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Research Article

Gastropod communities associated with *Ulva* spp. in the littoral zone in southeast Brazil

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ABSTRACT. Phytal communities are characterized by spatial and temporal variation and are influenced by fluctuating biological and physical parameters. This study aimed to describe and compare the gastropods associated with Ulva spp., at three sites of the Espirito Santo coast with ferruginous laterite substrate and different modes of wave exposure. Camburi is characterized by the presence of iron ore particles. Samples were collected bimonthly. At each site, five sampling quadrats were launched at random in the intertidal region. Individuals of Ulva spp. were collected (2964 individuals) and 53 taxa were found. In Camburi the dominant species was Amphitalamus vallei (Barleeidae), while in Capuba and Manguinhos Eulithidium affine (Phasianellidae) predominated. The analyses indicated that Camburi is distinct from the other sites. The lesser wave impacts and the more complex structure of the algae in Camburi, due to the presence of iron ore, may explain this variation.

Keywords: Mollusca, phytal, ferruginous laterite, intertidal, southeast Brazil.

Comunidades de gasterópodos asociados con *Ulva* spp. en la zona litoral del sudeste de Brasil

RESUMEN. Las comunidades phytales están influenciadas espacial y temporalmente por parámetros físicos y biológicos cambiantes. Este estudio describe y compara los gasterópodos asociados con *Ulva* spp. entre sitios en la costa de Espírito Santo, con sustrato laterítico ferruginoso y con diferentes modos de exposición al oleaje. Camburi está caracterizado por la presencia de partículas de mineral de hierro. Las muestras fueron recolectadas bimensualmente. En cada sitio se realizaron cinco cuadrantes de muestreo al azar en la region intermareal. Se encontraron 2.964 individuos y 53 taxa. En Camburi, la espécie dominante fue *Amphitalamus valley*, y en Capuba y Manguinhos fue *Eulithidium affine*. El análisis realizado indicó que Camburi es distinto de los otros sitios. El menor impacto de las olas y la estructura más compleja de las algas en Camburi, debido a la presencia de mineral de hierro, puede explicar esta diferencia.

Palabras clave: Mollusca, phytal, laterita ferruginosa, intermareal, sudeste de Brasil.

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INTRODUCTION

The term phytal describes a coastal marine environment dominated by macrophytes and the organisms associated with them (Masunari, 1987). Animals are attracted by the nutritional value of algae (Norderhaug *et al.*, 2007), and algae also provide shelters that protect the animals from physical stressors (such as desiccation and the impact of waves) and against predators (Viejo, 1999). Thus, marine macroalgae provide a microhabitat that is favorable for an abundant and diverse fauna (Pascal *et al.,* 2009).

Substrates made of living organisms such as algae are characteristically dynamic and vary both temporally and spatially (Barreto, 1999). Variations in phytal community structure can be caused by biological parameters (such as predation, competition and recruitment) and physical parameters (such as light intensity, nutrient availability, hydrodynamics and structure of the habitat) (Chemello & Millazo, 2002). The relative importance of these factors is difficult to ascertain due to their high number and the interactions between them (Little & Kitching, 1996). It is well known that the fauna in phytal communities can be influenced by several parameters, including wave action (Hovel *et al.,* 2002), architecture of algae (Chemello & Millazo, 2002; Kelaher, 2003), chemical defense by algae (Duffy & Hay, 1994) and sediment (Kelaher & Castilla, 2005).

The phytal community is composed predominantly of crustaceans, polychaetes and molluscs (Santos & Correia, 2001; Tanaka & Leite, 2003; Ramos *et al*., 2010). Molluscs are widely distributed in marine assemblages and may be extremely abundant in subtidal and intertidal habitats. They are common, highly visible and ecologically and commercially important on a global scale both as food and as a nonfood resource (Rittschof & Mcclellan-Green, 2005). The sedentary or sessile habit makes molluscs a prime candidate for use in studies of bioaccumulation and/or biomagnification of pollutants (Rittschof & Mcclellan-Green, 2005). Thus, molluscs, mainly gastropods, provide an ideal invertebrate model system for aquatic (and especially marine) environmental monitoring and toxicology (Rittschof & Mcclellan-Green, 2005).

Gastropods comprise one of the most abundant taxonomic groups (Montouchet, 1979; Tararam & Wakabara, 1981; Viejo, 1999; Balducci *et al*., 2001; Christie *et al*., 2003; Leite & Turra, 2003). Gastropod taxonomy has been well studied, and most studies have been devoted to quantifying their patterns of distribution with a very detailed level of taxonomic resolution (Terlizzi *et al*., 2005). There is much interest in the spatial and temporal patterns of distribution and activity of intertidal gastropods due to strong direct and indirect effects of grazing (Forrest *et al*., 2001).

Descriptive studies of phytal communities have been conducted by several authors in Brazil, such as Montouchet (1979), Albuquerque & Guerón (1989), Tanaka & Leite (2003), Santos & Correia (2001), Leite & Turra (2003) and Rocha *et al.* (2006). However few studies have been done in Espírito Santo. Sá & Nalesso (2000) described and analyzed the fauna associated with four different types of phytal communities, and Ramos *et al.* (2010) characterized the macrofauna associated with articulated calcareous algae occurring over a hydrodynamic gradient.

Throughout the 1970's and 1990's in the metropolitan region of Vitoria, Espírito Santo State, Brazil, an iron-ore processing complex had discharged the water used during the pelleting process onto Camburi beach, which is located in the inner part of Espírito Santo Bay (Nassar & Yoneshigue-Valentin, 2006). As a result, part of the sediment is covered by a layer of iron ore, frequently suspended and deposited over the benthic organisms by wave action, storms and tidal movements (Nassar & Yoneshigue-Valentin, 2006).

