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Gastropods associated with the green seaweed *Caulerpa racemosa*, on two beaches of the Northern coast of the State of São Paulo, Brazil

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Abstract

Seasonal variations in the composition, density and number of species of gastropod molluscs associated with fronds and sediment retained on rhizoids of the green seaweed *Caulerpa racemosa* were studied on two beaches on the North coast of the State of São Paulo. The two beaches have different hydrodynamics and degrees of human impact. Samples were collected at Praia das Cigarras (moderately agitated, with strong human influence) in Sebastião, and at Praia da Fortaleza (sheltered and little human influence) in Ubatuba, during the four seasons of the year (winter, spring, summer and autumn). Three samples were obtained from each beach for every season of the year. Gastropod molluscs were identified, when possible, to species level and counted. A total of 50 species were identified, and their number and composition varied according to the season of the year and the beach. Few species were dominant in both sites and all four seasons. Most of the species occurred in low number and densities, and were not always present in all seasons of the year. The physical and biological characteristics of each beach, regarding macroalgae morphology, sediment retained by rhizoids and hydrodynamics, may be the variables controlling composition, number of species, dominance and density of gastropods.

Key words: sediment, species composition, seasonal variation, spatial distribution, phytal.

Resumo

A variação sazonal da composição, densidade e número de espécies de moluscos gastrópodes associados às frondes e sedimento retido pelos rizóides da alga verde *Caulerpa racemosa*, foi estudada em duas praias do litoral norte do Estado de São Paulo com diferente hidrodinamismo e influência antrópica. As coletas foram realizadas na Praia das Cigarras (moderadamente agitada e com forte influência antrópica) em São Sebastião e Praia da Fortaleza (abrigada e baixa influência antrópica) em Ubatuba nas quatro estações do ano (inverno, primavera, verão e outono). Foram obtidas três amostras em cada praia por estação do ano. A fauna de moluscos gastrópodes foi identificada, quando possível, até o nível específico. Foi identificado um total de 50 espécies cujo número e composição variaram entre estações do ano e praia. Poucas espécies foram dominantes nos dois locais e quatro estações do ano. Observa-se que a maior parte das espécies ocorreu em baixas densidades e nem sempre em todas as estações do ano. As características físicas e biológicas de cada praia, relacionadas à morfologia da alga, sedimento retido pelos rizóides e hidrodinamismo, podem ser os fatores que controlam a composição, número de espécies, dominância e densidade dos gastrópodes.

Palavras chave: sedimento, composição de espécies, variação sazonal, distribuição espacial, fital.

Introduction

Seaweed on rocky shores provides shelter and food for the diverse assemblages of invertebrates inhabiting their fronds, in addition to providing protection against desiccation and wave impact (Duffy & Hay 2000). Macroalgae can attenuate wave action, providing better temperature and salinity conditions and creating a large number of ecological niches for both motile and sessile species. The presence and distribution of the animals depend on the structure and morphology of the seaweed (Jacobi & Langevin 1996) and on the habitat conditions that they provide.

Green seaweed of the genus *Caulerpa*, which is common in the sublittoral zone of the coast of the state of São Paulo, presents different frond morphologies

and types, and uses its rhizoids to attach to the rocks (Joly, 1967). Rhizoids retain sediment which, in turn, can provide shelter and food for a large numbers of species and individuals. The sediment retained may be organically enriched and undergo seasonal grain size changes, which favor the establishment of species with different living habits (Sánches-Moyano et al. 2000).

Molluscs associated with seaweed comprise a very diverse and abundant assemblage. Previous studies conducted in Brazil have examined species composition of molluscs including gastropods, associated with the brown macroalgae *Sargassum*, from the North (Montouchet 1979) and South (Jacobucci et al. 2006) coasts of the State of São Paulo, as well as, from several beaches with varying degrees of hydrodynamics in São Paulo and Rio de Janeiro (Széchy & Paula 2000). Masunari (1982), Mello & Perrier (1992) and Oliveira et al. (2003) studied gastropod species associated with calcareous and non-calcareous red and green seaweed. To date, there's no information available on gastropod fauna associated with *Caulerpa racemosa*. The only data available are on the composition of the ophiuroid fauna associated with this green macroalgae (Boffi 1972; Carvalho et al. 2000).

