Gastropod shell availability as a potential resource for the hermit crab infralittoral fauna of Anchieta Island (SP), Brazil.

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Abstract

The population dynamics of the hermit crabs' community is strongly related to the gastropod shell utilization process. This study characterized the gastropod shell availability in the infralittoral area of Anchieta Island, Ubatuba (SP), Brazil, to provide information on hermit crab community of this area. Gastropod and empty shells were monthly obtained throughout 2000 on the infralittoral rocky shores and sandy areas of the East beach of the Anchieta Island, whose surface is irregular, with many huge boulders. Specimens were captured during the daytime by three people using scuba diving techniques in a period of 30 min covering a same area of approximately 750 m^2. A total of 2428 gastropod specimens and empty shells belonging to 33 species were obtained. *Cerithium atratum* (34%) was the most available shell species, followed by *Pisania auritula* (22.5%) and *Astraea olfersii* (10.9%). The significant frequency (85%) of living gastropods during the study period reflected the shell stock potential in this area to the hermit crabs, considering that the most abundant hermit crab species occupy these shells.

Key words: gastropod shell, empty shell, availability, infralittoral

Introduction

Although some authors described hermit crabs occupying some objects other than gastropod shells (Gherardi and Cassidy, 1995; Garcia *et al*., 2003), there is an agreement among scientists about the importance and influence of these shells in all aspects of their life cycle (Mantelatto and Garcia, 2000). This resource can provide a limiting factor in hermit crab population dynamics, affecting both population size and the rates of individual growth, reproduction, development, and longevity (Raimondi and Lively, 1986; Lancaster, 1988; Mantelatto and Garcia, 1999).

The population dynamics of the hermit crabs is closely tied to the species of gastropods existent in their habitat (Mantelatto and Garcia, 2000). The availability of different shell types in nature is determined by the relative abundance of different live gastropods and their mortality rates. Thus, studies about the shell availability in the field are extremely important to explain the shell occupation patterns by hermit crabs. However, nowadays there is a dearth of publications in which the major attention is related to the availability of gastropod shells.

This study characterizes the gastropod shell availability based on the abundance (shell type percentage and shell size) of live gastropods and empty shells in the infralittoral area of Anchieta Island, Ubatuba (SP), Brazil, to provide information on hermit crab community of this area.

Material and Methods

Available shells (with either live gastropods or empty) were monthly obtained from January to December, 2000 on the infralittoral rocky shores and sandy areas of the East beach of Anchieta Island (23^0 33'S, 45^0 05'W), whose surface is irregular, with many huge boulders. This island was recently declared an ecological reserve of São Paulo State and it has a total area of about 10 km^2. It is located landwards, separated from the coast by a 300 m long and a 35 m deep canal. Such area is important concerning to its significant human activity, which it has led to the expansion of the tourist center. The physical and chemical features of this area have been described by Oliveira (1983) and Medeiros (1992).

All specimens were captured during the daytime by three collectors using scuba diving techniques in a period of 30 min covering a same area of approximately 750 m^2.

After collection the shells were frozen and transported to the laboratory, counted and identified according to Rios (1994) and confirmed by a specialist (Dr. O. Domaneschi, IB – USP). The shell aperture width (SAW) of all collected shells was determined with a caliper rule (0.1 mm). The chi-square test (χ^2) was used to compare the availability of both empty shells and those with live gastropods (Zar, 1996).

Results

A total of 2428 shells (2071 with gastropods and 357 empty) of 33 species were collected. Shells occupied by living gastropods (85.29%) were more frequently found than those empty (14.71%) (Table I).

Cerithium atratum (Born, 1778) (34%) was the most available shell species ($x^2 = 57.06$; $p < 0.01$), followed by *Pisania auritula* (Link, 1807) (22.5%) and *Astraea olfersii* (Philippi, 1844) (10.9%) (Table I). Furthermore, *C. atratum* was the most available shell with live gastropod (30.86%), while *Astraea olfersii* was the most available species among the empty ones (4.04%).

There was a significant difference ($p < 0.05$) of abundance between shells with gastropods and empty, for the majority of gastropod shell species collected, excepting for *Anachis lyrata* (Sowerby, 1832), *Calliostoma bullisi* Clench and Turner, 1960 and *Cypraea zebra* Linnaeus, 1758.

Shells found only with live gastropods in the present survey were: *Bulla striata* Buguiere, 1792, *Clathrodrillia solida* C. B. Adams, 1850, *Columbella mercatoria* (Linnaeus, 1758), *Coraliophila aberrans* (C. B. Adams, 1850), *Costoanachis sertularium* Orbigny, 1841, *Mitrella argus* Orbigny, 1842, *Nassarius albus* (Say, 1826) and *Pilsbryspira leucocyma* (Dall, 1883). The shells only found empty belonged to the following species: *Buccinanops gradatum* (Deshayes, 1844), *Natica isabelleana* Orbigny, 1840, *Oliva reticularis* Lamarck, 1810, *Olivancillaria urceus* (Roding, 1798), *Polinices lacteus* (Guilding, 1833), *Strombus pugilis* Linnaeus, 1758 and *Tonna galea* (Linnaeus, 1758) (Table I).

