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Responses of the molluscan fauna to environmental variations in a *Halodule wrightii* Ascherson ecosystem from Northeastern Brazil

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ABSTRACT

This study observed the spatial and temporal distributions of molluscs in a *Halodule wrightii* meadow, verifying if they respond satisfactorily to seasonal changes in this seagrass ecosystem. Twenty-four species were identified. Chitons were rare, bivalves had greater number of species (11), followed by gastropods (9) which were also the most abundant class (73%). All classes were more abundant in the belowground. The most common species was *Tricolia affinis*, especially in aboveground. The occurrence of some species in both strata or out of the expected stratum may have been influenced by shallow layer of the sediment considered in this study, hydrodynamic, and low biomass of the studied meadow. According to univariate and multivariate analyses, despite of molluscan descriptors had been related to variables associated with rainfall, the seagrasses had an important role on the seasonal and vertical variations of the molluscan fauna. The biomass of the epiphyte *Hypnea musciformis* was correlated to temporal variations of the species from aboveground, indicating its secondary role for this community. The molluscs were sensible to environmental variations, and also reflected seasonal changes of the seagrass, showing that damages on these meadows reflect even at lower levels of the marine food web.

Key words: Benthic communities, *Hypnea musciformis*, marine food web, northeast of Brazil, seagrasses, *Tricolia affinis*.

INTRODUCTION

Seagrass meadows are direct source of food for many marine organisms and they promote substrate for several epiphytic species, stability of the sediment and physicochemical variables, providing nursery, shelter from predators, and territory favorable to capture prey (Orth et al. 1984, Hall and Bell 1988, Phillips 1992, Marbà et al. 1996, Hemminga and Duarte 2000).

Among several communities associated with seagrasses, the molluscan fauna is one of the most abundant. The importance of molluscan grazer and scrapers of periphyton in these ecosystems has been reported for maintenance of the trophic web and control of epiphytes, favoring growth and productivity (Hootsmans and Vermaat 1985, Howard and Short 1986, Philippart 1995, Jernakoff and Nielsen 1997, Fong et al. 2000, Hemminga and Duarte 2000).

However, most of the studies which investigated relationships among molluscan fauna and seagrasses observed feeding preferences of grazer species and the effects of their activities on the leaves (Van Montfrans et al. 1982, Jensen 1983,

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Marbà et al. 1996, Zimmerman et al. 1996, Rueda and Salas 2007). Thus, there are few observations on the influences of seagrasses on molluscan communities (Alves and Araújo 1999, Creed and Kinupp 2011, Barros et al. in press).

Seagrasses are acutely responsive to environmental changes (Orth et al. 2006, Barros et al. 2013), inclusive climate global changes, which modify the distribution, productivity, and composition of seagrass communities (Short and Neckles 1999, Duarte et al. 2004, Orth et al. 2006). The large abundance in seagrass ecosystems and the sensitivity to environmental changes are essential requirements to use molluscs in environmental monitoring (Clarke and Ward 1994, García and Meneses 2000, Sánchez-Moyano et al. 2000). In short-term, studies on the effects caused by seasonal changes of seagrasses on specific communities may assist in diagnosis of local environmental changes. In long-term, these studies will even help in understanding of the global climate changes, since the associated communities reflect impacts along the trophic web.

The purpose of this study was to observe the spatial and temporal distributions of the molluscan fauna in a *Halodule wrightii* Ascherson meadow, verifying if they respond satisfactorily to seasonal changes in this seagrass ecosystem.

MATERIALS AND METHODS

Study Area

Goiabeiras Beach (03°41’31”S; 038°34’49”W) is bounded, on the west, by the mouth of Ceará River (Fig. 1), in which are found beach rocks covered by macroalgae and a small meadow of the seagrass *Halodule wrightii* Ascherson. The climate classification according to Köppen (1948) is Aw’, in other words, rainy tropical climate with a long dry season. Morais (1980) recorded mild winds

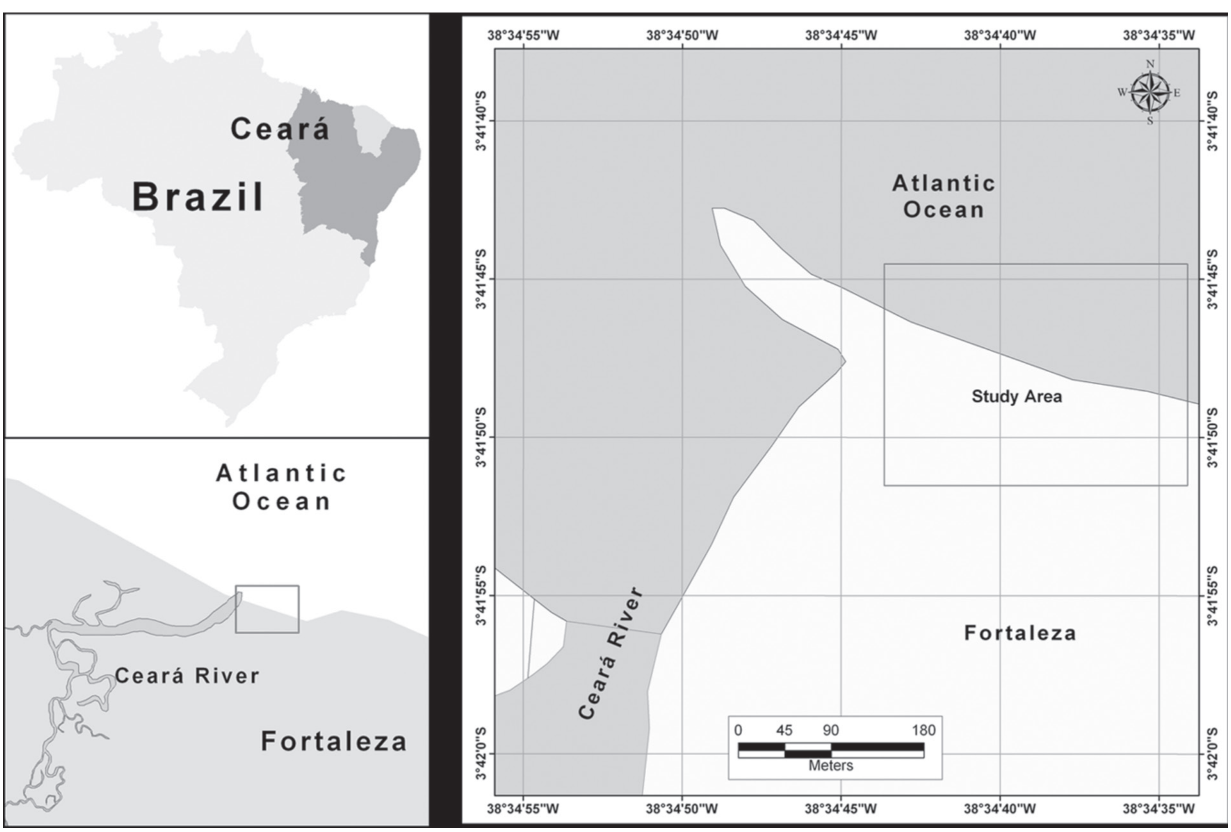

Figure 1 - Location of the study area. Goiabeiras Beach, Fortaleza-Ceará-Northeastern Brazil.

during rainy months (from February to May), and progressive increase in wind speed in the following months, which reaches the top from August to November (dry season).