The goal of this study was to evaluate seasonal and spatial variation in the composition and species density of the gastropod assemblage associated with the green seaweed *Caulerpa racemosa*. This study also aimed to contribute to the knowledge of fauna associated with this species of seaweed.

Material and Methods

Samples were collected at the sublittoral edge of two beaches with different degrees of wave exposure: Praia das Cigarras and Praia da Fortaleza. Praia das Cigarras, is moderately exposed, and located at the North end of the Canal of São Sebastião (23º43'52"S and 45º23'56"W), in the municipality of São Sebastião, on the Northern coast of the State of São Paulo. Along the beach there are summer holiday houses that attract a large number of tourists, especially during vacation seasons, and boat fishing activity, which indicate substantial human influence. The beach is bordered to the north and south by rocky shores. Samples were collected on the northern rocky shore, which presents lower hydrodynamism than the southern rocky shore.

The most sheltered beach is Praia da Fortaleza, located on Fortaleza inlet, about 27 km from the center of the municipality of Ubatuba (23º32'06"S; 45º09'28"W). This beach shows less anthropogenic influence than Praia das Cigarras. It has rocky shores that extend southwest-northeast, and two sides with different degrees of wave exposure (Jacobucci & Leite 2002). Samples were collected in the north sector, where hydrodynamic forces are low.

Samples were collected during the winter and spring of 2004 and the summer and autumn of 2005. In each of these seasons and locations, three randomly selected samples of submerged *Caulerpa racemosa* were obtained. Each sample is defined as all the green algae and sediment retained by their rhizoids, removed from one rocky fragment. Twelve samples were collected from each beach, totaling 24 samples in one year of fieldwork. Only rocks submerged of similar size (on average 900 cm²) were selected for removal of the *Caulerpa racemosa*. All the seaweed and sediment retained by the rhizoids were scraped off these boulders with a spatula. This material was placed in fabric bags of pore size 200 µm, to prevent loss of fauna. We could not collect the fronds separately from the sediment, for that reason and for the purpose of this study only the total number of gastropods per sample, i.e. the number of individuals found both in sediment and the fronds, were considered. The wet weight of the sample was obtained by weighing all the scraped material, that is, the seaweed and sediment contained in the fabric bag, after 2 hours, which is the time required to drain excess water.

The weight of the fabric bags was omitted in density calculations. After weighing, samples were preserved in 70% ethanol, and each sample was observed with a stereomicroscope for gastropod separation, identification (Rios, 2009) and counting.

Dominance (D) (relative abundance of a particular species within the season samples and total samples, expressed as a percentage) was calculated for each season and for the total collected. A frequency (F) was calculated as the percentage of total samples in which a particular species is present throughout the year at each beach. Species were classified as presenting high dominance (HD), when they presented dominance above of 25%, medium dominance (MD), between 24 to 1%, and low dominance (LD) when presenting less than 1%. The frequency of each species throughout the sample year varied from 100%, when it was present in all seasons of the year, to 25%, when it was present in only one season.

The mean density of the species of gastropods, per beach and season of the year, was obtained from the relationship between the total weight of the samples and the number of individuals in the samples.

The material studied was deposited in the mollusc collection of the Zoology Museum of the State University of Campinas (Unicamp), São Paulo, Brazil (ZUEC-GAS 267-471).

