Acta Biol. Venez., Vol. 18 (4): 17-25
Diciembre, 1998

DISTRIBUTION AND ASSEMBLAGES OF ANOMURAN CRUSTACEANS IN UBATUBA BAY, NORTH COAST OF SÃO PAULO STATE, BRAZIL

DISTRIBUCION Y ENSAMBLAJE DE CRUSTACEOS ANOMUROS EN LA BAHIA DE UBATUBA, COSTA NORTE DEL ESTADO DE SÃO PAULO, BRASIL

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ABSTRACT

The present study describes the community of anomuran crabs inhabiting non-consolidated sublittoral grounds in Ubatuba Bay (SP), Brazil, with emphasis on its composition and species' abundance. Anomuran crab samples were obtained on three consecutive days in a monthly basis from September 1995 to August 1996. In each day, eight diurnal trawlings covering a 1-km transect were carried out with a commercial fishery boat supplied with double rig nets. The distribution of collected species was correlated with abiotic factors. A total of 1.181 specimens was recorded, comprising 16 species and three families. Diogenids were represented by eight species, holding 74.2% of total sampled anomurans, while three pagurid species and five porcellanids enclosed, respectively, 3.4% and 22.4% of all specimens. In general, number of individuals and species' diversity were higher in transects where sediments are mainly compbsed by coarse sediments, with high organic matter contents. Variations among monthly diversity values, in which data from all transects are pooled toghether, are certainly related to the complexity and dynamics characterizing the studied system. Both abiotic factors and adaptive processes developed by each species during their evolution can be responsible for the structure changes of this anomuran community in Ubatuba Bay.

RESUMEN

En este estudio, se presenta la descripción de la comunidad de anomuros que habita los fondos blandos sublitorales en la bahía de Ubatuba (SP), Brasil, con énfasis en su composición y abundancia de espécies. Las muestras de estos decápodos fueron tomadas durante trés dias consecutivos en una base mensual, desde septiembre de 1995 hasta agosto de 1996. Cada dia de muestreo consistió de ocho arrastros de 1 km, efectuados con un barco pesquero equipado con dos redes del tipo *double rig*. La distribución de las espécies que habitan este local está correlacionada con los factores abióticos. Un total de 1.181 ejemplares fué obtenido, comprendiendo 16 espécies y trés famílias. La família Diogenidae estuvo representada por ocho espécies, sumando 74.2% de todos los indivíduos obtenidos, mientras que trés espécies de Paguridae y cinco de Porcellanidae representan respectivemante, 3.4% y 22.4% del total de anomuros. De modo general, el número de indivíduos y la diversidad de espécies son más elevados en los transectos en que se verificó una mayor proporción de sedimentos groseros y de contenidos orgánicos. La variación encontrada entre los valores mensuales de diversidad, en los que están agregados los valores obtenidos para cada transecto, está muy probablemente relacionada a la complejidad y la dinámica que caracterizan el sistema estudiado. No solamente los factores abióticos, sino también los procesos adaptativos resultantes de la evolución de estas espécies, peden ser responsables por los cambios en la estructura de la comunidad de anomuros en la bahía de Ubatuba.

Palabras clave: Anomura, estructura comunidades, composición, inventario, sublitoral, cangrejo hermitaño

Key words: Anomura, community structure, composition, check list, sublittoral, hermit crab, porcellanid.

INTRODUCTION

The characterization of natural populations have been considered as basic knowledge, and its main importance is to gather the greatest possible amount of information for the preservation of natural stocks (Valenti, 1984) and provide a basis for the surveillance of marine biodiversity. This information is essential for the development of exploitation management and environmental administration in order to allow the sustenance of biological wealth (González-Gurriarán *et al.*, 1991).

In this context, the Anomura represents a quite significant group in marine crustaceans, of which porcellanids and hermits, among others, are included. Porcellain crabs inhabit a variety of habitats, mainly hard (coral reefs) and soft (sand reefs, algal beds) substrata, which provide favorable conditions to their life cycle. A list of the 21 porcellanid species found along the Brazilian coast, together with their latitudinal range and geographic distribution, is given in Veloso and Melo (1993). With approximately 800 species described throughout the world (Ingle, 1993), hermit crabs represent a very important group within the intertidal community and also a significant taxon in the benthic sublittoral habitat, exerting an important role in the marine trophic chain. The systematics of hermit crabs from Brazil were chiefly brought up by Forest & Saint Laurent (1967) and Coelho & Ramos (1972). More recently, Rieger (1997) listed 42 hermit crab species for the Brazilian coast and only 17 to the coast of São Paulo State.

