



Research papers

Macrofauna associated with the brown algae *Dictyota* spp. (Phaeophyceae, Dictyotaceae) in the Sebastião Gomes Reef and Abrolhos Archipelago, Bahia, Brazil

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ARTICLE INFO

Available online 12 September 2013

Keywords:

Abrolhos

Brazil

Dictyota

Phytoplankton

Spatial distribution

Temporal distribution

ABSTRACT

The taxonomic richness and distributional patterns of the macrofauna associated with the algae genus *Dictyota* from the Abrolhos Bank (Eastern Brazilian coast) are analyzed. Macrofauna comprised a total of 9586 specimens; a complete faunal list of the most abundant taxa (Crustacea, Polychaeta and Mollusca, accounting for 95.6%) resulted in 64 families and 120 species. Forty six species are registered for the first time for the Abrolhos Bank, of which 3 are also new for the Brazilian coast. The most abundant families were Ampithoidae amphipods (with *Ampithoe ramondi* as the main faunal component), Janiridae isopods, Rissoellidae gastropods and Syllidae polychaetes. Comparisons were made between summer and winter periods and among sites from Sebastião Gomes Reef, near the coast, and from Siriba Island, in the Abrolhos Archipelago, away from the mainland. Algae size was lower in the summer, when faunal density was higher, suggesting a possible effect of grazing. Macrofaunal communities were significantly different among sites and periods. Coastal and external communities were markedly different and winter had the greatest effects on the fauna. Environmental conditions related to sediment type and origin and turbidity appear to be a good scenario for our macrofauna distribution results.

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1. Introduction

The Abrolhos Bank shelters the largest and most diverse reefal complex of the South Atlantic (Leão, 1982; Dutra et al., 2005) presenting high levels of coral endemism (Leão and Dominguez, 2000). Due to the high biodiversity and the uniqueness of its biological assemblages and reef formations, the first National Marine Park of Brazil was established in Abrolhos in 1983 (Dutra et al., 2005). Most studies on the biodiversity of this area have focused primarily on conspicuous taxa such as corals, fishes, birds and whales. Nonetheless, broadening research spectra in the area is a matter of high interest to scientists as well as to decision-makers given its biological importance and the current concern on the impact generated by climate change and human activities (Moura et al., 2013).

During the last decades, a rise in the economic activities has been witnessed in this marine region and its continental border, including tourism, mariculture, marine transportation, dredging activities, deforestation and monoculture practices (Leão and Dominguez, 2000). In addition, future actions may also include

oil exploitation. These activities have led to increased sedimentation rates (Silva et al., 2013), overfishing and other impacts on marine communities, such as breakage of coral heads and disturbance of sea grass beds, especially on shallow water reefs (Leão et al., 1993).

One of the major concerns for the long-term maintenance of the mosaic of marine and coastal ecosystems of the Abrolhos Bank is the insufficient representation of key habitats in the existing network of Marine Protected Areas (Dutra et al., 2005). This scenario makes Abrolhos a priority area for scientific studies, especially for biodiversity, that provide background information for conservation and management programs (Leão et al., 1993; Moura et al., 2013). Benthic studies play a key role since information on the present diversity and standing stock is urgently needed as baseline data for the evaluation of upcoming changes (Jackson et al., 2001; Montiel et al., 2011).

Seaweeds constitute one of the most abundant elements of the Abrolhos' shallow reefs, particularly over inter-reefal bottoms (Leão, 2002). Brown macroalgae may cover more than 90% of coastal reefs (Amado-Filho et al., 1997) and Phaeophyceae richness in the region is disproportionately high compared to other Brazilian sites (Paula et al., 2003; Torrano-Silva and Oliveira, 2013). Dictyotaceae is one of the most diverse families of seaweeds in Abrolhos (Figueiredo, 2005) and species of the genus *Dictyota* are recognized among the most abundant, varying from approximately 18% (August 1995) to 15% (April 1996) of the total biomass of macroalgae found between Siriba

Abbreviations: Sebastião Gomes Reef, SG

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and Redonda Islands in the Archipelago (Paula et al., 2003). The genus comprises about 70 species worldwide (Solé and Foldvik, 2003) and at least eight of them are confirmed in the sampled area, but caution is required in the identification due to phenotypic plasticity (Torrano-Silva and Oliveira, 2013). *Dictyota* is a chemically-defended seaweed (Cronin and Hay, 1996a; Hay et al., 1987a, 1987b; Paul et al., 2001) and usually thrives in overfished reefs, being responsible for allelopathic damage to corals (Rasher and Hay, 2010).

Phytoplankton communities encompass macrophytes and the associated fauna. Major effects of large herbivores such as fishes and sea urchins on benthic primary producers are already well documented (see Burkepile and Hay, 2006), and increasing evidence on the interaction between algae and their herbivorous epifauna suggests that top-down control by mesograzers (smaller grazers such as amphipods and gastropods) may regulate the size, growth and competitors of the host seaweed as well (Duffy and Hay, 2000; Newcombe and Taylor, 2010). Without herbivory, there would be no control over algal predominance, which could severely affect the habitat (Hay, 1997; Moksnes et al., 2008; Rasher and Hay, 2010). Establishing and understanding such relationships among these shallow reefs' elements should be useful for future impact assessments in this ecosystem (Jackson et al., 2001).

Although the faunal composition of phytoplankton communities at greater taxonomic levels is well known (Christie et al., 2007; Edgar, 1983; Gibbons and Griffiths, 1986; Leite et al., 2007; Tanaka and Leite, 1998), algal species along with a number of abiotic factors determine species diversity in each community. The morphological structure and the chemical components of the algae are relevant in habitat choice by the associated species, as different animals prefer distinct substrates (Bates, 2009; Christie et al., 2007; Hacker and Steneck, 1990; Norderhaug, 2004). Environmental factors such as water temperature, sediment particles in the water, hydrodynamics and organic matter are also frequently pointed as directly or indirectly correlated to phytoplankton macrofauna composition and distribution (Jacobucci et al., 2009; Ramos et al., 2010).