From the 4401 individuals collected, 4001 were

Results

obtained at Praia da Fortaleza. The highest number per season (n=2047) was obtained in autumn 2005. A total of 50 species were identified, and their number and composition varied between seasons and beaches (Tables I and II). Most of the species were collected from Praia da Fortaleza, 46 species, ranging from 18 in winter to 29 in autumn (Tables I and II). A total of 17 species were found at Praia das Cigarras. The number of species ranged from 5 in summer to 13 in autumn (Tables III and IV). A variable number of species occurred only in one beach. Praia da Fortaleza presented higher number of exclusive species. However, *Columbella mercatoria, Crepidula aculeata, Leucozonia nassa* and *Trachypollia nodulosa* were only found at Praia das Cigarras.

Only 4 species were present in all seasons of the year (100%) at Praia da Fortaleza, 12 species occurred during three seasons of the year (75%) , 10 species in 50% of the seasons and 19 species in only one season (25%) (Table II). At Praia das Cigarras, there was also a small number of species (three) present throughout the year (100% presence), four in 75%, seven in 50% and three in 25% (Table III). A species found only in one season's sample, may indicate accidental presence.

The assemblages of gastropods are dominated by a high number of Prosobranchia (92%; 46 species). Only 4 species of Opisthobranchia (8%) were identified (Tables I and III).

Samples contained several common phytal species associated with *Caulerpa racemosa*, such as species from the genus *Anachis, Bittium, Eulithium* and *Mitrella*, and the highest number of species of *Anachis* was found at Praia da Fortaleza (Tables I and III). Also, common rocky shore species were found, such as *Littorina ziczac, Leucozonia nassa, Trachypollia nodulosa, Fissurella rosea, Thais haemastoma* and *Tegula viridula* (Tables I and III).

At Praia da Fortaleza species dominance varied according to the season (Table I). In winter, only *Bittium varium* (53.2%) presented HD. Five species presented MD, two of which are not typical of phytal, and 12 species presented LD. In spring, only *Caecum* sp1 presented HD, with 81.70%. Five species

Table I. Praia de Fortaleza: Total number of individuals of each species of gastropods (N), dominance (D) and frequency (F) by season of the year (2004-2005).

Species	Winter		Spring		Summer		Autumn		Total		
	N	D	N	D	N	D	N	D	N	D	F
Acteocina candei (d'Orbigny, 1841)					1	0.20			1	0.02	25
Alvania auberiana (d'Orbigny, 1842)			2	0.17	1	0.20	1	0.05	3	0.07	75
Amphithalamus glaber Simone, 1996	10	4.00	15	1.25	317	62.52			342	8.55	75
Anachis fenneli (Radwin, 1968)	3	1.20	18	1.50	5	0.99	21	1.03	29	0.72	100
Anachis obesa (C.B. Adams, 1845)	4	16.00					14	0.68	18	0.45	50
Anachis sertulariarum (d'Orbigny, 1839)					2	0.39			2	0.05	25
Anachis sparsa (Reeve, 1859)	6	24.00	1	0.08			3	0.15	10	0.24	75
Ascobulla ulla (Marcus & Marcus, 1970)					6	1.18			6	0.15	25
Astraea latispina (Philippi, 1844)			1	0.08			2	0.10	3	0.07	50
Bittium varium (Pfeiffer, 1840)	133	53.20	70	5.85	42	8.28	746	36.44	991	24.80	100
Boonea jadisi (Olsson & McGinty, 1958)			2	0.17	5	0.20			7	0.17	50
Bulla striata Bruguière, 1792							1	0.05	1	0.02	25
Caecum sp.1			978	81.70	41	8.09	599	29.26	1618	40.44	75
Caecum sp.2			4	0.33	7	1.38	296	14.46	307	7.67	75
Caecum sp.3							25	1.22	25	0.62	25
Cerithiopsis emersonii (C.B. Adams, 1839)			1	0.08			3	0.15	4	0.10	50
Cerithium atratum (Born, 1778)	44	17.60	17	1.42			73	3.57	134	3.35	75
Cocculina sp.							1	0.05	1	0.02	25
Collisella subrugosa (d'Orbigny, 1842)	1	0.40	8	0.67					9	0.22	50

