Universidade de Aveiro Departamento de Biologia
2012

Maria Inês Rocha Maia Dias

Biodiversidade associada a gorgónias do Sul de Portugal

Epifaunal biodiversity of gorgonians from the South of Portugal

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Dissertação apresentada à Universidade de Aveiro para cumprimento dos requisitos necessários à obtenção do grau de Mestre em Biologia Aplicada-Ramo Biologia Aplicada, realizada sob a orientação científica da Doutora Susana Carvalho, Investigadora de Pós-Doutoramento do instituto Português do Mar e da Atmosfera, e coorientação científica da Doutora Marina Ribeiro da Cunha, Professora Auxiliar do Departamento de Biologia da Universidade de Aveiro.

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palavras-chave

Biodiversidade, gorgónias, *Eunicella gazella*, *Leptogorgia lusitanica*, comunidade epibentónica, variação temporal

resumo

As gorgónias são organismos sésseis que devido à sua estrutura complexa e tridimensional desempenham um papel ecológico importante nos ecossistemas costeiros, proporcionando substrato físico, local de refúgio e fonte de alimento a outros organismos. No entanto, apesar da sua importância como espécies estruturantes, poucos estudos têm tido em consideração os padrões ecológicos, tanto das gorgónias como da sua fauna associada. Este estudo tem como principal objectivo analisar os padrões temporais da fauna epibentónica de duas das gorgónias mais abundantes do sul de Portugal, *Eunicella gazella* e *Leptogorgia lusitanica*. Devido à diferença no tamanho das colónias de gorgónias presentes, os padrões ecológicos da sua fauna associada foram analisados considerando 3 classes de tamanho. Tendo como objectivo averiguar flutuações temporais, as amostras foram recolhidas em Julho e Novembro de 2010, Março, Junho e Agosto de 2011 na Pedra da Greta (Algarve). Os resultados observados, indicam que o organismo hospedeiro exerce um efeito importante na composição e estrutura da comunidade associada, ainda que a maioria dos taxa seja comum às duas gorgónias. Não obstante, com maior influência que o tamanho da colónia, a variabilidade temporal, foi considerada o principal contribuinte para a explicação dos padrões ecológicos observados na fauna associada, na qual anfípodes, moluscos e poliquetas foram os grupos mais ricos e comuns. Os padrões temporais foram caracterizados por uma elevada densidade e diversidade da epifauna no período Primavera-Verão, seguida de uma elevada mortalidade ou emigração de taxa raros ou ocasionais, resultando num decréscimo dos valores das variáveis biológicas. Durante o período Outono-Inverno, a comunidade foi maioritariamente dominada por taxa residentes (ou seja, taxa presentes em todos os períodos de amostragem). Após o aumento da abundância de fitoplâncton observado neste período e à medida que a temperatura da água aumenta, a recolonização durante a Primavera contribui para o restabelecimento da comunidade rica e abundante do Verão. Assim, a variabilidade temporal é um factor a ter em conta na elaboração de estudos de biodiversidade, visto ser provável a ocorrência de diferenças significativas durante o período de amostragem.

keywords

Biodiversity, gorgonians, *Eunicella gazella*, *Leptogorgia lusitanica*, epibenthic assemblage, temporal variation

abstract

Gorgonians are sessile cnidarians with a three-dimensional and complex structure that plays a relevant ecological role in coastal ecosystems, providing physical habitat, refuge and food sources for other small organisms. Despite their relevance as foundation species, very few studies have addressed the ecological patterns of hosts (gorgonians) and their attendant fauna. The present study aims to analyse the temporal variability of the epifaunal assemblages associated with two of the most abundant gorgonian species from southern Portugal, *Eunicella gazella* and *Leptogorgia lusitanica*. As gorgonian populations comprise colonies of different sizes, ecological patterns of attendant assemblages were also analysed with regards to colony size (3 size classes). Replicate samples were collected in July and November 2010, March, June and August 2011 in Pedra da Greta (Algarve, Portugal). The results suggest that the gorgonian host exert a significant effect on the composition and structure of the attendant epifaunal assemblages, although most taxa were common to both hosts. Time, more than size, was found to be a main driver of the ecological patterns of these assemblages, where amphipods, molluscs and polychaetes were the more abundant and richest groups. The temporal patterns were characterized by high densities and diversity in the attendant epifaunal assemblages during spring-summer, followed by a high mortality or emigration of rare and occasional taxa, leading to a sharp decrease in the values of biodiversity and abundance indicators. During the autumn-winter period, the assemblages were mainly dominated by the resident taxa (i.e. taxa present in all sampling dates). After the peak of phytoplankton observed during this period and as the seawater temperature increased, the spring recolonization contributed to the re-establishing of rich and abundant assemblages that persisted during the summer. Therefore, temporal variability must be taken into account for the design of future biodiversity assessment studies, as different patterns may be observed depending on the sampling time.

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1. Introduction

1.1. Gorgonians

Gorgonians are sessile organisms (phylum Cnidaria, order Alcyonacea) also known as horny corals or sea fans. They are primarily observed in shallow tropical waters (Bayer, 1961), but are also known to be common and widespread in shallow (e.g. Bayer, 1961; Yoshioka and Yoshioka, 1991; Goh *et al.*, 1999) and deep waters (e.g. Mortensen and Fosså, 2006) from the Arctic (Starmans *et al.*, 1999; Kenchington *et al.*, 2011) to the Antarctic (Starmans *et al.*, 1999). Although they are preferentially found on hard-bottoms (Gili and Coma, 1998; Bramanti *et al.*, 2005; Buhl-Mortensen *et al.*, 2010; Gori *et al.*, 2010), some species also occur on soft sediments (e.g. *Leptogorgia sarmentosa*, *Sidella lofotensi*s *Acanella arbuscula* and *Radicipes gracilis*) (Buhl-Mortensen *et al.*, 2010; Gori *et al.*, 2010). Therefore, patterns of distribution seem to be species-specific, as a result of different ecological requirements (Fabricius and Alderslade, 2001; Gori *et al.*, 2010).

The order Alcyonacea is formed by five suborders, Alcyoniina, Calcaxonia, Holaxonia, Scleraxonia and Stolonifera, comprising over than 1300 species grouped in 29 families (Fabricius and Alderslade, 2001; Daly *et al.*, 2007). The sub-order Holaxonia contains the majority of these species (~ 60%) (Daly *et al.*, 2007). Several families have a worldwide distribution and are speciose, namely Primnoidae, Isididae, Elisellidae, Plexauridae, Gorgoniidae, and Acanthogorgiidae (Daly *et al.*, 2007). However, the systematics of the order is still under debate with most of families and genera requiring a comprehensive taxonomic revision (McFadden *et al.*, 2006; Daly *et al.*, 2007).

1.1.1. Morphology

Gorgonians possess an internal axial organic skeleton formed by organic and inorganic components: the gorgonin, a complex protein rich in mucopolysaccharides (Kaestner, 1967) is secreted by the coenenchyme and provides flexibility for an efficient filtering of food particles and to withstand strong currents (Ehrlich, 2010); the sclerites (formed mainly by calcite) are responsible for the structural support and maintain the colony shape (Fautin and Mariscal, 1991).

Gorgonians are modular organisms as each individual colony is composed of multiple units or modules, the polyps. These genetically identical structures are distributed over the coenenchyme and are located around the internal axis (Fabricius and Alderslade, 2001) (Figure 1). Polyps are divided in two main parts: the anthocodia, the upper portion where the mouth and tentacles are located and that can extend and retract within the cortex (coenenchymal layer surrounding the medulla and comprising the polyps); and the anthostele, the lower and rigid part into which the anthocodia is withdrawn, it is the extension of the gastrodermal canal (Figure 1) (Bayer *et al.*, 1983). In each autozooid, there are eight pinnate tentacles and eight complete mesenteries (one for each tentacle), with only one siphonoglyph being present (Barnes. 1980; (Barnes, 1963; Bayer *et al.*, 1983). Polyps communicate by numerous stem canals and solenia in the coenenchyme that are used for food and water transport (Figure 1) (Fautin and Mariscal, 1991). The coenenchyme, which secretes the organic skeleton, holds calcareous ossicles or spicules (zooids) of various shapes and colours (in many cases they define the colour of the gorgonian) (Barnes, 1963).