Major studies and focused data collections for benthic higher taxa such as Crustacea (Young, 1998), Mollusca (Ríos, 2009) and Polychaeta (Amaral et al., 2012) have been carried out for the entire Brazilian coast, nonetheless, the Abrolhos region has been poorly sampled until now. This study is part of a large sampling program that included many Brazilian scientific groups investigating geological, physical, chemical and biological aspects of the region, providing an overview of the Abrolhos Bank never seen before. In particular, this is the first work to assess data on the biodiversity of phytoplankton communities from Abrolhos. The aim of this study is to describe the diversity of the macrofauna associated with the brown seaweed *Dictyota* spp. from a coastal reef and an offshore rocky substrate from the Abrolhos Bank. In order to characterize the temporal structure of the community, both areas were sampled during both a summer and a winter season.

2. Materials and methods

2.1. Study area

The Abrolhos Bank is a 46,000 km² projection of the Brazilian continental shelf, situated between the municipalities of Prado (Bahia State) and Regência (Espírito Santo State) (Dutra et al., 2005) (between the coordinates 17°20'–19°50'S and 37°90'–39°50'W). Mangroves, meadows and macroalgal banks border the coastline while offshore elements include submerged reefs, tidal reef flats, and five volcanic islands that compose the Abrolhos Archipelago (Leão et al., 2003). The reefal ecosystem of Abrolhos includes two arcs that are almost parallel to the coast, the coastal arc and the external arc (Leão, 2002; Leão and Kikuchi, 2001), affected mainly by processes from the mainland and

by the waters of the Brazil Current, respectively (Leipe et al., 1999). Constituting the coastal arc, Sebastião Gomes is a submerged reef with a flattened, wave-eroded top that is exposed during low tides. Seaweeds, gorgonians, and mixed communities also including scleractinian coral colonies thrive on its shallow borders (Leão and Kikuchi, 2001; Leão, 2002). The external arc surrounds the five volcanic islands of the Abrolhos Archipelago, among them the 300 m × 100 m Siriba Island. It is surrounded by a rocky shore and scleractinian coral colonies and functions as substrate to other reef species (Leão and Kikuchi, 2001; Leão, 2002; Villaça and Pitombo, 1997). In the shallow, sheltered areas, a diversified seaweed community dominates the rocky bottom (Torrano-Silva and Oliveira, 2013).

Austral summer and winter in Abrolhos are markedly different, with northeast winds dominating in the former and a more variable wind flow and rainy period during the latter (Teixeira et al., 2013). The southward Brazil Current carries warm, oligotrophic waters to the region, and surface temperatures vary from 27 °C to 28 °C from January to April and 24 °C to 25 °C from July to October (Leão, 1982; Souza et al., 2007), reaching 23 °C during winter cold front events (Dutra et al., 2005). Storms and cold winter winds from south suspend bottom sediments, increasing turbidity and sedimentation rates (Dutra et al., 2006). The sediments around coastal arc reefs are abundant and predominantly terrigenous, contrasting with the biogenic carbonate sediment in the adjacent areas of the external arc reefs (Dutra et al., 2006; Silva et al., 2013).

2.2. Sampling

Two 12-day data collections were performed from a catamaran in the summer (January) and the winter (September) of 2008, around the Sebastião Gomes Reef (SG) and Siriba Island. Samples were collected from three sites on the Sebastião Gomes Reef: North Reef (17°54'08.82"S, 39°07'39.24"W), West Reef (17°54'49.26"S, 39°08'43.08"W) and South Reef (17°55'22.62"S, 39°07'54.48"W). The fourth sample site was located at Portinho da Siriba (17°58'24.72"S, 38°40'27.36"W), a sheltered area with a rocky shoreline just north of the Siriba Island coastline (Fig. 1).

Algae were sampled by a free diver at depths of approximately 2 m. At each site, 5 fronds (replicates) of *Dictyota* spp. were collected in individual plastic bags, in which they were sealed along with a 4% buffered seawater formaldehyde solution to fix the material. In the laboratory, samples were washed through a 100 µm mesh sieve, retaining the adult and juvenile macrofauna. Although macrofauna is defined as the pool of organisms retained in a 500 µm sieve, a fraction of juveniles is usually lost, compromising the study of population dynamics (Bachelet, 1990). Using 200 µm and 100 µm mesh sizes also results in a better representation of both Polychaeta and Isopoda, important elements of phytoplankton communities, and of species richness and abundance in general (Tanaka and Leite, 1998). This allowed the collection of a representative sample of motile animals; sessile taxa were less well represented, but were not the focus of the present study.

The fauna was counted and identified under stereo and light microscopes and stored in 70% ethanol. The identification encompassed all the taxa found in higher taxonomic levels. The most abundant taxa, Crustacea, Polychaeta and Mollusca, were identified to species or the lowest possible taxonomic level. Faunal densities are reported as number of individuals per wet weight of the fronds, measured with a 0.1 mg precision weighing scale after placing them for 2 min in a salad spinner to remove excess water. The algae were then stored for future studies in 4% buffered formaldehyde solution.

