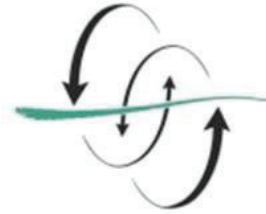FACULTAD
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**Macroalgal structural complexity as a key driver of
intertidal epifauna composition**

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Abstract

Habitat complexity is one of the most important factors structuring biotic assemblages and is of great importance in different ecosystems. Macroalgae are a clear example of this idea. They constitute ecosystems that harbor a high biodiversity because they provide a unique physical habitat to support production, making them dense, diverse and productive faunal assemblages. Thalli provide a substrate for the growth of epiphytic microalgae that feed food webs and a refuge for invertebrates and fish that reach substantially higher densities than in unvegetated benthic habitats and also provide essential shelter from predation. The present work studies the structural complexity of algae as an important factor driving the structure of epifaunal assemblages associated with marine macroalgae. For this purpose, three algal species were selected for their similar structural complexity, *Cystoseira humilis, Halopteris scoparia* and *Stypocaulon scoparium*. They harbor a rich epifauna and the small differences of the studied algae in terms of structural complexity generate a different epifaunal community. Crustaceans were the most abundant group in the epifaunal community, followed by polychaetes, mollusks and echinoderms. The maximum number of individuals was found in *Stypocaulon scoparium* whilst the minimum number of individuals was found in *Cystoseira humilis*. The intermediate number of individuals was found in *Halopteris scoparia*. On the other hand, the maximum number of species was found in *H. scoparia* and the minimum number of species was found in *C. humilis*. The intermediate diversity of species was found in *S. scoparium*. A total of 94 species were identified. In turn, multivariate analyses showed that there are significant differences in epifaunal composition amond the studied algae. The MDS analysis showed that the epifaunal community of each alga is different; that is, there is a high spatial variability within the three macroalgae. In turn, through the Permutational Multivariate Analysis of Variance (PERMANOVA) it was possible to verify that there were significant differences between the algae studied, specifically between the algal epifauna due to the different structural complexity of each one. These differences were due to the fact that the dominant species varied and in turn to the fact that there were several species that were only found in one of the three algae. Therefore, it is demonstrated that there is a clear relationship between the structural complexity of the algae and the abundance and richness of the associated fauna.

Keywords: Macroalgae, structural complexity, intertidal, epifauna community, Canary islands, *Cystoseira humilis, Stypocaulon scoparium*, *Halopteris Scoparia*.

Resumen

La complejidad del hábitat es uno de los factores más importantes que estructuran los ensamblajes bióticos y tiene una gran importancia en diferentes ecosistemas. Las macroalgas son un claro ejemplo de esta idea. Son ecosistemas que albergan una alta biodiversidad porque proporcionan un hábitat físico único para soportar la producción, lo que las convierte en ensambles faunísticos densos, diversos y productivos. Los talos proporcionan un sustrato

para el crecimiento de microalgas epífitas que alimentan las redes tróficas y un refugio para invertebrados y peces que alcanzan densidades sustancialmente más altas que en los hábitats bentónicos sin vegetación. También proporcionan un refugio esencial contra la depredación. Este trabajo estudia la complejidad estructural de las algas como un factor importante que impulsa la estructura de los conjuntos epifaunales asociados a las macroalgas marinas. Para ello se seleccionaron tres especies de algas por su similar complejidad estructural, *Cystoseira humilis, Halopteris scoparia* y *Stypocaulon scoparium*. Éstas albergan una rica epifauna y una complejidad estructural similar, con ligeras diferencias entre ellas. Estas pequeñas diferencias de las algas estudiadas en cuanto a complejidad estructural generan una comunidad epifaunal completamente diferente. Los crustáceos fueron el grupo más abundante en la comunidad epifaunística, seguidos de los poliquetos, los moluscos y finalmente los equinodermos. El número máximo de individuos se encontró en *Stypocaulon scoparium* mientras que el número mínimo de individuos se encontró en *Cystoseira humilis*. El número intermedio de individuos se encontró en *Halopteris scoparia*. Por otra parte, el número máximo de especies se encontró en *Halopteris scoparia* y el número mínimo de especies se encontró en *Cystoseira humilis*. La diversidad intermedia de especies se encontró en *Stypocaulon scoparium*. Se obtuvieron un total de 94 especies diferentes. A su vez, los análisis multivariantes mostraron que existen diferencias significativas en la composición epifaunística. El análisis MDS mostró que la comunidad epifaunal de cada alga es diferente; es decir, que existe una alta variabilidad espacial dentro de las tres macroalgas. A su vez, a traves del Análisis Multivariante Permutado de la Varianza (PERMANOVA) se pudo verificar que existen diferencias significativas entre las algas estudiadas, específicamente entre la epifauna algal debido a la diferente complejidad estructural de cada una. Estas diferencias se debieron a que las especies dominantes variaron y a su vez a que hubo varias especies que sólo se encontraron en una de las tres algas y no en las tres. Por tanto, se demuestra que existe una clara relación entre la complejidad estructural de las algas y la abundancia y riqueza de la fauna asociada.