Most octocorals are monomorphic, i.e. they possess only one type of polyp, the autozooid, mainly responsible for capturing food and reproduction (Fabricius and Alderslade, 2001). However, a few species (e.g. *Lobophytum sp.,* Fabricius and Alderslade, 2001; *Heteroxenia fuscescens,* Benayahu *et al.*, 1989; and *Heteroxenia coheni,* Benayahu, 1991) are dimorphic possessing two types of polyp: autozooids and syphonozooid (smaller polyp with none or rudimentary tentacles) (Fabricius and Alderslade, 2001).

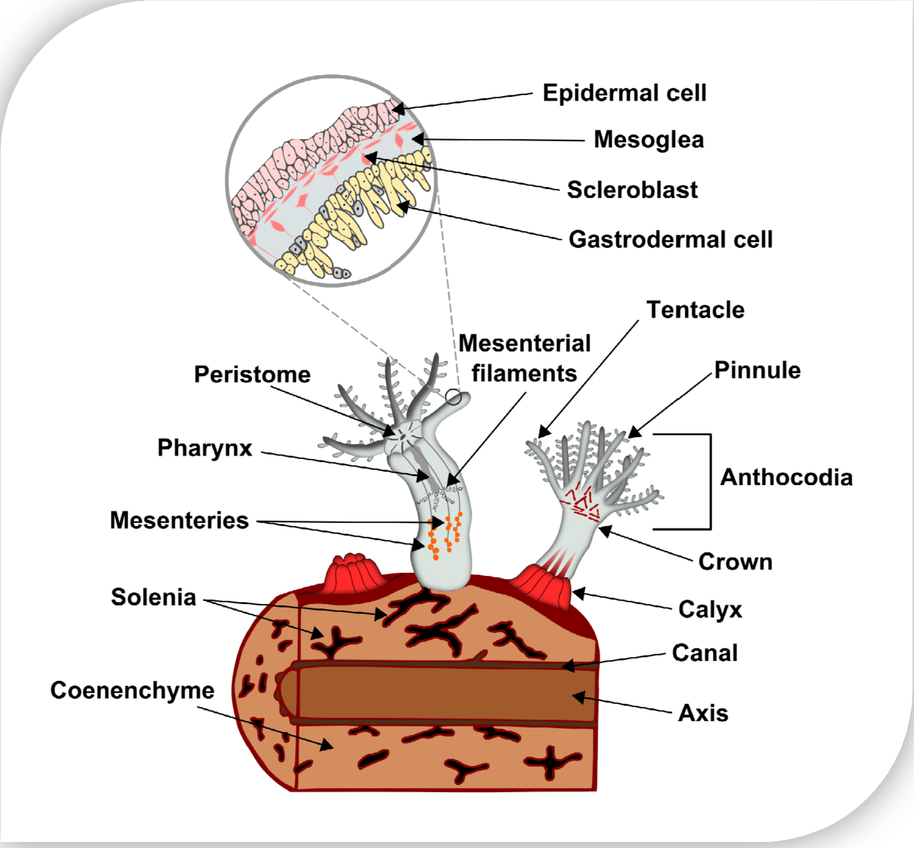

Figure 1. Representation of a polyp (modified from Hyman, 1940)

Most colonies are erect branched (Barnes, 1963), treelike, whiplike or bushy, and flexible (Kaestner, 1967) and may reach several meters in width (Brusca and Brusca, 2003). Size and shape of colonies are not only species-dependent (Ruppert and Barnes, 1994) but can also vary according to the hydrodynamic conditions. In areas with plane currents, the branches of the colony tend to grow in a single plane, whereas when currents are more variable, they tend to grow in two planes (Brusca and Brusca, 2003). Being attached to a small area of hard substrate, the arborescent morphology allows them to exploit a large volume of water column, while their flexibility permits bending in currents and avoid breakage (Wainright and Koehl, 1976).

1.1.2. Feeding and growth

Gorgonians are passive suspension feeders with a diverse diet that allows them to exploit variable resources in time and space (Ribes *et al.*, 1999). Although it is consensual that sea fans usually feed on zooplankton (nauplii, copepods and invertebrate eggs, ranging from 100 to 700 µm) (Lasker, 1981; Sebens and Koehl, 1984; Ribes *et al.*, 1999; Ribes *et al.*, 2003) brought by the currents (Sponaugle and Labarbera, 1991; Ballesteros, 2006), some studies demonstrated that they can feed on smaller particles, such as phytoplankton (3 to 20 µm) (Fabricius *et al.*, 1995; Ribes *et al.*, 1999; Ribes *et al.*, 2003) ciliates (Ribes *et al.*, 1998, 1999). In a study concerning the Mediterranean species *Leptogorgia sarmentosa,* Ribes *et al.* (2003) found that the main food source for the Mediterranean species *Leptogorgia sarmentosa* was zooplankton (61%), whereas detrital particulate organic carbon (POC) contributed to 30.4 % and other sources of live carbon (pico and nanoplankton, dinoflagellates, diatoms and ciliates) with 8.6%. The total ingestion rate was estimated as ranging between 8.7 and 11.0 mg C g_{AFDW}^{-1} d^{-1} (Ribes *et al.*, 2003). Similar results were obtained for another gorgonian species, *Paramuricea clavata:* zooplankton ~48 %, POC ~48 %, live carbon < 100 µm ~4 % with a total ingestion rate of 2 mg C g_{AFDW}^{-1} d^{-1} AFDM (Ribes *et al.*, 1999).

The presence of epidermal cilia in the tentacles and polyps is thought to be essential for the capture of small particles and subsequent delivery to the coelenteron (Ribes *et al.*, 1999). Furthermore, the siphonoglyph has a major role in gorgonians' feeding process as it drives constant water current through the gastrovascular cavity (Bouillon, 1995 in Ribes *et al.*, 1999). In order to optimize their feeding capacity (Barnes, 1963), gorgonians are usually oriented perpendicular to current (Wainwrig and Dillon, 1969). Gorgonians secrete mucus that when released into the water disintegrate and form matrices of detritus and microorganisms. The mucus provides a nutritious food source for marine biota, containing wax esters, triglycerides, steroids and other organic compounds (Coles and Strathma, 1973; Benson and Muscatin, 1974; Ducklow and Mitchell, 1979 in Coffroth, 1984).

Many gorgonians possess algal symbionts named zooxanthellae, also known to occur in scleractinian corals (Preston and Preston, 1975; Ribes *et al.*, 1998). Although the presence of zooxanthellae is more frequent in gorgonians with a tropical and sub-tropical distribution, these symbionts are also present in gorgonians from temperate waters (e.g. *Eunicella singularis* in the Mediterranean; Gori *et al.*, 2010). The zooxanthellae organisms usually reside in the host's gastrodermis or epidermis, and less frequently also in the mesoglea. It is thought that cnidarians only utilize a small part of the energy produced by these symbionts (Brusca and Brusca, 2003). The photosynthetic rates are low when compared with scleractinian corals (Fabricius and Alderslade, 2001), and the energy generated is thought to be used for rapid growth and efficient deposition of the calcareous skeleton (Brusca and Brusca, 2003). According to Fabricius and Alderslade (2001), the low rate of photosynthesis is due to the low surface/volume ratio, as larger surfaces enable a greater harvest of light. However, the presence of symbiotic algae partially contributing to the nutrition enables a lower feeding rate of plankton in symbiont-hosting (e.g. *Plexaura flexuosa* and *Pseudoplexaura porosa)* than in asymbiotic gorgonians (Ribes *et al.*, 1998).

