Microhabitat use and multivariate pattern of motile epifaunal community in relation to sediment grain size in a tropical Seagrass meadow

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RESUMEN

La relación entre la estructura física del habitat y la comunidad de la epifauna móvil asociada a una pradera dominada por *Thalassia testudinum*, fue estudiada en las isobatas de 1 y 3 m, en términos de diversidad de la especie, densidad de organismos, uso de microhábitats y el patrón multivariado de especies en asociación con la biomasa del pasto marino, densidad de brotes, largo y ancho de hojas, biomasa algal tanto epifitica como rizofítica, biomasa de las esponjas y tamaño de grano del sedimento. El pasto marino mostró diferencias significativas entre profundidades, pero no la biomasa algal epifitica y rizofítica, ni tampoco la biomasa de las esponjas y el tamaño de grano. A pesar de las diferencias presentadas en el pasto marino, diversidad de especies del epifaunal y densidad del organismos, no se presentaron diferencias de estos indicadores entre las profundidades. Ningún atributo del pasto marino mostró correlaciones fuertes con los descriptores de la fauna.

PALABRAS CLAVE: Pasto marino, Comunidad del epifaunal, Macroinvertebrados, Complejidad del hábitat, Tamaño de grano del sedimento.

ABSTRACT

The relationship between habitat physical structure and motile epifauna community associated to a Seagrass bed dominated by *Thalassia testudinum* was study over the isobaths of 1 and 3 m, in terms of species diversity, organisms density, micro habitat use and multivariate species pattern in association with Seagrass biomass, shoot and leaf density, leaves long and wide, epiphytic and rizophytic algae biomass, sponges biomass and sediment grain size. Seagrass features showed significant differences between depths, instead epiphytic and rizophytic algae, sponges biomass and sediment grain size did not. Though differences exhibited by Seagrass, epifaunal species diversity and organism density neither were different between depths. In the same way none Seagrass feature showed strong correlations with faunal descriptors, tending even to be negative instead positive.

KEY WORDS: Seagrass, Epifaunal community, Macro invertebrates, Habitat complexity, Sediment grain size.

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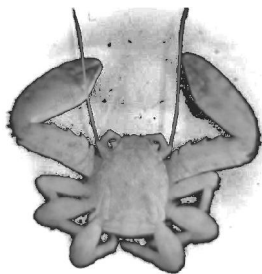
1. INTRODUCTION

Over the last three decades it has been pointed out the crucially significance of seagrass beds as nursery, recruitment and habitat areas for a large number of fish and invertebrate species around widespread coastal seas (Lakurm et al 1989, Hemminga & Duarte 2000). Therefore, the most important research efforts in seagrass ecology have focused on the identification and description of factors that regulate the structure of associated faunal communities (Duarte 1999). In this sense, both experimental and field sampling evidence have strongly suggested that faunal species richness and abundance in seagrass meadows are positively correlated to seagrass biomass (Heck & Westone 1977, Stoner 1980, Orth et al 1984, Leber 1985, Main 1987, Worthington 1992, Hsieh 1995, Conolly 1997, Ray-Clup et al 1999, Bologna & Heck 2000, Lee et al 2001, Hovel & Romauld 2002).

From those evidences many authors have concluded that plant biomass constitutes by itself a measure of habitat complexity and this interpretation is one of the most important currently paradigms in Seagrass ecology (Hsieh 1995, Conolly 1997, Ray-Clup et al 1999, Atrill et al 2000, Hovel & Romauld 2002). Nevertheless, this assumption is often the result of categorical approaches that, in one hand, neglect the influence of other ecological factors like sediment grain size or neighboring ecosystems (mangroves, rocky shores and coral reefs), and in the other hand, do not leave clear in what way an augment of Seagrass biomass introduces new kinds of microhabitats, neither discriminate the differential use that each faunal taxa makes on them, which necessarily shall occur if the augment of complexity by the augment of seagrass biomass is real. Hence, beyond the simple correlation between diversity indices and seagrass biomass, the use of this measure as analog of habitat complexity remains poorly supported and its ecological significance still is unclear (Atrill et al 2000).

The aim of this work was to study the structure of the macro invertebrate epifaunal community of a tropical seagrass meadow -not associated with coral reefs, mangroves or rocky shores- in relation with habitat structure and microhabitat use. In order to get a multidimensional overview, we collected and used information from three different approaches: whole community descriptors of epifauna (diversity and density), multivariate analysis of faunal species composition and a quantitative description of specific microhabitat use by each major taxa of macro invertebrates.