Palabras clave: Macroalgas, complejidad estructural, comunidad epifaunal, Islas Canarias, *Cystoseira humilis, Stypocaulon scoparium, Halopteris Scoparia.*

1. **Introduction**

Macroalgae are one of the most productive coastal ecosystems on Earth (Hurd et. al., 2014). They constitute some of the most heterogeneous landscape structures of the world's shallow water estuarine/marine ecosystems (Boström et. al., 2006). They are called biodiversity hotspots, as they are ecosystems that host a great biodiversity (Boström et. al., 2006). They have a physical structure in sediment bottoms that otherwise lack distinctive features, which enhances community diversity, biomass and primary and secondary production. That's why they show a complete or efficient use of resources, less niche space may be available for new species to occupy (White & Shurin, 2007). The leaves provide a substrate for the growth of epiphytic microalgae that feed food webs and a refuge for invertebrates and fish that reach substantially higher densities than in unvegetated benthic habitats (Hurd et. al., 2014). They also provide essential refuge from predation, so they are a unique physical habitat to support production, making them dense, diverse, and productive faunal assemblages (Valentine & Duffy, 2006a). Macroalgae harbour a lot of biodiversity because of the large amount of fauna that are associated with thalli. That is the reason that more biodiversity is found in seaweed beds and seagrass meadows than in sandy bare bottoms. Seaweed faunal assemblages consist of groups of animals with different life forms and ecological characteristics (Orth et. al., 1984). It is important to mention that the structural complexity of algae is an important factor driving the structure of epifaunal assemblages associated with marine macroalgae (Carvalho et al., 2018). As in all ecosystems, these environments are influenced by the abiotic environment, including climate, light and nutrient regimes (Valentine & Duffy, 2006b).

Generally, in habitats with more structural complexity is observed a greater abundance and richness of fauna, because the vegetation reduces predation, mitigates physical disturbance, increases food availability and increases the number of niches (Menéndez, 2016). These niches do not overlap with another niche and with another species, so that several species can live in the same place, which means that there is a compartmentalization of niches, which is why this type of algae will harbor greater biodiversity. The structural complexity of the algae is of utmost importance in marine environments and it is a key factor in the epifauna structure (Carvalho et al., 2018). It is an important factor driving the structure of epifauna assemblages (Carvalho et. al, 2018). This characteristic of algae is also an important descriptor of the diversity and abundance of their associated epifaunal assemblages (Carvalho et al., 2018). The morphology of macroalgae varies considerably (Torres et. al., 2015), so these organisms are considered ideal models for assessing the effects of structural complexity on ecological groups. Variation in macroalgae architecture (size of fronds and number of branches) and their functional or taxonomic composition (epiphytic hydroid and algae cover) have been found to be important descriptors of the diversity and abundance of their associated epifauna (Carvalho et. al, 2018). The substrate orientation is also the dominant influence on seaweed community composition, depending on the substrate we will find a different epifauna (Duran et. al., 2018).

The environmental factors conditioned the fauna and flora in marine ecosystems (Doney et. al., 2016), making a profound and diverse impact. There is a regression of intertidal algae due to the increase of ocean temperatures (Riera et. al., 2015) and there is also a change in the types of algae. The last decades coincided with the decrease in the morphological characteristics, especially on the length and width of the talus and the receptacles (Riera et. al., 2015). Algae that have less structural complexity, such as filamentous algae, are beginning to dominate. They are not branching algae (like Corallinacea algae for example), they have much less epifauna and much less associated biodiversity. Ambient conditions like intense storms, rising sea levels due to the climate change as the human influence on coastal processes (such as offshore dredging and land reclamation) have an extensive impact on the shorelines and obviously in seaweed (Loke et. al., 2016), but especially on rocky shores. For this reason, our study has focused on the rocky coasts of Gran Canaria.

The island of Gran Canaria (Canary Islands, NE Atlantic Ocean), is a high energy exposed area (Ramírez et. al., 2008). It belongs to the Canary archipelago (NE Atlantic Ocean) which is located at a distance of between 100 and 600 km from the NW coast of Africa and comprises 7 main islands as well as a group of small islets (Chinijo Archipelago) (Dóniz-Páez et. al., 2020). The nearshore waters of NW Africa are characterized by an almost annual wind-driven upwelling that brings cold, nutrient-rich groundwater to the surface, extending as a 50-70 km band along the coast. Consequently, The Canary Islands lie at the transition between the oligotrophic open ocean and the upwelling of NW Africa (the so-called Northwest African Coastal Transition Zone [NACTZ]) (Davenport et. al., 2001). Consequently, the islands are subject to different oceanographic conditions and regimes of "upwelling" effects that produce qualitative and quantitative differences (Davenport et. al., 2001). At the same time, the persistent trade winds induce strong turbulence (swell and wind) on the exposed coasts facing north and northeast, while those facing south and southwest are more sheltered (Davenport et. al., 2002). That's why the island of Gran Canaria is a suitable place for seaweeds and the impact of ambient conditions and anthropogenic factors on the shorelines (Ramírez et. al., 2008). Moreover, one study found that the Canary Islands harbor the largest number of taxa unique to any other archipelago within the Macaronesian zone, representing about one-third of its algal flora (Ramírez et. al., 2008). Architectural differences between macrophyte communities may affect epiphyte species composition. From all of the above we can say that on the island of Gran Canaria there will be a lot of variation among macrophyte communities, causing architectural differences in algae that may affect the composition of epiphyte species. Taking this into account, it is to be expected that among the different structural complexity of macroalgae, differences in faunal proportions for a given taxon are to be found (Menéndez, 2016).

The aim of the present study was to observe the differences in the epifauna of different species of algae with contrasting structural complexity in an intertidal zone. Three algal species were selected for their structural complexity, *Cystoseira humilis*, *Halopteris scoparia* and *Stypocaulon scoparium*. They harbor a rich epifauna and a similar structural complexity, with slight differences between them. *Cystoseira humilis* is the least branched. Its basal part is flattened with foliaceous expansions, the stems are coriaceous and cylindrical, and the primary ramifications are scarce, while the secondary ones can be very numerous. It

has a long thallus and short but very crowded branches (**WoRMS Editorial Board**, 2022). As for *Halopteris scoparia*, they are small, compact, dark brown bushes. Brown algae with erect thallus of bushy appearance. It consists of alternating segmented and highly branched axes, which end in limited-growth verticillate branches arranged radially, branched in turn into smaller and arched branches. That is, it has a very short thallus and many small branches (**WoRMS Editorial Board**, 2022). Finally, *Stypocaulon scoparium* is formed by a main axis that branches alternately to originate tufted branches, with the appearance of inverted cones one after the other. It has a very short thallus (**WoRMS Editorial Board**, 2022). What differs structurally in these three algae is the size of the thallus and the branching, i.e. the separation between the branches. Therefore, the abovementioned algae species were selected for the present study due to their structural differentiation and it could be stated that a higher epifauna abundance is expected in *Stypocaulon scoparium* due to its greater complexity and the orientation of the substrate (sandy and rocky), followed by *Halopteris scoparia* and lastly *Cystoseira humilis* because it is the least branched.