In general, gorgonian colonies have slow growth rates and medium or long residence times (Gili and Coma, 1998). *Plexaura clavata* has a mean growth rate ranging from 1.8 and 3.0 cm yr^{-1} (Mistri and Ceccherelli, 1994 and references therein). *Leptogorgia sarmentosa* (reported as *Lophogorgia ceratophyta*) shows growth rates ranging from 2.4 and 2.6 cm yr^{-1} (Mistri and Ceccherelli, 1994 and references therein) and *Paragorgia arborea* presents growth rates between 0.8 and 4 cm yr^{-1} (Sherwood and Edinger, 2009). Yoshioka and Yoshioka (1991) reported *Plexaurella dichotoma* and *Pseudopterogorgia americana* as having the lowest (0.8 cm yr^{-1}) and the highest (4.5 cm yr^{-1}) mean growth rate, respectively. These authors suggest that there is a positive correlation between growth rate and thickness of branches, and gorgonians with thicker branches generally present faster growth rates. However, Mistri and Ceccherelli (1994) refuted this interpretation, proving a non-linear relationship between these two factors and suggested that interspecific variations in growth of Mediterranean gorgonians are not as high as in Caribbean Sea fans.

Studies carried by several authors (Chamberlain and Graus, 1975; Sebens, 1984) postulated that, within given limits, octocoral colony size increases with increased current velocity and explained this relationship by the great availability of preys carried by moving water masses (Sebens, 1984) or by an increased oxygen diffusion due to the reduced thickness of the boundary layer (Sebens, 1987). However, colonies in habitats heavily exposed to wave action usually have small mean sizes, which may be explained by the high wave-induced mortality and the decrease of prey capture rates (Sebens, 1984). Other studies have suggested that light also plays a major role in coral growth (e.g. Glynn, 1976; Wellington, 1982; Reed, 1983). Corals were also reported to grow faster in areas exposed to upwelling, when compared with those located in non-upwelling areas (Reed, 1983; Sebens, 1984).

In corals, as modular organisms, colony growth occurs by the replication of their structural units (modules), the polyps, without the morphological and physiological limitations, such as maximum size and senescence, usually associated with aclonal animals (Garrabou, 1999). This growth mode allows corals to reproduce asexually (by fragmentation) but it has been suggested that fragmentation affects traits such as colony survival, reproduction and larval dispersal (Lasker, 1990).

1.1.3. Reproduction

Octocorals can reproduce both sexually and asexually (Lasker, 1988). Although asexual reproduction may be highly underestimated (Fautin, 2002), octocorals reproduce mainly sexually (Daly *et al.*, 2007; Kahng *et al.*, 2011).

Sexual reproduction and the subsequent dispersal of larvae are essential mechanisms to maintain genetic diversity and ensure connectivity of populations (Jackson, 1986). There are three modes of sexual reproduction in these animals: i) broadcast spawning with fertilization and planktonic embryonic development, ii) internal brooding whith fertilization and brooding occurring inside female polyps and iii) external brooding on the adult colony surface (Alino and Coll, 1989; Benayahu, 1991; Ben-Yosef and Benayahu, 1999; Brusca and Brusca, 2003).

Broadcast spawning is considered to be the most common strategy (Brusca and Brusca, 2003) and indeed, broadcast spawners may represent 49% of the 152 octocorals studied to date, whereas 40 % are internal brooders and 11% are external brooders (Kahng *et al.*, 2011).

Spawning is regulated by the lunar tidal cycle and/or sea temperature, leading to synchronization and increasing the chance of fertilization (Fabricius *et al.*, 1995). In the Medes Islands, *Paramuricea clavata,* a dominant species of Mediterranean biocenoses, spawning occurs generally in May, when sea temperature rises, and a few days after the full moon or the new moon (Coma *et al.*, 1995). Brazeau and Lasker (1989) also reported synchronized spawning with the full moon in May, June and July (higher temperatures). Gamete release was reported to be synchronized with full moon in several other gorgonians (e.g. *Diploria labyrinthiformis,* Alvarado Ch *et al.*, 2004; *Pseudoplexaura spp.*, *Plexaura homomalla* and *Plexaura kuna*, Coma and Lasker, 1997; Beiring and Lasker, 2000).

When the fertilization is internal, only a small number of eggs is fertilized, and few days to weeks later the larvae are released. When the fertilization is external, the eggs develop inside mucus pouches on the surface of the colony. In both cases, when the larvae are released, they settle and transform into new polyps (Fabricius and Alderslade, 2001).

In opposition to scleractinian corals, where hermaphroditism is the norm, gonochorism predominates among gorgonians. Furthermore, octocoral species can also have both gonochoric and hermaphroditic colonies, and parthenogenesis may occur with the oocytes developing into planula larvae without fertilization (see review by Kahng *et al.*, 2011).

In all anthozoans, gonads are the only sexual dimorphic characteristics of the colonies (Hyman, 1940). These structures are generally located in the autozooids (Benayahu and Loya, 1986; Achituv and Benayahu, 1990; Fabricius and Alderslade, 2001), though they can be found in autozooids and siphonozooids simultaneously (Kahng *et al.*, 2011 and references therein). There is no scientific evidence for a relationship between oocyte size and either sexuality, mode of reproduction or polyp fecundity (Kahng *et al.*, 2011). However, oocytes in octocorals are generally large sized suggesting that they are well supplied (of yolk) enhancing early survival (Kahng *et al.*, 2011). Additionally, zooxanthellate species have larger oocytes than azooxanthellate species suggesting that photosynthetic microalgae may aid in the provision of oocytes (Kahng *et al.*, 2011).

1.2. Ecological role of gorgonians in the ecosystem

Gorgonians can have a significant and longstanding impact in the environment (Bramanti *et al.*, 2005); they have a long lifespan (Gili and Coma, 1998) and build three-dimensional and often structurally complex colonies (Cadena *et al.*, 2010), which enhance substrate stability and reduce current velocity, provide new niches and, at the scale of the gorgonian gardens, may facilitate the settlement of several other organisms (Buhl-Mortensen *et al.*, 2010). Thereby, gorgonians are considered as “ecosystem engineers” (sensu Jones *et al.*, 1994), “foundation species” (Roff *et al.*, 2011) or “habitat-forming species” (Roff *et al.*, 2011) (Table 1). The habitats provided by gorgonians include the niches within each colony, but also the open space between several colonies, when they occur in stands (Buhl-Mortensen and Mortensen, 2005). The availability of ecological niches provided by gorgonians favors the colonization by several epibiont organisms that rely on their hosts as i) physical substrate; ii) refuge against predators; iii) food sources (in some cases the gorgonian itself); and iv) feeding grounds (Buhl-Mortensen and Mortensen, 2005). The arborescent morphology and perpendicular orientation of gorgonians to the current allows them to optimize the amount of water filtered through the polyps (Wainwrig and Dillon, 1969), consequently enhancing the feeding capacity of their associated epibionts (Buhl-Mortensen *et al.*, 2010). In addition, filter-feeding organisms may also utilize the nutritious particles trapped in the mucus secreted by gorgonians (Goh *et al.*, 1999). It is worth noting that “association” in the present study is used loosely referring to the co-occurrence of other species that may be found attached, on, or in the close vicinity of a gorgonian and does not imply necessarily a specific, preferential or dependent relationship between the gorgonian and the "associated" organisms.