2.3. Data analyses

Diversity indices, such as Shannon diversity (H') and Pielou's evenness (J'), along with total number of species (S), were used

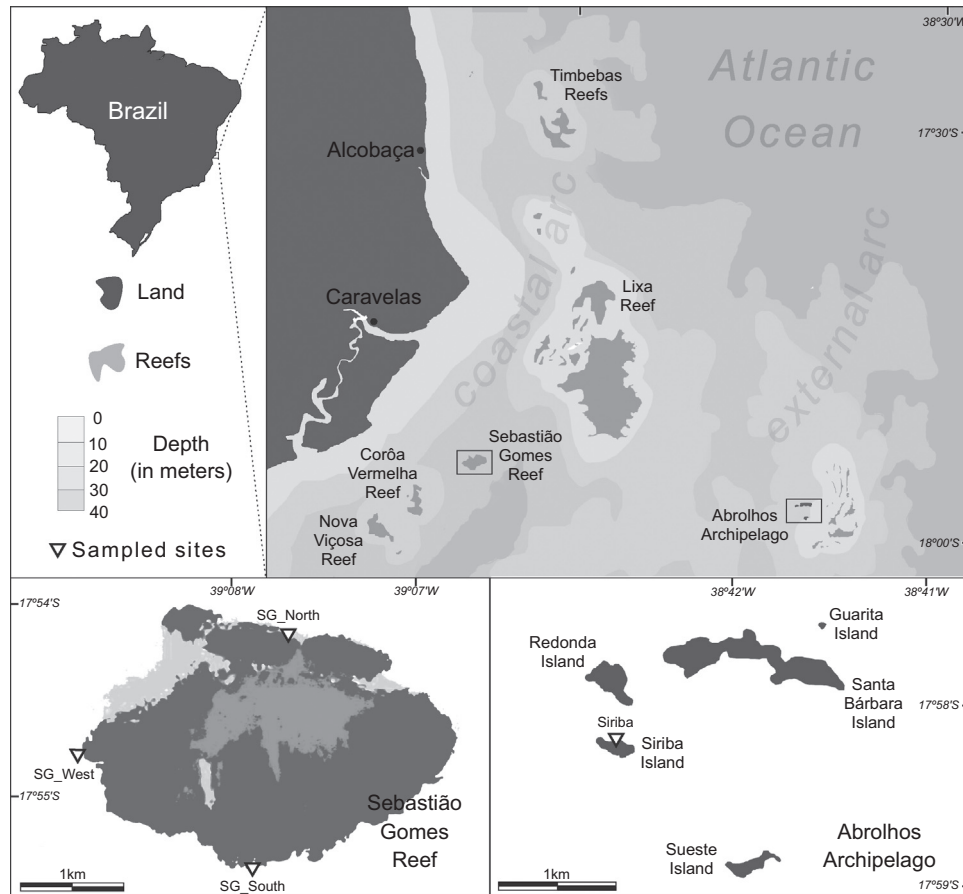


Fig. 1. Abrolhos Bank on the Brazilian coast and the four sample sites, indicated by the symbol ∇ (SG=Sebastião Gomes Reef).

to measure some community structure attributes within and between sites and seasons (Clarke and Warwick, 2001). The significance of differences in algae wet weight and macrofauna density among periods and sites was tested using two-way analysis of variance based on permutation methods (PERMANOVA) in the PERMANOVA computer program (Anderson, 2005).

Data for all multivariate analyses were square-root transformed. Analysis of similarities (ANOSIM) was employed to determine whether the macrofaunal assemblages from sites and periods were significantly different from each other. Results were expressed with non-metric multidimensional scaling (n-MDS) ordination technique (Kruskal and Wish, 1978) based on Bray–Curtis similarity index. The SIMPER procedure (Clarke, 1993) was performed in order to determine which taxa were responsible for similarities within and dissimilarities between assemblages. This analysis also compares pairs of samples presenting the average contribution of the main taxa to the dissimilarities among them. Thus, if a taxon shows a high contribution within a set of samples, and low contribution in the others, it may be considered a good discriminator taxon (Clarke and Warwick, 2001). Multivariate analyses were performed in PRIMER 6.0 (Clarke and Gorley, 2006).

3. Results and discussion

3.1. Algae biomass fluctuation

Three alga species were identified, *Dictyota ciliolata*, *D. mertensii* and *D. pinnatifida*, all of which are morphologically similar and produce diverse metabolites that function as defense against feeding by many herbivores (Cronin and Hay, 1996b; Marques

Table 1

Two-way analysis of variance (PERMANOVA) of algae wet weight (g) and macrofaunal density (ind/g) from fronds of *Dictyota* spp. from different sites and periods (SG=Sebastião Gomes Reef).

	Df	SS	MS	F	P
Algae wet weight					
Period	1	5362.1	5362.1	14.8	*
Site	3	6292.7	2097.6	5.8	*
Period \times site	3	6072.1	2024.0	5.6	*
Residuals	32	11,571.6	361.6		
Fauna density					
Period	1	6631.3	6631.3	18.0	*
Site	3	5761.9	1920.6	5.2	*
Period \times site	3	7935.0	2645.0	7.2	*
Residuals	32	11,787.0	368.3		

* $P < 0.001$.

et al., 2006; Torrano-Silva and Oliveira, 2013; Vallim et al., 2007). A single frond was posteriorly identified as *Dictyopteria plagiogramma*; the data were reanalyzed without this sample and no differences were found in the results.

Wet weight of *Dictyota* fronds was significantly different among samples from distinct periods and sites (Table 1), being generally higher in the winter (Fig. 2). Seasonal distribution of seaweeds is characterized by dominance of brown algae in summer, *Dictyota* species being among the most important (Duffy and Hay, 2000). In reefs along the coast of Bahia, *Dictyota* species have been observed in both summer and winter, also dominating the algal community and presenting greater biomass and coverage area in the dry season than in the rainy September period (Costa Jr. et al., 2002; Marins et al., 2008; Paula et al., 2003).

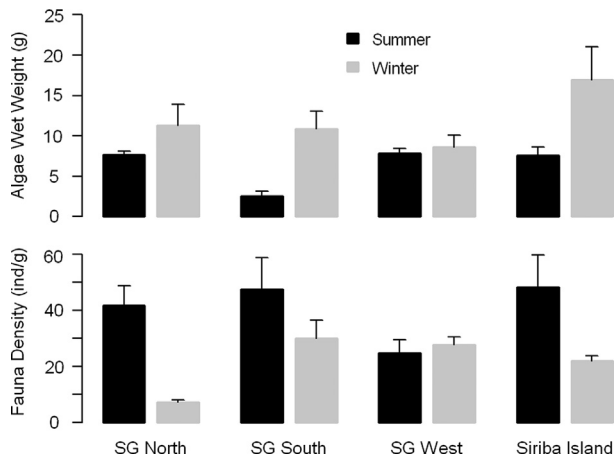


Fig. 2. Mean (+SE) values of algae wet weight (top) and macrofaunal densities (bottom) from fronds of *Dictyota* spp. from different sites and periods (SG=Sebastião Gomes Reef).

