	17047	

March to May (autumn), *L. schmitti* and *E. oplophoroides* during late autumn and winter and, finally, *A. longinaris* recorded during summer and winter months.

Diversity and equitability indices showed great variation throughout the study period being higher from November to January and from May to August, when lower mean temperatures were recorded (Fig. 2).

The occurrence of only three species, i.e. *X. kroyeri*, *A. longinaris* and *E. oplophoroides*, was shown to be correlated to environmental factors, chiefly to depth (Table 4). *Xiphopenaeus kroyeri* was captured in areas where Phi values for grain-size composition varied between 3 and 4. In the case of *A. longinaris*, abundance was negatively correlated with temperature and positively correlated with salinity.

Highest species richness and diversity were found in transects I and II. At those sites, sediments are mainly composed of very fine sand associated to other larger grains, and a high organic content in the sediment. High richness values were also obtained at transects VI and VII, but differences among the remaining transects were not significant. At those latter sites, relatively lower abundance values reflect lower diversity with a strong prevalence of *X. kroyeri* and *A. longinaris* compared to sites I and II. Lowest diversity and equitability indices were obtained at transect V (Fig. 2).

Table 3. *Number of shrimps collected from November 1988 to October 1989 in Fortaleza Bay.*

	Months												
Families/Species	**N**	**D**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**TO**
PENAEIDAE													
Xiphopenaeus kroyeri	946	383	628	383	968	1468	1063	848	1364	3066	1180	1001	13298
Farfantepenaeus brasiliensis	1	3	0	0	30	32	14	0	0	0	0	0	80
Farfantepenaeus paulensis	0	0	0	0	28	11	17	1	0	0	0	0	57
Litopenaeus schmitti	1	1	0	0	0	0	11	16	16	4	3	0	52
Rimapenaeus constrictus	26	1	0	0	0	1	2	3	0	0	1	1	35
Artemesia longinaris	145	810	863	108	1	2	15	199	684	261	0	0	3088
Subtotal	1119	1198	1491	491	1027	1514	1122	1067	2064	3331	1184	1002	
SOLENOCERIDAE													
Pleoticus muelleri	92	0	24	0	0	0	12	0	8	0	0	15	151
Subtotal	92	0	24	0	0	0	12	0	8	0	0	15	
SICYONIIDAE													
Sicyonia dorsalis	9	25	2	3	2	0	1	1	1	3	0	2	51
Sicyonia typica	0	3	9	0	0	0	0	1	3	0	0	0	16
Sicyonia laevigata	0	0	0	0	0	0	0	0	0	0	1	0	1
Subtotal	9	28	11	3	2	0	1	2	4	3	1	2	
PALAEOMONIDAE													
Nematopalaemon schmitti	2	0	0	0	0	0	0	1	0	1	1	0	5
Palaemon pandaliformes	0	0	0	0	0	0	0	0	0	0	0	1	1
Subtotal	2	0	0	0	0	0	0	1	0	1	1	1	
HIPPOLYTIDAE													
Exhippolysmata oplophoroides	18	3	1	0	11	4	34	43	1	61	1	34	212
Subtotal	18	3	1	0	11	4	34	43	1	61	1	34	
TOTAL	1240	1229	1527	494	1040	1518	1169	1113	2077	3398	1187	1053	17047

IV. DISCUSSION

From the 61 species of Dendrobranchiata already recorded along the Brazilian coast, 10 species were captured at Fortaleza Bay. Considering the limited area covered in the present study, it may be concluded that the shrimp fauna is well represented at the study area.

Within the dendrobranchiates, *X. kroyeri* is the dominant species. It represents the second most important fishery resource along the coast of the State of São Paulo, and its trophic relationships may be essential in maintaining the stability of benthic communities in the studied region (Pires 1992). The species *Litopenaeus schmitti*, *Farfantepenaeus brasiliensis* and *F. paulensis* were less abundant, probably due to the lack of large estuarine areas within the northern coast of the State of São Paulo (Costa and Fransozo 1999), where certain penaeid species often constitute large populations (Stoner 1988).

The diversity of the caridean group was comparatively lower. Near Ubatuba Bay, where overall abiotic characterisctics are similar, six other caridean species were additionally found (Costa et al.2000). The relative low richness at Fortaleza Bay may be associated to certain ecological features of caridean shrimps.