Establishment of biological habitat is an important step toward maintaining biodiversity. There are strong functional links between the components of a phytal community, and the importance of these links can be assessed by examining the community, at an appropriate scale, considering the influence of environmental factors such as the presence of iron ore and wave exposure.

The objectives of the present study are to investigate the spatial and temporal patterns of gastropod communities associated with macroalgae of the genus *Ulva* and to assess the environmental factors affecting the structure of communities in these areas, such as the presence of iron ore and wave exposure.

MATERIAL AND METHODS

Study area

Samples were collected from the northern littoral zone of Espírito Santo State, which is characterized by quaternary coastal deposits delimited by the Barreiras Formations (Martin *et al.,* 1996), presenting consolidated formations of ferruginous laterite as substrate. The coastline of Espírito Santo is approximately 400 km long and part of the coast has been impacted by domestic sewage discharge, industrial and port developments, including Tubarão Port, Vitória Port and others. Some marinas along the coast are also potential sources of pollution.

The most frequent and intense winds are those from the northeast and southeast, with the former prevailing during the greater part of the year and the latter being associated with the cold fronts that occur regularly in the State´s coastal zone (Albino *et al.,* 2001).

Sampling was conducted on ferruginous laterite in the following sites: Camburi beach, located in the Espírito Santo bay and characterized by the presence of iron ore particles (Nassar *et al.,* 2003; Nassar & Yoneshigue-Valentin, 2006); Manguinhos beach, an intensely urbanized beach possibly impacted by domestic sewage, located 12 km north of Camburi beach; and Capuba beach in an uninhabited region, protected by a strip of sandbank and located 23 km north of Camburi beach (Fig. 1).

The average water surface temperature was 24º ± 1ºC and salinity was 37 ± 2 in Camburi, 25º ± 1ºC and 38 ± 2 in Manguinhos and 25º ± 2ºC and 38 ± 3 in Capuba (data obtained using an American Optical refracto-meter and a Lutron oxygen meter).

Those sites located in bays, which provide a barrier against winds and currents, were considered to be sheltered sites, whereas sites that directly receive prevailing winds and incident waves were considered to be exposed, as suggested by Széchy & Paula (2000). Based on these criteria, Manguinhos and Capuba were consideredad as exposed and Camburi as sheltered, since it is localized in a bay (Fig. 1).

Sampling methodology

Samples were collected during diurnal spring tides in February, April, June, August, October, and December of 2003.

At each sampling site, a horizontal stretch of 10 m was selected in the mid-intertidal zone, and 5 sampling quadrats (25x25 cm) were launched at random within this stretch. All individuals of *Ulva* spp. were collected from within each quadrat. *Ulva* spp. was present during all of the sampling periods. The samples were chilled at approximately 4ºC for at least two hours and then washed in running water in a 0.5 mm mesh sieve. All gastropods retained in this sieve were preserved in 70% alcohol and identified. The biovolume of macroalgae was measured by the method of displacement in a graduated cylinder (Montouchet, 1979).

The identification of *Ulva* at the genus level only was justified by the fact that the species *U. rigida*, *U. fasciata* and *U. lactuca*, all of which are found in Espírito Santo, can be morphologically very similar, making field identification of these species difficult.

Data analysis

Community parameters such as number of species, number of individuals, density (100 mL of *Ulva* spp.), Shannon-Weaver's diversity index ($\log_{10}$ base) and Pielou's evenness index were calculated for each site in each sampling period. The bifactorial analysis of variance (two-way ANOVA) and multiple comparisons of means (Tukey-HSD) *a posteriori* (Zar, 1996) were used to evaluate the differences in these community parameters between sampling sites and periods.

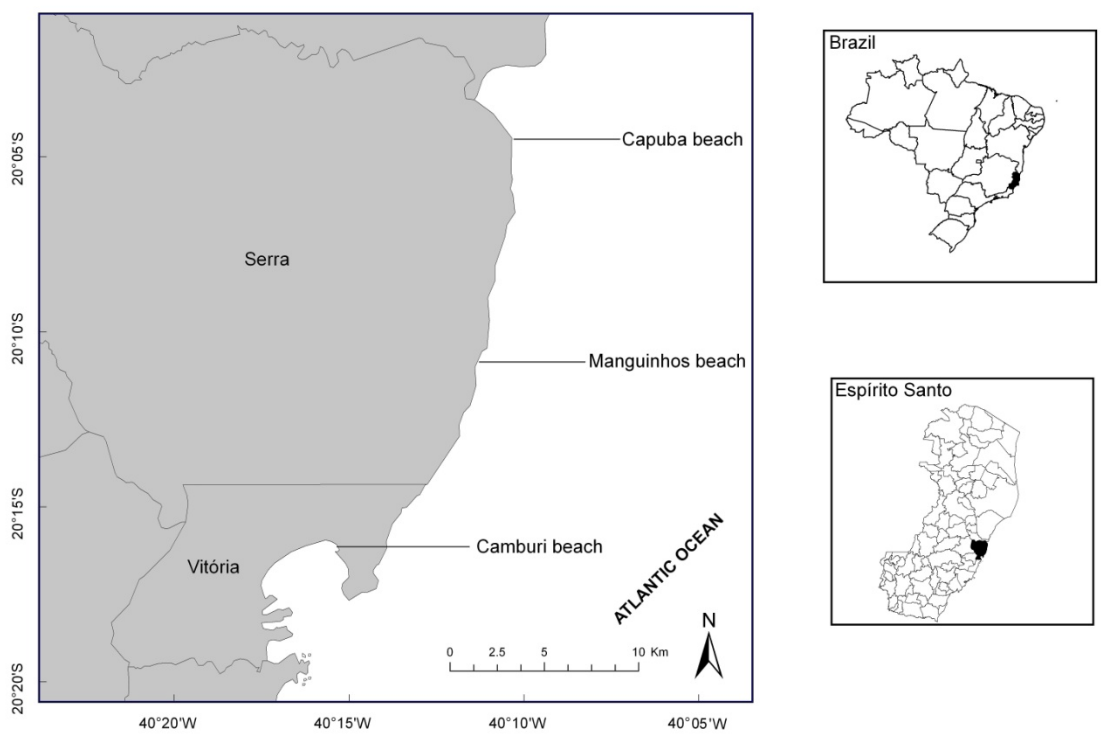

Figure 1. Map of the study area showing the locations of the three shores sampled in the littoral zone on the Espírito Santo coast, Brazil.