Experimental tests in Florida showed that disturbance leading to fragmentation and mortality, such as hydrodynamics or herbivory, is a strong influence over *Dictyota* (Yñiguez et al., 2010). Harsher environmental conditions in the Abrolhos region are more frequent in winter than in summer, including changes in wind direction, storms and higher water turbidity (Dutra et al., 2006; Teixeira et al., 2013). If these disturbances were the only phenomena regulating algal growth, then either a higher algal biomass in summer or only slight variation between seasons would be expected. However, algae size was larger in winter (Fig. 2), suggesting that pressures acting on this parameter were in favor of reducing it during summer.

Intense grazing pressures have been demonstrated to impact macrophyte fluctuation and specifically *Dictyota* (Duffy and Hay, 2000). Macrofaunal density was significantly higher in summer than winter (see Section 3.2 for further discussion on faunal density), which may imply an increased degree of grazing, exceeding the algae's capacity to endure mesograzers and hence affecting algal size.

Ampithoe longimana is known to choose and heavily graze on *Dictyota* over other algae (Duffy and Hay, 1991, 2000). As the main component of the macrofauna of this study is another species of the same genus, *Ampithoe ramondi*, it is possible that grazing pressures by this and other herbivorous mesograzers preferentially present in the summer played an important role in the algal size distribution. This is the case for the polychaete *Syllis* spp. (Fig. 3), genus that presents many species that feed on macroalgae (Giangrande and Licciano, 2000) and also for the polychaete *Platynereis dumerilii*, whose strong feeding preference for *Dictyota* was observed among ten species of algae (Hay et al., 1988). These and other species with similar feeding behavior may be functioning as important *Dictyota* regulators in the area.

Some other factors could be contributing to this significant algal biomass difference between periods, perhaps increasing algal frond size in the winter. Nutrient-rich waters brought to the surface by water mixing in the winter could stimulate *Dictyota* growth (Beach et al., 2006; Diaz-Pulido and Garzón-Ferreira, 2002). Nonetheless, it has been shown that herbivores have consistently stronger effects than nutrient enrichment for tropical macroalgae (Burkpile and Hay, 2006) and the contribution of natural processes to the observed seasonality in reef-associated macroalgae is not yet well defined. Bias associated with algal sampling is not expected even though some subjectivity is intrinsic to the collector. Sampling was manual and frond choice was dependent on the collector, which could theoretically cause a collector-dependent bias such as preferential collection of the biggest fronds, as they are more easily spotted. However, any

possible bias would be present in both periods and all four sites and therefore significant differences obtained in algae biomass could not be a result of a biased sampling.

Epifaunal abundance can be affected by fish predation and, by regulating the presence of mesograzers, invertivore fishes may even play a role in macroalgae performance (Moksnes et al., 2008; Pérez-Matus and Shima, 2010; Reynolds and Sotka, 2011). *Dictyota* is known as a chemically-defended seaweed against fishes (Hay et al., 1987a, 1987b), which turns it into a good choice of habitat for mesograzers (Christie et al., 2003, 2009; Duffy and Hay, 1991; Hay, 1997). Independently of the motivation behind habitat choice and although other factors also play a role in algae fluctuation, here we consider the hypothesis of grazing pressure by small herbivores as an important limiting factor for *Dictyota* growth.

3.2. Faunal density

Macrofaunal density was significantly different among sites and between periods and peaked in the summer (Table 1). It ranged from 7.3 ind/g (SG North, winter) to 51.1 ind/g (SG South, summer), with seasonal means of 21.7 ind/g in winter and 41.5 ind/g in summer (Fig. 2). Frequent resuspension events occur mainly in winter affecting shallow bottoms and sedimentation rates may double in coastal arc reefs in this period (Dutra et al., 2006). The lower density of organisms in winter could be the result of above-limit levels of suspended particles over the fronds of *Dictyota*, which could decrease the amount of surface area available for the recruitment and establishment of the epifauna and harm adult organisms that depend on filtration of the water for food acquisition. Bottom disturbance has already been shown to negatively affect the recruitment and vitality of corals (Dutra et al., 2006; Segal and Castro, 2011).

A total of 9586 specimens were collected (4803 in the summer, 4783 in the winter) within the four sampled sites. We found 9 higher taxa of marine invertebrates (Crustacea, Polychaeta, Mollusca, Cnidaria, Platyhelminthes, Nemertea, Enteropneusta, Ophiuroidea and Pycnogonida) from which only the most abundant (Crustacea, Polychaeta and Mollusca, accounting for 95.6% of the total or 9169 specimens) were identified to lower taxonomic levels and considered in subsequent analyses. The relative contribution of the most abundant and speciose taxa is presented in Table 2. A predominance of gammarideans, polychaetes and mollusks is typically found in phytal communities (Christie et al., 2007; Edgar, 1983; Gibbons and Griffiths, 1986; Leite et al., 2007; Ramos et al., 2010; Tanaka and Leite, 1998) and species of Ampithoidae such as the territorial and aggressive *Ampithoe ramondi* (Brawley and Adey, 1981) observed in our samples, are very common and often the dominant organisms on other algal species along the Brazilian coast (Jacobucci et al., 2009; Leite et al., 2007; Serejo and Licínio, 2002; Tanaka and Leite, 2003).