Table 1. Definitions of the terminology used (from Jones *et al.*, 1994; Roff *et al.*, 2011)

Terminology	Definition
Ecosystem engineers	Organisms that directly or indirectly modulate the availability of resources (other than themselves) to other species, by causing physical state changes in biotic or abiotic materials. In so doing they modify, maintain and/or create habitats.
Foundation species	Single species that define much of the structure of a community by creating locally stable conditions for other species, and by modulating and stabilizing fundamental ecosystem processes.
Habitat-forming species	Organism that create or modify habitats that are in turn used by other organisms for shelter, feeding, or other purposes

Gorgonian colonies, likewise hard corals, are known to attract and harbour a great number of species (Buhl-Mortensen and Mortensen, 2004, 2005; Cúrdia, 2012) with different biotic interactions (e.g. symbiosis, predation, commensalism). However, the knowledge on host specificities (see Patton, 1994; Buhl-Mortensen and Mortensen, 2005) and patterns of biodiversity associated with gorgonian gardens is still scarce, especially in temperate Atlantic areas. Concerning the invertebrate fauna associated with these anthozoans, crustaceans (particularly amphipods) are dominant within tropical gorgonians (Goh *et al.*, 1999), while ophiuroids are the most frequent taxa in deep-water gorgonians (Buhl-Mortensen *et al.*, 2010). The importance of secondary colonizers, such as hydrozoans, bryozoans and sponges, to the biodiversity patterns within gorgonian gardens has also been recognized (Cúrdia, 2012). Indeed, some amphipods, such as several caprellids, *Stenopleustes malmgreni* and *Metopa bruzelii,* have been found to be closely associated with gorgonians epibionts (Buhl-Mortensen and Mortensen, 2005). Buhl-Mortensen and Mortensen (2005) also reported that despite their higher species richness, deep-water corals have fewer obligate species than shallow gorgonians (311 and 36, respectively). Despite all chemical and physical defences of gorgonians (Koh *et al.*, 2000), a few predator species occur within their associate assemblages. So far, the main known coral predators are the polychaete *Hermodice carunculata*, the gastropod *Cyphoma gibbosum* (Yoshioka and Yoshioka, 1991; Burkepile and Hay, 2007), nudibranchs of genus *Tritonia* (e.g. *Tritonia hamnerorum*, *Tritonia wellsi, Tritonia odhneri*) (Patton, 1972; Cronin *et al.*, 1995; Muniain, 2011) and some parasitic copepods (Zulueta, 1908 in Bayer, 1961).

In comparison to scleractinian corals, and especially in Atlantic temperate waters, the faunal assemblages associated with gorgonians are still poorly known, despite their high diversity (e.g. Patton, 1972; Wendt *et al.*, 1985; Buhl-Mortensen and Mortensen, 2005). Besides, most of the studies undertaken are mainly focused on the local (α-) and regional (γ-) diversity, largely neglecting β-diversity (Sevastou *et al.*, 2011; Cúrdia, 2012). While α-diversity is an inventory diversity measure, beta-diversity (β) measures differentiation diversity across spatial or temporal scales (e.g. different habitats, areas or environmental gradients) (Magurran, 1988; Gray, 2000; Becking *et al.*, 2006; Henry *et al.*, 2010). β-diversity may be estimated using dissimilarity coefficients, namely Jaccard, Sorensen or Bray-Curtis indexes (Magurran, 1988). Although β-diversity is an important component of species richness, this is only the second study addressing this component of biodiversity within gorgonian gardens. In order to better understand the ecological patterns in these systems of high conservation value, it is of utmost importance to undertake studies on the different biodiversity components because each component can be driven by different factors. While at regional scales, historical, phylogenetic, and climate processes are important determinants for the species richness pool (γ-diversity), biotic interactions play a relevant role in determining species diversity at local scales, e.g. within patches of habitats (α-diversity) (Balata *et al.*, 2007). On the other hand, β-diversity is driven by qualitative and quantitative changes in the physical characteristics of the habitat, which can affect variation in composition and abundance of species among sites (Balata *et al.*, 2007).

1.3. Disturbance pressures affecting gorgonian populations

The coastal areas have been suffering several changes in the last decades. The exponential increase of human populations in the coastal areas worldwide is the ultimate cause for these changes. This proliferation has intensified the pressure along the shoreline and, hence, coastal ecosystems have been subjected to an increasing intensity and/or frequency of anthropogenic and natural disturbances. In areas characterized by the occurrence of biogenic habitats such as coral reefs, mangroves and kelp forests (Pratchett *et al.*, 2011), these disturbances resulted in significant loss of diversity and abundance of foundation species (Hughes *et al.*, 2003).

In what concerns to reef areas, effects of natural and anthropogenic disturbances can range from short-term to chronic (Bythell *et al.*, 1993; Bavestrello *et al.*, 1997; Fava *et al.*, 2010). Natural phenomena (e.g. storms, hurricanes, changes in sea water temperature and epidemic diseases) usually cause an immediate effect on the community (Fava *et al.*, 2010) being mostly responsible for maintaining the local diversity (Connell, 1978). Biological events such as predation, diseases and coral bleaching have a chronic effect on coral reefs and, normally, result in total or partial mortality of the colonies (Bythell *et al.*, 1993).

Additionally, anthropogenic activities, such as fishing (Bavestrello *et al.*, 1997; Fava *et al.*, 2010), anchorage and polluting activities, have been exerting pressure in these habitats to a point where mass mortality episodes are increasingly frequent in coral reefs, including octocorals (Cupido *et al.*, 2008; Fava *et al.*, 2010). The increase of mortality events may lead to a state of no return for many species (Bythell *et al.*, 1993; Linares *et al.*, 2005; Cupido *et al.*, 2008), especially because most of these organisms present high longevity, poor dispersal, delayed maturity, high post-settlement mortality, and low recruitment rates (Linares *et al.*, 2005; Cupido *et al.*, 2008).

Furthermore, the effect of human activities and subsequent mortality of coral colonies, including gorgonians, are intimately connected to colony size (Kapela and Lasker, 1999; Linares *et al.*, 2005; Shin *et al.*, 2005; Linares *et al.*, 2008). Colony size is also crucial for determining life history traits (e.g. survival, growth, and reproduction) (Sebens, 1987; Kapela and Lasker, 1999; Cupido *et al.*, 2008; Linares *et al.*, 2008), vulnerability and persistence of these animals (e.g. Bythell *et al.*, 1993; Cerrano and Bavestrello, 2008; Cupido *et al.*, 2008).

Fishing

Fishing causes the destruction of reef habitats, and consequently contributes to the reduction in abundance and biomass of the biological assemblages, severely impacting the structure and functioning of ecosystems (Kaiser *et al.*, 2006). Fishing activities can also cause serious injuries in gorgonians (Bavestrello *et al.*, 1997). In areas with gorgonian gardens, long-line fishing (e.g. *Paramuricea clavata*) (Bavestrello *et al.*, 1997) and trawling by-catch (e.g. Buhl-Mortensen and Mortensen, 2005; Sherwood and Edinger, 2009) have been considered activities of major concern.

Accordinging to Jones (1992), there are three main consequences of trawling: i) scraping and ploughing; ii) sediment resuspension; iii) physical destruction, removal, or scattering of non-targeted benthos. The increased resuspension of sediment particles can restrict light penetration, and the subsequent sediment resettlement can smother benthic organisms (Jones, 1992).

Repeated trawling is likely to favour more opportunistic recolonizers and, therefore, alter the population and community structure of benthos (Probert *et al.*, 1997). Moreover, once damaged, the gorgonians are colonized by epibionts that compete with the polyps for the available space (Giuliani *et al.*, 2005). Additionally, suspended sediments and its accumulation on coral tissues were proved to affect the survival and growth rates, and increase the probability of bleaching and colony death caused by limitation of light penetration (Fabricius, 2005).

Recreational activities

One of the fastest increasing activities worldwide is scuba diving with over a million divers being trained every year (Davenport and Davenport, 2006). Despite de efforts of most diving centres to make scuba diving a non-destructive activity, most corals, namely gorgonians, still suffer from unintentional contact by divers (Coma *et al.*, 2004; Lloret and Riera, 2008; Cúrdia, 2012). The main effect of diving in corals reefs is the physical impact: detachment; tissue lost and consequent overgrowing by epibionts (Medio *et al.*, 1997; Jameson *et al.*, 1999; Tratalos and Austin, 2001; Lloret and Riera, 2008) caused either by accidental kicks by fins, or climbing (Davenport and Davenport, 2006). In the gorgonian *Paramuricea clavata*, mortality by detachment can be four times higher than due to epibiont overgrowth (Coma *et al.*, 2004).