During the last years, an increasing number of studies have centered on the decapod fauna of soft sediments in São Paulo State. However, only few of those have been a matter of detailed study. Basic information, such as spatial and temporal distribution of anomuran communities, is still largely unknown. The studies carried out by Pires (1992) in the continental shelf offshore, Hebling *et al.* (1994) at Anchieta Island and Negreiros-Fransozo *et al.* (1997) in Fortaleza Bay are the most meaningful contributions in that subject.

The aim of the present study is to provide a description of anomuran assemblages collected from non-consolidated sublittoral grounds in Ubatuba Bay (SP), Brazil, and to assess species abundance, richness and their spatial and seasonal distribution.

MATERIALS AND METHODS

Ubatuba Bay (23° 26' S and 45° 02' W) is adjacent to Ubatuba town, northern coast of São Paulo, Brazil. The total area of the bay is about 8 km2, with approximately 4.5-km width at the entrance, decreasing landwards. Ubatuba Bay has a significant local importance because of its proximity with Ubatuba town, which is an important touristic center. Besides, it holds a substantial fishing potential, and it is considered a paradigmatic preservation area (Mantelatto, in press). The environmental conditions in this area are slightly modified, which enables standard comparisons with other strongly impacted areas in Brazil to be made (Mantelatto and Fransozo, 1999).

Ubatuba Bay was divided into eight subareas differing in terms of their location in relation to the bay mouth, the presence of a rocky wall or a beach along the boundaries, the inflow of fresh water, the proximity of an offshore area, depth and granulometric composition. Each transect was assigned to a subarea for sampling of anomurans and measurements of environmental factors (Fig. 1).

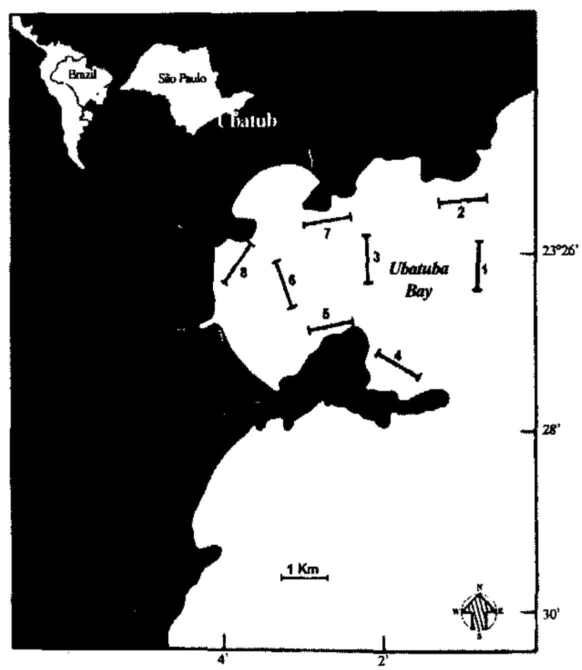

Figure 1. Map of Ubatuba Bay (Sao Paulo State), showing the position of the sampling transects

During the study period, depth recordings averaged 9.3 ± 3.66 m, ranging from 2.5 to 18.5, average temperature was 23.8 ± 0.62 °C (from 19.2 to 20.1), mean water salinity was 33.2 ± 0.35 % (from 33.5 to 34.8) and dissolved oxygen contents averaged 5.11 ± 0.29 mg/l (from 5.21 to 5.87). Overall mean of organic matter contents in bottom sediments was 11.8 ± 5.35 % (from 2.0 to 23.4) and pelitic sediments prevail in most subareas. Detailed descriptions of physical and chemical features characterizing this area and statistical similarity of environmental factors among transects can be found in Mantelatto and Fransozo (1999).

