HERMIT CRAB FAUNA FROM THE INFRALITTORAL ZONE OF ANCHIETA ISLAND (UBATUBA, BRAZIL)

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ABSTRACT

The checklist and biological aspects of hermit crab communities living on the infralittoral rocky bottom (Anchieta Island, Ubatuba) were studied through monthly samplings from January to December 1998. The specimens were captured by three persons using scuba diving methods. Data on seasonal distribution and abundance of each species are presented. Nine species were recorded: *Calcinus tibicen, Dardanus insignis, D. venosus, Paguristes calliopsis, P. erythrops, P. tortugae, Petrochirus diogenes, Pagurus brevidactylus*, and *P. criniticornis*. The species recorded on Anchieta Island correspond to 42.9% of the total hermit crab species catalogued for the State of São Paulo. The taxocoenosis was controlled by *P. tortugae* and *P. brevidactylus* during all seasons. In the present study *D. venosus* was recorded for the first time in the State of São Paulo. The large amount of resources utilized by the hermit crabs on Anchieta Island reveal a locality with high shell availability, constituting an important site for crabs to find, use and exchange shells.

I. INTRODUCTION

Reliable regional checklists of marine species have multiple uses, especially for biodiversity studies on zoogeographic regions or provinces in specific habitats, which serve as points of departure for studying several aspects of the community ecology (Hendrickx and Harvey 1999). In this sense, the literature on decapods from the Brazilian coast is often limited to restricted areas, which are important to understand the ecology of the benthic community. Among them, during the last 12 years a long-term effort has been made to identify and characterize the biology (i.e., larval phases, growth, reproduction, population dynamics, relationships with abiotic factors) of decapod crustaceans commonly and uncommonly occurring in the Ubatuba region, from the intertidal zone to 20 m of depth. This region is located along the northern coast of the State of São Paulo, and is considered an important area for crustacean investigations because it comprises a zone of faunal transition and presents a mixture of faunas of both tropical and Patagonian origins (Sumida and Pires-Vanin 1997). For this reason, an impressive number of studies are available on the intertidal zone and continental shelf, focusing on the crab, shrimp and hermit crab species composition from a variety of habitats in the Ubatuba area.

The Anomura represent a highly significant group among marine crustaceans, including approximately 800 species of hermit crabs, which have undergone considerable revision (Ingle 1993), and are now classified in 6 families with 86 genera. Hermit crabs represent a very important group within the intertidal community and also a significant taxon in the benthic sublittoral habitat, playing an important role in the marine trophic chain (Fransozo et al. 1998). Of the 46 hermit crab species recorded from Brazilian waters, 20 were recorded on the northern coast of the State of São Paulo, 13 of them belonging to the family Diogenidae and 7 to the family Paguridae (Melo 1999). Among the available reports, the following represent

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particularly important contributions to the knowledge of the hermit fauna of Ubatuba: Hebling et al. (1994) reported the crabs sampled in the soft bottom of Anchieta Island region; Negreiros-Fransozo et al. (1997) established the species composition and distribution of crabs along the non-consolidated sublittoral region of Fortaleza Bay; Mantelatto and Souza-Carey (1998) reported the species inhabiting the bryozoan colonies of *Schyzoporella unicornis* (Johnston, 1847), and recently Fransozo et al. (1998) provided an anomuran check-list and described ecological aspects of this fauna in terms of their composition and distribution along the non-consolidated sublittoral region of Ubatuba Bay.

Despite this promising situation, and a widespread interest in the faunal composition and ecology of the crustacean species inhabiting different areas of Ubatuba, the island community was poorly known until recently, mainly due to the distance from the coast and the sampling difficulties. Islands are typically species-poor systems because of their reduced area in comparison to mainland areas, and this poverty is accentuated by increasing isolation and decreasing island relief and altitude (Whittaker 1998). However, island communities possess characteristics, such as population growth that differ from populations in the continental coastal zone. Thus, the island biotope offers good perspectives for future studies in Brazil, considering the high number of islands found along the coast. The knowledge of the communities may contribute to the elucidation of evolution, speciation and distribution problems with respect to marine species (MacArthur 1972). On this basis, we studied the composition and some biological aspects of the hermit crab communities living on the infralittoral rocky bottom in Anchieta Island, Ubatuba, as a contribution to the study of the biodiversity of Anomura from the São Paulo coast.