Another significant activity is boating. The anchorage of recreational boats in areas of coral reefs, damages corals, in case of anchor contact (Davenport and Davenport, 2006). Additionally, boating can also increase the introduction of non-native species, which may alter the local community structure (Lloret and Riera, 2008).

Thermal stress

The Earth's surface temperature has been steadily increasing over the last decades. In the past century, average temperatures have increased 0.74°C (I.P.C.C., 2007). These higher temperatures are usually related to climate changes and specific climate phenomena, such as El Niño Southern Oscillation (ENSO) (Lasker, 2003). According to Cerrano and Bavestrello (2008) the thermal stress is the main factor causing gorgonian mass mortality in the Mediterranean.

The main impact of water warming in gorgonians is the coenenchyme necrosis: in *Corallium rubrum*, an observed increase of 6ºC in water temperature resulted in necrosis of 80% of the colony surface and exponential decrease in polyp activity, even reaching null activity (Torrents *et al.*, 2008). Polyp activity also seems to be reduced when there are damages in the coenenchyme even before necrosis (Torrents *et al.*, 2008).

An impact of thermal stress in symbiotic corals is the expulsion of their algal symbionts (zooxanthellae), a phenomenon known as coral bleaching (Harvell *et al.*, 1999). In fact, the increase of water temperature was proved to affect the maximal photochemical efficiency of the photosystem II (Ferrier-Pages *et al.*, 2009).

Diseases

Reef species are susceptible to diseases caused by a diversity of parasites and pathogens (Kaiser *et al.*, 2006), and mass mortality of gorgonians due to diseases has been the major cause for the alteration of rocky seascapes (Cerrano and Bavestrello, 2008).

The first reports on sea fan diseases date from the 1980's (Williams and Bunkley-Williams, 2000). Major gorgonian health problems are the red-band disease and aspergillosis. The first is caused by cyanobacteria infection, (e.g. *Oscillatoria* spp., *Schizothrix mexicana* and *Schizothrix calciola*), and the latter is caused by the fungus *Aspergillus sidowii* (Williams and Bunkley-Williams, 2000). The first symptom of these diseases is a change in the colour of the individuals that then evolves into damaged tissue, eventually to a point where areas of the skeletal axis are exposed (Williams and Bunkley-Williams, 2000; Bally and Garrabou, 2007).

Increased temperatures further enhance the probability of coral diseases (Harvell *et al.*, 1999). Although gorgonians have antimicrobial mechanisms, temperature increase appears to decrease the efficiency of these defences (Bally and Garrabou, 2007).

1.4. Southern Portugal gorgonian gardens

The Strait of Gibraltar, that separates Europe from Africa, is the area where the exchange of the Atlantic Ocean (at the surface) and the Mediterranean Sea (at the bottom) water masses occurs. This confluence provides unique oceanographic characteristics in the Southern Portugal (Sanchez *et al.*, 2006). Consequently, all the marine fauna and flora, and namely gorgonian assemblages are under the influence of different water masses. Indeed, the gorgonian fauna in the Southern Portugal is comprised by species from the Atlantic (*Eunicella verrucosa* and *Leptogorgia lusitanica*), the Mediterranean (*Leptogorgia sarmentosa*, *Eunicella singularis* and *Paramuricea clavata*) and North Africa (*Eunicella labiata* and *Eunicella gazella*) (Cúrdia, 2012). Specifically, gorgonian assemblages, down to 30m depth, are mainly composed by *Eunicella labiata* (recent colonization or previous incorrect identifications), *Eunicella verrucosa*, *Leptogorgia* sarmentosa, *Eunicella gazella* and *Leptogorgia lusitanica* (Cúrdia *et al.*, in press). At 59-120m depth, *Paramuricea clavata* is the dominant species in the assemblages (Anonymous, 2011) but, shallower than 30m, *Paramuricea clavata* colonies were found to be extremely rare and presenting low abundance. Likewise, the typical Mediterranean gorgonian *Eunicella singularis* was highly infrequent at this depth along the southern coast of Portugal (Cúrdia, 2012). A few other gorgonian species (*Leptogorgia viminalis*, *Echinomuricea atlantica* and *Paramuricea macrospina*) have been collected in the Algarve, especially from 30 to 70m (fishing by-catch) but the distribution of those species and their abundance patterns is largely unknown (Vieira, 2008).

Several environmental factors regulate the distribution patterns of gorgonians in Southern Portugal, especially because many of these factors vary with depth (e.g. light, currents) (Cúrdia *et al.*, in press). According to Cúrdia (2012), down to 15m depth, gorgonians were only sporadically observed, while between 15 and 30m depth, abundance was higher and increased with depth. Biological interactions, such as competition and coexistence with other fauna and flora also shape gorgonian populations (Cúrdia, 2012). The structure of the gorgonian assemblages was also influenced by depth: in deeper sites, *Eunicella labiata* and *Leptogorgia sarmentosa* have higher frequency and abundance (Cúrdia, 2012). Gorgonian assemblages showed a co-dominance of several species and were never highly dominated by single gorgonian species, contrasting greatly with the patterns found in the Mediterranean (Bianchi, 2007; Gori *et al.*, 2010), as observed by Cúrdia (2012).

In the eastern coast of Algarve, *Eunicella gazella* and *Leptogorgia lusitanica* presented higher density and *Eunicella verrucosa* was less frequent and abundant, while in deeper zones of western coast, the abundance of *Eunicella verrucosa* was much higher. Also, in the eastern coast, *Eunicella labiata* presented lower density at lower depth (down to 15m depth) (Cúrdia, 2012).

In the Algarve, fishing was pointed out as a stressor leading to changes in the population structure of gorgonian species. *Eunicella labiata* was less abundant in fished sites, while *Eunicela gazella* and *Leptogorgia lusitanica* appear to be more abundant in these areas. However, the size (height) of *E. gazella* and *L. lusitanica* was significantly lower in fished sites (Cúrdia, 2012). Other recreational activities such as boating, recreational fishing and scuba diving may contribute to additional sources of damage (Bavestrello *et al.*, 1997; Coma *et al.*, 2004; Davenport and Davenport, 2006). Direct impacts from scuba diving in the Algarve, although not frequent, can severely affect the ecology of gorgonians (Cúrdia, 2012).

Gorgonian gardens, similarly to coral reefs, may provide an array of goods and ecological services, conferring them a high relevance in the societal context of coastal ecosystems. Among those goods and services, several bioactive compounds can be valuable for human-health as anti-tumoral, anti-inflamatory, antimalarial, antimicrobial and anti-tuberculosis agents (Bhakuni and Rawat, 2005; Berrue and Kerr, 2009; Rocha *et al.*, 2011), but also to the environmental health, as some diterpenoids and pyridines can be an alternative to the banned chemical and anti-fouling agents (Cúrdia, 2012). On the other hand, healthy gorgonian gardens may be appreciated diving spots and add value to any region. However, in order to propose adequate conservation measures, studies on the dynamics of these systems are needed

1.5. Objectives

The high species richness associated with gorgonian gardens, including cases of obligate species, and the multiple pressures that they have been facing, increased the awareness of coastal managers to the degradation and/or destruction of gorgonian gardens leading to an increase of the effort to protect these “foundation species” (Coma *et al.*, 2004).

In this context, the main purpose of the present study is to describe the temporal patterns of biodiversity, abundance and community structure of epifaunal assemblages associated with the shallow water gorgonians *Eunicella gazella* and *Leptogorgia lusitanica*. Analysing samples across different temporal scales and taking into account the different components of biodiversity, this study aims to assess which are the main drivers of putative changes: i) gorgonian host; ii) colony size; or iii) time. Overall, this study will contribute to a more in-depth knowledge on the epibenthic dynamics of shallow and temperate Atlantic gorgonian gardens.

2. Methodology

2.1. Study area

The present study was undertaken in the rocky outcrop “Pedra da Greta“ located in the south of Portugal (Algarve) (Figure 2).

