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Small distances, great differences: a case study involving the biomass of reef seaweeds and fishes on the coast of Paraíba, Northeast Brazil

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Resumo

Pequenas distâncias, grandes diferenças: um estudo de caso envolvendo a biomassa de macroalgas recifais, no litoral paraibano. Os recifes costeiros paraibanos ainda são pouco conhecidos. A análise de três diferentes gradientes de exposição a ondas (Prot = protegido; SP = semi-protegido e Exp = exposto) revelou diferenças significativas ($p < 0,05$) em relação à biomassa das macroalgas bênticas (Prot = SP ≠ Exp). A estação Exp com 9,97g (23%) apresentou o menor valor de biomassa seguido de SP com 10,93g (25%) e Prot com 22,55g (52%). Os dados sugerem que o aumento gradativo à exposição as ondas atua inversamente na biomassa das macroalgas. Adicionalmente, *Wrangelia argus* (Montagne) Montagne foi registrada pela primeira vez no litoral paraibano.

Unitermos: hidrodinamismo, macroalgas, recife costeiro, Paraíba, peixes

Abstract

Shallow reefs on the coast of Paraíba state are poorly known. An analysis at three stations (Prot = protected; SP = semi-protected; Exp = exposed) with different gradients of wave exposure revealed significant ($p < 0.05$) differences related to the biomass of seaweed (Prot = SP ≠ Exp). Station Exp with 9.97g (23%) presented the lowest value followed by SP with 10.93 (25%) and Prot with 22.55g (52%). The values suggest that the biomass of seaweeds is inversely related to the gradative higher exposure to waves. Additionally, a first record of *Wrangelia argus* (Montagne) Montagne was made for the coast of Paraíba.

Key words: wave exposure**,** seaweed, coastal reef, Paraíba, fishes

Introduction

Shallow coral reefs are rich, productive and diverse environments with great ecological and economic importance on the northeastern coast of Brazil, be it in the protection of the coastline, fisheries, tourism and leisure or in the generation of services, incomes and jobs (Rocha et al., 1998).

In the state of Paraíba, shallow reefs are widely explored by tourist activities, artisanal fishing, seaweed collection and, recently, the cultivation of commercially important seaweed species.

Although considered by the Ministério do Meio Ambiente (2002) as a priority area for the conservation of many organisms that dwell in the intertidal zone (such as seaweeds, angiosperms, cianobacteria, benthic invertebrates and fishes, among others), the coast of Paraíba is still poorly known. In addition, the factors influencing small-scale differences within complex marine ecosystems such as coral reefs also require a better understanding. Thus, the perspective presented in this paper may help in further understanding the local peculiarities found in Brazil's shallow coastal reefs, particularly those on the northeastern coast. This work aims to elucidate the differences among small-scale distances in a shallow reef environment in order to understand the patterns responsible for seaweed distribution.

Materials and Methods

The seaweed biomass was evaluated among three different gradients of wave exposure (protected, semi-protected and exposed) on a small shallow coastal reef (7º04'59.10"S; 34º48'54.48"W), located in Bessa beach 690m off the coast of João Pessoa, Paraíba. The reef is characterized by a relatively shallow depth (varying between 0.5 and 2m with tide amplitude), in which the top of the reef becomes emerged during the low tides. The reef supports a rich seaweed assemblage along with aggregations of the corals *Palythoa caribaeorum* (Duchassaing & Michelotti, 1860) and *Zoanthus sociatus* (Ellis, 1767). The substrate in the adjacent areas of the reefs is basically composed of sand mixed with *Halimeda* sp. gravel.

The protected station (Prot) faced the mainland, while the semi-protected station (SP) was perpendicular to the mainland and the exposed station (Exp) faced the open sea (Figure 1). All samples were collected at the beginning of the dry season (October 2005) from about 9:00 to 13:00 hours during low tides (less than 0.4m).