Field Sampling and Laboratory Procedures

Five random replicates were monthly sampled from April 2006 to July 2007 at low spring tides, using a 10-cm-diameter core, inserted at 10cm depth. Subsequently, the samples were sectioned in aboveground (shoots, leaves and associated fauna, exposed to hydrodynamic) and belowground (roots, rhizomes and associated fauna, inside the sediment). The aboveground samples were bagged, cut, and tagged. Thereafter, belowground was placed in another plastic bag and tagged. The samples were preserved in a 4% formalin solution and transported to the Zoobentos Laboratory of the Institute of Marine Sciences (Laboratório de Zoobentos do Instituto de Ciências do Mar, Universidade Federal do Ceará).

Sediment samples were also monthly collected in order to obtain granulometric analysis and OM content. Physical and chemical variables (i.e. water and air temperatures, pH, salinity, and dissolved oxygen) were also obtained with a multiparameter probe. Pluviometric precipitations, wind speed, waves, and period of the waves data were obtained from the Brazilian Institute of Space Research (Instituto Brasileiro de Pesquisas Espaciais – INPE) (2006/2007). Seagrasses (shoots and roots) and epiphytes were dried at 60°C in order to obtain biomasses (g $dw.m^{-1}$). The molluscan fauna was preserved in 70% alcohol and identified under stereomicroscope with help of specific literature. The specimens were preserved at the Malacological Collection Prof. Henry Ramos Matthews of the Institute of Marine Sciences (CMPHRM 3812-3858).

STATISTICAL ANALYSIS

The seasons were based on Euclidean distance of the abiotic variables, whose the groups of samples were submitted to variance analyses. Frequency of occurrence ($F < 10\%$ - Rare; $10\% < F < 40\%$ - Few Common; $40\% < F < 70\%$ - Common; $F > 70\%$ - More Common), density (ind.g-1), and descriptors of the molluscan fauna (number of species, diversity and evenness) were also obtained for both strata (below and above ground) and seasons (dry and rainy). Euclidean distance, number of species, diversity and evenness were obtained using Primer® (Plymouth Routines in Multivariate Ecological Research), 6.1.6 version.

Parametric variances (t-test) were performed in order to verify if biotic and abiotic variables were significantly different considering seasons. Relationships among biotic and abiotic variables were tested using univariate, non-parametric Spearman rank correlations, and multivariate Canonical Correlation Analysis (CCA). CCA observed the influence of the data set of environmental factors and macrophytes (seagrass and epiphyte) on the molluscan community variance. In order to observe responses of the molluscan community to macrophytes influences, CCA were performed twice, one without macrophytes biomasses and another one with macrophytes biomasses as environmental factors. Variables strongly correlated were excluded in order to both avoid multicollinearity and decrease inflation factors. Data were natural log-transformed and the down weighting rare species option was selected in order to avoid the influence of rare species leading to biased results. Monte Carlo test with 499 permutations, under reduced mode, was used to test the significance ($p < 0.05$) of the environmental variables influencing on the ordination axes. Spearman rank and t-tests were obtained using Statistica® 7.0 and CCA was performed by CANOCO for Windows, 4.5 version.

RESULTS

Environmental and Macrophytes Variations

Euclidean distance (Fig. 2) determined two groups of samples associated mainly with presence and absence of pluviometric precipitations. Samples from April 2006 to June 2006, and from February 2007 to May 2007 were associated with rainfall. The samples associated with the dry season (from July 2006 to January 2007, and July 2007) were most homogeneous.

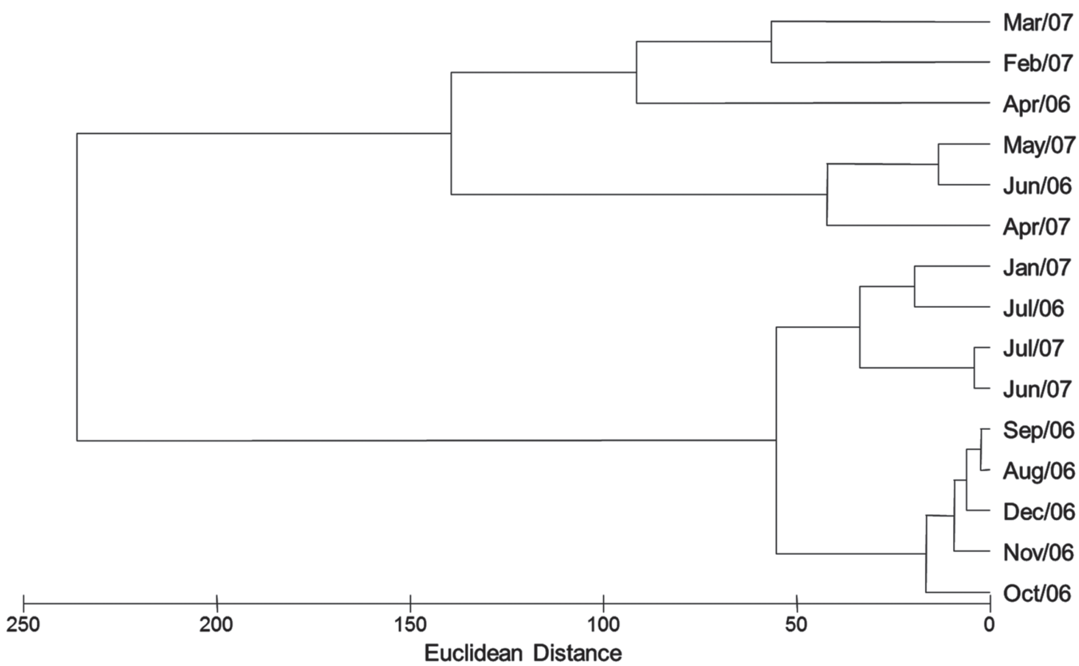

Figure 2 - Euclidean Distance dendrogram of the samples, based on environmental variables obtained throughout this study in Goiabeiras Beach, Fortaleza-Ceará-Northeastern Brazil.