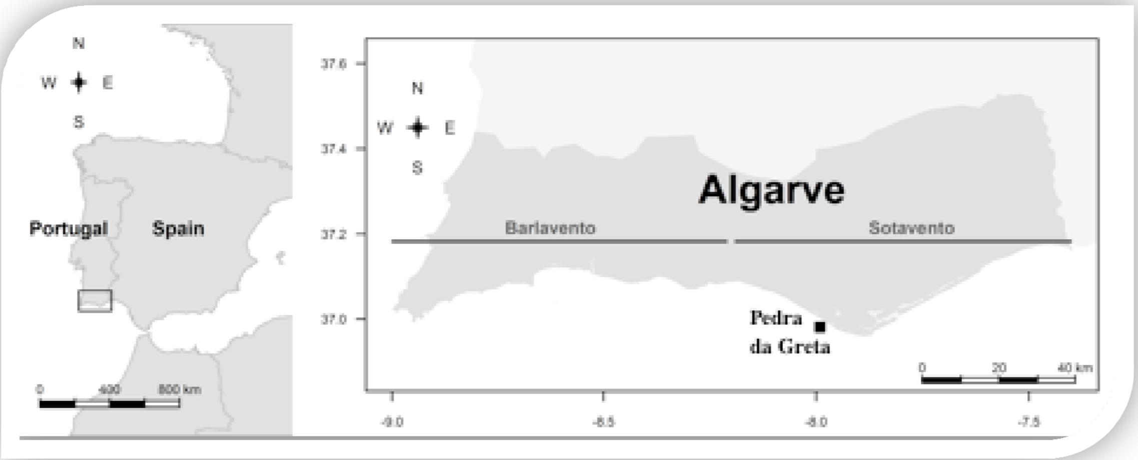

Figure 2. Location of Pedra da Greta in Algarve

The Algarve coast (South of Portugal) is populated by a number of features, such as abrupt and jagged coastlines, extensive sandy beaches, salt marshes, sand dunes and inlets, along a total of 320 km of coastline (www.ine.pt). It is divided into two main regions, a western region (Barlavento) and an eastern one (Sotavento) (Cúrdia, 2012). Barlavento consists in a number of rocky formations of several types (e.g. underwater spurs, boulders, smooth rocky plateaus), while Sotavento is mainly dominated by sandy areas and only two large rocky areas are known: Pedra da Greta and Pedra do Barril. Apart from these, only small rocky reefs can be found scattered in the sandy areas (Cúrdia, 2012). Pedra da Greta (Figure 2) is a shallow structure (15-18m depth), parallel to the coast, with approximately 3.6 km length, ranging from 20 to 90m in width, and 1 to 3.5 m in height. Originated in the Holocene (7500 BP), this formation is composed of alternate strata of quartz sandstones and conglomerates, with carbonate cement (Teixeira and Pinto, 2002).

This region is characterized by a semi-diurnal and mesotidal regime, with tides ranging from 2.70-1.36m during neap tides and from 3.82-0.64m during spring tides (Moura *et al.*, 2006). Salinity is rather constant, ranging from 35.0 to 36.0 psu. On the other hand, sea surface temperature shows a seasonal variation between 14° and 24°C (Cúrdia, 2012).

2.2. Sampling strategy

The sampling design included the delimitation of two sampling areas separated by more than 1 km: Pedra da Greta West (PGW) and Pedra da Greta East (PGE). The two most abundant gorgonians, *Leptogorgia lusitanica* and *Eunicella gazella*, were selected as study subjects. Three colony sizes were defined (small, medium and large), according to the size frequency distribution of each species (Cúrdia, 2012). The height ranges for small, medium and large were, respectively, <8 cm, 8–15 cm, 15 cm for *Eunicella gazella*, and <10 cm, 10–25 cm, >25 cm for *Leptogorgia lusitanica*. Three replicates of each size and species (3 colonies x 3 sizes x 2 species) were collected by hand during scuba diving in July and November 2010 and in March, June and August 2011. During the dive, the samples were placed individually in closed plastic bags. The colonies were preserved in 70% ethanol for further laboratory processing.

2.3. Studied species of gorgonians

Eunicella gazella Studer, 1901

The colonies of *Eunicella gazella* (Figure 3) are ramified in a single plan, with branches broadly spaced (Azcón *et al.*, 2008). The colonies may reach up to 20 cm height. The colour of *E. gazella* is milky white with orange or pink polyps (Azcón *et al.*, 2008).

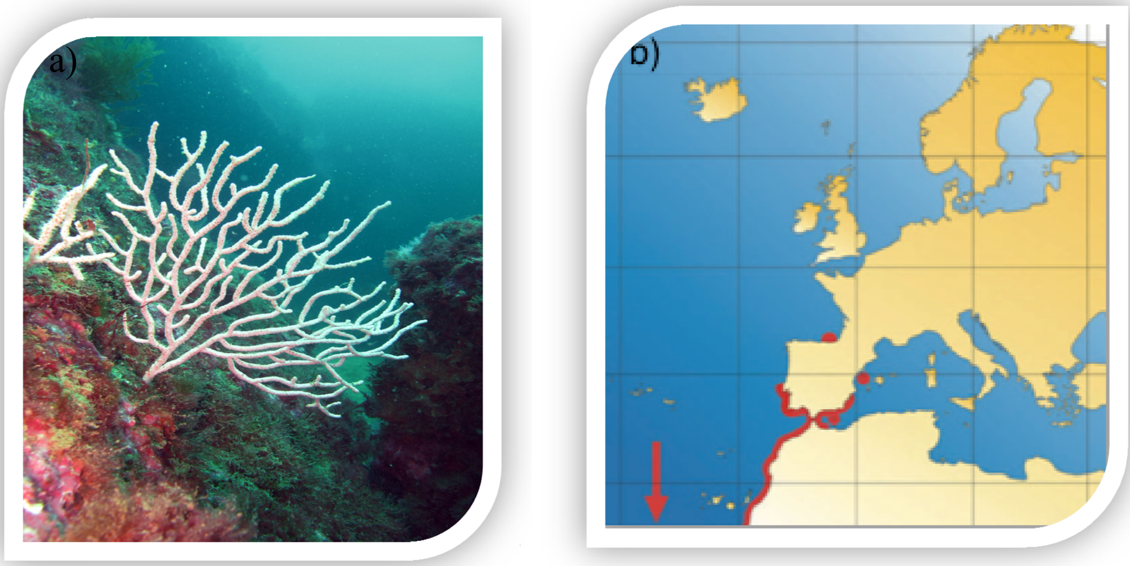

Figure 3. *Eunicella gazella.* a) Photography of a colony; b) distribution in the northeast Atlantic (Azcón *et al.*, 2008). Photo by João Cúrdia.

Except for large-sized species, where area increases with time, and number of branches in medium-sized colonies that decreased over time, no other variables showed clear patterns during the study period (Table 2). This species is found along the Atlantic coast, from Portugal to Angola (Grasshoff, 1992) and in the Mediterranean, in the Alboran Sea, Cape Palos and Columbretes Islands (Figure 3). It inhabits hydrodynamic areas with low light, from 5 to 35m of depth (Azcón *et al.*, 2008).

Table 2. Mean (±SD) area (mm^2), perimeter (mm), height (mm), width (mm) and number of branches of *Eunicella gazella* colonies in all sample occasions. S – small, M – medium, L – large.