2. MATERIALS AND METHODS

Study area. The study was undertaken in a Seagrass meadow dominated by *Thalassia testudinum* located at Punta San Bernardo, north of Morroquillo Gulf, in the Colombian Caribbean Coast, at 09º 42' north and 75º 41' west. The meadow is characterized by a soft inclination (5 - 10%), the sediment grain size varies between muddy-sand and grave-sand and there isn't any coralline formation near to the area. The tide regime is dilly with an oscillation lower than 0.5 m. Water temperature and salinity show little changes along the year because there is not a significant fresh water input.

Sampling design and fieldwork. A extension of 900 m on the isobaths of 1 and 3 m was taken as study area, at each 50 m three aleatory samples were took, being 18 points and 54 samples over each isobath. The sampling was made with scuba diver equipment within a 1 m^2 quadrant. Seagrass leaves, benthic algae and sponges were examined, and all epifaunal motile macro invertebrates (> 5 mm) were collected. The determination of total habitat covering was performed on base of another 1 m^2 quadrant, divided into 25 sub quadrants (of 0.2 m^2 each one), and expressed as full subquadrats/25 x 100 (Caricomp 2001). For each representative taxa of epifaunal macro invertebrates were compared the differential microhabitat use, taking into account the specific place where specimens were collected.

The estimation of Seagrass biomass, leaf and shoot density, algae (both benthic and epiphytic) and colonial fauna biomass, as well as the sampling for sediment grain size analysis were made with a core with 0.2 m of diameter putted to 0.2 m of deep in sediment.

Laboratory analysis. All material was marked and packaged for their transport to the Bioassays laboratory of the University of Antioquia. Where the faunal specimens were determined by the use of Diaz & Puyana (1994), Linder (1999) and Williams (1984). Habitat characterization were made by measuring Seagrass over ground and epiphyte biomass, shoot and leaf density, leaf length and wide (mean), total habitat covering, benthic algae and sponge biomass, and sediment grain size.

Data analysis. Univariate analysis of whole community descriptors was carried out with Shannon - Weaver diversity index and total epifaunal density per m². The relationship of these functions with habitat structure was assessed by Spearman ranks correlation (Sokal & Rolph 1981). Comparison of habitat and faunal descriptors between depths were made by Mann - Witney test at 0.95 confidence level.

Species composition at each sampling point as well as habitat variables values were used in a MDS (Multidimensional Scaling) ordination based on Euclidean distances (Legendre & Legendre 1998). For correlating multivariate pattern and whole descriptors both, community and habitat variables were associated with Shannon - Weaver diversity index at each sampling point by a qualification along high and low diversity. The intensity of the environmental pattern was tested by partial Mantel test (Mantel 1967), from habitat variables distance matrix and faunal composition distance matrix. For correcting the effect of spatial autocorrelation and ruling out the effect of depth a third distance matrix corresponding to sampling design was used. Mantel correlations were obtained by Pearson coefficients and confirmed by 999 Monte Carlo permutations. For all statistics, habitat variables data were fourth root transformed, whereas faunal species abundance data was ln (x+1) transformed (Legendre & Legendre 1998).

3. RESULTS

General description. The predominant substrate type in points 7 - 18 (1 m isobath), and 24 - 36 (3 m isobath) was muddy – sand. In points 1 - 6 (1 m isobath) and 19 - 24 (3 m isobath) the predominant type of substrate was grave - sand. Seagrass biomass, shoot and leaf density, leaves per shoot, and habitat covering were significant higher in 1 m isobath than in 3 m, instead Seagrass leaves were wider in former than in first. Seagrass leaves long, epiphytic and rizophytic algae, and sponge biomass, as well as sediment grain size did not show significant differences between depths. Though the differences showed by Seagrass features neither motile epifaunal diversity nor epifaunal density exhibited differences between depths (Table 1). Among macro algae only the rizophytic genus *Halimeda* was found being used as specific habitat by macro invertebrates. As colonial fauna only sponges were found, occurring as epiphytic forms of Seagrass and directly attached to sediment and also being used as habitat by epifauna.

Whole community descriptors and habitat variables relationship. Seagrass biomass was strongly correlated with total habitat covering, as well as shoot and leaf density, showing a poor relationship with epifaunal density and diversity, that besides was negative. No one seagrass variable showed positive correlations with faunal density or diversity. Epiphyte algae biomass did not show any relationship with habitat neither faunal variables. Rizophytic algae and sponges biomass, which at once are strongly related to sediment grain size showed the highest correlations with faunal community (Table 2).