Cluster analysis of the average density of species at each site and period was performed using the Bray-Curtis method. The analysis of similarity (ANOSIM; two factors) permutation test was used to assess differences among sites and periods. The percentage of similarity procedure (SIMPER) was used to rank the contribution of each species to similarity or dissimilarity between the sites. A cumulative contribution of 80% was applied as in Boaventura *et al.* (2002). The matrix of similarity for these tests included the mean density of species present in at least two samples, and data were transformed by the fourth root. For all tests, α was set at 0.05.

RESULTS

A total of 53 taxa and 2964 specimens of gastropods were recorded in association with *Ulva* spp., of which 79% were collected in Camburi, 16% in Manguinhos and 5% in Capuba (Fig. 2).

Table 1 shows the average density (individuals per 100 mL of *Ulva* spp.) and taxonomic list of species found at each site. Some young individuals could not be identified to species, and of these, 15 taxa were identified to genus and one to family.

Among all samples, six species had relative abundances greater than 1% of all individuals. *Amphitalamus vallei* was the most abundant species, comprising 66% of all individuals sampled, followed by *Eulithidium affine* (18.2%), *Fissurella rosea* (5.2%), *Crepidula aculeata* (1.4%), *C. mercatoria* (1.1%) and *Fissurella* sp. (1.1%).

The species that had relative abundance values over 5% at each site are shown in Figure 3. The numerically dominant species were *A. vallei* in Camburi (relative abundance of 84%) and *E. affine* in Manguinhos and Capuba (relative abundance of 76% and 59% respectively).

The average values for number of species, number of individuals and density were highest in Camburi, the highest average diversity index was recorded in Manguinhos, and the highest evenness index was recorded in Capuba (Fig. 4). Significant differences across sites were found only in the number of species (P = 0.03) and the number of individuals (P = 0.04), and these resulted from the higher values recorded in Camburi as compared to Capuba.

Temporal analyses indicated no significant differences within sites across time ($P > 0.05$).

The cluster analysis indicated that more than 55% of the observed similarity resulted from a distinction between the samples collected in Camburi (excluding those collected at this site in April) and the samples collected at the other sites (Fig. 5). Samples from Camburi exhibited a predominance of *A. vallei*. Samples from the other sites were characterized by a greater abundance of *E. affine*. The analysis of similarity (ANOSIM) revealed significant differences between Camburi and the other sites (R = 0.40, P = 0.002) but did not indicate significant differences between periods (R = 0.073, P = 0.33).

The percentage of similarity procedure (SIMPER) revealed which species contributed most to similarity within groups in relation to the sites of sampling (Table 2). *Amphitalamus vallei* contributed most to the similarity among the samples from Camburi and the dissimilarity between these samples and those from the other sites. *Eulithidium affine* contributed most to the similarity between the samples from Manguinhos and Capuba.

DISCUSSION

Spatial variation was found across the sampling sites, but temporal variation was not found between the study periods. Differences in the composition of species and the number of individuals were observed in Camburi.

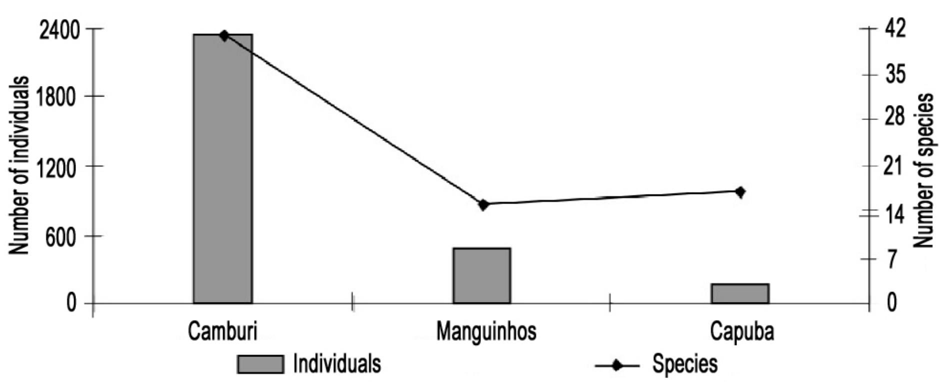

Figure 2. Number of individuals and number of species of gastropods associated with *Ulva* spp. at three sites of the Espirito Santo coast for all periods sampled (February-December 2003).

Table 1. Taxonomic list and average density (ind 100^{-1} mL ± standard error) of gastropods associated with *Ulva* spp. at three sites along the Espirito Santo coast (February-December 2003).