		Eunicella gazella			***Leptogorgia lusitanica***		
	Size class	**L**	**M**	**S**	**L**	**M**	**S**
July 2010	Area	6376±1004.2	5214±2393.4	879±348.4	18512±4295.9	5795±2386.4	2279±1015.9
	Perimeter	2135±559.42	1882±335.43	596±232.3	7913.1±2162.8	3735±1309.5	1375±406.11
	Height	199.0±23.804	152.7±32.014	75.5±13.528	371.51±69.367	223.4±37.879	79.00±16.285
	Width	163.7±15.753	153.4±39.687	58.8±22.342	372.99±25.870	229.0±59.283	145.9±34.318
	No. Branches	238.0±85.995	214.3±140.04	36.5±19.817	2477.7±877.92	717.2±444.07	383.2±193.46
November	Area	6578±1961.1	3632±645.5	1190±502.7	12437±5350.1	6106±4152.6	1307±1002.0
	Perimeter	2780±884.47	1987±521.8	957±350.8	9555.8±2964.0	3458±1101.3	1203±349.62
	Height	205.4±41.671	135.8±13.59	73.3±18.07	361.42±37.826	193.1±39.318	93.82±32.363
	Width	182.0±29.902	137.9±19.75	94.7±14.41	433.56±121.40	218.3±56.719	111.3±25.556
	No. Branches	324.5±86.067	221.2±121.6	582±28.00	2054.7±638.46	958.8±719.63	346.2±321.77
March 2011	Area	5557±1240.0	2760±1096.1	805±576.7	19640±9477.8	6796±2378.7	2254±723.2
	Perimeter	3239±447.65	1682±546.83	679±245.2	8521.6±544.18	3898±910.49	1725±403.1
	Height	220.0±14.764	121.4±18.597	76.6±22.41	354.58±58.635	189.2±20.098	85.44±20.67
	Width	175.7±35.962	139.0±27.966	70.1±27.63	363.38±48.541	241.2±70.232	148.0±24.52
	No. Branches	376.0±191.70	153.2±73.350	51.0±32.13	3342.3±1492.9	1166±486.25	338.4±98.41
June	Area	6206±1825.4	3200±848.8	1233±573.3	18464±4550.0	7581±1603.3	1069±547.0
	Perimeter	3731±756.39	2094±614.5	810.4±262.3	7002.8±2610.0	3890±455.52	956.4±350.1
	Height	194.9±14.769	140.9±20.73	75.12±8.975	334.82±38.352	218.3±32.115	56.08±11.84
	Width	191.8±37.645	139.8±27.40	85.92±22.54	383.72±101.45	244.0±26.837	103.4±36.05
	No. Branches	318.2±90.442	147.0±55.80	70.40±32.30	2976.7±1276.9	967.5±214.67	173.5±93.62
August	Area	7483±2725.3	3096±576.6	286±116.8	16309±3500.0	8287±3388.7	1401±775.1
	Perimeter	2719±804.81	1659±456.7	924±182.1	7150.2±1698.1	3839±1018.4	1194±653.2
	Height	203.1±19.904	138.9±21.35	70.8±12.03	332.02±25.583	210.4±53.215	68.99±15.74
	Width	167.8±37.842	11.28±16.30	93.6±16.81	377.47±38.650	252.2±47.341	120.1±38.69
	No. Branches	337.8±171.63	89.67±23.50	55.8±14.82	2549.2±831.33	1199±437.95	222.3±135.3

Leptogorgia lusitanica Stiasny, 1937

Leptogorgia lusitanica (Figure 4) is a large-sized species (up to 50 cm; (Grasshoff, 1988), bushy shaped and branched in a single plane (Grasshoff, 1988; Azcón *et al.*, 2008). The ramifications are sideways in which the terminal branches are short and thin (Azcón *et al.*, 2008). This species possesses a variety of colours, ranging from white to violet (Grasshoff, 1988; Azcón *et al.*, 2008).

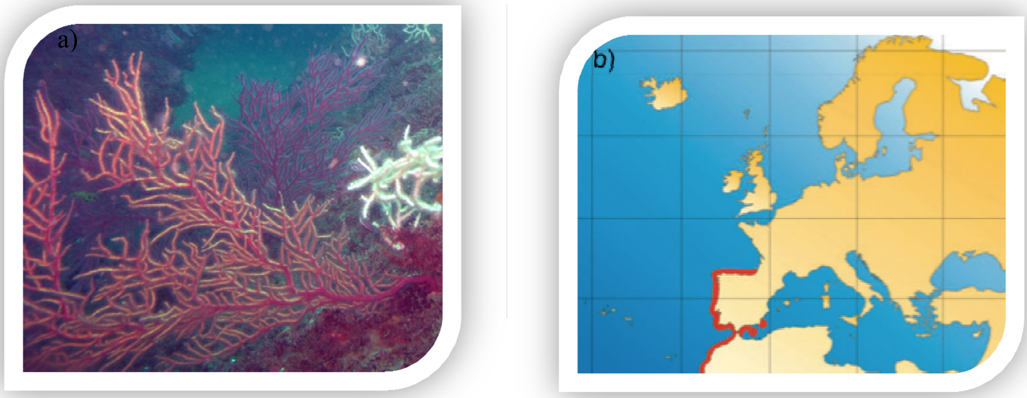

Figure 4. *Leptogorgia lusitanica*. a) Photography of a colony; b) distribution in the northeast Atlantic (Azcón *et al.*, 2008). Photo by João Cúrdia.

Leptogorgia lusitanica has a wide geographical distribution, from Bay of Biscay in the North along the Atlantic coast of the Iberian Peninsula (Grasshoff, 1988), continuing eastwards into the Mediterranean (Alboran Sea) and southwards in the Atlantic coast of Morocco (Figure 4) (Azcón *et al.*, 2008).

In *Leptogorgia lusitanica* colonies sampled in Pedra da Greta, the mean area values increased in medium-sized colonies and height decreased in large colonies over time during the study period (Table 2).

2.4. Laboratory analyses

The preserved samples were washed over a 100 μm mesh and kept in 96% ethanol in plastic recipients. The identification of the macrofauna was made using a stereoscopic microscope. Because of the large amount of samples and high diversity observed, it was impossible to dedicate the same taxonomic effort to all groups. Therefore, diversity is certainly under-estimated; for example annelids that were previously found to be highly diverse within the colonies of these gorgonians were mainly identified to the family level. The number of specimens of each taxon was counted for each replicate.

2.5. Data analyses

Although the study included two different areas (West and East) in Pedra da Greta, these have been proved to be not significantly different (Cúrdia, 2012). Therefore, for the following analyses samples taken from these two areas were considered as replicates.

Species richness (S), abundance (N), Shannon-Wiener diversity (*H'*, log e), Pielou's evenness index (*J'*) (Pielou (1969)) and Hurlbert expected species richness (Hurlbert, 1971) ($ES_{(n)}$) were calculated and used to describe biodiversity patterns and to assess changes in the structure of epibenthic assemblages associated with gorgonians. β-diversity was analysed in terms of turnover (differences between consecutive months), based on the following expression:

$$t = \frac{l + g}{S \; x \; ci}$$

where *l* is the number of species lost, *g* is the number of species gained, *S* is the total number of species present and *ci* is the census interval (months). β-diversity was also measured based on the Bray-Curtis dissimilarity, which takes both abundance and species richness into account.

Changes in community structure were assessed by using ordination techniques, namely the non-metric multidimensional scaling (nMDS), based on the Bray-Curtis similarity, after square root transformation of the data. An analysis of similarities by randomization/permutation tests (ANOSIM) was performed on the samples grouped according to the relevant factors: Host, Colony size and Time. Specifically, 2 tests were undertaken. Test 1, a one way layout addressed the factor Host (2 levels: *Eunicella gazella*, *Leptogorgia lusitanica*) and tested the null hypothesis of no differences in the associated assemblages of both gorgonian species. Test 2, a two way crossed layout addressed the factors Size and Time for each gorgonian separately and tested the null hypothesis of no significant differences regarding colony size and sampling date on the composition and structure of the attendant assemblages.

In order to better understand the temporal dynamics of the attendant epifaunal assemblages, the samples of all colonies were pooled for each month and the occurrence of each taxon during the study period was analysed. Taxa were subsequently classified into three categories: i) residents, taxa present in all sampling dates; ii) occasional, taxa present in three or four sampling dates; and iii) rare, taxa present in only one or two dates.