2. **Material and methods**

2.1. Study area and sample collection

Samples were collected in the intertidal zone of the coasts of Gran Canaria during April and May 2022, namely in Bañaderos (north coast) and Confital (northeastern coast) (Fig. 1). The sample collection in the first area was in two intertidal areas that had abundant *Cystoseira humilis* and *Stypocaulon scoparium*. The other species of algae was collected in one of the intertidal areas before reaching the Confital beach, *Halopteris scoparia*. Twenty samples were collected for each species of algae using 25x 25 cm quadrats. Within these 20 samples of each algae were divided into 4 zones, zone 1, 2, 3 and 4, in each zone 5 samples equally distributed in the intertidal. These five zones were divided in the tidal flat so that the five samples from each zone were about three meters apart from each other. At each sampling station, the species studied were collected manually in the intertidal, separating the base of the species with a scraper to separate them from the rocky substrate without causing sudden movements that could shake the thalli, eliminating part of the associated fauna. Samples were transferred to the laboratory and immediately frozen to be preserved.
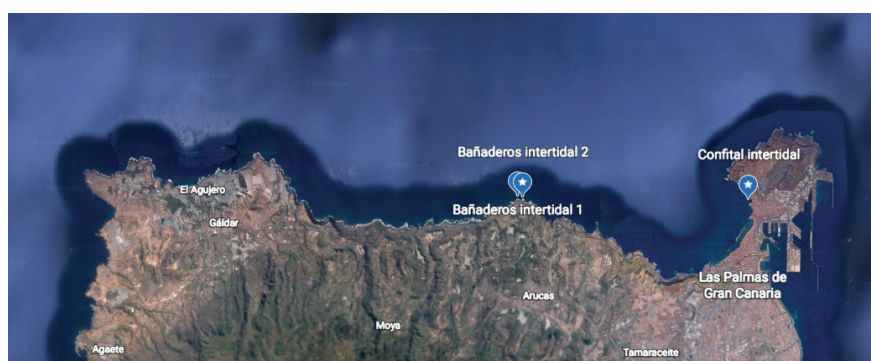
Figure 1. Sample locations in the island of Gran Canaria.

2.2. Algae description

- *Stypocaulon scoparium.*

Stypocaulon scoparium (Linnaeus) is an erect alga up to 20 cm high that forms dense masses (Fig. 2). Dark brown-green color. It is fixed to the substrate by means of rhizoids 1 to 3 mm wide. Frayed appearance in summer, but not so much in winter. The main axis is thick and divides into several main branches that divide in turn into twigs oriented in all directions (which do not branch out again), so that they look like shaving brushes arranged one on top of the other.

Figure 2. Specimen of *Stypocaulon scoparium*.

- *Cystoseira humilis.*

This is a cespitose seaweed (3-20 cm high), characterized by an apical region very different from the basal region, and by the presence of air-filled vesicles, which serve to keep the fronds erect in the water (Fig. 3). Older specimens have an elongated main axis, which arises from a compact disk by which the alga is attached to the substrate. Its basal part is flattened with foliaceous expansions, the stems are coriaceous and cylindrical, and the primary ramifications are scarce, while the secondary ones can be very numerous. The receptacles or fertile organs are cylindrical or fusiform, sometimes bifurcate, and are found at the tips of the branches.

Figure 3. Specimen of *Cystoseira humilis*.

- *Halopteris scoparia.*

Brown algae with erect thallus of bushy appearance rough texture and up to 15 cm long (Fig. 4). It consists of alternating segmented and highly branched axes, which end in limited growth whorls arranged radially, branched in turn into smaller and arched branches (Clarke and Warwick, 1994, 2001).

Figure 4. *Halopteris scoparia* sample.

2.3. Fauna sorting and identification

The separation of the epifauna found in the algae was carried out. They were put in a bucket with water and with the help of several tweezers the branches were separated and all the epifauna that was found were separated in a Petri dish. The fauna trapped in the Petri dish was separated with 70º alcohol and deposited in individual jars for each algae sample. The method by which the samples were analyzed consisted of separating the organisms individually with a small brush and placing them in vials according to taxa of major occurrence.

Subsequently, all the organisms were collected and classified into four large groups: crustaceans, annelids, mollusks and echinoderms. Later, the species identification was carried out by means of a stereo microscope. This identification was done using specialized bibliography of the different taxonomic groups (Lincoln, 1979, Pérez-Sánchez & Moreno, 1991, Riera et. al., 2003; Hanquet, 2014).

2.4. Data analysis

Statistical data analysis was performed using the R software. Boxplots were used to represent the data distribution of species richness and individual abundances. In addition, it shows the median or second quartile, the distance between the third quartile and the first quartile and extreme values that cannot be explained by the distribution. The first quartile indicates that 25% of the values are equal to or less than this and the third quartile with 75% of the values.

Standardization and logarithmic transformation were applied to the data prior to the analysis (Clarke and Warwick, 2001), after which a resemblance matrix using the Bray-Curtis similarity index was constructed (Clarke and Warwick, 2001; Clarke and Gorley, 2006). A non-metric multidimensional scaling (n-MDS) was carried out as a multivariate analysis that allows the ordination of the sampling sites in a two-dimensional spatial system where the disparity or similarity of the sites is observable. In other words, it represents similarity (or dissimilarity) measurements between pairs of objects as distances between sites in a reduced dimensional space (Clarke and Warwick, 2001; Clarke and Gorley, 2006). To conduct this, a

code was created for the automatic selection of the lowest stress in a total of 20 trials. Five n-MDS were performed with different factors of interest to the study (Clarke and Warwick, 1994, 2001). The first one shows the distribution considering algae species and temporal (time) variables. Thus, the differences of the epifaunal communities at temporal and spatial scales were observable.