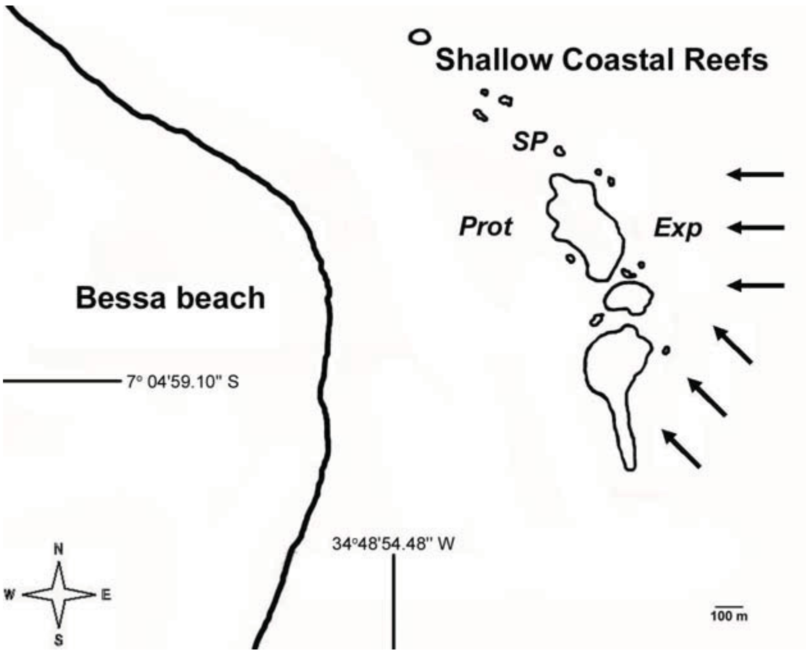

FIGURE 1: Outline representing the regime of predominant waves and winds. Prot = protected, SP = semi-protected and Exp = exposed stations. The arrows indicate the predominant direction of the waves and winds (E/W and SE/NW).

Snorkeling for seaweed collection was employed along a 5m length line transect line in all three stations. Each sample consisted of three squares of 25 x 25cm, lineally and equally separated, and was labeled and taken to the laboratory for trial and taxonomic determination. After, the seaweeds were dried in a greenhouse and weighed on a precision scale.

In parallel, the fish assemblages were investigated using a visual census, which was made along the 5m transect, and the names of the fishes were recorded on PVC boards. Three censuses were made at each station. Taxonomic determination of fishes followed Carvalho-Filho (1999) and the trophic categories followed Ferreira et al. (2004).

A one-way analysis of variance (ANOVA) was used to detect significant differences among the three sampling stations. Additionally, a non-metric multidimensional scaling analysis (MDS) was carried out to identify relationships among the stations. The analyses were made with the use of electronic spreadsheets and the Primerâ program.

Results

Eighteen seaweed species and a colonial diatom of the order Pennales were found. At the three stations, the total biomass of seaweed was 43.45gm², with Rhodophyta, Chlorophyta and Phaeophyta presenting 29.69, 9.53, and 4.23gm², respectively. *Bryothamnion seaforthii* (Turner) Kützing (Rhodophyta) presented the highest percentage (62%) of total biomass followed by *Cryptonemia* sp. (Rhodophyta) and *Caulerpa sertularioides* (S. G. Gmeling) M. Howe (Chlorophyta) with 12% and 9%, respectively. The other species represented together 17% of total biomass: *Caulerpa prolifera* (Forsskal) J. V. Lamouroux, *Halimeda opuntia* (Linnaeus) J. V. Lamouroux and *Udotea* sp. (Chlorophyta); *Dictyopteris delicatula* J. V. Lamouroux and *Dyctiota* sp. (Phaeophyta); *Amansia multifida* J. V. Lamouroux, *Amphiroa* sp., *Botryocladia occidentalis* (Børgesen) Kylin, *Champia* sp., *Gelidium* aff. *floridanum* W. R. Taylor, *Gracilaria cervicornis* (Turner) J. Agardh, *Hypnea musciformis* (Wulfen) J. V. Lamouroux, *Jania* sp., *Peyssonnelia simulans* Weber-van Bosse and *Wrangelia argus* (Montagne) Montagne (Rhodophyta). With regard to the total biomass of seaweed, the Prot station presented the highest average value of dry weight with 22.55g (52% of total biomass), while SP and Exp presented similar values, 10.93 (25%) and 9.97g (23%), respectively (Figure 2).