In the first half of the year, both percentages of fine grains (silt/clay) and organic matter (OM) content varied according to pluviometric precipitations, while wind speed decreased. In the second half of the year, besides decrease in pluviometric precipitations, there was a progressive increase in wind speed, which peaked in September 2006 and October 2006. Waves and period of the waves varied (directly and inversely proportional, respectively) to wind speed. Pluviometric precipitations, percentages of fine grains, organic matter content, wind speed and waves were significantly different considering seasons (Table I).

These environmental changes also influenced *H. wrightii*. This seagrass was more developed during the rainy season, when the biomasses were higher. The average values of total biomass, in dry and rainy seasons, were 454 g dw.m^{-2} and 656 g.dw.m^{-2}, respectively. In contrast, the biomass of the one single epiphyte species, *Hypnea musciformis* Lamourox, increased in the dry season (Table II). However, no statistically significant differences were found regarding the seasons (Table II).

Community Descriptors and Spatiotemporal Distribution of the Molluscan Fauna

Two hundred and thirty molluscs were captured, being 141 in the belowground and 89 in the aboveground. Gastropoda was the most abundant class, corresponding to 73% of the molluscan fauna, and Polyplacophora was the less abundant, corresponding to 4%. Twenty-four species were identified, and bivalves had greater number of species (11 species), followed by gastropods (9 species). All classes were more abundant in the belowground (Table III).

TABLE I
Variance analyses of the abiotic variables studied in Goiabeiras Beach, Fortaleza-Ceará-Brazil.

Variables	Mean (dry)	Mean (rainy)	t-Value	df	p	N (dry)	N (rainy)	SD (dry)	SD (rainy)	p Variances
Water temperature	29.0	29.6	-0.824	13	0.4244	9	6	1.3501	1.5715	1.354
Air temperature	28.3	28.1	0.294	13	0.7733	9	6	1.5000	0.8524	3.096
Ph	7.8	8.9	-1.990	12	0.0698	8	6	1.3115	0.6816	3.702
Salinity	36.4	34.4	1.106	13	0.2887	9	6	2.3292	4.7576	4.172
Dissolved oxygen	6.7	4.0	1.406	9	0.1933	7	4	3.5899	1.1006	10.639
Low tides	0.6	0.5	1.157	13	0.2678	9	6	0.0632	0.0547	1.339
Waves	1.8	1.6	2.486	13	0.0273	9	6	0.0877	0.1815	4.281
Wave period	7.3	8.0	-1.260	13	0.2297	9	6	1.0000	1.1673	1.362
Pluviometric precipitations	44.4	250.4	-4.618	13	0.0005	9	6	60.2180	113.2470	3.536
Wind speed *	6.5	5.0	4.157	13	0.0011	9	6	0.4814	0.9487	3.884
Organic matter *	0.9	1.4	-3.674	13	0.0028	9	6	0.2197	0.3028	1.900
Selection	0.5	0.7	-1.315	13	0.2110	9	6	0.2899	0.2272	1.627
Gravel (%)	2.0	2.9	-0.580	13	0.5718	9	6	3.4212	2.6280	1.694
Sand (%)	97.5	95.2	1.390	13	0.1876	9	6	3.3092	2.8649	1.334
Fine (%)*	0.4	1.7	-3.155	13	0.0076	9	6	0.7323	0.9169	1.567

*Variables with significant difference between dry and rainy seasons.

TABLE II
Variance analyses of the *Halodule wrightii* and *Hypnea musciformis* biomasses sampled in Goiabeiras Beach, Fortaleza-Ceará, Northeastern Brazil.

Variables	Mean (dry)	Mean (rainy)	t-value	df	P
Belowground biomass *	407.2	586.9	2.843	73	0.005
Aboveground biomass*	47.0	69.1	2.230	73	0.028
Epiphyte Biomass**	0.060	0.0096	1.788	73	0.097

* *Halodule wrightii*.
*******Hypnea musciformis*.

The species *Tricolia affinis* C. B. Adams (1850) was the most abundant, corresponding to 25.7% of the molluscan fauna from the belowground, and 60% of the molluscs from the aboveground. According to the frequency of occurrence, most of the molluscan fauna was considered few common or rare (Table III), especially in aboveground. In the belowground, *T. affinis* was common (F = 53.3%) as well as the bivalve *Ctena orbiculata* Montagu (1808) (F = 46.6%). In the aboveground, *T. affinis* was very common (F = 80%) and the other species were few common or rare. This gastropod was also the densest species in both strata (Table III), and still the dominant species in belowground (41.2%) (Fig 3a) and aboveground (61.2%) (Fig 3b).

Shannon's diversity and Pielou's evenness were greater in the rainy season. However, according to t-test, diversity was not significantly different between seasons, both in belowground (p = 0.180; df = 13) and aboveground (p = 0.148; df = 13). The indexes of evenness were significantly different in belowground (p = 0.032; df = 13), but was not different in aboveground (p = 0.173; df = 13).

INFLUENCES OF ENVIRONMENTAL AND MACROPHYTES VARIATIONS ON THE MOLLUSCAN FAUNA

In general, Spearman rank showed several weak, positive correlations among descriptors of the molluscan fauna and environmental variables associated with

TABLE III

Check-list, frequency of occurrence, density, and spatiotemporal distribution of the molluscan fauna associated with *Halodule wrightii* from Goiabeiras Beach, Fortaleza-Ceará, Northeastern Brazil.

Class	Species	Frequency of occurrence (%)		Density (ind m^{-2})				Distribution			
		belowground	aboveground	belowground		aboveground		belowground		aboveground	
				dry	rainy	dry	rainy	dry	rainy	dry	rainy
Polyplacophora	*Ischnochiton* sp.	_	rare	0.000	0.000	0.000	0.135			X	
	Ischnochiton niveus Ferreira, 1987	few common	_	0.140	0.200	0.000	0.000	X	X		
	Ischnochiton striolatus Gray, 1828	rare	rare	0.009	0.003	0.116	0.000		X		X
	Chaetopleura isabellei d´Orbigny, 1841	_	rare	0.000	0.000	0.130	0.000			X	
Gastropoda	*Diodora dysoni* Reeve, L.A., 1850	rare	few common	0.009	0.000	0.383	0.175	X		X	X
	Tricolia affinis C. B. Adams, 1850	common	very common	0.166	0.155	2.573	1.573	X	X	X	X
	Caecum ryssotitum Folin, 1867	few common	few common	0.000	0.023	0.000	0.252		X		X
	Caecum aschironum Folin, 1867	rare	rare	0.000	0.022	0.000	0.075		X		X
	Caecum pulchellum Stimpson, 1851	rare	rare	0.000	0.005	0.000	0.100		X		X
	Olivella minuta Link, 1807	rare	_	0.000	0.003	0.000	0.000		X		
	Anachis obesa Adams, 1845	rare	_	0.000	0.003	0.000	0.000		X		
	Bittium varium Pfeiffer, 1840	few common	rare	0.009	0.005	0.116	0.000	X	X	X	
	Mitrella lunata Say, 1826	_	rare	0.000	0.000	0.000	0.035				X
Bivalvia	*Pinctada radiata* Leach, 1814	rare	few common	0.000	0.080	0.000	0.398		X		X
	Chione intrapurpurea Conrad, 1849	_	rare	0.000	0.000	0.000	0.260				X
	Ervilia subcancelata E. A. Smith, 1885	rare	rare	0.000	0.027	0.035	0.000		X		X
	Tagelus plebeius Lightfoot, 1786	few common	few common	0.000	0.012	0.000	0.252		X		X
	Corbula cymella Dall, 1881	few common	_	0.008	0.003	0.000	0.000	X	X		
	Crassinella lunulata Conrad, 1834	few common	_	0.015	0.015	0.000	0.000	X	X		
	Pitar circinatus Born, 1778	few common	_	0.000	0.000	0.010	0.000		X		
	Ctena orbiculata Montagu, 1808	common	few common	0.038	0.030	0.184	0.148	X	X	X	X
	Lima lima Linnaeus 1758	_	rare	0.000	0.000	0.000	0.075				X
	Coralinophaga sp.	rare	_	0.006	0.000	0.000	0.000	X			
	Diplodonta sp.	few common	_	0.006	0.012	0.000	0.000	X	X		