Anomuran crab samples were obtained on three consecutive days in a monthly basis from September 1995 to August 1996. In each day, eight diurnal trawlings covering a 1-km transect were carried out with a commercial fishery boat equipped with double rig nets (10 mm of mesh size cod end). Each trawl was performed at a constant speed for 20 minutes. After sorted out, the material was frozen. In the laboratory, the material was defrosted and examined at room temperature.

The species' Constancy Index (C) was calculated according to Dajoz (1983): C = p X 100/ P, where "p" is the number of samples in which a given species was recorded, and "P" is the number of total analyzed samples. Species were then classified in three different constancy categories; i.e. constant (C^3 50 %), accessory (25 % < C < 50 %) and accidental (C £ 25 %). For diversity analyses, the Shannon-Weaver index (Shannon and Weaver, 1963) was used, while equitability (J') was calculated as performed by García Raso and Fernandez Muñoz (1987).

RESULTS

In total, 1.181 specimens were collected (Table 1), comprising 16 species and three families. Diogenids outnumbered pagurids and porcellanids. The anomuran taxocoenosis was dominated by a few species (constant species). Five of those comprised a relative abundance higher than 10%, representing together 92% of the total number of collected anomurans. The family Diogenidae was represented by eight species, enclosing 74.2% of all individuals; i.e. *Dardanus insignis* (Saussure, 1858), *Isocheles sawayai* (Forest & Saint Laurent, 1967), *Loxopagurus loxochelis* (Moreira, 1901), *Paguristes calliopsis* Forest & Saint Laurent, 1967, *Paguristes erithrops* Holthuis, 1959, *Paguristes tortugae* Schmitt, 1933, *Petrochirus diogenes* (Linné, 1758) and *Paguristes* sp. These species show differential distribution in Ubatuba Bay. The most abundant species was *D. insignis*, with an outstanding occurrence in transects V and IV. The second ranked species was *L. loxochelis*, whose relative frequency at transect I was 87.2%, followed by *I. sawayai*, which was specially abundant in transects VII and VIII, and P. diogenes, with significant occurrence at transects IV, V and VI.

Pagurids were represented by three species: *Pagurus criniticornis* (Dana, 1852), *Pagurus exilis* (Benedict, 1892) and *Pagurus leptonix* (Forest & Saint Laurent, 1967). These species encompassed 3.4% of all collected anomurans.

Five porcellanid species were recorded, i.e. *Megalobrachium roseum* (Rathbun, 1900), *Myneocerus angustus* (Dana, 1852), *Petrolisthes rosariensis* Werding, 1978, *Pisidia brasiliensis* Haig, 1968 and *Porcellana sayana* (Leach, 1820), corresponding to 22.4% of all individuals. Of these, *P. sayana* is undoubtedly the most abundant species (n = 240, 90.6%), occurring mainly at transect IV, followed by transects V, I and VI.

In general, number of individuals and species' richness were higher in transects where sediments are mainly composed by coarse grains associated to high organic matter contents (Figs. 2 and 3).

All constant species, except L. loxochelis, showed a continuous occurrence throughout the sampling period. Number of species and their respective frequency showed a seasonal variation, both decreasing during the warmest months (Fig. 4). In this period, the abundance of constant species attained maximum values.

The diversity index ranged from 0.58 to 2.17 within transects, and from 1.45 to 2.64 within months, depending mostly on equitability than on richness (Table 2 and Fig. 5). However, lowest richness values at transect II (3.0) significantly

Table 1. Species composition and number of individuals each transect in Ubatuba Bay. (CN = constancy; Co = constant; Ac = accessory and Ad = accidental).