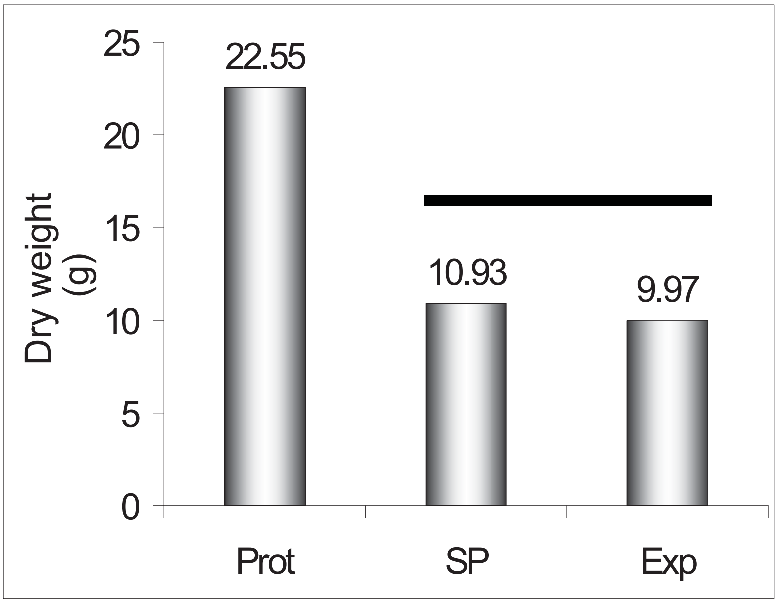

FIGURE 2: Total biomass of seaweed found in three different gradients of wave exposure. Bar above indicates significantly equal areas (ANOVA; p = 0.05). Prot = protected (n = 3), SP = semi-protected (n = 3) and Exp = exposed stations (n = 3).

A total of 10 genera and 13 species of fishes were registered. Overall, representatives of six trophic categories were found as follows: 1) roving herbivores (33 %): *Acanthurus bahianus* Castelnau, 1855, *A. chirurgus* (Bloch, 1787), *A. coeruleus* Bloch & Schneider, 1801 (Acanthuridae) and *Sparisoma radians* (Valenciennes, 1840) (Scaridae); 2) territorial herbivores (17 %): *Stegastes fuscus* (Cuvier, 1830) and *S. variabilis* (Castelnau, 1855) (Pomacentridae); 3) carnivores (17%): *Labrisomus nuchipinnis* (Quoy & Gaimard, 1824) (Labrisomidae) and *Odontoscion dentex* (Cuvier, 1830) (Scianidae); 4) mobile invertivores (17 %): *Anisotremus virginicus* (Linnaeus, 1758) (Haemulidae) and *Halichoeres poeyi* (Steindachner, 1867) (Labridae); 5) omnivores (8%): *Abudefduf saxatilis* (Linnaeus, 1758) (Pomacentridae) and 6) detritivores (8 %): *Mugil curema* Valenciennes, 1836 (Mugilidae).

Significant differences ($p < 0.05$; ANOVA) among the three stations sampled were found with the SP and Prot stations being separated from the Exp station. The MDS analysis revealed the same result (Figure 3).