II. MATERIALS AND METHODS

Study area

Anchieta Island (23° 33'S, 45° 05'W) was recently declared an ecological reserve of the State of São Paulo. The island has a total area of about 10 km², which makes it the largest island off the coast of the State of São Paulo north of São Sebastião Island. This island is separated from the coast by a 300 m long and 35 m deep canal. There are 6 small beaches, and almost the entire shore area is rocky with an irregular surface and areas with large boulders. This collection area is important in view of the significant anthropogenic activity, which has led to the expansion of the tourist center. The physical and chemical features of the area have been described by Oliveira (1983) and Medeiros (1992). However, scientific information about the crustacean fauna from this area is sparse.

Sampling and analysis

Hermit crabs were obtained monthly from January to December 1998, in the infralittoral rocky shores of South, East and Small Beaches and Wind Bay of Anchieta Island, whose surface is irregular, with many large boulders. Every month, at least one of these sites was sampled depending on ocean and weather conditions. Specimens were captured during the daytime by three persons using scuba over a period of 30 min over the same area of about 850 m².

Animals were frozen and transported to the laboratory where they were carefully removed from their shells and measured for cephalothoracic shield length (CSL = from the tip of the rostrum to the V-shaped groove at the posterior edge). Sex was determined from the gonopore position. Measurements were made with a caliper rule (0.1 mm) or by drawing with the aid of a camera lucida. Shell species were identified according to Rios (1994) and by Dr. Osmar Domaneschi.

The constancy index (C) for each species was calculated according to Dajoz (1983): $C = p \times 100 / P$, where "p" is the number of samples belonging to a given species, and "P" is the total number of samples analyzed. Species were then classified into three different constancy categories: constant ($C \geq 50$ %), accessory (25 % < C < 50 %) and accidental (C < 25 %). Diversity was calculated using the Shannon-Weaver index (Shannon and Weaver, 1963): $H' = \sum^{s} \log_2 P_i$, where "s" is the number of species and "P_i" is the proportion of i^{th} species. The equitability index (J') was calculated as indicated by García Raso and Fernandez Muñoz (1987): $J' = H' / \log_2 s$.

III. RESULTS

A total of 4,155 specimens were collected (Table 1), comprising nine hermit crab species and two families. Diogenids outnumbered pagurids. The anomuran taxocoenosis was dominated by a few species (constant species). Four of those had a relative abundance higher than 5%, representing together 95.5%

Table 1. *Number of individuals collected from January to December 1999 in Anchieta Island (CN = constancy: Co = constant; Ac = accessory; Ad = accidental).*

SPECIES	MONTHS													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	CN	Total
C. tibicen	16	02	13	01	05	04	18	09	14	17	07	18	Co	124
D. insignis	-	-	-	01	-	-	-	18	-	02	-	-	Ad	21
D. venosus	-	-	01	-	-	-	01	02	-	02	-	-	Ac	06
P. calliopsis	-	-	-	-	-	-	-	-	-	40	42	34	Ad	116
P. erythrops	-	05	02	05	02	-	-	97	-	111	02	32	Co	256
P. tortugae	41	144	178	207	161	173	36	406	187	334	281	281	Co	2429
P. diogenes	-	-	-	-	-	-	-	01	-	-	-	-	Ad	01
P. brevidactylus	08	85	81	123	79	86	61	91	67	120	121	215	Co	1135
P. criniticornis	-	01	01	05	03	01	01	-	01	-	07	25	Co	45
TOTAL	65	235	276	342	230	264	117	624	269	626	460	605		4133

of the total sample. The family Diogenidae was represented by seven species, contributing with 71.5% of all individuals: *Calcinus tibicen* (Herbst, 1791), *Dardanus insignis* (Saussure, 1858), *D. venosus* (H. Milne Edwards, 1848), *Paguristes calliopsis* Forest and Saint Laurent, 1967, *P. erythrops* Holthuis, 1959, *P. tortugae* Schmitt, 1933, and *Petrochirus diogenes* (Linnaeus, 1758). Pagurids were represented by *Pagurus brevidactylus* (Stimpson, 1859) and *P. criniticornis* (Dana, 1852). These species represented 28.5% of the total sample.

The species showed different distribution patterns on Anchieta Island. The most abundant species were *P. tortugae* and *P. brevidactylus*, with an outstanding occurrence on rocky areas covered by algae. The third ranked species was *P. erythrops*, almost always found on soft bottoms where the sediments are mainly composed of very coarse sand or coarse sand and medium sand, followed by *C. tibicen*, which was especially abundant in rock crevices. *Paguristes calliopsis* occurs in the same area as the previous more abundant species, while *D. insignis* and *D. venosus* were found with *P. erythrops*. Almost all the specimens of *P. criniticornis* were found on sediments composed mainly of very coarse sand.