The Permutational Multivariate Analysis of Variance (PERMANOVA) allows an analysis of a group of objects that are distributed or dispersed according to the factors taken into account (Anderson et al., 2008). PERMANOVA is performed taking into account the factors algae and location, both are fixed factors. Pseudo-F test (p-F) and a pairwise test for significant effects were estimated. The latter to be significant must have a value of $p<0.05$. To summarize overall trends in, we used the proportion of studies reporting significant (P <0.05) and non-significant (P > 0.05) results.

The abovementioned statistical analyses were carried out using a set of R packages. Mainly the *vegan* package contains the codes to perform the NMDS and PERMANOVA, *ggplot2* allows to perform graphs, among them the box_plot. Other packages such as *tidyverse*, *janitor, flextable* and *readxl* were also used in order to read the data and make graphsand tables with higher quality.

3. Results

A total of 5,094 individuals were collected, belonging to 94 species, within the 6 taxonomic groups, i.e. crustaceans, polychaetes, echinoderms, mollusks, sipunculids and nemertines. Crustaceans were the most abundant group in the epifaunal community (3,448 individuals, 67.69% of the overall abundance), followed by polychaetes (1,096 individuals, 21.52%), mollusks (324 individuals, 6.36%), echinoderms (171 individuals, 3.36%), sipunculids (32 individuals, 0.63%) and nemertines (23 individuals, 0.45%).

The maximum number of individuals was found in *Stypocaulon scoparium* with a mean of 103.809 ± 0.12 whilst the minimum number of individuals was found in *Cystoseira humilis* (54.48 ± 0.08 ind.). The intermediate number of individuals was found in *Halopteris scoparia* with a mean of 75.64 ± 0.09. As for the maximum number of species, the same results were obtained as for the number of individuals. The maximum number of species was found in *Halopteris scoparia* (65 species) and the minimum number of species was found in *Cystoseira humilis* (30 species). The intermediate diversity of species was found in *Stypocaulon scoparium* (62 species).

The highest abundance of mollusks (203 ind.) and polychaetes (760 ind.) was found in *Stypocaulon scoparium*. The epifauna of *Cystoseira humilis* showed the highest abundance of crustaceans (1,282 ind.) and sipunculids (14 ind.). The algae *Halopteris scoparia* obtained the highest abundance of echinoderms (122 individuals) and nemertines (13 ind.). Contrastly, the lowest abundance of molluscs (18 ind.), echinoderms (16 ind.), polychaetes (70 ind.) and nemertines (0 ind.) was obtained in *Cystoseira humilis*. And the lowest abundance of crustaceans (973 ind.) and sipunculids (6 ind.) was obtained in *Halopteris scoparia*. The intermediate abundances of crustaceans (1,193 ind.), echinoderms (33ind.), sipunculids (12 ind.) and nemertines (10 ind.) were obtained in *Stypocaulon scoparium*, and the intermediate

abundances of mollusks (103 ind.) and polychaetes (266 ind.) were found in *Halopteris scoparia*.

In terms of number of species, mollusks were the most diverse group with the highest species richness (41 species, 43.62% of the total number of species), followed by crustaceans (29 species, 30.85%), polychaetes (16 species, 17.02%), echinoderms (5 species, 5.32%) sipunculids (2 species, 2.13%) and nemertines (1 specie, 1.07%). The highest species diversity was found in *Halopteris scoparia* concerning the following taxonomic groups, i.e. mollusks (26 species, 63.42%), and echinoderms (3 species, 60%) and crustaceans (20 species, 68.97%), sipunculids (2 species, 100%) and nemertines (1 species, 100%), the last ones together with *Stypocaulon scoparium*. The highest diversity of polychaetes (16 species, 100%) was obtained in *S. scoparium*. On the other hand, the lowest species diversity of the six taxonomic groups was obtained in *Cystoseira humilis*, crustaceans (14 species, 48.28%) , mollusks (7 species, 17.07%), echinoderms (1 species, 20%), polychaetes (7 species, 43.75%), sipunculids (1 species, 50%) and nemertines (0 species, 0%). The intermediate species richness of mollusks (20 species, 48.8%) were obtained in *Stypocaulon scoparium*, and of polychaetes (13 species, 81.25%) in *Halopteris scoparia*. In terms of species, the most abundant in the three algae from high to low were *Apohyale perieri* (1,148 ind., 22.54%), *Ampithoe rubricata* (927 ind., 18.19%), *Dynamene edwardsi* (729 ind., 14.31%), *Polyophthalmus pictus* (628 ind., 12.33%), *Calcinus ornatus* (492 ind., 9.66%) and *Perinereis cultrifera* (195 ind., 3.83%).