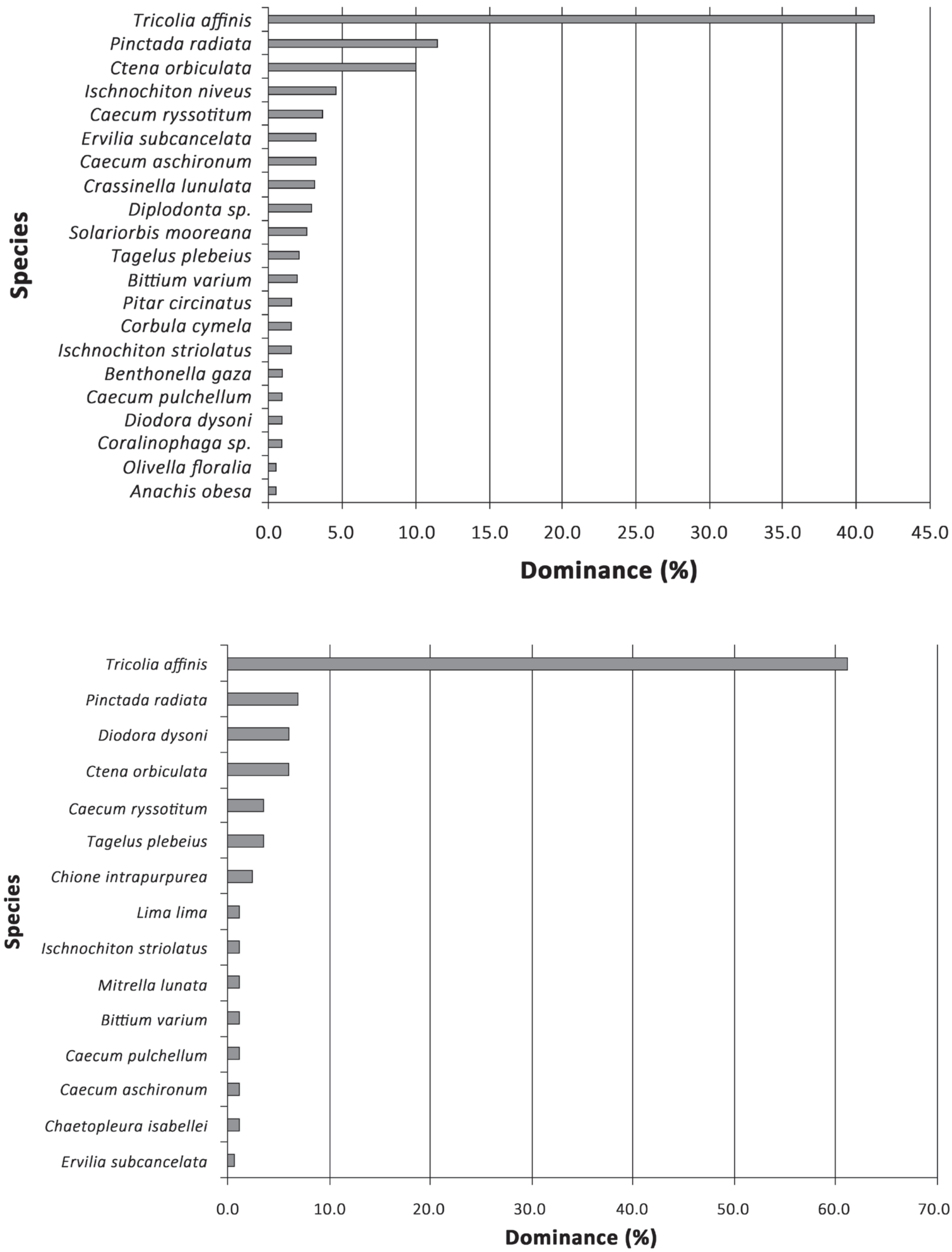

Figure 3 - Dominance of molluscan species in the belowground **(a)** and aboveground **(b)** of *Halodule wrightii* bed, in Goiabeiras Beach, Fortaleza-Ceará.

rainfall (pluviometric precipitations, organic matter content, and percentage of fine grain), whereas there were negative correlations among these descriptors and variables directly related to the dry season (winds speed, waves) (Table IV). Those descriptors were also positively correlated to *H. wrightii* biomasses, especially in aboveground, and the molluscan density was weakly correlated to *H. musciformis* biomass (Table V). The gastropod *Tricolia affinis* was the only species which was significantly correlated to some environmental variables (Table V).

In the CCA without macrophytes biomasses (Fig. 4a), the Monte Carlo test does not indicated significant correlation of environmental variables to variance of the molluscs abundance, both considering the first canonical axis (eigenvalue = 0.357; F = 1.514; p = 0. 694) and all canonical axes (Trace = 0.988; F = 0.975; p = 0.516). In this case, abiotic variables explained 20.4% of all canonical axes; species-environment correlation explained 64.2% of the two first axes variances, and 36.1% of the axis 1 variance. The environmental variables more strongly correlated to the axis 1 was fines percentage (-0.536), followed by sand percentage (-0.506) and gravel percentage (0.483). Organic matter content (-0.689) was the variable more strongly correlated to the axis 2. The samples dispersion showed similarities among samples from belowground and their respective samples from aboveground.