Cryoturris adamsii (E.A. Smith, 1884)					1	0.20	5	0.24	6	0.15	50
Ctena pectinella (C.B. Adams, 1852)							3	0.15	3	0.07	25
Diodora jaumei Aguayo & Rehder, 1936							1	0.05	1	0.02	25
Eulithidium affine (C.B. Adams, 1850)	29	11.60	45	3.92	47	9.26	146	5.25	267	6.67	100
Finella dubia (d'Orbigny, 1840)							2	0.10	2	0.05	25
Fissurella rosea (Gmelin, 1791)			6	0.50	5	0.20	58	0.83	69	1.72	75
Haminoea antillarum (d'Orbigny, 1841)					1	0.20			1	0.02	25
Littorina ziczac (d'Orbigny, 1840)	4	1.60	2	0.17	3	0.59			9	0.22	75
Littoridiina australis (d'Orbigny, 1835)			2	0.17	6	1.18	7	0.34	15	0.37	75
Mitrella dichroa Sowerby 1844	3	1.20	7	0.58			3	0.15	13	0.32	75
Odostomia laevigata (d'Orbigny, 1841)	1	0.40							1	0.02	25
Olivella sp.	1	0.40							1	0.02	25
Parviturboides interruptus (C.B. Adams, 1850)					2	0.39			2	0.05	25
Puncturella sp.					1	0.20			1	0.02	25
Pyramidellidae (young)					3	0.59			3	0.07	25
Pyrgocythara albovittata (C.B. Adams, 1845)	1	0.40	6	0.50	2	0.39	5	0.24	14	0.35	100
Schwartziella bryerea (Montagu, 1803)	1	0.40					2	0.01	3	0.07	50
Schwartziella catesbyana (d'Orbigny, 1842)	1	0.40	1	0.08			1	0.05	3	0.07	75
Scissurella sp.					7	1.38			7	0.17	25
Siphonaria hispida Hubendick, 1946			2	0.17					2	0.05	25
Tegula sp.	5	2.00	6	0.50	1	0.20			12	0.30	75
Tegula viridula (Gmelin, 1791)	2	0.80					22	1.07	24	0.60	50
Tenaturris fulgens (E.A. Smith, 1888)							6		6	0.15	25
Thais haemastoma (Linnaeus, 1767)	2	0.80							2	0.05	50
Turbonilla nivea (Stimpson, 1815)			3	0.251					3	0.07	50
Turbonilla sp.					1	0.20	1	0.05	2	0.05	50
Vitrinella filifera Pilsbry & McGinty, 1946							1	0.05	1	0.02	25
Total	250		1197		507		2047		4001		

presented MD, among which there were *B. varium* and *Amphithalamus glaber*, whereas, the highest number of species (16) presented LW. In summer, only *A. glaber* presented HD, with 62.52%. Seven species presented MD, among which there were *B. varium, Caecum* sp1 and *Eulithidium affine*, and 15 presented LD. In Autumn *B. varium* and *Caecum* sp1 presented HD, six species, among which there were *E. affine* and *Caecum* sp2, presented MD and 19 species presented LD. In spite of the high number of species identified, and taking all the seasons of the year into account, only two species, *Caecum* sp1 and *B. varium*, in this order, can be regarded as dominant. Five species presented MD and 39 presented LD.

At Praia das Cigarras (Table III), in winter, only *Caecum* sp1 presented HD and all other nine species presented MD. In spring, *Bittium varium* presented HD, with 80.30%, three species presented MD and two species presented LD. In summer, *Eulithium affine* was the only species to present HD (61.11%), whereas the other species presented MD. In autumn, *Anachis sparsa* and *B. varium* presented HD, with 30.30 and 28.03, respectively. Nine species presented MD and only two species presented LD. Overall, taking all seasons of the year into account, observations shows that only *B. varium* presented HD, 11 species presented MD and five species presented LD. Few species presented HD on both beaches, and for the majority of months they were the same. Only *A. glaber* drew our attention at Fortaleza due to having been collected only on that beach (Table III).