Family/Species	Transects									
	I	II	III	IV	V	VI	VII	VIII	Total	CN
DIOGENIDAE										
Dardanus insignis	24	3	-	83	262	12	1	1	386	Co
Isocheles sawayai	-	-	-	1	-	1	53	95	150	Co
Loxopagurus loxochelis	157	6	6	-	-	4	3	4	180	Co
Paguristes calliopsis	-	-	-	1	1	1	-	-	3	Ac
Paguristes erythrops	-	-	-	1	6	2	-	-	9	Ac
Paguristes sp.	-	-	-	-	1	-	-	-	1	Ad
Paguristes tortugae	-	-	-	4	13	-	-	-	17	Ac
Petrochirus diogenes	3	-	1	57	31	36	1	1	130	Co
Subtotal	**184**	**9**	**7**	**147**	**314**	**56**	**58**	**101**	**876**	
PAGURIDAE										
Pagurus criniticornis	-	-	-	3	13	-	-	-	16	Ac
Pagurus exilis	5	-	-	2	1	-	1	-	9	Ac
Pagurus leptonix	1	-	1	2	-	2	9	-	15	Ac
Subtotal	**6**	**-**	**1**	**7**	**14**	**2**	**10**	**-**	**40**	
PORCELLANIDAE										
Megalobrachium roseum	-	-	-	-	2	-	-	-	2	Ad
Myniocerus angustus	2	-	1	1	-	-	-	-	4	Ac
Petrolisthes rosariensis	-	-	-	9	5	2	-	-	16	Ac
Pisidia brasiliensis	-	-	-	-	3	-	-	-	3	Ac
Porcellana sayana	37	3	1	127	40	27	2	3	240	Co
Subtotal	**39**	**3**	**2**	**137**	**50**	**29**	**2**	**3**	**265**	
TOTAL	**229**	**12**	**10**	**291**	**378**	**87**	**70**	**104**	**1181**	

contrasted with that observed at transects IV and V (12.0). Highest diversity and equitability values were recorded at transects VI and II, respectively, while lowest ones were obtained at transect VIII. During the study period, both indexes showed wider variation along the sampling periods between September/October and February/March.

DISCUSSION AND CONCLUSIONS

This study reveals that the biodiversity of hermit crab and porcellanid species in Ubatuba Bay is considerably high. From all hermit and porcellanid species recorded for the Brazilian coast, 26.2 and 23.8 %, respectively, were also found in Ubatuba

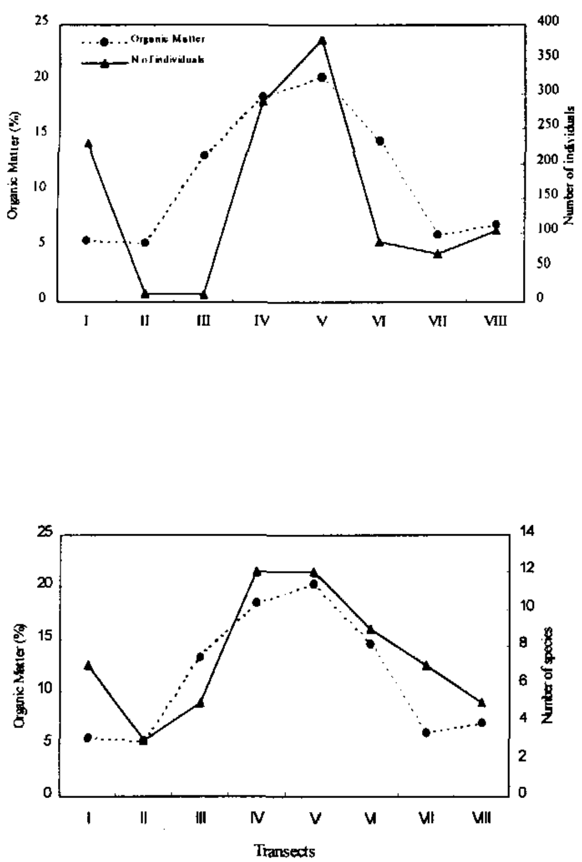

Figure 2. Number of individuals and species in function of organic matter contents in each transects samples in Ubatuba Bay.