Considering the CCA with macrophytes biomasses as environmental factors (Fig. 4b), the Monte Carlo test indicated significant correlation between environmental variables and the variance of the samples, both for the first canonical axis (eigenvalue = 0.999; F = 4.422; p = 0.002) and all canonical axes (Trace = 2.011; F = 1.726; p = 0.002), although some variables have increased the inflation factor, probably because of correlations among them. Nevertheless, these factors were within acceptable limit (Table VI). Abiotic variables explained 41.5% of all canonical axes; species-environment correlation explained 65% of the two first axes variances, and 49.7% of the variance of the axis 1. The environmental variable more strongly correlated to the axis 1 was sand percentage (-0.999), followed by *Halodule wrightii* biomass (-0.868) and *Hypnea musciformis* biomass (0.497). Organic matter content (-0.689) was, once more, the variable more strongly correlated to the axis 2. The inclusion of the macrophytes biomasses positioned belowground samples on the negative fraction of the Axis 1 and aboveground samples on the positive fraction of this Axis.

TABLE IV
Spearman rank correlations among descriptors of the molluscan fauna and abiotic variables in Goiabeiras Beach, Fortaleza-Ceará, Northeastern Brazil.

		Precipitations	Organic matter (%)	Fine grains (%)	Winds speed	Waves	Period of the waves
Above	N	r = 0.275; p = 0.001*	r = 0.159; p = 0.160	r = 0.213; p = 0.058	r = 0.047; p = 0.676	r = 0.362; p = 0.001*	r = 0.356; p = 0.001*
	S	r = -0.324; p = 0.002*	r = 0.170; p = 0.123	r = 0.210; p = 0.062	r = 0.108; p = 0.341	r = 0.344; p = 0.000*	r = 0.310; p = 0.005*
	H’	r = -0.238; p = 0.034*	r = 0.076; p = 0.504	r = 0.108; p = 0.342	r = 0.123; p = 0.277	r = 0.180; p = 0.111	r = 0.287; p = 0.010*
	J’	r = 0.135; p = 0.629	r = 0.024; p = 0.931	r = -0.016; p = 0.954	r = -0.002; p = 0.991	r = -0.147; p = 0.599	r = -0.135; p = 0.629
	Density	r = -0.295; p = 0.008*	r = 0.076; p = 0.502	r = 0.115; p = 0.311	r = 0.107; p = 0.345	r = 0.403; p = 0.000*	r = 0.287; p = 0.010*
	T. affinis	r = 0.302; p = 0.006*	r = -0.438; p = 0.000*	r = -0.128; p = 0.260*	r = -0.368; p = 0.000*	r = -0.184; p = 0.103	r = -0.058; p = 0.606

*Significant correlations.

TABLE IV (continuation)

		Precipitations	Organic matter (%)	Fine grains (%)	Winds speed	Waves	Period of the waves
Below	N	r = 0.285; p = 0.010*	r = -0.448; p = 0.000*	r = 0.480; p = 0.000*	r = 0.437; p =0.000*	r = 0.961; p = 0.000*	r = -0.386; p = 0.000*
	S	r = 0.280; p = 0.012*	r = -0.464; p = 0.000*	r = 0.463; p = 0.000*	r = 0.415; p =0.001*	r = 0.951; p = 0.000*	r = -0.372; p = 0.000*
	H'	r = 0.222; p = 0.425	r = -0.581; p = 0.000*	r = 0.444; p = 0.096*	r = -0.591; p = 0.022*	r = - 0.783; p = 0.000*	r = 0.478; p = 0.007*
	J'	r = 0.135; p = 0.629	r = 0.024; p = 0.931	r = 0.016; p = 0.954	r = -0.002; p = 0.991	r = -0.147; p = 0.599	r = 0.231; p = 0.406
	Density	r = 0.135; p =0.234	r = -0.140; p = 0.218	r = 0.275; p = 0.014*	r = -0.011; p = 0.920	r = 0.157; p = 0.164	r = -0.238; p = 0.034*
	T. affinis	r = 0.424; p = 0.000*	r = 0.411; p = 0.000*	r = 0.521; p = 0.000*	r = 0.432; p = 0.000*	r = -0.246; p = 0.028*	r = 0.380; p = 0.000*

*Significant correlations.

TABLE V
Spearman rank correlations among descriptors of the molluscan community with *Halodule wrightii* and *Hypnea musciformis* biomasses in Goiabeiras Beach, Fortaleza-Ceará, Northeastern Brazil.

		H. wrightii	*H. musciformis*
Above	N	r = 0.262; p = 0.019*	r = 0.258; p = 0.050
	S	r = 0.266; p = 0.017*	r = 0.104; p = 0.788
	H'	r = 0.233; p = 0.038*	r = -0.130; p = 0.328
	J'	r = -0.543; p = 0.036*	-
	Density	r = 0.211; p = 0.006	r = 0.278; p = 0.034*
	T. affinis	r = 0.267; p = 0.017*	r = 0.075; p = 0.505
Below	N	r = 0.328; p = 0.003*	-
	S	r = 0.336; p = 0.002*	-
	H'	r = 0.133; p = 0.634	-
	J'	r = 0.219; p = 0.927	-
	Density	r = 1.000	-
	T. affinis	r = 0.253; p = 0.014*	-

*Significant correlations.

TABLE VI
Factors inflation in Canonical Correlation Analysis without and with the macrophytes biomasses as environmental variables, acting on the molluscan community from Goiabeiras Beach, Fortaleza-Ceará, Northeastern Brazil.

	CCA without macrophytes	CCA with macrophytes
Salinity	1.1119	1.3776
Gravel (%)	1.5982	1.2549
Sand (%)	1.6413	2.2312
Fine (%)	1.6624	6.5226
Organic Matter (%)	1.6092	2.6113
H. wrightii biomass	-	6.2966
H. musciformis biomass	-	1.9288

DISCUSSION

The molluscan fauna of the studied *Halodule wrightii* ecosystem seemed use these seagrass as its main substrate, although many groups also widely found in these ecosystems as nematodes, polychaetes, crustaceans and fishes, are not directly related to seagrasses (cf. Corbisier 1994, Garcia et al. 1996, Garcia and Vieira 1997, da Rocha et al. 2006). However, several studies have indicated that even little seagrasses may provide greater density and diversity of macrofauna than non-vegetated