All constant species, except *P. erythrops*, showed a continuous occurrence throughout the sampling period. Number of species and their respective frequency varied seasonally, both increasing during the warmest months and decreasing during the coldest ones (Fig. 1).

The diversity index ranged from 1.05 to 1.85, depending more on equitability than on richness (Table 1, Fig. 1). During the study period, both indexes showed a wide variation, decreasing from January to June and increasing from July to December.

The hermit crab species were found occupying, in different percentages, 29 species of gastropod shells, belonging to 23 genera (Table 2). *Cerythium atratum*, *Pisania auritula* and *Morula nodulosa* were the shells most commonly occupied by hermit crabs at the study site, accounting for more than 74.9% of the collected shells.

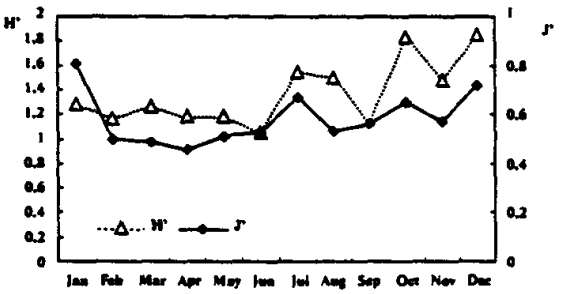

Figure 1. *Monthly oscillation of diversity (H') and equitability (J') of hermit crab species during the study period (January to December, 1998) in Anchieta Island.*

IV. DISCUSSION

The sampling methodology used in this study, which provided large amounts of material from irregular surfaces, should be used in other areas to make comparisons possible. The efficiency of this sampling method reveals that the diversity of hermit crab species on Anchieta Island is considerably high. More than 40% of the 21 species recorded for the São Paulo coast, have been captured in this area. Among them, *D. venosus* was recorded for the first time in the State of São Paulo (Mantelatto et al. 2001). This may be regarded

Table 2. *Total number of occupied shells by the hermit crab species collected in the studied area (Ct: **Calcinus tibicen**; Di: **Dardanus insignis**; Dv: **Dardanus venosus**; Pc: **Paguristes calliopsis**; Pe: **Paguristes erythrops**; Pt: **Paguristes tortugae**; Pd: **Petrochirus diogenes**; Pb: **Pagurus brevidactylus**; Pcr: **Pagurus criniticornis**).*

Shells	Ct	Di	Dv	Pc	Pe	Pt	Pd	Pb	Pcr	Total
Adelomelon beckii	-	-	-	-	-	-	1	-	-	1
Anachis lyrata	-	-	-	1	-	-	-	17	-	18
Astraea sp.	1	-	-	-	-	-	-	1	-	2
Astraea latispina	4	-	1	1	3	25	-	-	-	34
Astraea olfersii	23	9	2	4	5	40	-	-	-	83
Astraea phoebia	3	-	-	4	1	18	-	2	-	28
Buccinanops gradatum	-	-	-	-	3	1	-	-	-	4
Calliostoma bullisi	-	-	-	1	-	-	-	-	-	1
Cerithium atratum	17	-	-	88	6	676	-	334	37	1158
Chicoreus tenuivaricosus	2	1	-	-	35	13	-	2	-	53
Coralliophila aberrans	-	-	-	-	-	5	-	2	-	7
Cymatium parthenopeum	3	-	-	-	11	22	-	1	-	37
Cypraea acicularis	-	-	-	-	1	-	-	-	-	1
Favartia cellulosa	-	-	-	-	-	1	-	1	-	2
Fusinus brasiliensis	1	2	-	2	20	9	-	-	-	34
Leucozonia nassa	6	-	-	-	12	166	-	15	-	199
Modulus modulus	1	-	-	1	-	1	-	-	-	3
Morula nodulosa	-	-	-	7	-	308	-	645	5	965
Muricopsis necocheanus	-	-	-	-	-	1	-	-	-	1
Oliva reticularis	-	-	-	-	2	-	-	-	-	2
Olivancillaria urceus	-	5	-	-	8	-	-	-	-	13
Phalium granulatum	-	-	1	-	-	1	-	-	-	2
Pisania auritula	43	-	-	-	48	862	-	17	1	971
Pisania pusio	2	-	-	-	5	59	-	3	-	69
Polinices hepaticus	-	-	-	-	3	2	-	-	-	5
Polinices lacteus	-	-	-	-	1	4	-	-	1	6
Stramonita haemastoma	9	4	-	1	57	68	-	11	-	150
Strombus pugilis	1	-	2	-	31	-	-	-	-	34
Tegula viridula	8	-	-	6	4	131	-	8	1	158
no identification	-	-	-	-	-	16	-	76	-	92
Total	124	21	6	116	256	2429	1	1135	45	4133

as a very high diversity, considering the relatively small area of the island compared to the range of the Brazilian coast, with a total of 46 species recorded (Melo 1999).