	Taxa	Average density (ind 100^{-1} mL) (standard error)		
		Camburi	Manguinhos	Capuba
Fissurellidae	*Diodora sayi* Dall, 1899	0.09 (0.09)	-	-
	Fissurella sp.	3.22 (1.87)	1.74 (0.91)	1.17 (0.75)
	Fissurella clenchi Farfante, 1943	0.76 (0.76)	-	-
	Fissurella rosea Gmelin,1791	38.78 (22.2)	12.05 (5.98)	31.67 (19.4)
	Lucapina philippiana Finlay, 1930	0.19 (0.19)	-	-
	Lucapinella sp.	0.34 (0.34)	-	-
	Lucapinella limatula Reeve, 1850	0.61 (0.51)	-	-
Acmaeidae	*Collisella* sp.	9.27 (3.53)	0.42 (0.42)	1.36 (1.36)
	Collisella subrugosa Orbigny, 1846	1.39 (0.88)	-	-
Trochidae	*Tegula viridula* Gmelin, 1791	-	0.85 (0.54)	0.68 (0.68)
	Calliostoma depictum Dall, 1927	0.76 (0.76)	-	-
	Calliostoma militaris Ihering, 1907	-	-	6.94 (6.94)
Phasianellidae	*Eulithidium affine* C.B. Adams, 1850	29.98 (11.13)	278.97 (244.33)	72.06 (24.21)
Rissoidea	*Alvania auberiana* Orbigny, 1842	0.09 (0.09)	-	-
Barleeidae	*Amphitalamus vallei* Aguayo & Jaume, 1947	757.25 (292.79)	0.93 (0.6)	24.04 (20.36)
Assimineidae	*Assiminea succinea* Pfeiffer, 1840	-	0.20 (0.20)	-
Caecidae	*Caecum ryssotitum* Folin, 1867	4.76 (4.76)	-	-
Vitrinellidae	*Vitrinella filifera* Pilbry & McGinty, 1946	1.57 (1.57)	-	-
	Solariorbis sp.	0.85 (0.74)	-	-
Cerithiidae	*Cerithium elburneum* Bruguière, 1792	0.31 (0.31)	-	-
	Bittium varium Pfeiffer, 1840	0.76 (0.76)	-	-
Calyptraeidae	*Crepidula* sp.	3.88 (3.77)	-	5.44 (5.44)
	Crepidula aculeata Gmelin, 1791	7.15 (3.31)	0.42 (0.42)	-
	Crepidula protea Orbigny, 1835	1.36 (0.89)	-	-
	Calyptraea sp.	0.09 (0.09)	-	-
Naticidae	*Polinices* sp.	-	-	0.68 (0.68)
Cerithiopsidae	*Cerithiopsis gemmulosa* CB Adams, 1847	0.76 (0.76)	-	-
Triphoridae	*Triphora* sp.	0.09 (0.09)	-	-
Columbellidae	*Columbella mercatoria* Linnaeus, 1758	-	15.92 (8.10)	8.52 (6.75)
	Anachis sp.	0.19 (0.19)	0.54 (0.54)	-
	Anachis catenata Sowerby, 1844	2.37 (2.26)	0.93 (0.93)	8.99 (6.84)
	Anachis fenneli Radwin, 1968	-	-	6.94 (6.94)
	Anachis sparsa Reeve, 1859	0.28 (0.28)	-	-
	Anachis obesa C.B. Adams, 1845	0.37 (0.37)	-	-
	Mitrella dichroa Sowerby, 1844	2.69 (1.87)	5.84 (3.42)	1.36 (1.36)
	Non identified	-	8.15 (7.87)	-
Marginellidae	*Prunum "avenaceae"* Deshayes, 1844	0.76 (0.76)	-	-
	Volvarina sp.	-	0.74 (0.53)	-
Cysticidae	*Gibberula* sp.	0.09 (0.09)	-	-
Turridae	*Carinodrillia braziliensis* E.A. Smith, 1915	-	-	0.25 (0.25)
Pyramidellidae	*Odostomia* sp.	-	-	0.68 (0.68)
	Odostomia seminuda C.B. Adams, 1837	-	1.16 (0.91)	-
	Chrysallida gemmulosa C.B. Adams, 1850	0.76 (0.76)	-	-
	Chrysallida jadisi Olsson & McGinty, 1958	0.34 (0.34)	-	0.68 (0.68)
	Cingulina babylonia C.B. Adams, 1845	2.27 (2.27)	-	-
	Miralda robertsoni Altena, 1975	0.76 (0.76)	-	-
	Turbonilla abrupta Bush, 1899	0.76 (0.76)	-	-

Continuation

	Taxa	Average density (ind 100^{-1} mL) (standard error)		
		Camburi	Manguinhos	Capuba
Cylichnidae	*Cylichna* sp.	0.63 (0.63)	-	-
Hamineidae	*Haminoea* sp.	8.09 (5.42)	-	-
Siphonariidae	*Siphonaria* sp.	0.31 (0.31)	-	-
	Siphonaria hispida E.A. Smith, 1890	-	-	0.67 (0.67)
	Siphonaria lessoni Blainville, 1824	1.02 (1.02)	-	-
	Williamia krebsis Morch, 1877	0.19 (0.19)	-	-

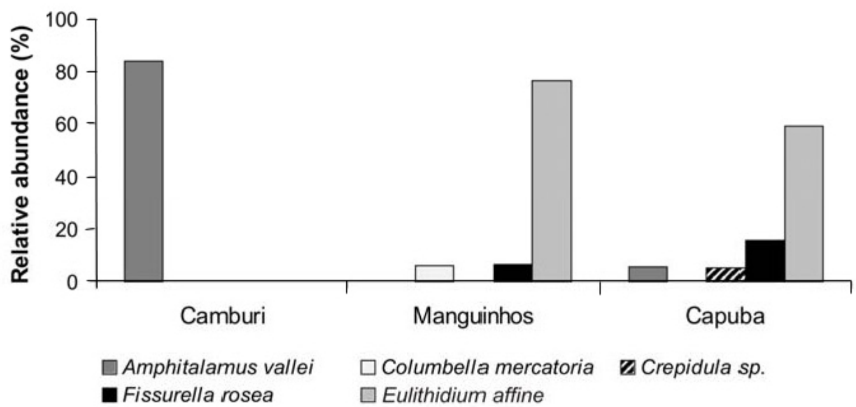

Figure 3. Relative abundances of the most common gastropod species associated with phytal *Ulva* spp. in each sampling area on the coast of Espirito Santo (February-December 2003).