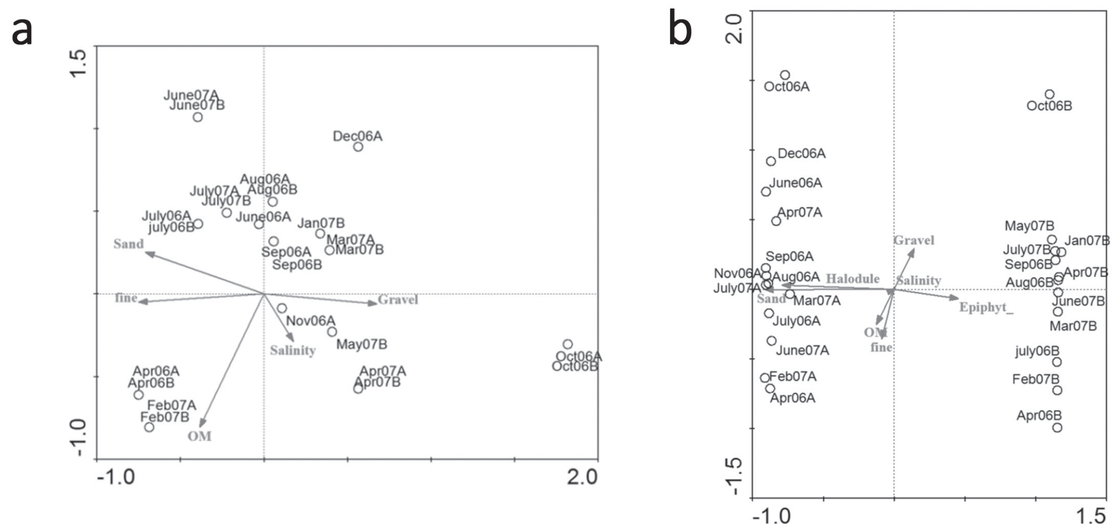

Figure 4 - Canonical Correlation Analysis (CCA) diagrams and samples (months) dispersion of the abundance of molluscan **(a)** and descriptors of community **(b)**. Legend of Vectors: Gravel – Percentage of Gravel percentage; Salinity - Salinity; Epiphyt_ – *Hypnea muscioformis* biomass; Fine – Percentage of Fine; OM – Organic matter content; Sand – Percentage of Sand; Halodule – *Halodule wrightii* biomass. Legend of samples: A – Belowground; B – Aboveground.

areas (cf. Corbisier 1994, Lee et al. 2001, Casares and Creed 2008, Rosa and Bemvenuti 2007). Despite the environmental influences recorded, this studied seagrass meadow had a significant role on the spatial and temporal distributions of the molluscan fauna.

The most representative molluscan species of the studied meadow was *Tricolia affinis*. The literature reports this microgastropod in beach rocks, coral reefs and macrophytes, occurring from intertidal zone to 50m depth, with higher dry mass between 1-2m in subtidal zone, and on the base of algae, where greater accumulation of sediment occurs. This species is herbivorous, grazer-scrapers of periphyton, and the epiphytic diatoms are its main supplementary feeding (Mountouchet 1979, Rios 1994, Alves and Araújo 1999, Széchy and Paula 2000, Fernandes et al. 2006). Because of its significant presence in many phytal ecosystems, *T. affinis* has attracted attention of marine ecologists. Its geographic distribution, anatomy, physiology, behavior (cf. Marcus and Marcus 1960), ecology, population dynamics, and spatial distribution on macroalgae (cf. Braga 1983, Széchy and Paula 2000, Pereira et al. 2010) have been studied. Relationships of this species with other seagrasses and macrophyte species also have already been recorded. Bandel and Wedler (1987) observed the common presence of *T. affinis* associated with *Syrigodium filiforme* Kützing and *Thalassia testudinum* Banks and Sol. ex K.D. Koenig, in Caribbean Sea (Colombia). Pereira et al. (2010) did not observe a clear pattern of seasonal variation of *T. affinis* in the macroalgae *Sargassum* spp. At the studied *H. wrightii* meadow, correlations and variances of descriptors indicated explosion of *T. affinis* during rainfall, when doubled its density. Furthermore, correlations between *T. affinis* abundance and *H. wrightii* biomass also showed that this macrophyte were the main substrate for this gastropod, even considering secondary contribution of *H. musciformis* as substrate for all molluscan fauna.

This epiphyte allowed the maintenance of the molluscs when the seagrass biomass decreased, during the dry season. The complexity of stems provides habitat availability, protection against predators and hydrodynamic, and retains food particles, increasing abundance and density of fauna (Hall and Bell 1988, Leite and Turra 2003, Chemello and Milazzo 2002, da Rocha et al. 2006, Pereira et al. 2010). The algae also provide an excellent microhabitat for molluscs, rather than as a source of food (Ávilla 2003). The architecture of *H. musciformis* operates as an environmental extension for establishment of species and retains particles necessary for feeding (Hall and Bell 1988, Leite and Turra 2003, da Rocha et al. 2006). The algae architecture may be more important for abundance of fauna than its biomass (Pereira et al. 2010). Studying effects of the architecture of five algae species on abundance, richness and diversity of molluscan fauna, Chemello and Milazzo (2002) observed that greater structural complexity, greater abundance and diversity species. Similarly to present study, Leite and Turra (2003) noted positive correlations between abundance of fauna and biomass of *Sargassum* sp., and also between abundance and *Sargassum* + *Hypnea* complex. This may explain the correlations of epiphyte biomass both to the density of molluscs and variances of the samples.

Some studies observed synchronism between biomass of seagrasses and density of molluscan communities (Mukai 1976, Alves and Araújo 1999, Barros et al. in press), and between the life cycle of molluscs and seasonal fluctuations of macrophytes (Toyohara and Nakaoka 1999). Spatiotemporally, relationships among molluscs and seagrasses were observed through variations according to the seasonality (Alves and Araújo 1999, Barros et al. in press), above and below strata (Barros et al. in press) and depth (Creed and Kinupp 2011) of *H. wrightii*. Mainly in the aboveground, positive correlations between community descriptors and wind speed may be related to windy influences on hydrodynamic, which may causes horizontal transport of organisms (i. e. algae and fauna) from adjacent areas for inside the meadow. Belowground, however, seemed more stable than aboveground as seem in other studies on seagrasses (Gambi et al. 1995) and associated fauna (Williams and Heck 2001), in these ecosystems. Meanwhile, the shallow part of the sediment considered in this study (10cm), due to the presence of reef rocks under the meadow, may be a part of the sediment more vulnerable to hydrodynamic.

Barros and Rocha-Barreira (2009/2010) observed vertical and temporal segregation of benthic macrofauna, but these authors suggested, in addition to seagrass effects, influences of environmental variables on the ecosystem. In fact, the biomass of *H. wrightii* was not the exclusive factor to cause a vertical segregation of the species. Barros et al. (in press) observed that chiton population, commonly found in rocky environments, were found in *H. wrightii* established on reef rocks. As well as all molluscan fauna studied here, these authors verified that chiton species were more abundant during the rainy season, and recorded *Ischnochiton niveus* Ferreira, 1987 for the first time in Brazil, in the root system of these meadow.

Although the molluscan fauna had been qualitatively similar in both strata, the analyses showed temporal variation due to environmental influences, through of weak, direct Spearman correlations with variables associated with the rainfall, probably because of their positive influence on *H. wrightii*. Also, multivariate analyses showed vertical segregation of strata (when considered macrophytes influences).