The shell aperture width (SAW) of all available shells ranged from 0.90 (*M. argus*) to 36.20 mm (*T. galea*) (Figure 1). Empty shells were generally larger (mean SAW = 7.65 ± 4.13mm) than those occupied by gastropods (mean SAW = 5.15 ± 2.27 mm). *Stramonita haemastoma* (Linnaeus, 1767) ($1.5 \leq SAW \leq 15.7$mm) presented the largest size variation among gastropods and *A. olfersii* ($4.5 \leq SAW \leq 17.1$mm) among empty shells.

Discussion

Despite the promising situation, and a widespread interest in the faunal composition and ecology of the crustacean species inhabiting different ecosystems, the island community from Brazilian coast was poorly known until some years ago, especially on scientific information about the crustacean fauna (Mantelatto and Sousa, 2000). In this way, during the last 5 years a long-term effort has been made by our group of study to identify and characterize the biology (growth, reproduction, population dynamics, shell occupation, and population coexistence) of

the hermit crab community occurring in the infralittoral rocky bottom of Anchieta region, from the intertidal zone to 12 m of depth.

Table I: Total number of gastropod shell species available in the field (with live gastropods and empties) on Anchieta Island, Brazil.

Shell Species	Live Gastropods		Empties		Total	
	N	%	N	%	N	%
Anachis lyrata	1	0.04	1	0.04	2	0.08
Astraea latispina (Philippi, 1844)	42	1.73	68	2.80	110	4.53
Astraea olfersii	168	6.92	98	4.04	266	10.96
Astraea phoebia Röding, 1798	27	1.11	6	0.25	33	1.36
Buccinanops gradatum	-	-	1	0.04	1	0.04
Bulla striata	1	0.04	-	-	1	0.04
Calliostoma bullisi	10	0.41	14	0.58	24	0.99
Cerithium atratum	749	30.86	78	3.21	827	34.07
Chicoreus tenuivaricosus (Dautzenberg, 1927)	6	0.25	1	0.04	7	0.29
Clathrodrillia solida	1	0.04	-	-	1	0.04
Collumbela mercatoria (Linnaeus, 1758)	1	0.04	-	-	1	0.04
Coralliophila aberrans (C.B. Adams, 1850)	4	0.16	-	-	4	0.16
Costoanachis sertularium	8	0.33	-	-	8	0.33
Cymatium parthenopeum (von Salis, 1793)	34	1.40	13	0.54	47	1.94
Cypraea zebra	1	0.04	2	0.08	3	0.12
Favartia cellulosa (Conrad, 1846)	30	1.24	1	0.04	31	1.28
Fusinus brasiliensis (Grabau, 1904)	10	0.41	1	0.04	11	0.45
Leucozonia nassa (Gmelin, 1791)	28	1.15	4	0.16	32	1.32
Mitrella argus	1	0.04	-	-	1	0.04
Modulus modulus (Linnaeus, 1758)	23	0.95	1	0.04	24	0.99
Morula nodulosa (C.B. Adams, 1845)	249	10.26	12	0.49	261	10.75
Nassarius albus	2	0.08	-	-	2	0.08
Natica isabelleana	-	-	1	0.04	1	0.04
Oliva reticularis	-	-	2	0.08	2	0.08
Olivancillaria urceus	-	-	8	0.33	8	0.33
Pilsbryspira leucocyma	2	0.08	-	-	2	0.08
Pisania auritula	543	22.37	4	0.16	547	22.54
Pisania pusio (Linnaeus, 1758)	13	0.54	2	0.08	15	0.62
Polinices lacteus	-	-	8	0.33	8	0.33
Stramonita haemastoma	58	2.39	6	0.25	64	2.64
Strombus pugilis	-	-	5	0.21	5	0.21
Tegula viridula (Gmelin, 1791)	56	2.31	17	0.70	73	3.01
Tonna galea	-	-	1	0.04	1	0.04
Not identified	3	0.12	2	0.08	5	0.21
TOTAL	2071	85.29	357	14.71	2428	100