Few species showed high density of individuals in all seasons. The majority of the species were present in very low densities and, many times, in only one season of the year (Tables II and IV).

Bittium varium and *Eulithidium affine* were among

the most common species and present in higher density, occurring throughout all seasons at Praia das Cigarras, along with *Mitrella dichroa*, which was also present but with lower density. Species of *Caecum* also occurred in high density on both beaches, but not in all seasons (Tables II and IV). At Praia da Fortaleza, the highest density of gastropods was observed in autumn, especially *B. varium*, *E. affine* and two species of *Caecum*. The species of *Caecum* occurred in high density also in spring. *Amphithalamus glaber* occurred only at Praia da Fortaleza presenting high densities in autumn (Table II). The species of gastropods from Praia das Cigarras presented large variation in density over the seasons, but, generally, their densities were lower than the observed at Praia da Fortaleza. The most conspicuous species in this beach were *Anachis* spp, *B. varium*, *Caecum* spp and *E. affine* (Tables II and IV).

Table II. Praia de Fortaleza: Mean density and standard deviation of the individuals of each species (± SD No ind/100g) by season of the year (2004-2005)

Species	Winter	Spring	Summer	Autumn
Acteocina candei (d'Orbigny, 1841)			0.034 ± 0.059	
Alvania auberiana (d'Orbigny, 1842)		0.238 ± 0.21	0.034 ± 0.059	0.038±0.066
Amphithalamus glaber Simone, 1996	2.01 ± 3.49	1.532 ± 1.34	11.649±16.296	
Anachis fenneli (Radwin, 1968)	0.40 ± 0.35	2.019 ± 1.37	0.286±0.333	0.804±1.393
Anachis obesa (C.B. Adams, 1845)	0.50 ± 0.46			0.536±0.929
Anachis sertulariarum (d'Orbigny, 1839)			0.536±0.929	
Anachis sparsa (Reeve, 1859)	0.18 ± 0.31	0.119 ± 0.206		0.114±0.199
Ascobulla ulla (Marcus & Marcus, 1970)			0.205±0.356	
Astraea latispina (Philippi, 1844)		0.119 ± 0.206		0.076±0.132
Bittium varium (Pfeiffer, 1840)	10.54 ± 12.12	8.27 ± 13.25	1.980±2.330	44.765±6.286
Boonea jadisi (Olsson & McGinty, 1958)		0.238 ± 0.206	0.182±0.209	
Bulla striata Bruguière, 1792				0.197±0.341
Caecum sp.1		101.37 ± 91.65	2.921 ± 5.06	22.978±39.626
Caecum sp.2		0.476 ± 0.824	0.508 ± 0.879	19.733±34.179
Caecum sp.3				0.957±1.659
Cerithiopsis emersonii (C.B. Adams, 1839)		0.119 ± 0.206		0.114±0.199
Cerithium atratum (Born, 1778)	3.82 ± 6,02	2.026 ± 1.833		3.750±3.854
Cocculina sp.				0.038±0.066
Collisella subrugosa (d'Orbigny, 1842)	0.10 ± 0.17	0.696±1.205		
Cryoturris adamsii (E.A. Smith, 1884)			0.034±0.059	0.333±0.577
Ctena pectinella (C.B. Adams, 1852)				0.114±0.199
Diodora jaumei Aguayo & Rehder, 1936				0.038±0.066
Eulithidium affine (C.B. Adams, 1850)	2.671 ± 3.643	5.237 ± 3.668	1.986 ± 2.309	9.737 ± 7.435
Finella dubia (d'Orbigny, 1840)				0.076±0.132
Fissurella rosea (Gmelin, 1791)		0.522±1.169	0.335±0.468	2.222±3.849
Haminoea antillarum (d'Orbigny, 1841)			0.034±0.059	
Littorina ziczac (d'Orbigny, 1840)	0.704±0.972	0.238±0.412	0.141±0.122	
Littoridiina australis (d'Orbigny, 1835)		0.206±0.185	0.435±0.754	0.268±0.464
Mitrella dichroa Sowerby, 1844	0.299±0.517	0.801±1.169		0.114±0.199
Odostomia laevigata (d'Orbigny, 1841)	0.029±0.051			
Olivella sp.	0.099±0.172			