Syllidae was the most abundant polychaete family (64.6% of the polychaete fauna), followed by Sabellidae (18.4%). Syllidae presents a broad spectrum of types of feeding and reproduction and is the dominant polychaete family in many benthic communities, especially in coral reefs and macrophyte beds (Franke, 1999; Giangrande and Licciano, 2000; Rouse and Pleijel, 2001). The most conspicuous observation related to the polychaete assemblage was the greater number of Sabellidae, especially *Branchiomma patriota*, at Siriba Island than in SG (Fig. 3). Sabellids are tube-constructing polychaetes that filter water for particles. Reefs along the coastal arc of the Abrolhos Bank are subject to mainland processes, such as fluvial discharge and erosion of the coastline, to a greater extent than the external arc (Dutra et al., 2006; Silva et al., 2013). The conspicuous presence of *B. patriota* within the external arc could indicate better conditions for filter-feeding organisms in this area, which may highlight the species as a good discriminating taxon for

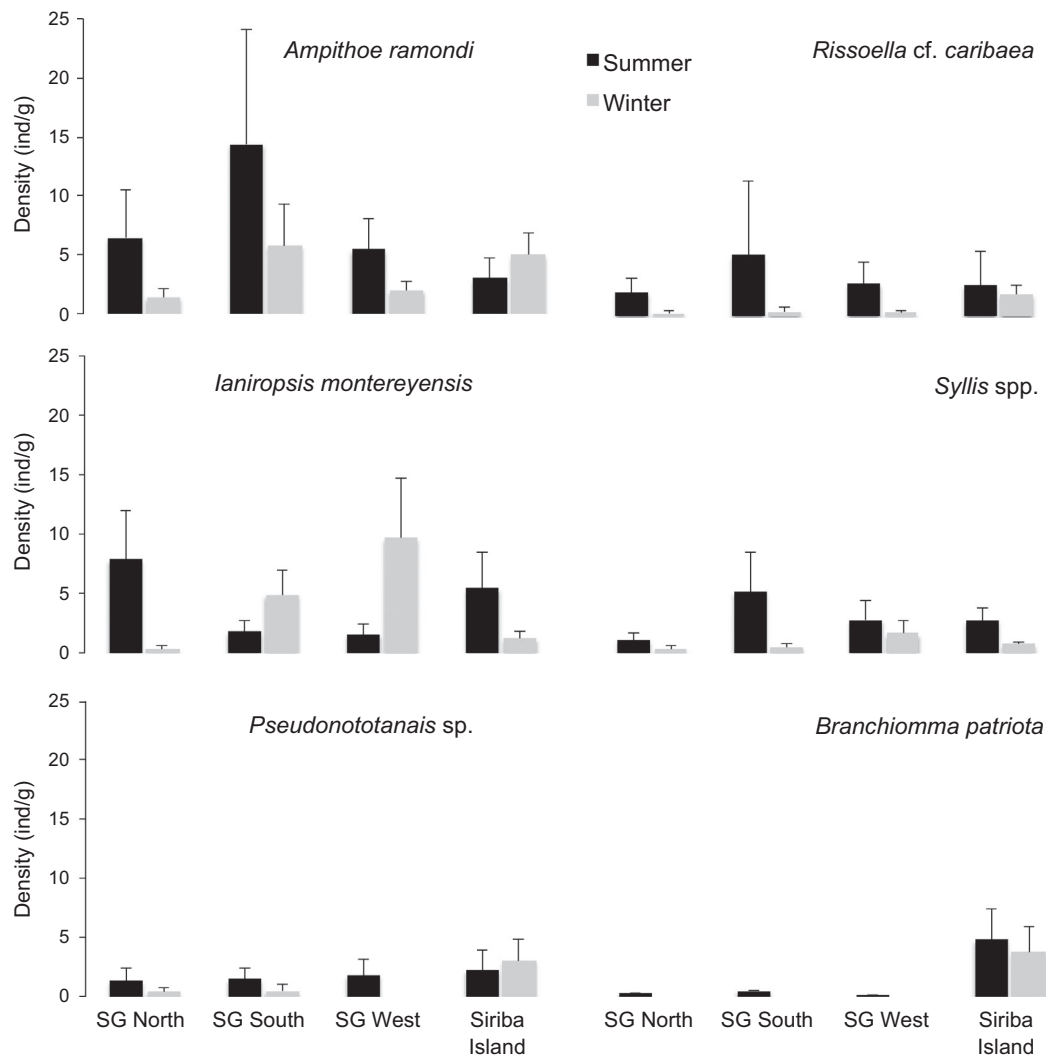


Fig. 3. Mean densities (\pm SD) of some of the most abundant and contributor species to similarities within and dissimilarities among samples of *Dictyota* spp. from different sites and periods (SG=Sebastião Gomes Reef).

turbidity conditions. More detailed studies of particular species may identify those that are good indicators of environmental water quality in future studies.

3.3. Taxonomic diversity and endemism

The identified specimens belonged to 64 families and 120 morphospecies, most of which are identified to species or genus (Table 3). Some species could not be identified and are possibly new to science. Total species richness varied from 37 (SG South, summer) to 61 (Siriba, summer), while the highest average species richness for both periods was found at Siriba Island (32.2 in summer, 26.6 in winter; Table 4). The Shannon diversity index was higher in Siriba in the summer and in SG North in the winter, as were the equitability values (Table 4).

While many previous studies on phytal communities have focused on different taxa identified to above-family levels (Bates, 2009; Christie et al., 2007; Tanaka and Leite, 2003) or on identifying species of single groups (Chemello and Milazzo, 2002; Jacobucci et al., 2009; Omena and Creed, 2004), here we present a detailed characterization of the macrofauna inhabiting fronds of *Dictyota* to the species level. To our knowledge, 46 of our 120 identified species are new records for the Abrolhos Bank, including 24 crustaceans, 19 polychaetes and 3 mollusks, and 3 of them are new for the Brazilian coast (Table 3). The only broad

survey of the Abrolhos Bank was performed in 2000 in soft bottoms (Dutra et al., 2005), when 23 crustaceans, 86 polychaetes and 36 mollusks had their geographic ranges extended to the area, besides the 27 new records for the country. The elevated number of new records reported herein is indicative of the gap still present in scientific knowledge about the Abrolhos fauna, and highlights the importance of biodiversity studies in different environments. Furthermore, 11 of our species appear to be endemic for Brazil (4 crustaceans, 5 polychaetes and 2 mollusks). Although many of the unidentified species may increase this number by potentially being new to science, current knowledge of the Abrolhos fauna indicates a low level of endemism, particularly for crustaceans and polychaetes (Paiva, 2005; Young and Serejo, 2005), whereas it is considered high for corals of the region (Laborel, 1969).