Significant influences of environmental variables on the samples variance and vertical segregation were found only when the macrophytes biomasses were considered as environmental variables. This indicates that, although some species have occurred on both strata and the environment has significant effects on the molluscan community, the seagrasses caused different effects in each stratum. As observed by Nakaoka et al. (2001), studying epifaunal communities in meadows of *Zostera marina* L. and *Zostera caulescens* M., variations in these communities is not determined by a single or some strong external factors, but by complex interactions of multiple factors operating differently for each component species.

Thus, although is considered influences both of the environment and macrophytes on molluscs, seagrasses were the main substrate for this community and were also determinant for the spatial and temporal distributions of the species. This show the importance of seagrasses for this community structure, even is evidenced the secondary role for the temporal distribution of aboveground species played by epiphytes. The occurrence of some species in both strata, and species out of their original stratum, may have been influenced by the shallow part of the sediment considered in this study, low values of *H. wrightii* biomass, and strong influences of external factors on the meadow. Thus, besides environmental influences on molluscan fauna, these species reflected also seasonal changes of the seagrass, showing that damages on these meadows reflect even at lower levels of the marine food web.

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RESUMO

Este estudo observou as distribuições espaciais e temporais de moluscos em um prado de *Halodule wrightii*, verificando se eles respondem satisfatoriamente a mudanças sazonais neste ecossistema. Vinte e quatro espécies foram identificadas. Os quítons foram raros, os bivalves tiveram o maior número de espécies (11), seguidos pelos gastrópodes (9), que constituíram também a classe mais abundante (73%). Todas as classes foram mais abundantes no extrato subterrâneo. A espécie mais comum foi *Tricolia affinis*, especialmente na parte aérea. A ocorrência de algumas espécies em ambos os estratos ou fora do estrato esperado pode ter sido influenciada pela rasa camada de sedimento considerada neste estudo, hidrodinâmica e baixa biomassa do prado estudado. De acordo com análises univariadas e multivariadas, apesar dos descritores dos moluscos terem sido relacionados a variáveis associadas à estação chuvosa, as angiospermas marinhas tiveram um importante papel sobre as variações sazonal e vertical da malacofauna. A biomassa da epífita *Hypnea musciformis* foi relacionada às variações temporais das espécies do extrato aéreo, indicando seu papel secundário para esta comunidade. Os moluscos foram sensíveis a variações ambientais e refletiram também as mudanças sazonais da angiosperma, mostrando que prejuízos sobre estes prados refletem até mesmo nos menores níveis da teia trófica destes ecossistemas.

Palavras-chave: comunidades bentônicas, *Hypnea musciformis*, teia trófica marinha, nordeste do Brasil, angiospermas marinhas, *Tricolia affinis*.

REFERENCES

ALVES MS AND ARAÚJO MJG. 1999. Moluscos associados ao fital *Halodule wrightii* Ascherson na ilha de Itamaracá-PE. Trabs Oceanogr 27(1): 91-99.

ÁVILLA S. 2003. The littoral molluscan (Gastropoda, Bivalvia and Polyplacophora) of São Vicente, Capelas (São Miguel Island, Azores): ecology and biological associations to algae. Iberus 21 (1):11-33.

BANDEL K AND WEDLER E. 1987. Hydroid, Amphineuran and Gastropod Zonation in the littoral of Caribbean Sea, Colombia. Senckenbergiana Marit 19(1/2): 1-129.

BARROS KVS, JARDIM J AND ROCHA-BARREIRA CA. IN PRESS. Ecological observations on Polyplacophora in a *Halodule wrightii* Ascherson meadow and new records for Northeast and Brazilian coast. Rev Nord Zool, 20 p.

Barros KVS and Rocha-Barreira CA. 2009/2010. Caracterização da dinâmica espaço-temporal da macrofauna bentônica em um banco de *Halodule wrightii* Ascherson (Cymodoceaceae) por meio de estratificação. Rev Nord Zool 4(1): 73-81.

Barros KVS, Rocha-Barreira CA and Magalhães KM. 2013. Ecology of Brazilian seagrasses: Is our current knowledge sufficient to make sound decisions about mitigating the effects of climate change? Iheringia Sér Bot 68(1): 155-170.

Braga RAP. 1983. Participação de *Tricolia affinis* C. B. Adams, 1850 (Mollusca: Gastropoda) na comunidade dos animais vágeis associados às macroalgas dos recifes de Piedade (PE). Anais Soc Nord Zool 1(1): 259-269.

Casares FA and CREED JC. 2008. Do Small Seagrasses Enhance Density, Richness, and Diversity of Macrofauna? J Coastal Res 243: 790-797.

Chemello R and Milazzo M. 2002. Effect of algal architeture on associated fauna: some evidence from phytal molluscs. Mar Biol 140: 981-990.

Clarke PJ and Ward TJ. 1994. The response of southern hemisphere saltmarsh plants and gastropods to experimental contamination by petroleum hydrocarbon. J Exp Mar Biol Ecol 175: 43-57.

Creed JC and Kinupp M. 2011. Small scale change in mollusk diversity along a depth gradient in a seagrass bed off Cabo Frio, (Southeast Brazil). Braz J Oceanogr 59(3): 267-276.

Corbisier TN. 1994. Macrozoobentos da Praia do Codó (Ubatuba, SP) e a presença de *Halodule wrightii* Ascherson. Bol Inst Ocean 42: 99-111.

Da Rocha CMC, Venekey V, Bezerra TNC and Souza JRB. 2006. Phytal marine nematode assemblages and their relation with the macrophytes structural complexity in a Brazilian tropical rocky beach. Hydrobiologia 553: 219-230.

Duarte CM, Marbà N and Santos R. 2004. What may cause loss of seagrasses? In: BORUM J ET AL. (Eds), European Seagrasses: an introduction to monitoring and management, Denmark: Monitoring and Management of European Seagrass Beds, p. 24-32.

Fernandes MLB, Barros KVS, Silva AKP, Andrade RM and Chaves AC. 2006. Mollusca associados a macroalgas de costões rochosos do litoral sul de Pernambuco. Cad Fafire 4: 29-35.

Fong CW, Lee SY and Wub RSS. 2000. The effects of epiphytic algae and their grazers on the intertidal seagrass *Zostera japonica*. Aquat Bot 67: 251-261.

Gambi MC, Giangrande MA, Martinelli M and Chessa LA. 1995. Polychaetes of a *Posidonia oceanica* bed of Sardinia (Italy): spatial and seasonal distribuition and feeding guilding analysis. Sci Mar 59: 129-141.

Garcia AM and Vieira JP. 1997. Abundância e diversidade da assembleia de peixes dentro e fora de uma pradaria de *Ruppia maritima* L., no estuário da Lagoa dos Patos (RS-Brasil). Atlântica 19: 161-181.