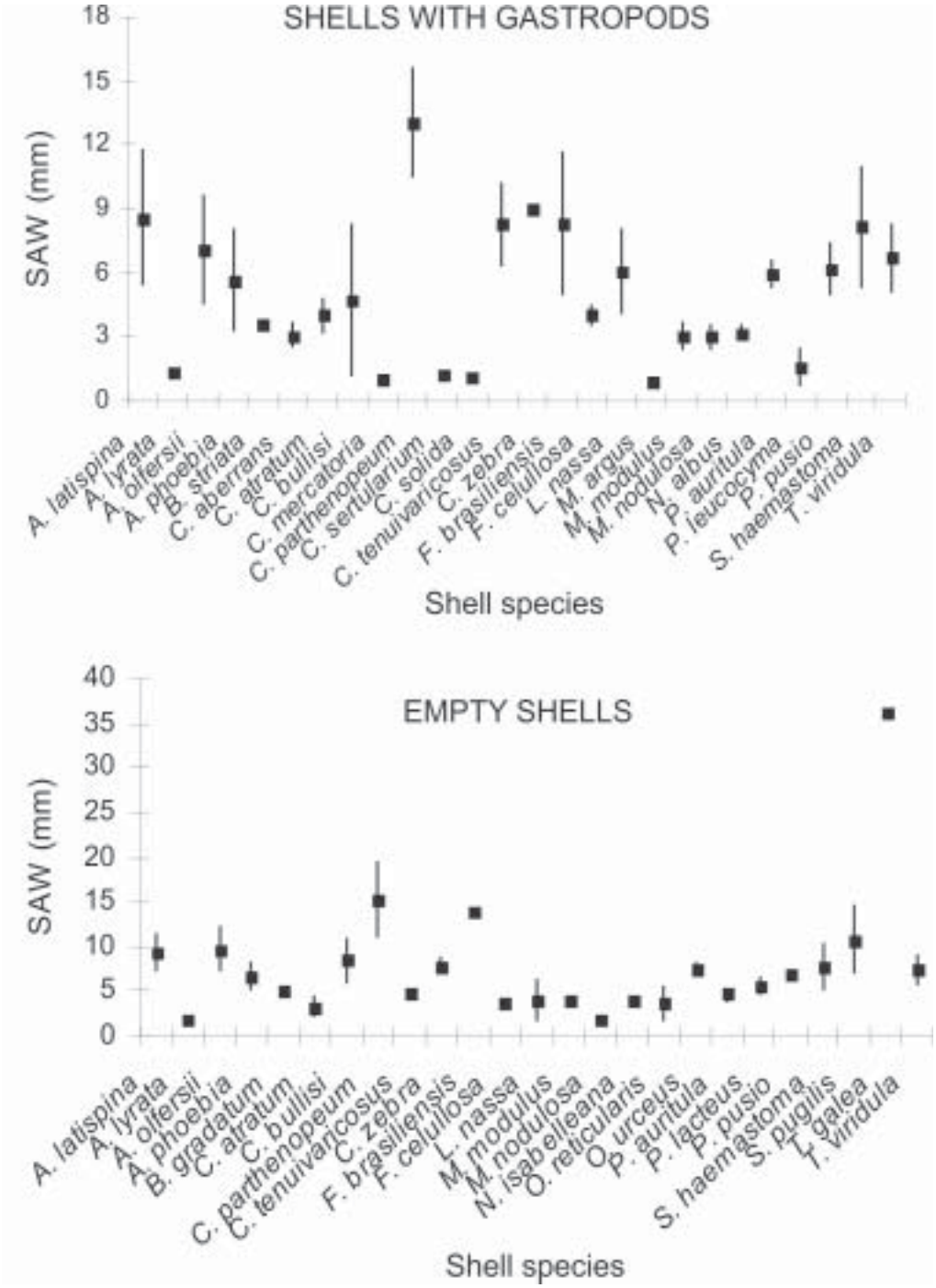

Figure 1: Shell aperture width variation of live gastropods and empty shells from Anchieta Island (SAW = shell aperture width; ╋ = mean ± standard deviation).

During this work, we have been using a procedure (scuba diving for capture effort), which provided large amounts of material from an irregular surface. The efficiency of this sampling technique reveals that the biodiversity of hermit crab (Mantelatto and Garcia, 2002) and gastropod species on Anchieta Island is considerably high. However, according to Martinelli and Mantelatto (1999), high shell availability does not necessarily imply that these shells present favorable conditions for occupation, due to high damage and/or to a limited size range. In this way, empty gastropod shells tend to be scarce in natural habitats occupied by hermit crabs, and therefore sub-optimal sized, damaged shells and unusual shelters are frequently used (Lancaster, 1988; Meireles *et al.*, 2003; Garcia *et al.*, 2003). Empty shells are less common in the field

since: 1) empty shells are generally scarce in the hermit crabs' community (Childress, 1972; Kellogg, 1976; Abrams, 1980; Bertness, 1980) and 2) hermit crabs are generally found inhabiting smaller shells than those preferred in laboratory experiments (Vance, 1972; Bach *et al*., 1976; Bertness, 1980).