Voucher specimens were deposited in the Museu de Zoologia of the Universidade de São Paulo (MZUSP) in São Paulo, Brazil under the following numbers: MZUSP Crustacea 28541–29068; MZUSP Mollusca 113347–113369, 113492–113503; MZUSP Polychaeta 1501–1675.

3.4. The macrofaunal assemblages

The structure of the assemblages was distinct among sites and periods (ANOSIM: global $R=0.757$, $p=0.001$). Significant differences between the two seasons were observed for all sites

(pairwise tests with R values equal or greater than 0.756, $p=0.008$); the temporal gradient can be observed in the n-MDS

Table 2

The relative contribution of the most abundant and speciose taxa of the macrofauna associated with fronds of *Dictyota* spp. from different sites and periods (SG=Sebastião Gomes Reef). Special attention is given to data in bold: taxa with the highest abundances within a group or most speciose families.

Taxon	Number of families	Number of species	Percentage of total fauna (%)
Crustacea	27	48	67.3
Amphipoda	13	21	43.4
Caprellidea	1	3	1.0
Gammaridea	12	18	42.5
Ampithoidea		3	20.6
<i>Ampithoe ramondi</i>			15.9
Cumacea	1	1	0.4
Decapoda	3	8	0.2
Isopoda	10	12	17.1
Janiridae		1	14.2
<i>Ianiropsis montereyensis</i>			14.2
Tanaidacea	3	6	6.1
Mollusca	16	24	6.6
Gastropoda	13	20	6.4
Rissoellidae		1	5.4
<i>Rissoella cf. caribaea</i>			5.4
Polychaeta	21	48	21.8
Sabellidae		2	6.1
<i>Branchiomma patriota</i>			5.6
Syllidae		8	12.2
<i>Crubeosyllis</i> sp.			5.7
<i>Syllis</i> spp.			5.0
Terebellidae		9	0.9

Table 3

Species composition of the macrofauna associated to fronds of *Dictyota* spp. in the Sebastião Gomes Reef and Siriba Island, Bahia, Brazil. (*)=first report for Abrolhos; (**)=first report for Brazil; (•)=Occurrence found in non-published material, not included in the count of new records; (#)=Brazilian endemic (the Un. abbreviation stands for unidentified).

CRUSTACEA

Amphipoda

Caprellidae Leach, 1814

Hemiaegina minuta Mayer, 1890

Metaprotella sp.

*Pseudaeginella biscaynensis** (McCain, 1968)

Ampilochidae Boeck, 1871

*Ampilochus neapolitanus** Della Valle, 1893

Ampithoidea Stebbing, 1899

*Ampithoe divisura** Shoemaker, 1933

Ampithoe ramondi Audouin, 1826

Cymadusa filosa Savigny, 1816

Aoridae Walker, 1908

Aoridae sp.

Hyalidae Bulycheva, 1957

Hyale sp.*

Ischyroceridae Stebbing, 1899

*Erichthonius punctatus** (Bate, 1857)

Leucothoidae Dana, 1852

Leucothoe sp.

Lysianassidae Dana, 1849

*Bonassa brasiliensis** # Senna and Serejo, 2008

*Lysianopsis concavus** # Senna, 2007

Maeridae Krapp-Schickel, 2008

Elasmopus sp.

Quadrimeaera spp.

Melitidae Bousfield, 1973

*Dulichieilla anisochit** # (Krøyer, 1845)

Phliantidae Stebbing, 1899

Pariphinotus seclusus (Shoemaker, 1933)

Photidae Boeck, 1871

Gammaropsis sp.*

Photidae sp.*

Stenothoidae Boeck, 1871

*Stenothoe valida** Dana, 1852

Gammaridea sp.

Cumacea

Nannastacidae Bate, 1866

Nannastacidae spp.*

Decapoda

Epialtidae MacLeay, 1838

Acanthonyx sp.1

Acanthonyx sp.2

Epialtidae sp.

Hippolytidae Bate, 1888

Hippolyte sp.1

Hippolyte sp.2

Mithracidae Balss, 1929

Microphrys sp.1

Microphrys sp.2

Anomura sp.

Isopoda

Paranthuridae Menzies and Glynn, 1968

Colanthur sp.*

Paranthur sp.1*

Paranthur sp.2*

Paranthur sp.3*

Paranthur *urochroma** # Pires, 1981

Joeropsididae Nordenstam, 1933

Joeropsis sp.* •

Munnidae Sars, 1897

*Uromunna reynoldsi** (Frankenberg and Menzies, 1966)

Stenetriidae Hansen, 1905

Tristenium sp.**

Janiridae Sars, 1897

*Ianiropsis montereyensis*** Menzies, 1952

Cirolanidae Dana, 1852

Cirolana cf. parva Hansen, 1890

Sphaeromatidae Latreille, 1825

Cymodoce sp.

Cymodocella sp.*

(Fig. 4). The greatest differences among sites were observed between Siriba Island and Sebastião Gomes Reef as a whole, probably due to the higher species richness (Table 4) and different community composition of Siriba Island. Community structure differences based on distance from the coast and its environmental consequences, such as terrigenous sediment distribution and turbidity, have been observed for corals in Abrolhos as well (Segal and Castro, 2011).