Parviturboides interruptus (C.B. Adams, 1850)			0.145±0.251	
Puncturella sp.			0.034±0.059	
Pyramidellidae (young)			0.102±0.178	
Pyrgocythara albovittata (C.B. Adams, 1845)	0.099±0.172	0.715±0.619	0.145±0.251	0.827±1.334
Schwartziella bryerea (Montagu, 1803)	0.099±0.172			0.076±0.132
Schwartziella catesbyana (d'Orbigny, 1842)	0.029±0.051	0.119±0.206		0.197±0.341
Scissurella sp.			0.508 ± 0.879	
Siphonaria hispida Hubendick, 1946		0.174±0.301		
Tegula sp.	0.358±0.475	0.714±1.237	0.045±0.079	
Tegula viridula (Gmelin, 1791)	0.199±0.345			1.001±1.258
Tenaturris fulgens (E.A. Smith, 1888)				0.547± 0.596
Thais haemastoma (Linnaeus, 1767)	0.199±0.345			
Turbonilla nivea (Stimpson, 1815)		0.357 ± 0.618		
Turbonilla sp.			0.072 ± 0.125	0.038 ± 0.066
Vitrinella filifera Pilsbry & McGinty, 1946				0.038 ± 0.066

Discussion

The composition and number of species of gastropods associated with seaweed varied temporal and spatially (Montouchet 1979; Masunari 1982; Sánches-Moyano et al. 2001a; Jacobucci et al. 2006). These differences can be attributed to the structural complexity of the seaweed (Hacker & Steneck 1990), to biomass (Sánches-Moyano et al. 2001a), to spatial distribution related to geographical factors (Montouchet 1979; Jacobucci et al. 2006), and to seasonal and anthropogenic factors (Leite et al. 2000). Environmental variables, such as sediment or type of physical structure of the habitat, are important for structuring macrofaunal assemblages in algal turf (Dean & Connel 1987; Gibbons 1988; Sánches-Moyano et al. 2001a). The amount of sediment retained by the seaweed is positively associated with the large number of species and abundance of invertebrate fauna (Sánches-Moyano et al. 2001a,b), including gastropods (Kalaher et al. 2001), as it constitutes habitat and an important food source (Olibarria & Chapman 2001). Chemello & Milazzo (2002) found correlations between mollusc assemblages and several aspects of seaweed architecture, and observed that more complex seaweed fronds present more diverse fauna than do simple or flattened fronds.

Sediment retention by rhizoids observed in architecturally complex algae, such as those from the genus *Caulerpa* (Joly 1965), is important for gastropod assemblages (Sánches-Moyano et al. 2001a,b). The sediment shelters a diverse and numerous gastropod fauna, as confirmed by this study and observed in *Caulerpa prolifera* (Rueda & Salas 2003). Gastropod species composition identified by Rueda & Salas (2003) differed from the findings in *Caulerpa racemosa* in this work.

In spite of the higher number of species identified, few species showed dominance. Rueda et al. (2001), studying deep soft mollusc fauna, and Rueda & Salas (2003), studying molluscs present in sediments retained by *Caulerpa prolifera*, found low dominance of gastropod species, similarly to what was observed in the *Caulerpa racemosa* samples from the two beaches studied.

The larger number of species observed at Praia da Fortaleza, in comparison with the findings from Praia das Cigarras during all the seasons of the year, can be attributed to several factors from differences in volume and characteristics of the sediment retained to hydrodynamics, biomass and structural complexity of the *Caulerpa racemosa*, in addition to other factors both abiotic and biotic, not contemplated by this study. The relationship between the sediment retained and gastropod assemblages associated with *Caulerpa racemosa* is being assessed (Leite et al. in prep).