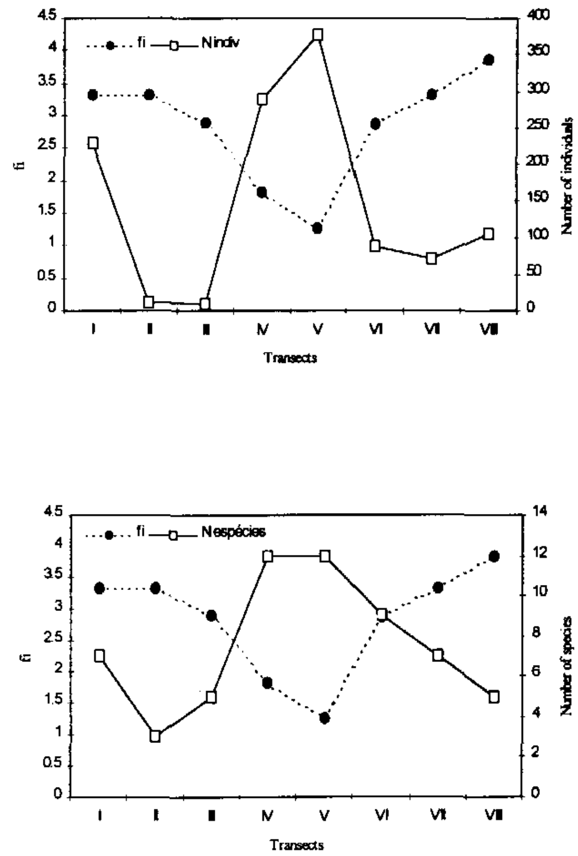

Figure 3. Number of individuals and species in function of sediment texture contents in each transects samples in Ubatuba Bay.

Bay. Those may be regarded as high percentages, considering the small relative area of this bay compared to the range of the Brazilian coast.

The structure and dynamics of the anomuran community in Ubatuba Bay depend basically on the seasonal abundance of dominant species, i.e. *D. insignis, I. sawayai, L. loxochelis, P. diogenes* and *P. sayana.* Recently, Hebling *et al.* (1994) and Negreiros-Fransozo *et al.* (1997) carried out similar studies at the Achieta Island and in Fortaleza Bay, both located within the Ubatuba region. At these locations, the anomuran diversity was considerably lower than in Ubatuba Bay, where only 12 and 7 species were respectively recorded. This difference is in great part attributed to the high diversity of porcellanids verified in the present study. Except for *P. diogenes*, the dominant species are the same than those recorded in Fortaleza Bay, where *L. loxochelis* is the most abundant species instead. At Anchieta Island, the dominant species are *D. insignis, L. loxochelis* and *P. sayana.*

In general, the anomuran taxocoenosis at these three Ubatuba areas are qualitatively similar, with small differences among them regarding species' composition. This similarity is probably related to the fact that all areas are exposed to the influence of the same prevailing water masses, which directly affect the dynamics of environmental factors (Castro-Filho *et al.*, 1987). Quantitative analyses of abiotic factors (Mantelatto and Fransozo, 1999) showed that environmental conditions in Ubatuba Bay are similar to those verified in nearby loca-tions,

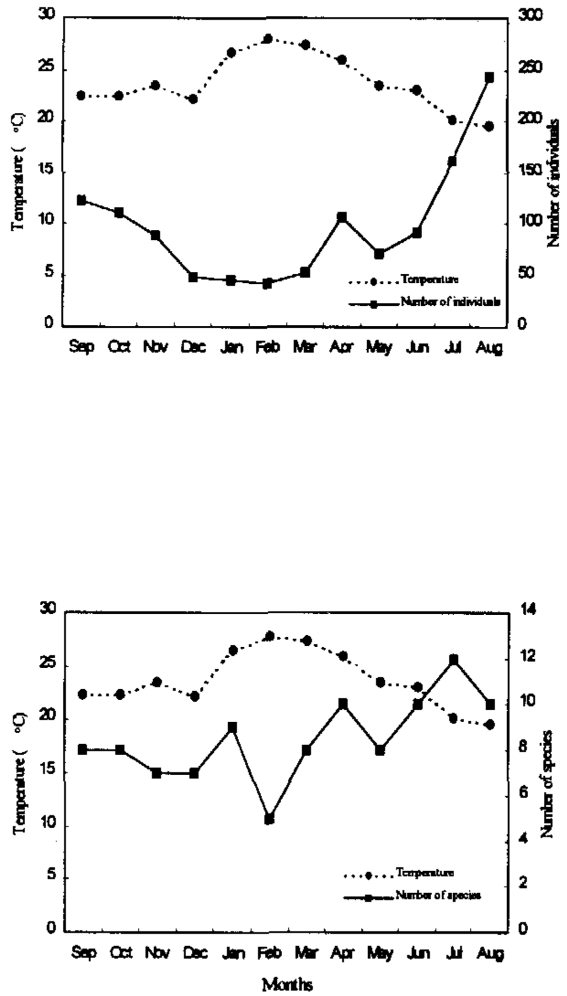

Figure 4. Number of individuals and species as a function of temperature throughout the study period (september/95 to August/96) in Ubatuba Bay