Garcia AM, Vieira JP, Bemvenuti CE and Geraldi RM. 1996. Abundância e diversidade de crustáceos decápodos dentro e fora de uma pradaria de *Ruppia maritima* L. no estuário da Lagoa dos Patos (RS – Brasil). Nauplius 4: 113-128.

García EM and Meneses GM. 2000. Moluscos. In: ESPINO GL, PULIDO SH AND PÉREZ JLC; Organismos Indicadores de la calidad del agua y de la contaminación (Bioindicadores). Primeira edição. San Rafael: Plaza Y Valdés, S.A. e C. V. Editora, México, p. 309-403.

Hall MO and Bell SS. 1988. Response of motile epifauna to complexity of epiphytic algae on seagrass blades. J Mar Res 46: 613-630.

Hemminga MA and Duarte CM. 2000. Seagrass Ecology. Cambridge University Press, Cambridge.

Hootsmans MJM and Vermaat JE. 1985. The effect of periphyton-grazing by three epifaunal species on the growth of *Zostera marina* L. under experimental conditions. Aquat Bot 22: 83-88.

Howard RK and Short FT. 1986. Seagrass growth and survivorship under the influence of epiphyte grazers. Aquat Bot 24: 287-302.

INPE - Instituto Nacional de Pesquisas Espaciais. 2006/2007. Base de dados de precipitações pluviométricas, ventos e ondas. http://www.cptec.inpe.br/ (Acessed August 1, 2007).

Jensen KR. 1983. Further notes on the ecology and systematic of *Elysia serca* Marcus (Opisthobranchia, Ascoglossa). J Mollus Stud 12: 69-72.

Jernakoff P and Nielsen J. 1997. The relative importance of amphipod and gastropod grazers in *Posidonia sinuosa* meadows. Aquat Bot 56: 183-202.

Köppen W. 1948. Climatologia: un estudo de los climas de la Tierra. Trad. Pedro R. H. Perez. Fondo de Cultura Econômica, México, 479 p.

Lee SY, Fong CW and Wu RSS. 2001. The effects of seagrass *Zostera japonica* canopy structure on associated fauna: a study using artificial seagrass units and sampling of natural beds. J Exp Mar Biol Ecol 259: 23-50.

Leite FPP and Turra A. 2003. Temporal variation in Sargassum Biomass, *Hypnea* epiphytism and associated fauna. Braz Arch Biol Techn 46(4): 665-671.

Marcus E and Marcus E. 1960. On *Tricolia affinis* cruenta. Bol Fac Fil Ciênc Let, USP 23: 171-211.

Marbà N, Cebriàn J, Enrìquez S and Duarte CM. 1996. Growth patterns of western Mediterranean seagrasses: species-specific responses to seasonal forcing. Mar Ecol Prog Ser 133: 203-215.

Morais JO. 1980. Aspectos do transporte de sedimentos no litoral do município de Fortaleza, estado do Ceará, Brasil. Arq Ciênc Mar 20(1/2): 71-100.

Mountouchet PGC. 1979. Sur la communauté des animaux vagiles associes à *Sargassum cymosum* C. Agardh, à Ubatuba, Etat de São Paulo, Brésil. Stud Neotr Fauna Env 18: 151-161.

Mukai H. 1976. Molluscan on the thalli of *Sargassum serratifolium*. Venus Jap J Malacol 35: 119-133.

NAKAOKA M, TOYOHARA T AND MATSUMASA M. 2001. Sesonal and between-substrate variation in mobile epifaunal community in a multiespecific seagrass bed of Otsuchi Bay, Japan. Mar Ecol 22(4): 379-395.

ORTH RJ ET AL. 2006. A global crisis for seagrass ecosystems. Bioscience 56: 987-996.

ORTH RJ, HECK KL AND MONTFRANS J. 1984. Faunal communities in seagrass beds: a review of influence of plant structure and prey characteristics on predator: prey relationships. Estuaries 7(4): 339-350.

PEREIRA PHC, BIASI PC AND JACOBUCCI GB. 2010. Dinâmica populacional e distribuição espacial de *Tricolia affinis* (Mollusca: Gastropoda) associados a *Sargassum* spp. no litoral norte de São Paulo. Rev Bras Zooc 12(1): 7-16.

PHILIPPART CJM. 1995. Effect of periphyton grazing by *Hydrobia ulvae* on the growth of *Zostera noltii* on a tidal flat in the Dutch Wadden Sea. Mar Biol 122: 431-437.

PHILLIPS RC. 1992. The seagrass ecosystem and resources in Latin America. In: SEELINGER U (Ed), Coastal plant communities of Latin America, San Diego: Academic Press, p. 108-121.

RIOS EC. 1994. Seashells of Brazil. 2nd ed., Rio Grande: Fundação Universidade do Rio Grande, 368 p.

ROSA LC AND BEMVENUTI CE. 2007. Seria a macrofauna bentônica de fundos não consolidados influenciada pelo aumento na complexidade estrutural do habitat? O caso do estuário da Lagoa dos Patos. Braz Journ Aquat Sci Technol 11(1): 51-56.

RUEDA JL AND SALAS C. 2007. Trophic dependence of the emerald neritid *Smaragdia viridis* (Linnaeus, 1758) on two seagrasses from the European coasts. J Mollus Stud 73: 211-214.

SÁNCHEZ-MOYANO JE, ESTACIO FJ, GARCÍA-ADIEGO EM AND GARCÍA-GÓMEZ JC. 2000. The molluscan epifauna of the alga *Halopteris scoparia* in southern Spain as a bioindicator of coastal environmental conditions. J Mollus Stud 66: 431-448.

SHORT FT AND NECKLES HA. 1999. The effects of global climate changes on seagrasses. Aquat Bot 63: 169-196.

SZÉCHY MTM AND PAULA EJ. 2000. Padrões estruturais quantitativos de bancos de *Sargassum* (Phaeophyta, Fulales) do litoral dos estados do Rio de Janeiro e São Paulo, Brasil. Rev Bras Bot 23: 17.

TOYOHARA T AND NAKAOKA MAK. 1999. Population dynamics and reproductive traits of phytal gastropods in seagrass bed in Otsuchi Bay, northeastern Japan. Mar Ecol 20(3-4): 273-289.

VAN MONTFRANS J, ORTH RJ AND VAY SA. 1982. Preliminary studies of grazing by *Bittium varium* on eelgrass periphyton. Aquat Bot 14: 75-89.

WILLIAMS SL AND HECK KL. 2001. Seagrass community ecology. In: Bertness SDG and Hay ME (Eds), Mar Com Ecol. Sinauer Associates Inc., Sunderland, p. 317-338.

ZIMMERMAN RC, KOHRS DG AND ALBERTE RS. 1996. Top-down impact through a bottom-up mechanism: the effect of limpet grazing on growth, productivity and carbon allocation of *Zostera marina* L. (eelgrass). Oecologia 107: 560-567.