It is observed that *Stypocaulon scoparium* (62 species) and *Halopteris scoparia* (65 species) have a similar species richness (Fig. 5). In contrast, in *Cystoseira humilis* a very low species richness is observed (30 species). The species diversity among the algae *Halopteris scoparia* (65 species, in green) and *Stypocaulon scoparium* (62 species, in blue) is very similar in the four zones. In contrast, the species diversity of *Cystoseira humilis* (30 species, in red) is much lower than the other two algae. It is also observed that the highest number of species is shown in *Halopteris scoparia* with 65 species, whilst *Cystoseira humilis* harbors the lowest number of species (30 taxa).
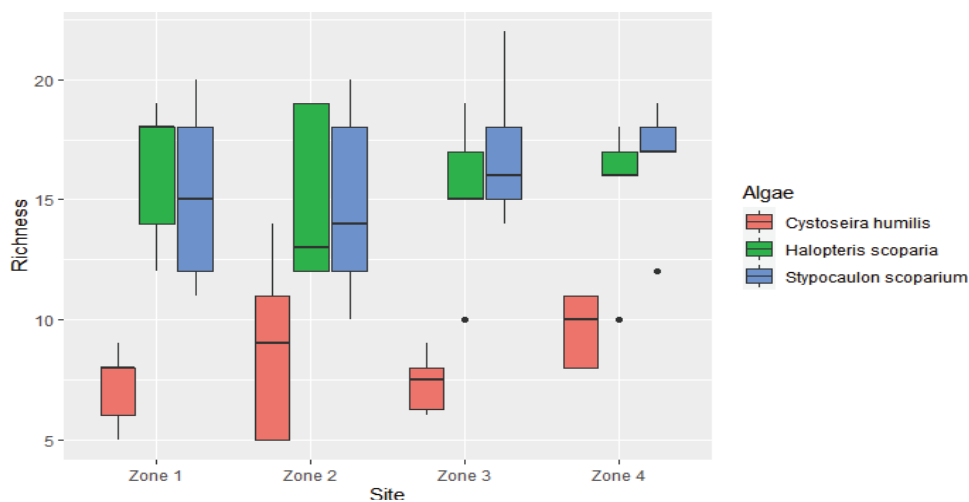
Figure 5. Epifaunal richness of the studied macroalgae at the sampling locations.

The maximum individual abundance (Fig. 6) is observed in *Stypocaulon scoparium (*103.809 ± 0.12), while the minimum is clearly observed in *Cystoseira humilis* (54.48 ± 0.08 ind.). The intermediate abundance is observed in *Halopteris scoparia* (75.64 ± 0.09). It is also observed how the abundance of individuals is quite similar in *H. scoparia* and *S. scoparium* in zones 2 and 3. In zones 1 and 4 there is a greater disparity in the abundance of individuals. Whilst in *C. humilis* is much lower than in the former two algae species.
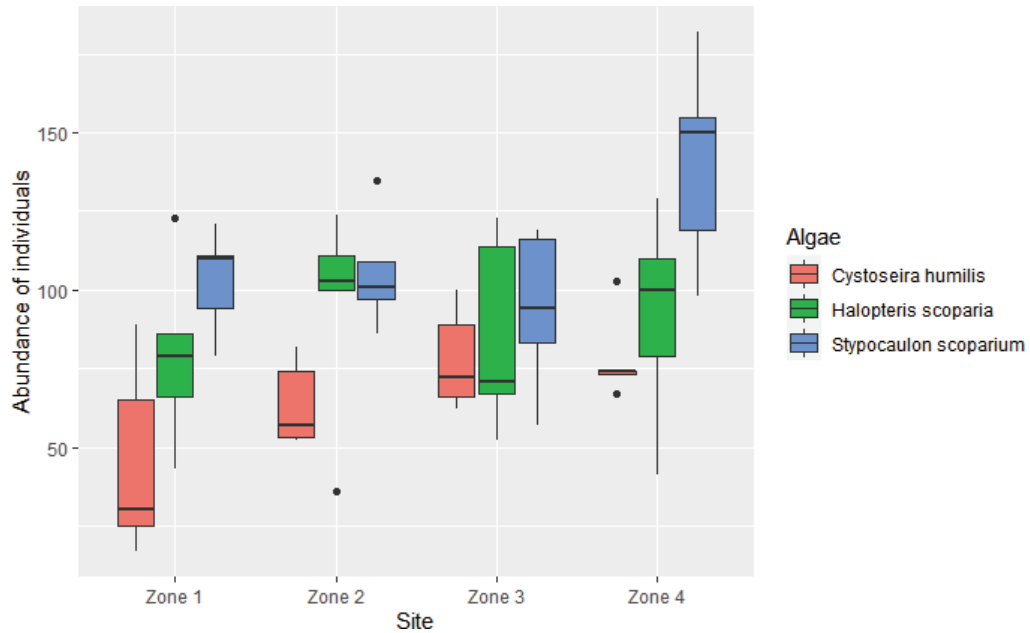
Figure 6. Epifaunal abundance of the studied macroalgae

at the sampling locations.

This MDS analysis (Fig. 7) shows no overlapping of the epifaunal community, which indicates that the epifaunal community of each algae is different. As can be seen, the different points that represent each species of algae are separated, they do not mix, they are very well separated.That data indicate high spatial variability within the three macroalgae.

It is observed that there is greater homogeneity in the epifaunal community of the algae *Halopteris scoparia* whilst the algae *Cystoseira humilis* and *Stypocaulon scoparium* have greater heterogeneity. The samples of *H. scoparia* are separated from the other two, this is because it presents a greater diversity of species with respect to the other algae. Each of the dots represents the species that are present with their abundances. As the locations of *C. humilis* and *S. scoparium* are very far apart, it indicates that there is no similarity between these algae and that the magnitudes of abundances are very different. This indicates that they have a different epifaunal community. The *H. scoparia* locations are closer to the other two algae, indicating that their epifaunal community is similar to the other two algae, it is an intermediate location in terms of species abundance and diversity.
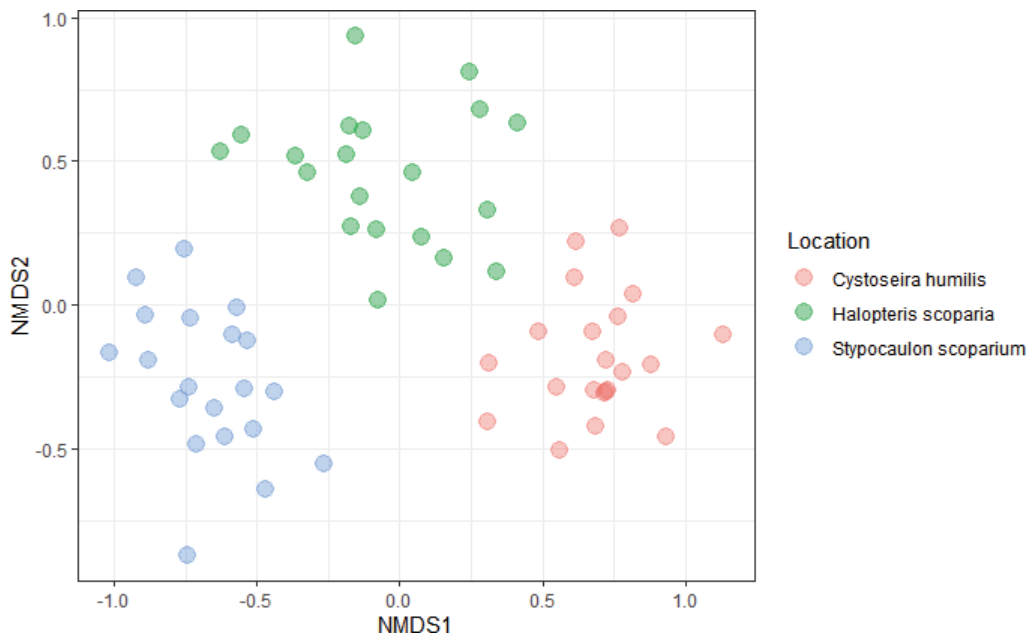
Figure 7. The distribution considering algae species and temporal (time) variables. It can be observed the differences of the epifaunal communities at temporal and spatial scales.