Considering the differences in environmental conditions, especially in sediment type and turbidity, between the coastal and the external arcs (Dutra et al., 2006; Silva et al., 2013), it is plausible that the community structure in Siriba in the most turbulent period (winter) would be more similar to Sebastião Gomes in the less affected period (summer). This was observed in the n-MDS (Fig. 4) with the superposition of Siriba samples from the winter over samples from Sebastião Gomes in the summer. The density distribution of some species corresponded to this scenario. For example, both the distributions of the gastropod *Rissoella cf. caribaea* and the tanaid *Pseudonototanaia* sp. showed lower densities in the winter in Sebastião Gomes, but no decrease was evident at Siriba Island (Fig. 3).

Sebastião Gomes sites showed more similarity in the summer than in the winter (Fig. 4), when larger differences were observed between assemblages. This can be seen through cluster cut-off marks, which grouped replicates at the four winter sites distinctly from each other (Fig. 4), showing more consistency within these winter assemblages than among them.

The SIMPER procedure demonstrated that the most common faunal species explained the majority of both similarities and differences between the associated faunal communities among

Table 3 (continued)

CRUSTACEA

Tanaidacea

Leptocheliidae Lang, 1973

- Leptochelia* cf. *forresti* (Stebbing, 1896a)
Leptochelia dubia Krøyer, 1842
Pseudonototanaia sp.**

MOLLUSCA

Bivalvia

Condylocardiidae Bernard, 1896

- Carditopsis smithii* (Dall, 1896)

Crassatellidae Férussac, 1823

- Crassinella lunulata* (Conrad, 1834)

Tellinoidea sp.

Mytilidae Rafinesque, 1815

- Musculus lateralis* (Say, 1822)

Gastropoda

Caecidae Gray, 1850

- Meioceras nitidum* (Stimpson, 1851)

Cerithiidae Fleming, 1822

- Bittiolium varium* (Pfeiffer, 1840)

Columbellidae Swainson, 1840

- Astyrus lunata* (Say, 1826)
Columbella mercatoria (Linnaeus, 1758)
Parvanachis cf. *isabellei** (d'Orbigny, 1839)

Cylichnidae H. Adams and A. Adams, 1855

- Acteocina* cf. *lepta* Woodring, 1928

Cystiscidae Stimpson, 1866

- Granulina ovuliformis* (d'Orbigny, 1842)
Pugnus tarasconii# Rios, 2009

POLYCHAETA

Amphinomidae Savigny in Lamarck, 1818

- Eurythoe complanata* (Pallas, 1766)

Arenicolidae Johnston, 1835

- Branchiomaldane* sp.*

Capitellidae Grube, 1862

- Decamastus* sp.*

Chrysopetalidae Ehlers, 1864

- Chrysopetalum occidentale* Johnson, 1897

Cirratulidae Carus, 1863

- Cauleriella* sp.*
Chaetozone sp.1
Chaetozone sp.2

Dorvilleidae Chamberlin, 1919

- Dorvillea* sp.*
Ophryotrocha sp.

Eunicidae Berthold, 1827

- Eunice insularis*# Nogueira, Steiner and Amaral, 2001
Lysidice ninetta Audouin and Milne-Edwards, 1833
Nematonereis schmarda McIntosh, 1885

Hesionidae Grube, 1850

- Hesionidae un.

Lumbrineridae Schmarda, 1861

- Lumbrineris inflata* Moore, 1911
Lumbrineris sp.
Lumbrineris tetraura (Schmarda, 1861)

Nereididae Blainville, 1818

- Nereididae juvenile
Nereis sp.
Platynereis cf. *dumerilii* (Audouin and Milne Edwards, 1834)
Nereididae epitokes

Opheliidae Malmgren, 1867

- Ophelia* cf. *acuminata** Örsted, 1843

Orbiniidae Hartman, 1942

- Proscoplos* sp.*
Proscoplos sp.1*
Scoloplos rubra (Webster, 1879)

Oweniidae Rioja, 1917

- Galathowenia* sp.*

Pholoidae Kinberg, 1858

- Pholoe minuta** (Fabricius, 1780)

Parapseudidae Gutu, 1981

- Parapseudes* sp.
Tanaidomorpha sp.

Metapseudidae Lang, 1970

- Synapseudes* sp.*

Fissurellidae Fleming, 1823

- Fissurellidae sp.

Litiopidae Gray, 1847

- Litiopa melanostoma** Rang, 1829

Phasianellidae Swainson, 1840

- Eulithidium affine* (C. B. Adams, 1850)
Eulithidium bellum (M. Smith, 1937)

Pyramidellidae Gray, 1840

- Pyramidellidae sp.1
Pyramidellidae sp.2

Rissoellidae Gray, 1850

- Rissoella* cf. *caribaea** Rehder, 1943

Rissoidae Gray, 1847

- Schwartzella* sp.

Scissurellidae Gray, 1847

- Scissurella morretesi*# Montouchet, 1972

Vitrinellidae Bush, 1897

- Vitrinellidae sp.

Nudibranchia

- Nudibranchia* sp.1
Nudibranchia sp.2

Phyllodocidae Örsted, 1843

- Phyllodocidae un.

Polynoidae Malmgren, 1867

- Harmothoe* sp.
Lepidonotus caeruleus# Kinberg, 1856
Lepidonotus sp.
Polynoidae un.

Sabellidae Latreille, 1825

- Branchiomma patriota** # Nogueira, Rossi and Lopez, 2006
Chone sp.
Sabellidae juvenile
Sabellidae un.

Sphaerodoridae Malmgren, 1867

- Sphaerodoropsis* sp.*

Spionidae Grube, 1850

- Prionospio* sp.
Spio sp.*

Syllidae Grube, 1850

- Eurysyllis* sp.*
Exogone dispar (Webster, 1879)
Odontosyllis sp.
Opisthosyllis sp.*
Salvatoria sp.*
*Sphaerosyllis brasiliensis** # Nogueira, San Martin and Amaral, 2001
Syllis spp.
Trypanosyllis zebra (Grube, 1840)
Syllidae un.