The structure and dynamics of the hermit crab community on Anchieta Island basically depend on the seasonal abundance of the dominant species, *P. tortugae* and *P. brevidactylus*, with a moderate influence of *P. erythrops* and *C. tibicen*. This pattern of dominance of a few species in the community was also recorded during previous studies on brachyurans and anomurans from a non-consolidated substratum in the Ubatuba region (Fransozo et al. 1992, Negreiros-Fransozo et al. 1997, Fransozo et al. 1998). Recently Hebling et al. (1994), working on a non-consolidated area on Anchieta Island, recorded a hermit crab community composed of 11 species, including four (*P. criniticornis*, *P. erythrops*, *P. tortugae*, and *D. insignis*) of those captured in the present study. These authors reported relatively low numbers of individuals for most of the species, except for *D. insignis*. This fact confirms the preference of this species for rocky areas close to sand substrates. The presence of different types of substrates may also allow for the coexistence of various species by means of their differential use of space. While some species are able to use the substratum as shelter, others might use it as a feeding ground or even as a food me-

dium from which organic particles can be obtained, thus reducing competitive interactions among species (Abele 1976).

In general, the anomuran taxocoenosis in the different areas of Ubatuba Bay is qualitatively similar, with small differences in 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). Number of individuals and species diversity decrease during the summer months, a fact probably correlated with raising temperatures during this period, and tend to increase during the winter months. In the Ubatuba region, the interaction of two main water masses, the Coastal Water (CW) and the South Atlantic Central Water (SACW), results in a mixing zone with temporal and spatial effects dependent on penetration intensity of SACW (Pires 1992). The SACW has a strong influence on the seabed temperature, especially on the inner shelf during summer. These conditions contribute to the development of the local community providing nutrients and favoring recruitment, allowing each species to occupy a favorable habitat for growth and reproduction, a fact that probably occurs on Anchieta Island. Evidence for such a scenario is the high number of young individuals of all species captured.

Once established in a locality, hermit crab populations can adapt to local conditions and coexist with other species inhabiting the area. Specifically for hermit crabs, these relationships involve an important aspect, which is the sharing of shells by various species (Gherardi and Nardone 1997). The resource partition can directly affect the distribution of individuals, possibly reducing the abundance of the population (Miller 1967).

In the natural environment, almost all hermit crab populations occupy a wide variety of shell types and sizes as a function of local availability (Bertness 1980, Reddy and Biseswar 1993), which is considered a limiting factor for hermit crab survival (Kellogg 1976). On the basis of the large quantities of resources used by hermit crabs on Anchieta Island (Table 2), we can infer that shells are readily available in this locality, representing an important site for crabs to find, use, and exchange shells. Ohmori et al. (1995) postulated that shell type availability in nature is determined by the relative abundance of living gastropods and their mortality rates. The abundance of living gastropods reflects directly on the shell stock since the most available shells are generally the most occupied in the field (Mantelatto and Garcia 2000).

Hermit crabs are mainly deposit feeders (Schembri 1982), and their abundance is strongly associated with food (Bertness 1981) and shell availability (Raimondi and Lively, 1986). We can infer that these factors may be responsible for the seasonal abundance pattern of hermit crabs on Anchieta Island, as recorded for other anomurans studied in the non-consolidate substrate of Ubatuba Bay (Fransozo et al. 1998).

The seasonal availability of shells for shelter renewal in adults and the abundance of suitable shells for new settlers may also affect hermit crab distribution (McLean 1983). Hermit crabs may obtain new housing by exchanging shells among themselves, seeking empty shells, or even by migrating to specific areas where gastropod predation is intense (Rittschoff 1980).

Detailed information on the population structure and reproductive biology of the species reported herein will provide important data to elucidate questions about the dynamics of the anomuran community on this island. In addition, comparative data for biodiversity studies are provided, which can also be used to detect the potential impact of anthropogenic activities in the area.

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