Epifaunal composition and microhabitat use. For a total of 108 samples, were collected 779 motile epifaunal organisms belonging to 51 species of phylum mollusca, crustacea and echinodermata. 31% of mollusks species were collected from over the sediment 19% on Seagrass leaves and 30% inside Seagrass shoots. Only a 6% of crustacean species were collected over sediment, whereas 40% were encountered on sponges and 44% were captured on *Halimeda* algae. Among echinoderms, ophiuran species were collected in a 46% on sponges and 54% on *Halimeda* algae. Echinoids and asteroids were encountered only over sediment.

As consequence of this differential microhabitat use and, as is possible to deduce from the correlation matrix, on sampling points where sediment was characterized by muddy - sand, motile epifauna showed a low density, and homogeneous composition, being dominated by gastropods,

asteroids and echinoids. In contrast, where sediment was characterized by grave – sand, epifauna was dominated by decapods and ophiurans, but mollusks, asteroids and echinoids were also present, making epifauna more diverse and showing also a higher density of organisms.

Multivariate pattern. MDS ordination obtained by habitat variables showed a clear separation between sampling points.. Indeed, dimension 2 separates the two isobaths, meaning that this dimension corresponds to Seagrass features (see table 1). Dimension 1 separates sampling points according to the remaining habitat characteristics (benthic algae and sponges biomass, and sediment grain size). Points with high values for these features have positive values on this dimension.

MDS ordination obtained by epifaunal species composition showed that most points, even belonging to different isobaths have the same composition in spite of the described differences of Seagrass biomass, density and leaf morphology. Only points having high values of sediment grain size are clearly separated, but species composition differs so much among them (figure 1). If labels of original sampling points numbers are substituted by labels of faunal diversity ranges values, both habitat variables and species composition ordinations, separates high and medium diversity values from lower ones (figure 2). This correspondence between the spatial structure of epifaunal community and habitat structure was tested by a Partial Mantel test, which showed a significant correlation between species and habitat matrices, confirming that correlations showed for whole community descriptors coincide with a quantifiable pattern of species distribution, which at once, results from the correlation between sediment grain size and the remaining habitat variables. As could be expected from the microhabitat use, the taxonomic group better related to habitat structure variables are crustaceans followed by echinoderms, whose organisms prefers *Halimeda* algae and sponges as specific habitat. Mollusks showed a poor tendency to a pattern, indicating that, for this group, species distribution is more independent on habitat variables measured (table 3).

Table 1. Mann - Wihtney test evaluating differences of habitat and faunal descriptors between depths.

Variable	Rank Sum 1 m	Rank Sum 3 m	P -level
Total habitat covering	451,0	215,0	0,00019
Dry seagrass over ground biomass	443,0	233,0	0,00156
Shoot density (per m^2)	433,0	243,0	0,00146
Leaf density (per m^2)	463,0	203,0	0,00004
Leaves per shoot	465,0	201,0	0,00003
Leaves long (mean)	352,5	313,5	0,53727
Leaves wide (mean)	244,0	422,0	0,00487
Epiphytic algae biomass	316,0	350,0	0,59068
Sponges biomass	338,5	327,5	0,86186
Rizophytic algae biomass	363,5	302,5	0,33456
Sediment grain size	336,0	330,0	0,92438
Shannon's epifaunal diversity	361,0	305,0	0,37569
Epifaunal organism density (per m^2)	347,0	319,0	0,65781

Variable	2	3	4	5	6	7	8	9	10	11	12	13
1. Total habitat covering	0.91	0,90	0,89	-0,01	0,10	0,37	0,08	-0,17	-0,50	-0,40	-0,24	-0,23
2. Dry seagrass over ground biomass		0,91	0,87	-0,11	0,26	0,54	0,01	-0,31	-0,65	-0,48	-0,31	-0,32
3. Shoot density (per m^2)			0,97	0,00	-0,03	0,31	0,14	-0,25	-0,45	-0,30	-0,31	-0,34
4. Leaf density (per m^2)				0,14	-0,05	0,31	0,25	-0,23	-0,44	-0,30	-0,34	-0,35
5. Leaves per shoot					-0,15	0,03	0,40	0,10	0,13	0,07	-0,07	0,05
6. Leaves long (mean)						0,75	0,01	-0,51	-0,78	-0,78	-0,43	-0,37
7. Leaves wide (mean)							0,21	-0,34	-0,78	-0,63	-0,27	-0,33
8. Epiphytic algae biomass								0,00	-0,10	-0,05	-0,11	-0,01
9. Sponges biomass									0,67	0,69	0,43	0,50
10. Rizophytic algae biomass										0,81	0,81	0,79
11. Sediment grain size											0,68	0,62
12. Shannon's epifaunal diversity												0,88
13. Epifaunal organism density (per m^2)												1.00