In addition, the Permutational Multivariate Analysis of Variance (PERMANOVA) showed significant differences between the studied algae (F=23.223, p=0.0001, highly significant). This indicates that the epifaunal community of *Cystoseira humilis* is different from the epifaunal community of *Stypocaulon scoparium* and *Halopteris scoparia*; that is, there are significant differences between the algal epifauna due to the different structural complexity of each one.

4. **Discussion**

In the present study, it was observed that the structural complexity plays an important role in the organization of the intertidal epifaunal community. The MDS analysis showed the high dissimilarity between the epifauna-associated communities to each of the studied algae since there is no overlap between sampling sites. The no overlapping of the epifaunal community indicates that the epifaunal community of each algae is different. This verifies that the structural complexity of the alga does affect the composition of the epifauna community associated with the algae. These parameters are due to the structural complexity of the algae and the substrate on which the algae are found. The fact that the algae is more branched and compact means that it reduces predation, mitigates physical disturbance, increases food availability and increases the number of niches, among others (Menéndez, 2016). In the case of the studied algae, the most branched are *Stypocaulon scoparium* and *Halopteris scoparia* and both present a rocky and sandy substrate. They have the highest abundance of organisms and species diversity. On the other hand, the *Cystoseira humilis* does not have as many branches, nor it is as compact as the other algae, and it has a rocky substrate. All these factors result in a lower abundance of individuals and species diversity, which is shown in the data obtained.

Habitat complexity is one of the most important factors structuring biotic assemblages and is of great importance in different ecosystems (Kovalenko et. al., 2012). It is commonly accepted that an increase in habitat complexity will result in an increase in diversity and/or abundance in the associated fauna (Sueiro et al., 2011). Habitat complexity encompasses the absolute abundance of individual structural components of the habitat and has long been considered one of the determinants of biological diversity. Thus, the magnitude of the influence of different organisms often depends on the habitat complexity introduced by them, and the way this habitat complexity modulates the environmental forces and/or biological processes that shape the associated community, in terms of their species richness, diversity and density (Sueiro et al., 2011). Although it is one of the main objectives of conservation management, methods for comparing complexity between ecosystems are not available and system-specific qualitative assessment predominates. Despite their overwhelming importance for faunal diversity and abundance, there has been surprisingly little interest in examining their effects on other community and ecosystem attributes. Many studies have evaluated the local effects of habitat complexity, reporting greater richness and abundance in more complex habitats. The positive effect of complexity on richness and abundance is likely to level off with increasing density of small uniform structures as the habitat becomes "homogeneously diverse" '(Kovalenko et. al., 2012). This highlights the importance of assessing more attributes of complexity than presence-absence or density of structures, as their arrangement, variability, and the scale of perception by organisms of interest play a critical role in mediating the effect of structural habitats (Kovalenko et. al., 2012). The relationship between habitat complexity and species richness may be universal. Notably, macroinvertebrate habitats are more varied - the macroinvertebrate assemblage is more diverse because a greater number of taxa can find suitable ecological niches. Thus, a greater number of substrate types with similar relative areas promotes a greater number of taxa (Jähnig & Lorenz, 2008). The three studied species that were selected have a similar structural complexity, and it can be seen that even being similar at the structural level, the epifaunal community is different. Therefore, it can be deduced that the epifaunal communities are specifid to the type of algae, they do not generate certain ecological niches that are exploited by these three species. So this confirms the importance of habitat structure for epifaunal communities, in thiscase the structural complexity of the algae.

Most historical reviews of ecology do not emphasize studies of the physical structure of the environment. Most studies on this topic have focused primarily on terrestrial plants and to a lesser extent, on terrestrial vertebrates. (McCoyand & Bell, 1991). Terrestrial plants provide the structure and vertebrates are the responding organisms (McCoyand & Bell, 1991). On the other hand, marine studies focus predominantly on non-insect invertebrates associated with plant and geological structures, or on vertebrates associated with animal structures. A recent study showed that complexity associated with coral reefs resulted in increased rates of evolution of both trophic novelty and morphological diversity, which contributes to consider complexity as an important factor not only to support but also to generate biodiversity (Kovalenko et. al., 2012).

The effects of predation may be altered by spatial heterogeneity and the presence of spatial refugia (Danovaro et. al., 2007). For example, macroalgal cover increases the spatial complexity of the habitat, providing refugia from predation and helping to reduce the impact

of epibenthic predation on rocky bottom meiofauna. In one study (Danovaro & Fraschetti, 2002) showed that the presence of macroalgae on rocky substrates increased the fractal complexity of the system, which could act as a refuge for prey of metazoan meiofauna. (Danovaro et. al., 2007). Most studies on macroalgae deal with the predator-prey relationship and the central role of grazing in seagrass ecology. in fact, there was one study that dealt with a mesocosm experiment that tested effects of grazer diversity on seagrass beds (Grazer diversity effects on ecosystem functioning). The main aim of those studies using epifauna was the role of grazing and the biodiversity of those ecosystems. Predation model has been most frequently put forward to explain faunal response variables in seagrass landscapes (Böstrom et. al., 2006). Compared to these studies on grazing, there are very few studies that deal with the structural complexity of seagrass using the epifauna associated with them (see exception, Duffy et. al., 2006).