In the present study, a total of 53 gastropod taxa associated with *Ulva* spp. were recorded, taking into account that some individuals could not be identified to species. For many groups of benthic organisms, it has been demonstrated that environmental effects can be detected even when analyses are based on taxonomic higher levels than species (Ferraro & Cole, 1995; Sanchez-Moyano *et al*., 2006).

Spatial variation in epifaunal assemblages among and within habitats may be shaped by temporal variation at different scales ranging from weeks to months (Cacabelos *et al.,* 2010). Epifauna frequently present strong temporal fluctuations due to a range of physical and biological factors (Leite & Turra, 2003; Rueda & Salas, 2008). In the present study, variations in species composition were found, but these differences were not statistically significant.

The accumulation of particulate iron ore on the fronds influences photosynthesis and consequently growth of seaweeds (Nassar *et al.,* 2002; Nassar & Yoneshigue-Valentin, 2006). This phenomenon likely contributed to the occurrence of small *Ulva* specimens in Camburi. At this site, the algae are distributed in dense layers forming mats of short fronds that allow sediment to accumulate among the fronds, and consequently increase in complexity. At the other study sites, in contrast, the fronds are isolated and greater in length. Complex surfaces create a variety of niches that serve as refuges for animals of corresponding size (Kostylev *et al.,* 2005). Thus, the communities of gastropods that inhabit more complex algae exhibit greater abundance and species richness (Chemello & Millazo, 2002).

Eulithidium affine has previously been found to be the dominant species of gastropod in phytal communities along the Brazilian coast (Montouchet, 1979; Dutra, 1988; Sá & Nalesso, 2000; Tanaka & Leite, 2003). The present results for Manguinhos and Capuba corroborate the above finding, confirming that *E. affine* is a representative gastropod species in phytal communities in this region.

However, in Camburi, *Amphitalamus vallei* was found to be the dominant species. Possibly the small size of *Ulva* spp. at this site enabled the occurrence of *A. vallei*, as individuals of this gastropod species are relatively small (approximately 1.14x0.78 mm, according to Rios, 1994). *Eulithidium affine* individuals are relatively large (approximately 7x5 mm, according to Rios, 1994) and require as substrate seaweed with larger fronds that provide more surface

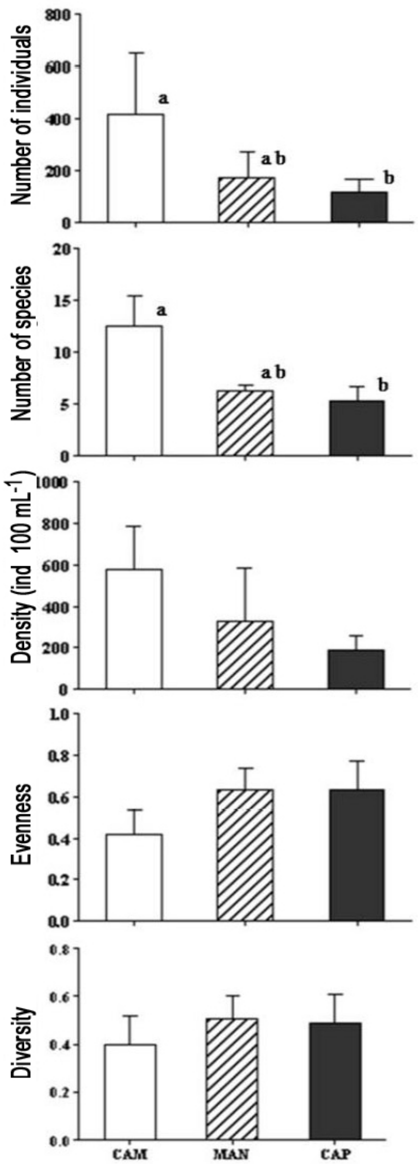

Figure 4. Mean values (+ standard error) of number of individuals, number of species, density, evenness and diversity indices of gastropods associated with phytal communities of *Ulva* spp. at the three sampling sites (February-December, 2003). Homogeneous groups are represented by shared letters next to error bars (ANOVA followed by Tukey test). Study areas: CAM: Camburi, MAN: Manguinhos, CAP: Capuba.

for adhesion (Dutra, 1988). Indeed, in order to assess the relationship between habitat complexity and its associated fauna with that habitat, it is necessary to consider body size (Kelaher, 2003).

The habitats provided by different types of macroalgae are affected differently by wave action (Tuya *et al*., 2008). Large algae with wider and more flattened fronds have a greater surface area exposed to water flow, and the animals that live on them may be more strongly affected by water motion than small algae and their fauna (Tuya *et al*., 2008). Thus, the phytal communities at Manguinhos and Capuba, where the algae have wider fronds, are possibly more strongly affected by wave action when compared with the algae and its associated fauna at Camburi. Moreover, the Camburi site suffers less wave action because it is in a sheltered area.

Anchana *et al*. (2003) observed a relationship between the accumulated sediment by algal turf and wave action, with greater accumulation of sediment in sheltered sites. The higher concentrations of sediment, accumulated between the fronds of algae, at Camburi may be related to lower wave impacts and may also have contributed to the greater number of gastropod species and individuals, especially individuals of *A. vallei*, at this site. According to Olabarria & Chapman (2001), *Amphitalamus incidata* experiences greater rates of survival and growth in habitats enriched with sediment because it can feed on diatoms and detritus in the sediment. Sediment accumulated by tufts of algae has a strong and consistent relationship with macrofauna (Kelaher *et al.,* 2001), providing habitat for many species of gastropods (Olabarria & Chapman, 2001). According to Schmidt & Scheibling (2007), increased sedimentation in stands of *Codium* might favor colonization by sediment-dwelling invertebrates such as small molluscs, crustaceans and polychaetes.