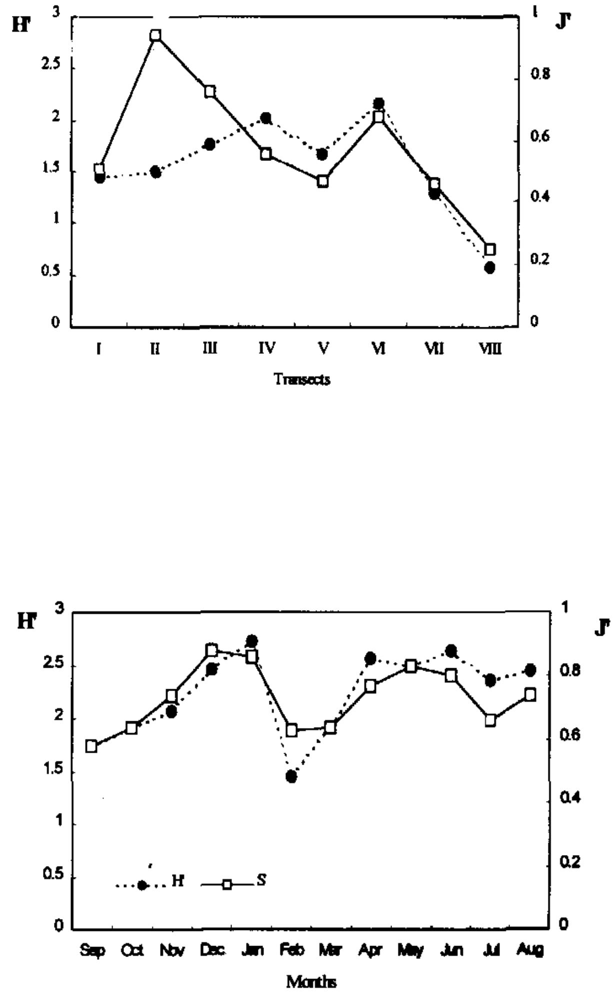

Figure 5. Spatial and monthly oscillations of diversity (H') and Equitability (J') during the study period (September/95 to August/96) in Ubatuba Bay

such as Flamengo Bay (Forneris, 1969) and Fortaleza Bay (Abreu, 1980; Negreiros-Fransozo *et al.*, 1991).

Number of individuals and species diversity decrease during summer months, a fact much probably correlated with raising temperatures in that period (r = 0.58), and tend to increase during winter months. In the Ubatuba region, the interaction of two main water masses, i.e. Coastal Water (CW) and South Atlantic Central Water (SACW), result in a mixing zone with temporal and spatial effect dependent on the penetration intensity of SACW (Pires, 1992). The SACW has a strong influence on the sea bed temperature, especially on the inner shelf during summer.

Sediment texture and organic contents are the most important agents influencing the distribution and maintenance of anomuran populations in Ubatuba Bay, as already suggested by Negreiros-Fransozo *et al.* (1997). Organic matter can be deposited among sediment particles or laid over the substratum as a covering layer. Both forms are food resources available for benthonic organisms, comprising the epifauna, infauna or the meiofauna, including scavenger crustaceans, which may be consumed by predators.

Main sea currents operating in Ubatuba Bay are slow-moving water masses, describing a clockwise

Table 2. Number of individuals collected from September/95 (S) to August/96 (A).