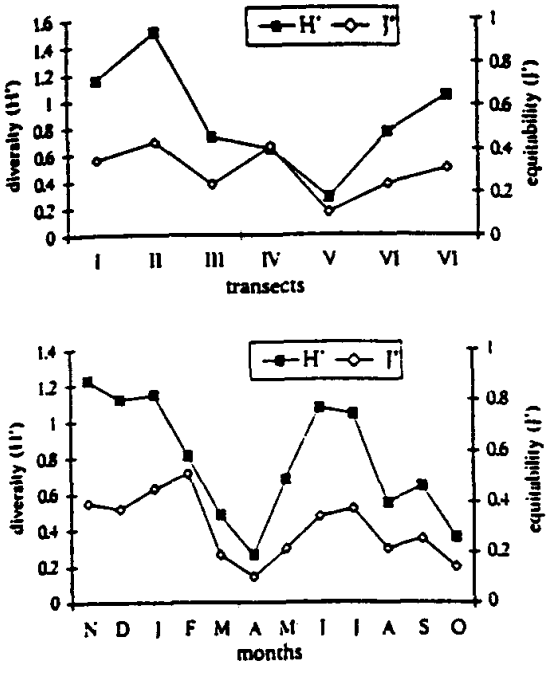

Figure 2. *Spatial and temporal variation of the Shannon-Wiener diversity index (H') and equitability (J') during the study period (November 1988 to October 1989) at Fortaleza Bay.*

Table 4. *Pearson's linear correlation coefficients between the abundance of shrimps and abiotic factors at Fortaleza Bay. (* indicates significant correlations. P < 0.05)*

Species / Abiotic factors	*Xiphopenaeus kroyeri*	*Artemesia longinaris*	*Pleoticus muelleri*	*Exhippolysmata oplophoroides*
Temperature	- 0.16	- 0.3*	- 0.16	- 0.16
Salinity	0.14	0.32*	0.09	0.07
Deep	0.42*	0.32*	0.19	0.25*
Organic matter	0	0.4	0.1	- 0.03
Phi	0.34*	0.11	0.6	0.18

Many caridean species occur on microhabitats associated to the rocky shallow subtidal. They often use algal canopy, shallow burrows and hydroid substrates as commensals during their life cycle or just as shelter to avoid predation.

The shrimp community at Fortaleza Bay is largely dependent on the migration events of *A. longinaris*, the second most abundant species, since the presence of the seabob *X. kroyeri* is constant throughout the year. High diversity and equitability indices were found from November, 1988 to January, 1989 and from June to July, 1989, when large numbers of *A. longinaris*, *P. muelleri*, *E. oplophoroides* and *L. schmitti* were captured. The lowest indices were found in April, 1989 and from August to October, 1989, due to the strong prevalence of *X. kroyeri* at Fortaleza Bay.

Pires (1992) studied the benthic macrofauna off the coast of Ubatuba and showed that permanent benthic communities rely on trophic relationships in which *X. kroyeri* is a key-role species. The author also found that the abundance of *X. kroyeri* is related to the hydrologic dynamics taking place in the study region. During fall and winter, bottom temperature of the CW water mass ranges from 22 to 25°C, providing favourable conditions for the establishment of *X. kroyeri* populations. In contrast, average bottom temperature falls to values lower than 20°C during the summer period due to the influence of the SACW water mass. The present study corroborates the data obtained by Nakagaki et al. (1995) and Costa (1997), who observed seasonal changes in the abundance of several shrimp species at Ubatuba Bay, such as *A. longinaris* and *P. muelleri*, which entered the bay during late fall and remained in the bay throughout the winter. The presence of these species was also noted during summer, when water temperature decreases due to the emergence of the SACW water mass.

The highest number of species registered during the fall is mainly related to the presence of *F. paulensis*, *F. brasiliensis* and *L. schmitti*. These species occupy the bay during short periods, co-occurring in this area only during May. They need to migrate to sheltered areas for the completion of their life cycle.

Regarding spatial distribution, the highest diversity and species richness were observed at transect II, where coarse sand contains high percentage of organic matter. In transects II and V, fewer *X. kroyeri* and *A. longinaris* were captured compared to the other transects, probably because sediments at those sites are mainly composed by coarser sediments known to be unfavourable for the establishment of those species at Ubatuba Bay (Castro 1997, Costa 1997).

According to Boschi (1963, 1989), *P. muelleri* and *A. longinaris* do not require low salinities to complete their life cycles but prefer lower temperatures from 15 to 21°C. Such results would explain the seasonal occurrence of those species and their presence in deeper areas.

Most of the recorded species are present in Fortaleza Bay because very fine sand is the predominant sediment fraction at this area (phi > 4). *Rimapenaeus constrictus*, *S. dorsalis*, *P. muelleri* and *X. kroyeri* are known to be associated to muddy sediments (Sanchez and Soto 1987, Boschi 1989, Dall et al. 1990, Nakagaki et al. 1995, Castro 1997, Costa 1997).

Based on the present findings and previous research (Fransozo et al. 1992, 1998, Negreiros-Fransozo et al. 1997, Costa et al. 2000), it is suggested that environmental conditions at Fortaleza Bay are favourable for the establishment and development of a diverse shrimp guild. Continuing research on both inshore and offshore areas in this subtropical region will provide a more accurate characterization of the shrimp diversity and contribute to a better understanding of their life cycles.

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