On the rocky/sandy shore of East Beach, Anchieta Island, despite the large number of living gastropods, <15% of the total shells collected were empty, possibly indicating: 1) low gastropods mortality rates, 2) shell limitation in this locality as a function of its loading or destruction by the force of the currents, and/or 3) a limited stock due to the constant use of these shells by the hermit crabs.

Despite of the high variety of shell resources presented in the area, eight [*Calcinus tibicen* (Herbst, 1791), *Dardanus insignis* (de Saussure, 1858), *Dardanus venosus* (H. Milne Edwards, 1848), *Paguristes calliopsis* Forest and de Saint Laurent, 1967, *Paguristes erythrops* Holthuis, 1959, *Paguristes tortugae* Schmitt, 1903, *Pagurus brevidactylus* (Stimpson, 1862) and *Pagurus criniticornis* (Dana, 1852)] of the nine hermit crab species that live at infralittoral rocky area of Anchieta Island (Mantelatto and Garcia, 2002) occupied the three (*Astraea olfersii*, *Cerithium atratum* and *Pisania auritula*) most available gastropod shell species. Furthermore, *Cerithium atratum*, the most available shell species, was mainly occupied by five (*Calcinus tibicen*, *Paguristes calliopsis*, *Paguristes tortugae*, *Pagurus brevidactylus* and *Pagurus criniticornis*) of the nine hermit crab species inhabiting this area (Mantelatto and Garcia, 2002) (Table II).

Table II: Shell utilization pattern of all hermit crabs species from Anchieta Island (Mantelatto and Garcia, 2002).

Hermit crabs species	Most occupied shell species				Other	Total
	A. olfersii	*C. atratum*	*P. auritula*	*M. nodulosa*	shells	
Calcinus tibicen	23	17	43	-	41	124
Dardanus insignis	9	-	-	-	12	21
Dardanus venosus	2	-	-	-	4	6
Paguristes calliopsis	4	88	-	7	17	116
Paguristes erythrops	5	6	48	-	197	256
Paguristes tortugae	40	676	862	308	543	2429
Pagurus brevidactylus	-	334	17	645	139	1135
Pagurus criniticornis	-	37	1	5	2	45
Petrochirus diogenes (Linnaeus, 1758)	-	-	-	-	1	1
TOTAL	83	1158	971	965	956	4133

Mantelatto and Dominciano (2002), studying the patterns of shell utilization by *Paguristes tortugae*, the most abundant hermit crab species inhabiting Anchieta Island, found that the shell utilization patterns follows the pattern of shell-type availability that is related to the size and weight of the shells and varies between sexes. Mantelatto and Meireles (2004), studying the second most abundant hermit crab species of the area (*Pagurus brevidactylus*), also found that the shell occupation occurred in function of shell availability on Anchieta Island, although specific shell selection is related to hermit crab size and sex, and it is strongly based on the shell internal volume and dry weight (SDW). Furthermore, Biagi (pers. obs.) verified that *P. erythrops* was found inhabiting *P. auritula* shells in higher percentage, that is the second most available in the field when considering the total shell availability. Thus, we may consider that the hermit crab species of Anchieta Island occupy the most available shells depending on their size relations (Mantelatto and Dominciano, 2002; Mantelatto and Garcia, 2002; Mantelatto and Meireles, in press).

The majority of collected shells (with gastropod and empty) had small size (SAW < 10.8 mm), representing 95% of the total sample. However, available shells of small size that were collected empty represented 12% of the total. Thus, despite of their abundance, small sized shells represent a limiting resource to the hermit crabs, because they are available in a reduced amount for immediate occupation. Otherwise, the majority of the empty shells had large size, which might represent a potential resource of available shells for occupancy by other larger species inhabiting this area.

Some shell species were collected in low percentages, similar to that found by Mantelatto and Garcia (2000) in other sites of the same island. This pattern led us to infer that these specimens does not live in the present area but they probably come from other areas, by means many ways: 1) transported by currents (Vance, 1972), 2) or by hermit crabs that migrate to other areas, bringing back these shells (Lowery and Nelson, 1988), and 3) or even by fishermen who tend to select their products from deeper areas in the region before taking them to a commercial landing site (Mantelatto *et al.*, 2001), introducing new resources to the area.

The significant frequency (85%) of living gastropods obtained during the study period reflected the shell stock potential in the area to the hermit crabs, considering that the most abundant hermit species occupy these shells (Mantelatto and Garcia, 2002). We believe that the knowledge about the fauna of gastropod (live and empty) shells is essential to the studies of the hermit crab communities especially that ones involving shell utilization and selection. Thus, we recommend that information on both hermit shell occupation and gastropod shells could be provided together in future studies to facilitate further comparative analysis.

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