At Praia das Cigarras the number of species, and their respective densities throughout the year, was lower than the findings for the more sheltered Praia da Fortaleza. Széchy (1996) also observed differences in occurrence, dominance and abundance of species of gastropods associated with *Sargassum* from protected and unprotected beaches. Hydrodynamic forces can be regarded as structural variables affecting gastropod assemblages associated with *Sargassum* (Széchy 1996). Nonetheless, more studies are needed to make this association plausible for gastropod assemblages

from *Caulerpa racemosa*.

It can also be observed that few species were dominant in the four seasons of the year, both at Praia da Fortaleza and at Praia das Cigarras. *Bittium varium* presented high dominance values for both beaches, prevailing at Praia das Cigarras. Frequency for this species was 100% for both beaches.

At Praia da Fortaleza, the highest dominance was presented by *Caecum* sp1, with frequency of 75%. However, was the dominant species in winter at Praia das Cigarras. Some of the dominant species, such as *Anachis* spp and *Mitrella dichroa*, *B. varium* and *Eulithidium affine*, are typical of phytal assemblages (Montouchet 1979; Masunari 1982; Jacobucci et al. 2006). *Caecum* sp1, *Amphithalamus glaber* and *Cerithium atratum* presented high numbers and are not common species in these assemblages. A possible explanation for the occurrence of the first species is that it may be associated either to the sediment or to the algae, and the second may be associated with the sediment (Olabarria & Chapman 2001; Olabarria et al. 2002; Kelaher et al. 2003), whereas *C. atratum*, is a common species on rocky shores, as it feeds on algae (Pereira et al. 2009; Rios 2009), but lives on sediment. The occurrence of the genus *Caecum* was previously recorded in *Sargassum* (Montouchet 1979), and associated with the seaweed *Padina gymnospora* and *Hypnea musciformis* (Oliveira et al. 2003) at a beach in Pernambuco. Species of *Amphithalamus* were found in the sediment retained by calcareous seaweed (Olabarria & Chapman 2001; Olabarria et al. 2002; Kelaher et al. 2003).

Presence of a high number of species of gastropods that inhabit seaweed *Caulerpa racemosa* may be related to their different living and feeding habits. Species that are typical of phytal assemblages have diverse feeding habits, and they can be detritivores, such as *Bittium varium*, or periphyton scrapers, such as *Eulithidium affine* (Montouchet 1979; Masunari 1982; Jacobucci et al. 2006). Predators, such as *Thais haemastoma* and *Leucozonia nassa*, and scraping micrograzers, such as *Littorina ziczac* and *Collisella subrugosa*, among others, are species typically found on rocky shores and may occasionally occur in seaweed gastropod assemblages (Montouchet 1979). The macro herbivores *Astraea latispina* and *Cerithium atratum* feed directly on the seaweed. *Caecum* species are herbivorous and detritivorous, and are food for carnivorous crustaceans and other gastropods (Oliveira et al. 2003). *Amphithalamus* feeds on microalgae retained in this sediment (Olabarria & Chapman 2001; Olabarria et al. 2002).

Also, must not be overlooked the fact that this algae, like several species of the order Caulerpales, produce secondary metabolites which are toxic to, or a deterrent, for several microorganisms and larvae of invertebrates (Sánchez-Moyano et al. 2001b). Those secondary metabolites prevent settlement of most epiphytes and grazing by herbivores (Paul & Fenical, 1987 *in* Sánchez Moyano et al. 2001b) and it may be a factor influencing gastropod fauna, especially herbivores. It is imperative that the gastropod fauna of *Caulerpa racemosa* and the biotic features, as well as, the abiotic relations affecting both spatial and seasonal distribution of the assemblages, must be studied in detail.