Despite the large quantity of iron ore at Camburi, this site had the highest number of gastropod species and individuals. Ramos *et al*. (2010) also found higher values of abundance, richness and diversity in this same area, in addition to a high level of organic matter present in the sediment retained below the algal mat. According to Nassar & Yoneshigue-Valentin (2006), even with the fronds covered with iron ore at Camburi beach, the algae survive, with variable abundances across species. Thus, it can be concluded that the algae and their associated communities have adapted to the presence of this mineral.

The lesser wave impacts and the more complex structure of the algae in Camburi may contribute to explain the variation in gastropod fauna among the sites in this study. However, other factors not considered in this study, such as reproduction, recruitment and competition, might also have influenced the gastropod species distributions here observed. Both spatial and temporal patterns in communities are generally affected by physical and biological processes influencing recruitment, growth, reproduction and mortality of organisms (Benedetti-Cecchi *et al*., 2000).

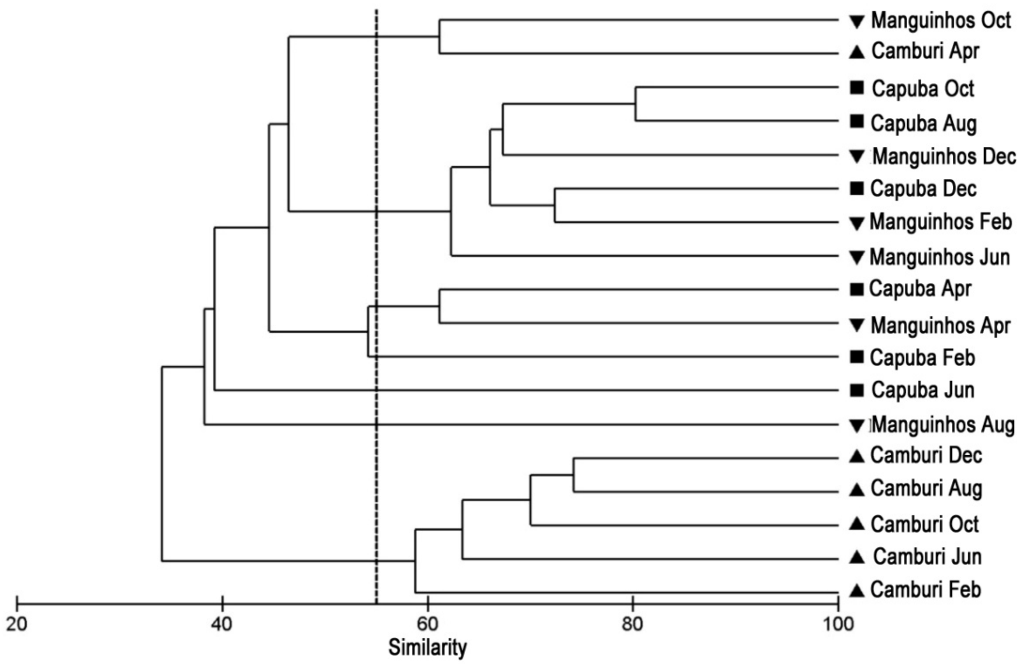

Figure 5. Cluster analysis of gastropods associated with *Ulva* spp. based on the values of average density of species at each site (Camburi, Manguinhos and Capuba) for each period. Data was transformed by the fourth root and the Bray-Curtis coefficient was used for the analysis.

Table 2. SIMPER analysis with the percentage and the rank order of gastropod species' contributions to similarity within sample sites and dissimilarity between sites (Camburi, Manguinhos and Capuba), based on the values of average density, transformed by the fourth root, using the Bray-Curtis coefficient.

Species	Percentage (order) of similarity within groups			Percentage (order) of dissimilarity between groups	
	Camburi	Manguinhos	Capuba	Camburi x Manguinhos	Camburi x Capuba
Amphitalamus vallei	38.77 (1)			22.62 (1)	24.34 (1)
Anachis catenata				2.68 (11)	4.75 (10)
Collisella sp.	9.16 (4)			6.70 (3)	7.96 (3)
Columbella mercatoria		18.64 (3)		8.60 (2)	5.53 (7)
Crepidula aculeata				5.61 (7)	6.82 (5)
Fissurella rosea	12.57 (3)	18.91 (2)	20.64 (2)	6.23 (6)	7.97 (2)
Fissurella sp.				4.39 (9)	5.15 (8)
Giberulla sp.				3.34 (10)	
Haminoea sp.	7.54 (5)			6.36 (4)	7.45 (4)
Mitrela dichroa		9.77 (4)		5.39 (8)	5.12 (9)
Tegula viridula				2.51 (12)	
Eulithidium affine	18.63 (2)	40.87 (1)	60.64 (1)	6.26 (5)	5.87 (6)

Conservation of species is often based on conservation of their habitats or microhabitats. It is therefore important to have a mechanistic understanding of how associations between species and habitats are maintained (Olabarria *et al*., 2002). Coherent predicttions about potential changes o populations in response to disturbances require understanding of interactive variances (Olabarria & Chapman, 2001).

CONCLUSION

Possible causes of differences in the composition of species observed in the community of gastropods of Camburi, in comparison with other areas, are lesser wave impacts in Camburi, which is located in a bay, and the presence of iron ore in this area. Therefore, the present study expands the knowledge of the distribution of gastropods in intertidal habitats and increases the understanding of both the ecological patterns and the processes that influence phytal communities and the changes in such assemblages that may occur in response to human disturbances.