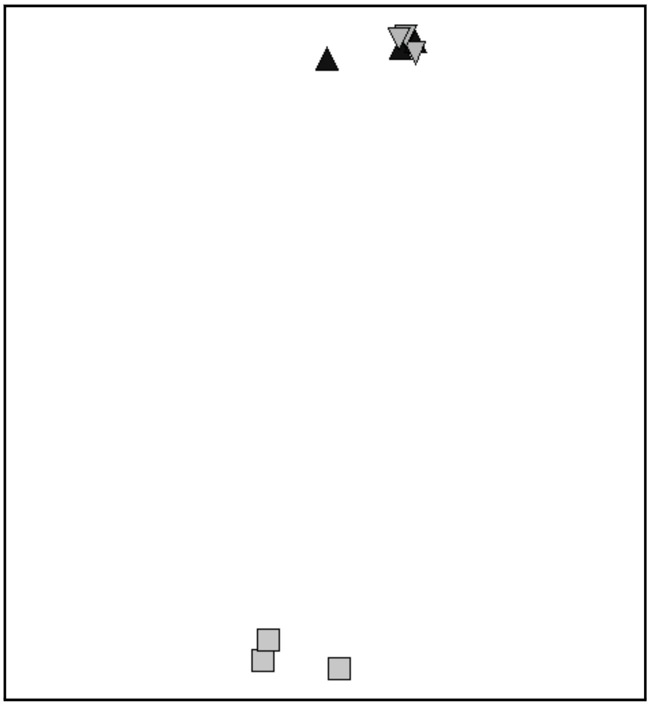

FIGURE 3: Grouping of three different gradients of wave exposure using seaweed biomass and fish species as variables. Light squares represent the exposed station (Exp; n = 3), light triangles the semi-protected (SP; n = 3) and dark triangles the protected (Prot; n = 3).

Discussion

Differences in the biomass of seaweeds among the three stations sampled might have been related to the wave action. The station with the highest exposure to waves presented the lowest biomass, while the most protected station presented the highest seaweed biomass, with approximately twice the value found at the exposed station. Furthermore, the SP and Exp stations presented similar values, suggesting that although they were under different degrees of wave exposure, other factors could explain the similar conditions observed. According to Hurd et al. (1996), water movement is important to marine ecosystems because it increases nutrient availability, thus increasing the primary productivity and consequently influencing the biomass of benthic seaweeds. However, wave impact can also be a physical factor limiting the development of some organisms. Therefore, only species that are adapted to these extreme conditions are capable of persisting in these areas (Díez et al., 2003). In fact, the wave action could be responsible for the removal of algae and their respective herbivores (Leigh et al., 1987), supporting the results obtained in the present study.

Additionally, *Wrangelia argus* (Montagne) Montagne was recorded for the first time on the coast of Paraíba. As stated by Horta and Oliveira (2005), this species occurs in the neighboring states (Rio Grande do Norte and Pernambuco).

The high biomass registered for *Bryothamnion seaforthii* compared to the other species can be related to several factors. According to De Lara-Isassi et al. (2000), *B. triquetrum* has ichthyotoxic properties, thus effectively preventing it from being consumed by herbivors fishes. Dias et al. (2001), studying the feeding habits of *Acanthurus bahianus, Acanthurus chirurgus* and *Acanthurus coeruleus o*n the coast of Paraíba, found low levels of herbivory on *B. seaforthii*, *Cryptonemia* sp. and *Caulerpa sertularioides* and suggested that these species have efficient mechanisms of defense against herbivory attack. This demonstrates the important role played by herbivores in shaping patterns of distribution of seaweeds in these ecosystems.

However, this alone only explains the abundance of *B. seaforthii* in comparison to the others, but not the distribution of the whole assemblage within different areas of the ecosystem. Therefore, wave exposure is the variable mostly responsible for the spatial arrangement of the seaweed species on the reefs of Bessa beach. Also, since the study site was a fairly small area in which the fishes had free access to every side of the reef, access restrictions, imposed by environmental constraints such as small physical or ecological barriers, were not clear. Thus, no access limitations were evident for the herbivores within the three stations sampled. Furthermore, future studies should be stimulated in order to discover the relationships among the several abiotic and biotic aspects in complex environments such as shallow coastal reefs, particularly in the northeastern region of Brazil.

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