Figure 1. NMDS ordinations obtained by epifaunal species composition and habitat variables

Figure 1a. NMDS ordinations obtained by epifaunal composition. Numbers represents sampling points (1 – 18 belong to 1 m isobath, 19 – 36 belong to 3 m isobath). RP = Represents all remaining points.

Figure 1b. NMDS ordinations obtained by habitat variables. Numbers represents sampling points (1 – 18 belong to 1 m isobath, 19 – 36 belong to 3 m isobath).
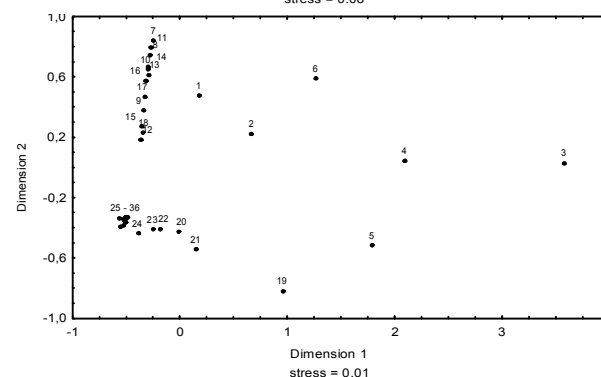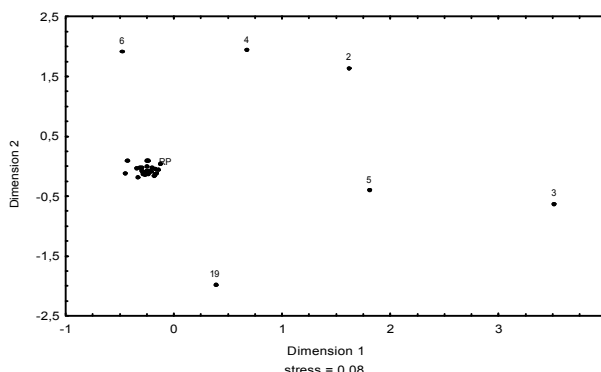
Figure 2. NMDS ordinations obtained by habitat variables and epifaunal composition labeled by epifaunal Shannon's diversity index at each point.

Figure 2a. NMDS ordinations obtained by epifaunal composition. Labels represents values of Shannon diversity index at each point. L = Low diversity (0 – 1.0), M = Medium diversity (1.0 – 2.0), H = High diversity (> 2.1)

Figure 2b. NMDS ordinations obtained by habitat variables. Labels represents values of Shannon diversity index at each point. L = Low diversity (0 – 1.0), M = Medium diversity (1.0 – 2.0), H = High diversity (> 2.1)
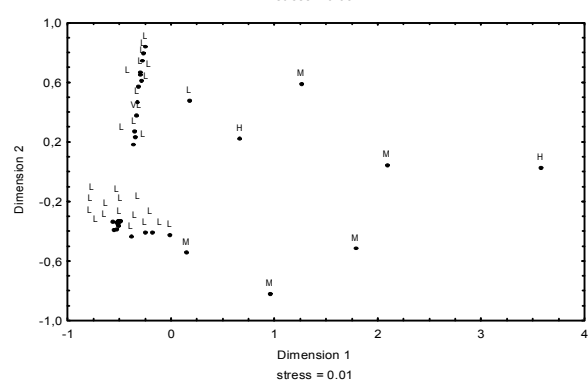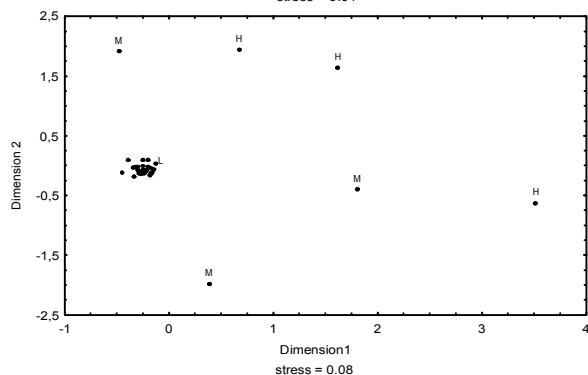
Faunal component	R value
Total epifauna	0.57
Mollusks	0.22
Echinoderms	0.48
Crustaceans	0.68

Table 3. R coefficient value for Mantel test correlating distance matrix to habitat variables and faunal species distribution. All values were validated by Monte Carlo permutation test (999 permutations).