Terebellidae Malmgren, 1867

- Amaeana* sp.
Amphitrite sp. •
Loimia cf. *grubei* • Holthe, 1986
Lysilla sp.
*Nicolea ceciliae** # Santos, Nogueira, Fukuda and Christoffersen, 2010
Nicolea sp.*
Polycirrus sp.1
Polycirrus sp.2
Streblosoma sp.*
Terebellidae juvenile

Table 4

Total (S) and mean (S') number of species; mean density; Shannon Diversity Index (H'); and Pielou Evenness Index (J') related to Crustacea, Mollusca and Polychaeta on fronds of *Dictyota* spp. from different sites and periods (SG=Sebastião Gomes Reef).

Site	Period	S	S'	Density (ind/g)	H'	J'
SG North	Summer	45	23.2	40.8	2.2	0.7
	Winter	41	19.4	6.8	2.5	0.8
SG South	Summer	37	17.4	47.4	2.2	0.8
	Winter	49	24.8	27.5	2.4	0.8
SG West	Summer	52	24	22.2	2.4	0.8
	Winter	40	22.8	26.5	2.2	0.7
Siriba Is.	Summer	61	32.2	45.5	2.8	0.8
	Winter	50	26.6	21.4	2.3	0.7

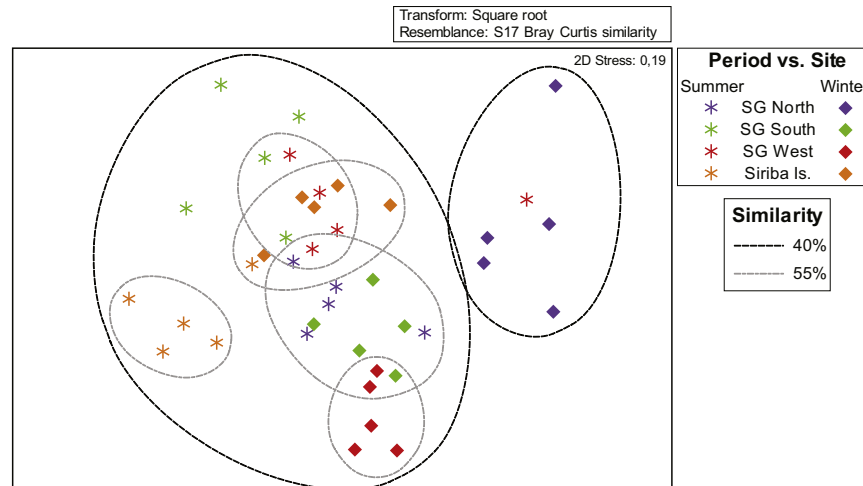


Fig. 4. n-MDS plot of macrofauna associated with *Dictyota* spp. from different sites and periods (SG=Sebastião Gomes Reef). Superimposed cluster analysis at similarity levels of 40% and 55%.

the different sites and periods. This indicates that these species are present in most samples, but at different scales of abundance, as can be seen with *Ampithoe ramondi* and *Ianiropsis montereyensis* (Fig. 3). Abundant but less widespread species also contributed significantly to dissimilarities between sites, such as *Branchiommata patriota*, which was present in high densities only at Siriba Island (Fig. 3).

4. Conclusions

This is the first study on Abrolhos phytal communities and one of the few to identify most of the marine phytal invertebrate fauna to species. The relatively high number of new occurrences and possible undescribed species that are reported herein is indicative of the incomplete state of knowledge on the Abrolhos region. More detailed taxonomical studies may result in additional new records and new descriptions for the area.

Macrofauna density was higher in the summer; in contrast, algal wet weight was reduced during this period. We hypothesize that this is the result of more intense grazing pressures during this period. This same pattern of distribution was observed for several species that graze on seaweeds, such as the amphipod *Ampithoe ramondi* (the most abundant species) and the polychaetes *Platynereis dumerilii* and *Syllis* spp.

The communities were significantly different between seasons and among sites, especially between Sebastião Gomes Reef, located in the coastal arc, and Siriba Island, in the more distant Abrolhos Archipelago. This was observed through community analysis, higher species richness for Siriba Island, and specific taxa that were preferentially present at this site. The sediment-related

conditions in the Bank are one of the most conspicuous features of the environment in Abrolhos, with greater terrigenous sediment output along the coastal arc and elevated water turbidity in the winter. Our data distribution fits this scenario with higher quantity of some of the filter feeders in Siriba Island, which would be less affected by the amount of suspended terrigenous sediment, and also with lower density of organisms in winter, as a possible result of difficulty in recruitment and settlement of the organisms on the fronds. However, further testing is required to establish more assertive correlations between phytal community structure and sedimentation data at these sites.

This study resulted in a more comprehensive understanding of the phytal environment, specifically from the Abrolhos region, regarding macrofaunal distribution and contributing to the knowledge on biodiversity. Future studies and management efforts should consider the influence of temporal and spatial heterogeneity in the phytal assemblages from the Abrolhos Bank.

Acknowledgments

We are grateful to Edmundo Ferraz Nonato, Sergio Antonio Vanin, Ana Maria Pires-Vanin and Beatriz Torrano-Silva for help with the Polychaeta, Mollusca, Isopoda and *Dictyota* identification, respectively. We also thank Katia C. dos Santos and Juliana Genistretti for discussions and references for Tanaidacea and Pedro Cristales for verifying the Cumacea identification. We thank Linda Waters for the English revision and the valuable comments on the paper, as well as all the people that helped in the field. This work was funded through a fellowship to T.J.C. from FAPESP (Fundação de Amparo à Pesquisa do Estado de São Paulo; 2009/13972-5) and

research grants to P.Y.G.S. from FAPESP (2007/00535-0) and CNPq/Institutos do Milênio (Conselho Nacional de Desenvolvimento Científico e Tecnológico; 420219/2005-6).

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