THE EFFECTS OF A MACROALGAL COMMUNITY COMPOSITION ON ITS FUNCTIONAL STABILITY

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INTRODUCTION

Habitat destruction and fragmentation, overexploitation of natural resources, pollution, among other factors, have been promoting a continuous and increasing biodiversity loss in most ecosystems. Recent studies, focused on the interactions between biodiversity and ecosystem function, showed that rates and magnitude of ecosystem processes are more consistently related to the species functional traits than by its taxonomic identity solely [4,5,6]. Thus, investigating the relationship between communities taxonomic and functional diversity is essential to improve our efforts on ecosystem management and conservation [9,12].
Functional diversity can guarantee the provision of ecological functions in a community through resource use complementarity, contributing, thus, to the ecosystem functioning. Nevertheless, the stability of these ecological functions in environmental conditions changes depends on the functional redundancy of the taxa within the groups. In this way, the understanding of community dynamics and assembly is an important step towards the better knowledge of the functional stability of a community.

OBJECTIVES

The aim of this work is to analyze the temporal and spatial variations in the structure and composition of subtidal macroalgae community and how it affects its functional stability. To achieve this, a functional - form group approach was adopted in order to categorize species into ecologically meaningful groups.

MATERIAL AND METHODS

The study was carried out in Arvoredo Island (Arvoredo Island Marine Reserve, Santa Catarina, Brazil; $27^0$15' S, $48^0$25' W), in a bay highly exposed to wave action. Sampling was conducted seasonally from November 2006 to July 2007. In order to access temporal and spatial patterns of subtidal macroalgae distribution and abundance, three 10m - long transects were placed parallel to the coastline at each of four depths (3, 6, 12 and 18m) throughout SCUBA diving. The relative areal cover of functional - form groups and their representative taxa (at genus level) was estimated within 1m2 graded quadrats (25 sub - quadrats of 20x20cm), positioned along the transects (10 quadrats per each transect). The functional - form groups were Filamentous, Foliose, Coarsely - branched, Thick - leathery branched, Calcareous articulate and Encrusting algae. The determination of these groups was based on similarities in thallus morphology taking into account that ecological and physiological attributes are associated with anatomy and morphology of the thallus [8,15,16]. Punctual samples were collected for more detailed taxonomic determination in laboratory. Sea surface water temperature (thermometer) and transparency (Secchi disk) were measured daily during the sampling periods.

Variability across season, depths and transects in functional - form group abundance were analised by a three - way Multivariate Analysis of Variance (MANOVA), with the *post - hoc* Tukey HSD test. The data were square root transformed prior to analysis. The correspondence among the abundance of functional and taxonomic groups and the parameters season and depth was also investigated by a multivariate method (Correspondence Analysis - CA). Taxonomic and functional evenness, richness and diversity (Shannon - Wiener Index) were calculated per season, depth and also using the all data set. To evaluate the relationship between functional and taxonomic diversity (both hereafter referred as FD and TD), Linear Regression Analysis (significance level=0.5%) was applied.

RESULTS AND DISCUSSION

A total of 65 genera were recorded (8 Chlorophyta, 16 Ochrophyta and 41 Rhodophyta), with the group Coarsely Branched algae showing the highest taxonomic richness (12

taxa). The community structure was dominated by the group Calcareous Articulate followed by Filamentous and Encrusting algae. In general, it was observed a temporal stability of the relative abundance of the functional - form groups although some groups, such as Filamentous and Foliose algae, have showed a marked temporal variation. In order to improve the power of the MANOVA method, only the most abundant groups (Calcareous articulate, Filamentous and Encrusting algae) were included in that analysis. According to MANOVA results, the effects of season, depth and transects were highly significant (Wilks, $p < 0.001$), as well as the interaction among those factors Wilks,$p < 0.05$).

The group Calcareous Articulate (represented by *Amphiro*a spp., *Jania* spp. and *Haliptilon cubense*) showed the highest cover values, with significant decreases observed only in shallow areas for the periods summer and autumn (Tukey, $p < 0.05$). This was followed by a simultaneous increase in the abundance of Filamentous algae (Tukey, $p < 0.05$). This last group included *Feldmannia irregularis*, *Hincksia mitchelliae* and *Asparagopsis taxiformis*. Encrusting algae had its higher values of relative abundance at 12m and 18m depth in the winter (Tukey, $p < 0.01$), composed mainly of non - geniculate coralline algae and *Peyssonnelia capensis*. The group Coarsely - branched showed slightly variations in their abundance throughout the seasons. This last group was the most diverse, characterized by the occurrence *Laurencia* spp., *Hypnea* spp., *Chondria* spp., *Codium* spp., *Colpomenia sinuosa*, *Gelidiopsis variabilis*, *Plocamium brasiliense*, *Champia parvula* and *Sebdenia flabellata*, among others. All these taxa showed changes in their relative abundance across seasons. Foliose algae had the highest values of abundance in summer and was represented mainly by the family Dictyotaceae, including the presence of *Dictyopteris delicatula* and *Rhodymenia* spp.. The group Thick - Leathery algae was composed of *Lobophora variegata*, *Padina gymnospora* and *Sargassum* spp., the last one being the most abundant taxa in the group.