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REFERENCES

Albino, J., D.S. Paiva & G.M. Machado. 2001. Geomorfologia, tipologia, vulnerabilidade erosiva e ocupação urbana das praias do litoral do Espírito Santo, Geografares, 2: 63-69.

Albuquerque, E.F. & C.O.C. Guerón. 1989. Variação sazonal da fauna vágil de *Sargassum stenophyllum* (Martens) em duas estações com diferentes graus de exposicão às ondas, em Ibicuí, Baía de Sepetiba, estado do Rio de Janeiro, Brasil. Mem. Inst. Oswaldo Cruz, 84: 9-17.

Anchana, P., R.H. Marrs & T.A. Norton. 2003. Spatial and temporal variations in sediment accumulation in an algal turf and their impact on associated fauna. Mar. Biol., 142(2): 381-390.

Balducci, C., A. Sfriso & B. Pavoni. 2001. Macrofauna impact on *Ulva rigida* C. Ag. Production and relationship with environmental variables in the lagoon of Venice. Mar. Environ. Res., 52(1): 27-49.

Barreto, C.C. 1999. Heterogeneidade espacial do habitat e diversidade específica: implicações ecológicas e métodos de mensuração. Oecol. Bras., 7: 121-153.

Benedetti-Cecchi, L., S. Acunto, F. Bulleri & F. Cinelli. 2000. Population ecology of the barnacle *Chthamalus stellatus* in the northwest Mediterranean. Mar. Ecol. Prog. Ser., 198: 157-170.

Boaventura, D., P. Ré, L.C. da Fonseca & S.J. Hawkins. 2002. Intertidal rocky shore communities of the continental Portuguese coast: analysis of distribution patterns. Mar Ecol., 23: 69-90.

Cacabelos, E., C. Olabarria, M. Incera & J.S. Troncoso. 2010. Effects of habitat structure and tidal height on epifaunal assemblages associated with macroalgae. References and further reading may be available for this article. To view references and further reading you must purchase this article). Estuar. Coast. Shelf. Sci., 89: 43-52.

Chemello, R. & M. Millazo. 2002. Effect of algal architecture on associated fauna: some evidence from phytal molluscs. Mar. Biol., 140: 981-990.

Christie, H., N.M. Jorgensen, K.M. Norderhaug & E. Waage-Nielsen. 2003. Species distribution and habitat exploitation of fauna associated with kelp (*Laminaria hyperborea*) along the Norwegian Coast. J. Mar. Biol. Assoc. UK., 83(4): 687-699.

Duffy, J.E. & M.E. Hay. 1994. Herbivore resistance to seaweed chemical defense: the roles of mobility and predation risk. Ecology, 75(5): 1304-1319.

Dutra, R.R.C. 1988. A fauna vágil do fital *Pterocladia capillacea* (Rhodophyta, Gelidiaceae) da Ilha do Mel, Paraná, Brasil. Rev. Bras. Biol., 48(3): 589-605.

Ferraro, S.P. & F.A. Cole. 1995. Taxonomic level sufficient for assessing pollution impacts on the southern California bight macrobenthos - revisited. Environ. Toxicol. Chem., 14(6): 1031-1040.

Forrest, R.E., M.G. Chapman & A.J. Underwood. 2001. Quantification of radular marks as a method for estimating grazing of intertidal gastropods on rocky shores. J. Exp. Mar. Biol. Ecol., 258: 155-171.

Hovel, K.A., M.S. Fonseca, D.L. Myer, W.J. Kenworthy & P.E. Whitfield. 2002. Effects of seagrass landscape structure, structural complexity and hydrodynamic regime on macrofaunal densities in North Carolina seagrass beds. Mar. Ecol. Prog. Ser., 243: 11-24.

Kelaher, B.P. 2003. Changes in habitat complexity negatively affect diverse gastropod assemblages in coralline algal turf. Oecologia, 135: 431-441.

Kelaher B.P. & J.C. Castilla. 2005. Habitat characteristics influence macrofaunal communities in coralline turf more than mesoscale coastal upwelling on the coast of Northern Chile. Estuar. Coast. Shelf Sci., 63: 155-165.

Kelaher, B.P., M.G. Chapman & A.J. Underwood. 2001. Spatial patterns of diverse macrofaunal assemblages in coralline turf and their associations with environmental variables. J. Mar. Biol. Assoc. UK., 81: 917-930.

Kostylev, V.E., J. Erlandsson, M.Y. Ming & G.A. Williams. 2005. The relative importance of habitat complexity and surface area in assessing biodiversity: fractal application on rocky shores. Ecol. Complex., 2: 272-286.

Leite, F.P.P. & A. Turra. 2003. Temporal variation in *Sargassum* biomass, *Hypnea epiphytism* and associated fauna. Braz. Arch. Biol. Technol., 46(4): 665-671.

Little, C. & J.A. Kitching. 1996. The biology of rocky shores. Oxford University Press, New York, 240 pp.

Martin, L., K. Suguio, J.M. Flexor & J.D. Arcanjo. 1996. Coastal quaternary formations of the southern part of the State of Espírito Santo, Brazil. Anais Acad. Bras. Cienc., 68(3): 389-404.

Masunari, S. 1987. Estudo das comunidades fitais. In: S. Watanabe (ed.). Simpósio de ecossistemas da costa Sul e Sudeste Brasileira. Publicações ACIESP, São Paulo, 1(54): 195-253.

Montouchet, P.G.C. 1979. Sur la communauté des animaux vagiles associés à *Sargassum cymosum* C. Agardh, à Ubatuba, Etat de São Paulo, Brésil. Stud. Neotrop. Fauna Environ., 14: 33-64.