Most faunal research has focused on vegetated patches, while there is little information on faunal patterns in unvegetated patches embedded within seagrasses (Böstrom et. al., 2006). Compared to terrestrial studies, seagrass landscape studies are still conducted on a small scale. Apart from a few studies that relate seagrass ecosystems to other habitats (mangroves, salt marshes, reefs), there are few studies that provide the context of the landscape itself (Böstrom et. al., 2006) and there are even fewer studies on the importance of structural complexity for biodiversity in seaweeds ecosystems. For future studies, more information is needed on seagrass landscapes with high structural and seagrass species diversity, on patterns and mechanisms of subtidal (>2 m depth) seagrass landscapes, and on studies addressing faunal community variation or ecosystem performance with landscape structure. Furthermore, to test the hypotheses of this work, the geographic distribution of macroalgal landscape studies should be significantly expanded to cover different regions of Gran Canaria. Sampling should be done in the east, south and west of the area and in different seasons, to observe the dynamics of these ecosystems throughout the year at different points. This study could even be extended to the other islands that make up the Canary archipelago.

5. <u>Conclusions</u>

This study demonstrates the relationship between the structural complexity of the algae and the abundance and richness of the associated fauna. It is worth mentioning that the small differences of the studied algae in terms of structural complexity generate different epifaunal community. The fact that a macroalgae has a greater structural complexity means that it has more associated epifauna, since these may result in some benefits to the epifauna assemblages. Vegetation reduces predation, mitigates physical disturbance, increases food availability and increases the number of niches (Menéndez, 2016). The more branched and compact the algae are, the more epifauna they will encompass. On the other hand, if it does not have a great structural complexity, there will be less epifauna associated with that macroalgae and less species diversity, as has been observed in this study.

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Annex

5094 ind, 94 species	*Stypocaulon scoparium* 62 species, 65.96%, 2,211 ind., 43.4 ± 30.12	*Halopteris scoparia* 65 species, 69.15%, 1,483ind., 29.11± 1.68	*Cystoseira humilis* 30 species, 31.91%, 1,400ind., 54.48 ± 0.08
Crustaceans 3448 ind., 67.69%, 29 species, 30.85%	1193 ind., 41.14 ±22.39, 20 species, 68.97%	973ind., 33.55 ±15.81, 20 species, 68.96%	1,282 ind., 44,21 ±21.24, 14 species, 48.28%
Amphilochus neapolitanus	0	1 (0.07±0.93)	1(0.07±0.93)
Ampithoe gammaroides	0	6 (0.40±5.60)	0
Ampithoe rubricata	368 (16.64 ±351.36)	277 (18.68±258.32)	282 (20.14±261.86)
Anthura gracilis montagu	0	0	0
Apohyale pierieri	543 (24.56 ±518.44)	279 (18.81±260.19)	326 (23.29±302.71)
Calcinus ornatus	8 (0.36±7.64)	0	0
Clibanarius aequabilis	156 (7.06±148.949	29 (1.96±27.04)	177 (12.64±164.36)
Crapella acantifera	5 (0.23±4.77)	2 (0.13±1.87)	0
Crapella cavenidae	7 (0.32±6.68)	0	0
Cymodose truncatus	0	14 (0.94±13.06)	21(1.50±19.50)
Cypridina mediterranea	1 (0.05±0.95)	0	0
Dardanus calidus	7 (0.32±6.68)	2 (0.13±1.87)	1(0.07±0.93)
Dexamine spinosa	2 (0.09±1.91)	1 (0.07±0.93)	0
Dynamene edwardsi	1 (0.05±0.95)	275 (18.54±256.46)	453 (32.36±420.64)
Elasmopus caneoe	9 (0.41±8.59)	2 (0.13±1.87)	2 (0.14±1.86)

Elasmopus rapax	24(1.09±22.91)	1 (0.07±0.93)	0
Erichtonius brasiliensis	0	1 (0.07±0.93)	0
Iljeborgia pallida	0	66 (4.45±61.55)	11 (0.79±10.21)
Maera grossimana	0	2 (0.13±1.87)	0
Nanocassiope melanodactylus	7 (0.32±6.68)	2 (0.13±1.87)	0
Orchestia gammarellus	0	0	1(0.07±0.93)
Orchomene humilis	1 (0.05±0.95)	0	0
Palaemon elegans	2 (0.09±1.91)	0	0
Pycnogonids	0	0	2 (0.14±1.86)
Pisa carimana	10 (0.45±9.55)	1 (0.07±0.93)	1(0.07±0.93)
Plagusia depressa	11 (0.50±10.50)	10 (0.67±9.33)	2 (0.14±1.86)
Sunampithoe pelagica	21 (0.95±20.05)	1 (0.07±0.93)	2 (0.14±1.86)
Tanais dulongii	5 (0.23±4.77)	0	0
Xantho sp1	5 (0.23±4.77)	1 (0.07±0.93)	0
Mollusks 324 ind., 6.36%, 41 species, 43.62%	203 ind., 4.83±2.27, 20 species, 48.8%	103 ind., 2.48±0.87, 26 species, 63.42%	18 ind., 0.43±0.25, 7 species, 17.07%
Acanthochitona sp.	1 (0.05± 0.95)	0	0
Alchitoe wilsonae	0	0	1(0.07±0.93)
Amyelina pfeifferi	51 (2.31±48.69)	4 (0.27±3.73)	0
Aplysiosis formosa	0	32 (2.16±29.84)	0
Barleeia unifasciata	1(0.05±0.95)	8 (0.54±7.46)	0
Bittium latreilli	15 (0.68±14.32)	0	0
Calliostoma laugieri	0	1 (0.07±0.93)	0
Calliostoma			