	Months												
Family / Species	**S**	**O**	**N**	**D**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**TO**
DIOGENIDAE													
Dardanus insignis	79	66	38	12	5	6	2	19	23	22	38	76	386
Isocheles sawayai	9	12	27	12	4	1	8	19	7	3	7	41	150
Loxopagurus loxochelis	12	11	6	6	11	-	1	4	7	-	71	51	180
Paguristes calliopsis	-	-	-	-	-	-	-	1	-	1	-	1	3
Paguristes erythrops	-	-	-	-	-	-	1	1	-	2	4	1	9
Paguristes sp.	-	-	-	-	-	-	1	-	-	-	-	-	1
Paguristes tortugae	-	-	-	1	-	-	-	1	-	10	-	5	17
Petrochirus diogenes	6	5	10	8	3	6	6	11	14	21	12	28	130
PAGURIDAE													
Pagurus criniticornis	1	1	-	-	-	-	-	10	-	-	3	1	16
Pagurus exilis	1	3	1	-	1	-	-	-	2	-	1	-	9
Pagurus leptonix	-	1	-	1	9	-	-	-	-	1	2	1	15
PORCELLANIDAE													
Megalobrachium roseum	-	-	1	-	-	-	-	-	-	-	1	-	2
Myniocerus angustus	-	-	-	-	1	1	-	-	-	1	1	-	4
Petrolisthes rosariensis	1	-	-	-	-	-	2	2	2	9	-	-	16
Pisidia brasiliensis	-	-	-	-	1	-	-	-	1	-	1	-	3
Porcellana sayana	13	11	6	8	10	28	31	38	15	22	20	38	240
TOTAL	**122**	**110**	**89**	**48**	**45**	**42**	**52**	**106**	**71**	**92**	**161**	**243**	**1181**

movement, with offshore water entering at the southern side (Ponta Grossa) and inshore water moving outward at the northern side (Ponta do Respingador) (Mahiques, 1992). Because of the particular hydrodynamism acting on this area, water currents at transects IV, V and VI are relatively weak, favoring the deposition of coarser grains. Organic matter contents were also higher at these transects averaging 14 to 20%, which are typical values from areas where organic matter is mainly of continental origin (Saito *et al.*, 1989). *P. diogenes* and *D. insignis* are considered as scavenger, omnivourous and oportunistic species, what may explain their high occurrence at these transects. Caine (1975) observed that *P. diogenes* preferentially feeds on living macrofauna, such as polychaetes and ophiuroids.

In spite of being regarded as suspension feeders, *L. loxochelis* and *I. sawayai* were mainly captured in areas with low organic matter contents. *L. loxochelis* is more abundant at deeper areas, not affected by freshwater drainage. *I. sawayai* was mostly found in transects VII and VIII, near swash zones. Even sharing a similar feeding habit, these species showed a clearly different bathimetric distribution, minimizing therefore niche overlap.

The presence of different substratum types may also allow the coexistence of various species by means of their differential partitioning. While some species are capable to use the substratum as shelter, others might use it as a feeding ground or even as a food medium from which organic particles can be obtained, thus reducing competitive interactions among species (Abele, 1976).

Biotic factors may also significantly affect the distribution of hermit crabs, namely the seasonal availability of shells for shelter renewal in adults and the abundance of suitable shells for newly settlers (McLean, 1983). Hermits may obtain new housing by means of exchanging shells between them, seeking for empty shells, or even by migrating to specific areas where gastropod predation is intense (Rittschoff, 1980).

Among the five porcellanid species recorded, *P. sayana* is the most abundant. Its distribution in Ubautuba Bay is tightly related to the presence of *P. diogenes* and *D. insignis*, since its occurrence is almost restricted to transects I, IV, V and VI. This typical case of comensalism reveals that porcelain crabs not only use hermit crabs' shells for shelter, but may also use loose particles from their host's feeding activity as a food resource.

Variations on diversity among monthly samples are certainly a result of the high complexity and dynamism of the studied system associated to environmental variability within Ubautba Bay. These factors together with the adaptive processes acting in each species during evolution may be accounting for the variability of the anomuran community structure in Ubatuba Bay. However, assessing the influence of many other parameters will be necessary before confirming this assumption. Similar hypotheses have been postulated in other less important biotopes where many decapod crustaceans spend all or part of their life (García Raso, 1990; López de la Rosa and García Raso, 1992). Details of the population structure and reproductive biology of the species reported in this study, will provide important information in order to elucidate questions about the particular dynamics of the anomuran community in this bay.

ACKNOWLEDGEMENTS

The authors are grateful to the "Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP)" (Grant # 95/2833-0) for financial support. Special thanks are due to NEBECC co-workers for their help in field and laboratory work. Thanks are due to Dr. Nilton José Hebling (Paulista State University - Brazil) and Dr. Alan Harvey (Department of Biology - Georgia Southern University - USA) for assistance with species identification.

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