4. DISCUSSION

A large number of authors have found significant correlations between plant biomass and epifaunal species diversity and organism density in Seagrass ecosystems (Connolly 1997, Atrill et al 2000, Lee et al 2001, Graham & Neville 2002). Based on this observation it has been concluded that more dense vegetated areas provides additional microhabitats for macro invertebrate species, and therefore Seagrass biomass has been used as indicator of habitat complexity (Heck & Westone 1977, Virnstein et al 1983, Leber 1985, Graham & Neville 2002). But those conclusions are poorly supported, because habitat structural complexity depends upon multiple morphological variables, and sectors with the same biomass values over a bed may show different levels of habitat complexity (Atrill et al 2000).

Our results show that more dense vegetated areas don't have more epifaunal diversity or density. At the same time, MDS ordination showed that species composition is almost the same in the majority of study area, independently to seagrass biomass or leaf morphology. Mollusks, echinoids and asteroids have a wide distribution and they can be found at all system studied, whereas crustaceans and ophiurans are more abundant at points with grave in sediment, and most species of these taxonomic groups are completely exclusive from such a points.

The conjunction of these facts has as consequence a significant relationship between epifaunal species composition and its diversity. So that, patterns in this community occur as a result of the accumulation of numerous species in sites where grave in sediment clearly provides a good substrate for the colonization of sponges and rizophytic algae. Which is evident also by higher species diversity and organisms density, and suggest that sponges and *Halimeda* algae generates more habitat heterogeneity than it's provided by the lonely presence of Seagrass, independently to the Seagrass biomass, Seagrass density and leaf morphology.

In the specific case of the system studied, sediment grain size appears to have the highest importance. The importance of sediment for faunal communities has been looked only for the infaunal component, which inhabits it (Orth 1977, Orth et al 1984, Webster et al 1998, Eckrich & Holmquist 2000, Graham & Neville 2002), whereas the studies of epifaunal communities are focused only on the aboveground elements and never include sediment analysis. Hence there is none evidence about the relationship between epifaunal assemblages and sediment in Seagrass meadows, but according to evidences cited, it should be expected that epifauna are more diverse in beds growing on muddy - sand environments, but our results show the opposite.

Interpretations about relationships between Seagrass biomass and associated faunal diversity are quite often the result of categorical approaches which only includes univariate analysis of species diversity, and that hardly ever include analysis of community patterns and don't leave in clear how the incidence of Seagrass biomass on faunal communities is manifest in species composition, spatio-temporal distribution or microhabitat use.

Here we assessed both univariate and multivariate approaches and results showed a conspicuous relationship between the two of them. But, when community is decomposed by the independent contribution of the three main taxonomic groups in multivariate analysis, mollusks doesn't show the same pattern exhibited by whole community, indicating that univariate community variables does not completely reflects multivariate structure, whole community descriptors are not completely related with species pattern. These two kinds of approaches provide different, but complementary information that in fact allows to say that community structure in this seagrass bed are poorly related to Seagrass features and strongly related to other habitat variables. Thus, we suggest as

did Atrill et al (2000) that current accepted idea that Seagrass biomass as univariate measure can be used as analog for habitat complexity -based in the fact that faunal species richness appear often related with it- should be reviewed, because it's to simplistic for a complex ecological suitability.

It's necessary to carry out different kinds of analysis upon the same data sets for better understanding ecological relationships between communities and their environment. Seagrass associated fauna studies, and often, most studies on marine environments have concentrated on individual species or have employed only categorical approaches for community structure assessing, multivariate analysis are uncommon (Somerfield & Gage 2000). There is a need for new studies using multivariate methods to examine how whole community and single species vary in relation to habitat features, because patterns in nature result from multiple biological and physical processes interacting together and not from a linear response to environmental variables. Only such a studies could provide a more realistic picture about functioning of fragile and endangered ecosystems as Seagrass meadows.

5. ACKNOWLEDGMENTS

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