Table III. Praia das Cigarras: Total number of individuals of each species of gastropod (N), dominance (D) and frequency (%) by season of the year (2004-2005)

Species	Winter		Spring		Summer		Autumn		Total		
	N	D	N	D	N	D	N	D	N	D	F
Alvania auberiana, (d'Orbigny, 1842)							1	0.76	1	0.25	25
Ascobulla ulla (Marcus & Marcus, 1970)							8	6.61	8	2.0	25
Anachis obesa (C.B. Adams, 1845)	1	1.14	3	2.72			5	3.09	9	2.25	50
Anachis sertularium (d'Orbigny, 1839)							28	21.21	28	7	25
Anachis sparsa (Reeve, 1859)	1	1.14					40	30.30	41	10.25	50
Bittium varium (Pfeiffer, 1840)	1	1.14	106	80.30	4	22.22	37	28.03	148	37.00	100
Boonea jadisi (Olsson & McGinty, 1958)	5	5.68	1	0.76			4	3.03	10	2.5	75
Caecum sp.1	55	62.50					7	5.30	62	15.46	75
Caecum sp.2	14	15.91							14	3.50	50
Columbella mercatoria (Linnaeus, 1758)					1	5.55	2	1.51	3	0.75	75
Crepidula acuelata (Gmelin, 1791)							5	3.79	5	1.25	50

Eulithidium affine (C.B. Adams, 1850)	04	4.54	17	2.88	11	61.11	19	14.19	51	12.75	100
Leucozonia nassa (Gmelin, 1791)			1	0.76					1	0.25	50
Littorina ziczac (d'Orbigny, 1840)	1	1.14							1	0.25	50
Mitrella dichroa Sowerby 1844	1	1.14	4	3.03	1	5.55	5	3.79	11	2.75	100
Parviturboides interruptus (C.B. Adams, 1850)	5	5.68							5	1.25	50
Trachypollia nodulosa (C.B. Adams, 1845)					1	5.55	1	0.76	2	0.50	75
Total	88		132		18		162		400		

Table IV. Praia das Cigarras: Mean density and standard deviation of the individuals of each species of gastropods (± SD No ind/100g) by season of the year (2004-2005)

Species	Winter	Spring	Summer	Autumn
Alvania auberiana, (d'Orbigny, 1842)				0.055 ± 0.096
Anachis obesa (C.B. Adams, 1845)	0.086 ± 0.150	0.250 ± 0.434		0.277 ± 0.481
Anachis sertularium (d'Orbigny, 1839)				2.365 ± 2.052
Anachis sparsa (Reeve, 1859)	0.086 ± 0.150			2.222 ± 3.849
Ascobulla ulla (Marcus & Marcus, 1970)				1.254 ± 1.891
Bittium varium (Pfeiffer, 1840)	0.086 ± 0.150	7.940 ± 4.340	0.550 ± 0.597	5.410 ± 4.718
Boonea jadisi (Olsson & McGinty, 1958)	0.685 ± 0.869	0.131 ± 0.227		0.460 ± 0.120
Caecum sp.1	9.201 ± 14.128			0.969 ± 0.569
Caecum sp.2	2.111 ± 3.000			
Columbella mercatoria (Linnaeus, 1758)			0.161 ± 0.280	0.214 ± 0.242
Crepidula acuelata (Gmelin, 1791)				0.952 ±1.650
Eulithidium affinis (C.B. Adams, 1850)	0.262 ± 0.455	1.783 ± 1.563	1.722 ± 1.264	2.557 ± 1.431
Leucozonia nassa (Gmelin, 1791)		0.061 ± 0.106		
Littorina ziczac (d'Orbigny, 1840)	0.184 ± 0.320			
Mitrella dichroa Sowerby 1844	0.065 ± 0.113	0.524 ± 0.909	0.161 ± 0.280	0.412 ± 0.360
Parviturboides interruptus (C.B. Adams, 1850)	0.328 ± 0.568			1.001±1.258
Trachypollia nodulosa (C.B. Adams, 1845)			0.161 ± 0.280	0.055 ± 0.096

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