The results from Correspondence Analysis showed a marked distribution of functional form groups across the depths (inertia for dimension 1 = 68%) and of taxa across seasons (inertia for dimension 1 = 53, 78, 51 and 69%, respectively). The distribution of the functional groups across seasons and depths was strongly affected by the distribution of their most abundant taxa. However, since these major taxa showed temporal variations in their abundances, its seasonal decreases were compensated by increases of the abundance of certain minor species maintaining, hence, the temporal stability of the groups. The results of the Linear Regression Analysis revealed a significant and positive correlation between the FD and the TD ($p < 0.001$, $r^2 = 0.8$), indicating low functional redundancy within the community. However, there were differences of taxonomic diversity, evenness and richness within each functional group, probably reflecting different levels of functional redundancy among groups.

The dominance of the group Calcareous Articulate algae suggests that wave action may be one major factor affecting the structure of the community. Representative taxa of this group are characterized by a thallus with flexible joints that enable them to withstand the physical stress caused by wave shearing [8]. On the whole, our results of the spatial distribution of the community are in agreement with the findings of Horta *et al.*, (2008) for the same region, which showed a clear stratification of the community across the depths. These patterns of depth distribution are often related to the attenuation of light incidence, despite other factors such as sedimentation and water motion may also be affected. In this way, our results seem to reflect the trade - off's between the morphological and functional attributes of the algal groups and their tolerance to different levels of light availability [8,15]. In addition, factors such as grazing pressure (sea urchins were often observed grazing directly over algal patches) and competitive interactions between algae from different morphological groups, seems also to affect the patterns of distribution.

The temporal stability of functional groups highlights the essential role played by the functional redundancy within the groups promoting the replacement of species that are functionally similar but show different tolerances to environmental conditions. Consequently, there is a compensation mechanism between the abundances of major and minor taxa along an environmental gradient resulting, thus, in a long - term stability of the functional groups and, consequently, ecosystem functioning [2,6,10,11,17,18]. The result of the Linear Regression analysis between the FD and TD indicated the occurrence of a low redundancy in the community, implicating that small changes in the diversity of taxa could result in a rapidly disappearance of a whole functional group. However, the analysis of the taxa diversity by group revealed differences in redundancy among them. While some groups showed high taxa richness that provided an insurance against species loss, other groups, such as Thick - leathery algae, were more vulnerable to losses. In this way, the monitoring and conservation efforts must be focused on such critical groups [17].

The use of macroalgae functional - form groups has been controversial and several studies have discussed about its inadequacy or inefficiency in reflecting disturbances through changes in community's structure. It occurs due to the variability of physiological responses contained across the taxa of a single functional group [1,3,13,14]. This variability of responses allows that the functional - form groups remain in constant levels of abundance, even under environmental changes, avoiding the appropriate detection of local disturbances. At the same time, it contributes to the temporal maintenance of the community's ecological functions, that is, its functional stability. Thus, the functional approach really seems to fail as a biological indicator of environmental changes but acts as important tool to the investigation of the resistance and resilience of communities.

CONCLUSION

Despite the temporal variability in the abundance of taxonomic groups, a functional stability was probably maintained within the community, since the observed changes in species or genus composition were not followed by similar changes in functional - form groups. This fact reflects the importance of a high functional redundancy, once that it implies in a replacement of species within functional groups

acting as insurance against changes in environmental conditions. For some groups, however, a low functional redundancy was detected, highlighting their high vulnerability to species losses.

The use of macroalgae functional - form groups approach seems to be more efficient if applied to investigations about the resilience of communities and ecosystems. The complementarity between the functional and taxonomic approaches is desirable to assess the level of functional redundancy within communities and, hence, its ability to maintain their functions under changing conditions.

Acknowledgements

To Pata da Cobra Diving School (Bombinhas, SC) and Brazilian Navy, for the logistical support . We are very grateful to Julia Reisser and Maíra Proietti (Project "Arvoredo Sea Turtles"), and the colleagues M. Satake, K. Koerner, C. Florian, M. Rossato, D. Maio, C. Salame and R. Pinotti for field assistance. This project was conducted under the IBAMA research license 186/2006, process number 02001.003880/06 - 5.

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