lusitancium	0	1 (0.07±0.93)	0
Calliostoma zizyphinum	0	2 (0.13±1.87)	0
Cardita calcyculata	0	11(0.74±10.26)	0
Chauvelia cf. turritelata	4 (0.18±3.82)	0	0
Columbella adansoni	82 (3.71±78.29)	1 (0.07±0.93)	2 (0.14±1.86)
Diplodonta rotundata	0	1 (0.07±0.93)	0
Echineulima leucophaes	0	1 (0.07±0.93)	0
Fossaris ambiguus	0	0	1(0.07±0.93)
Phorcus atratus	0	2 (0.13±1.87)	10 (0.71±9.29)
Raphitoma philberti	0	1 (0.07±0.93)	0
Glans trapezia	0	1 (0.07±0.93)	0
Lima inflata	0	0	2 (0.14±1.86)
Littorina striata	2 (0.09±1.91)	0	0
Luria lurida	2 (0.09±1.91)	0	0
Lyonsia norwegica	0	1(0.07±0.93)	0
Mitrella cf. broderipi	2 (0.09±1.91)	1 (0.07±0.93)	0
Mitrella sp1	4 (0.18±3.82)	8 (0.54±7.46)	0
Musculus costulatus	3 (0.14 ± 2.86)	0	0
Parvicardium scriptum	1 (0.05± 0.95)	0	0
Philinopsis depicta	0	1 (0.07±0.93)	0
Philippia hybrida	0	1 (0.07±0.93)	1(0.07±0.93)
Rissoa albugo	0	1 (0.07±0.93)	0
Rissoa guerinii	7 (0.32±6.68)	1 (0.07±0.93)	0

Rissoa lia	0	1 (0.07±0.93)	0
Tricolia pullus canarica	0	7 (0.47±6.53)	0
Triphora atlantica	2 (0.09±1.91)	0	0
Triphora perversa	6 (0.27±5.73)	12 (0.81±11.19)	0
Triphora sp2	12 (0.54±11.46)	0	0
Triphora sp3	1 (0.05± 0.95)	0	0
Triphoris alternata	1 (0.05± 0.95)	0	0
Trochidae	0	0	1(0.07±0.93)
Turbonilla campanellae	3 (0.14 ± 2.86)	0	0
Vexilium zebrinum	0	1 (0.07±0.93)	0
Vexinum zebrina	3 (0.14 ± 2.86)	1 (0.07±0.93)	0
Polychaetes 1,096 ind., 21.52%, 16 species, 17.02%	760 ind., 47.5±36.66, 16 species, 100%	266 ind., 16.625±6.95, 13 species, 81.25%	70 ind., 4.38±2.02, 7 species, 43.75%
Amphiglena mediterranea	4 (0.18±3.82)	10 (0.67±9.33)	19 (1.36±17.64)
Chironomidae sp1	1 (0.05±0.95)	4 (0.27±3.73)	0
Chone sp. duneri	1 (0.05±0.95)	1 (0.07±0.93)	9 (0.64±8.36)
Cirratulidae aoudinia	1 (0.05±0.95)	5 (0.34±4.66)	0
Cirratulidae sp1	9 (0.41±8.59)	31 (2.09±28.91)	10 (0.071±9.29)
Folyophtalaris pictus	592 (26.78±565.22)	33 (2.23±30.77)	3 (0.21±2.79)
Harmothoe sp	1 (0.05±0.95)	1 (0.07±0.93)	1(0.07±0.93)
Maldanidae sp1	64 (2.89±61.11)	49 (3.30±45.70)	0
Micidiom caribaea	3 (0.14 ± 2.86)	9 (0.61±8.39)	0
Nereididae sp2	3 (0.14 ± 2.86)	0	0
Perinereis cultrifera	62 (2.80±59.20)	106 (7.15±98.85)	27 (1.93±25.07)

Psamathe fusca	5 (0.23±4.77)	4 (0.27±3.73)	0
Scolectoma funchaelensis	5 (0.23±4.77)	0	0
Scolophos armiger	3 (0.14 ± 2.86)	9 80.61±8.39)	0
Syllidae sp1	5 (0.23±4.77)	4 (0.27±3.73)	1(0.07±0.93)
Syllidae sp2	1 (0.05±0.95)	0	0
Sipunculids 32 ind., 0.63%, 2 species, 2.13%	12 ind., 6±5, 2 species, 100%	6 ind., 3±2, 2 species, 100%	14 ind., 7±7, 1 species, 50%
Aspidosiphon muelleri	1 (0,05±0.95)	1 (0.07±0.93)	0
Phascolosoma stephensoni	11 (0.50±10.50)	5 (0.34±4.66)	14 (1±13)
Nemertines 23 ind., 0.45%, 1 species, 1.07%	10 ind., 1 specie, 100%	13 ind., 1 species, 100%	0 ind., 0 species, 0%
Nemertine sp1	10 (0,45±9.55)	13 (0.88±12.12)	0
Echinoderms 171 ind., 3.36%, 5 species, 5.32%	33 ind., 6.6±5.38, 3 species, 60%	122 ind., 24.4±23.41, 3 species, 60%	16 ind., 3.2±3.2, 1 species, 20%
Amphipholis squamata	28 (1,27±26.73)	118 (7.96±110.04)	16 (1.14±14.86)
Asterina gibbosa	0	1 (0.07±0.93)	0
Coscinasterias tenuispina	0	3 (0.20±2.80)	0
Marthasterias glacialis	2 (0.09±1.91)	0	0
Paracentrotus lividus	3 (0.14±2.86)	0	0

Table 1. Abundance and diversity of species obtained in total and in each taxonomic groupof the three studied macroalgae.