Nassar, C.A.G. & Y. Yoneshigue-Valentin. 2006. Iron ore particles on four seaweed species from Camburi Beach (Espírito Santo state, Brazil). Braz. J. Oceanogr., 54(2-3): 155-159.

Nassar, C.A.G., H.P. Lavrado & Y. Yoneshigue-Valentin. 2002. Effects of iron-ore particles on propagule release, growth and photosynthetic performance of *Sargassum vulgare* C. Agardh (Phaeophyta, Fucales). Rev. Bras. Bot., 25(4): 459-468.

Nassar, C.A.G., L.T. Salgado, Y. Yoneshigue-Valentin & G.M. Amado-Filho. 2003. The effect of iron-ore particles on the metal content of the brown alga *Padina gymnospora* (Espírito Santo Bay, Brazil). Environ. Pollut., 123(2): 301-305.

Norderhaug, K.M., H. Christie & S. Fredriksen. 2007. Is habitat size an important factor for faunal abundances on kelp (*Laminaria hyperborea*)? J. Sea Res., 58(2): 120-124.

Olabarria, C. & M.G. Chapman. 2001. Habitat-associated variability in survival and growth of three species of microgastropods. J. Mar. Biol. Assoc. UK., 81: 961-966.

Olabarria, C., A.J. Underwood & M.G. Chapman. 2002. Appropriate experimental design to evaluate preferences for microhabitat: an example of preferences by species of microgastropods. Oecologia, 132: 132-159.

Ramos, R.J., M.P. Travassos & G.R. Leite. 2010. Characterization of macrofauna associated with articulated calcareous algae (Corallinaceae, Rhodophyta) occurring in a hydrodynamic gradient on the Espírito Santo state coast, Brazil. Braz. J. Oceanogr., 58(4): 275-285.

Pascal, R., E. Carole & L. Cédric. 2009. Trophic ecology of the rocky shore community associated with the *Ascophyllum nodosum* zone (Roscoff, France): A $\delta^{13}C$ vs $\delta^{15}N$ investigation. Estuar. Coast. Shelf Sci., 81: 143-148.

Rios, E. 1994. Seashells of Brazil. Fundação Universidade do Rio Grande, Rio Grande, 492 pp.

Rittschof, D. & P. McClellan-Green. 2005. Molluscs as multidisciplinary models in environment toxicology. Mar. Poll. Bull., 5: 369-373.

Rocha, C.M.C., V. Venekey, T.N.C. Bezerra & J.R.B. Souza. 2006. Phytal marine nematode assemblages and their relation with the macrophytes structural complexity in a Brazilian tropical rocky beach. Hydrobiologia, 553: 219-230.

Rueda, J.L. & C. Salas. 2008. Molluscs associated with a subtidal *Zostera marina* L. bed in southern Spain: linking seasonal changes of fauna and environmental variables. Estuar. Coast. Shelf Sci., 79: 157-167.

Sá, F.S. & R.C. Nalesso. 2000. Fauna associada aos bancos de algas na área de influência da Companhia Siderúrgica de Tubarão-CST, município da Serra, ES. In: S. Watanabe (ed.). Simpósio de ecossistemas da Costa Sul e Sudeste Brasileira. Publicações ACIESP, São Paulo, 2(109): 118-125.

Sanchez-Moyano, J.E., D.A. Fa, F.J. Estacio & J.C. Garcia-Gomez. 2006. Monitoring of marine benthic communities and taxonomic resolution: an approach through diverse habitats and substrates along the Southern Iberian coastline. Helgol. Mar. Res., 60: 243-255.

Santos, C.G. & M.D. Correia. 2001. Composição quali-quantitativa do fital *Halimeda opuntia* (Linnaeus) (Chlorophyta) do recife de coral da Pajuçara, Maceió, Alagoas, Brasil. Rev. Bras. Zoociências, 3(1): 93-104.

Schmidt, A.L. & R.E. Scheibling. 2007. Effects of native and invasive macroalgal canopies on composition and abundance of mobile benthic macrofauna and turf-forming algae. J. Exp. Mar. Biol. Ecol., 341: 110-130.

Széchy, M.T.M. & E.J. Paula. 2000. Padrões estruturais quantitativos de bancos de *Sargassum* (Phaeophyta, Fucales) do litoral dos Estados do Rio de Janeiro e São Paulo, Brasil. Rev. Bras. Bot., 23(2): 121-132.

Tanaka, M.O. & F.P.P. Leite. 2003. Spatial scaling in the distribution of macrofauna associated with *Sargassum stenophyllum* (Mertens) Martius: analyses of faunal groups, gammarid life habits, and assemblage structure. J. Exp. Mar. Biol. Ecol., 293: 1-22.

Tararam, A.S. & Y. Wakabara. 1981. The mobile fauna - especially Gammaridea- of *Sargassum cymosum*. Mar. Ecol. Prog. Ser., 5: 157-163.

Terlizzi, A., D. Scuderi, S. Fraschetti & M.J. Anderson. 2005. Quantifying effects of pollution on biodiversity: a case study of highly diverse molluscan assemblages in the Mediterranean. Mar. Biol., 148: 293-305.

Tuya, F., T. Wernberg & M.S. Thomsen. 2008. The spatial arrangement of reefs alters the ecological patterns of fauna between interspersed algal habitats. Estuar. Coast. Shelf Sci., 78: 774-782.

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Viejo, R.M. 1999. Mobile epifauna inhabiting the invasive *Sargassum muticum* and two local seaweeds in northern Spain. Aquat. Bot., 64: 131-149.

Zar, J.H. 1996. Biostatistical Analysis. Prentice Hall, New Jersey, 662 pp.