The relationship between assemblage structure, environmental factors (sea surface temperature, chlorophyll *a*, particulate organic carbon and photosynthetic active radiation) and colony attributes (area, width, number of branches) was analysed by a distance-based redundancy analysis (dbRDA) (McArdle and Anderson, 2001), as this method provides the flexibility to choose the dissimilarity index to be used. For each gorgonian species, data were also analysed separately for each size level to minimize the scale effects related to colony size. This methodology places the main focus on the variation of gorgonian associated fauna along time but also takes into account the colony characteristics at small scale. Particulate organic carbon (POC) and chlorophyll *a* (chl *a*) data presented high skewness. This could be solved in the case of chl *a* using a log 10 transformation, but POC data remained skewed after transformation. As these two variables were highly correlated (0.97), only photosynthetically available radiation (PAR), temperature and chlorophyll *a* (log 10 transformed) were used for the dbRDA analysis. In terms of gorgonian attributes, the area of the gorgonian is highly correlated to height, width, perimeter and number of branches (EG: 0.75-0.88; LL: 0.85-0.95). All morphometric variables were evenly distributed and there was no need for further transformation. However, to prevent co-linearity effects only three variables were retained for the analysis: area, width and number of branches.

PRIMER v6 software (Clarke and Gorley, 2006) and the open source software R version 12.1 (R Development Core Team, 2010) were used to carry out the data analyses.

3. Results

3.1. Physico-chemical variability in the water column

The Sea surface temperature showed a clear seasonal pattern: it reached minimum values in March and peaked in August (Figure 5). In opposition to temperature, chl *a* showed a clear peak in March 2010. From April to November 2010, chl *a* values were relatively low and then they gradually increased until January 2011, with a small peak again in March (Figure 5).

PAR increased gradually towards July 2010, when it reached a maximum value and then decreased to its minimum in December 2010. The same pattern was observed in 2011 (Figure 5).

The concentration of organic particulates increased drastically in March 2010, when it reached its highest value. Afterwards, it abruptly decreased in April 2010. Henceforth, POC value was kept fairly constant up to November 2010, when it started increasing again to another peak (although slightly lower than the previous year) observed in March 2011 (Figure 5).

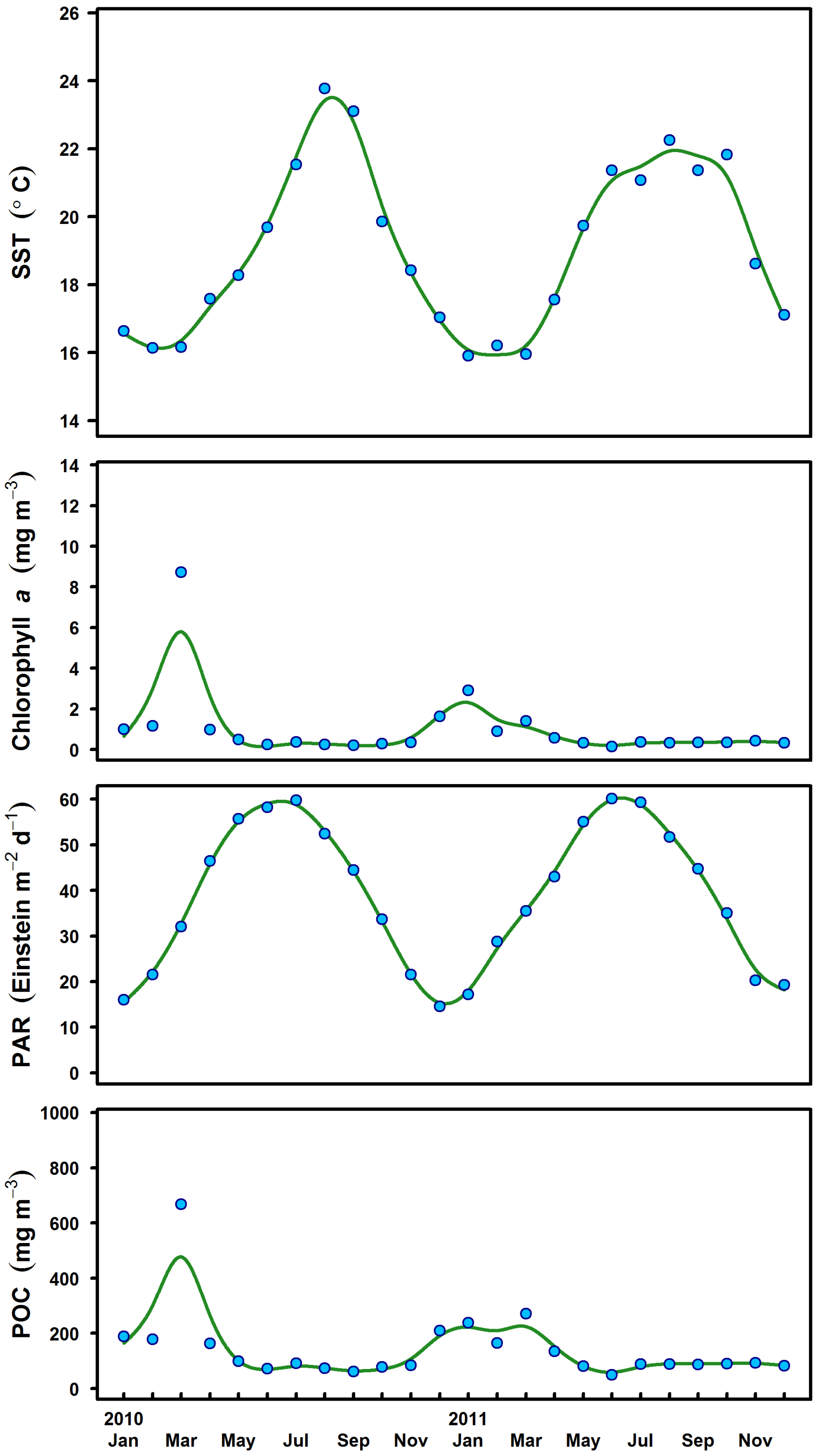

Figure 5. Values of sea surface temperature (SST), chlorophyll *a,* photosynthetically active reaction (PAR) and particulate organic carbon (POC) concentration from January 2010 to December 2011 in Pedra da Greta.

3.2. Attendant epibenthic assemblages

In the present study, 178 taxa were identified from a total of 19204 individuals collected in 180 gorgonian colonies (129 taxa in *Eunicella gazella* and 155 in *Leptogorgia lusitanica*). Epifaunal assemblages associated with *E. gazella* were numerically dominated by annelids, which accounted for 49% of total abundance. Among annelids, the Canalipalpata (47%) showed the higher contribution to abundance. Arthropoda (25%), and especially Amphipoda (16%), were also abundant. This phylum was the dominant in *L. lusitanica* colonies, accounting for 59% of total abundance (39% of amphipods). In this gorgonian, molluscs (26%) were the second most abundant group. These overall patterns fluctuated over time, as described below in this section (3.2.1.2 and 3.2.2.2).

Species richness showed the same general pattern in both gorgonians: Arthropoda accounted for the highest number of taxa (38% in both hosts), particularly Amphipoda (20% in *E. gazella* and 19% in *L. lusitanica*). Annelida (27% and 24% in *E. gazella* and *L. lusitanica*, respectively), and Mollusca (26% and 28% in *E. gazella* and *L. lusitanica*, respectively), also had a high contribution to the overall diversity.

These differences in the general composition of epifaunal assemblages associated with both gorgonian hosts are reflected in the results of the MDS (Figure 6). The ordination analysis was undertaken with the whole dataset and, consequently, included the variability in colony size, time and gorgonian host. The diagram showed a clear separation between the faunal assemblages of *E. gazella* and *L. lusitanica*, which is supported by the ANOSIM results (R=0.348, *P* <1%). Because of this very clear separation between the epifaunal assemblages associated with the two gorgonians, the subsequent analyses were performed for each gorgonian species separately.

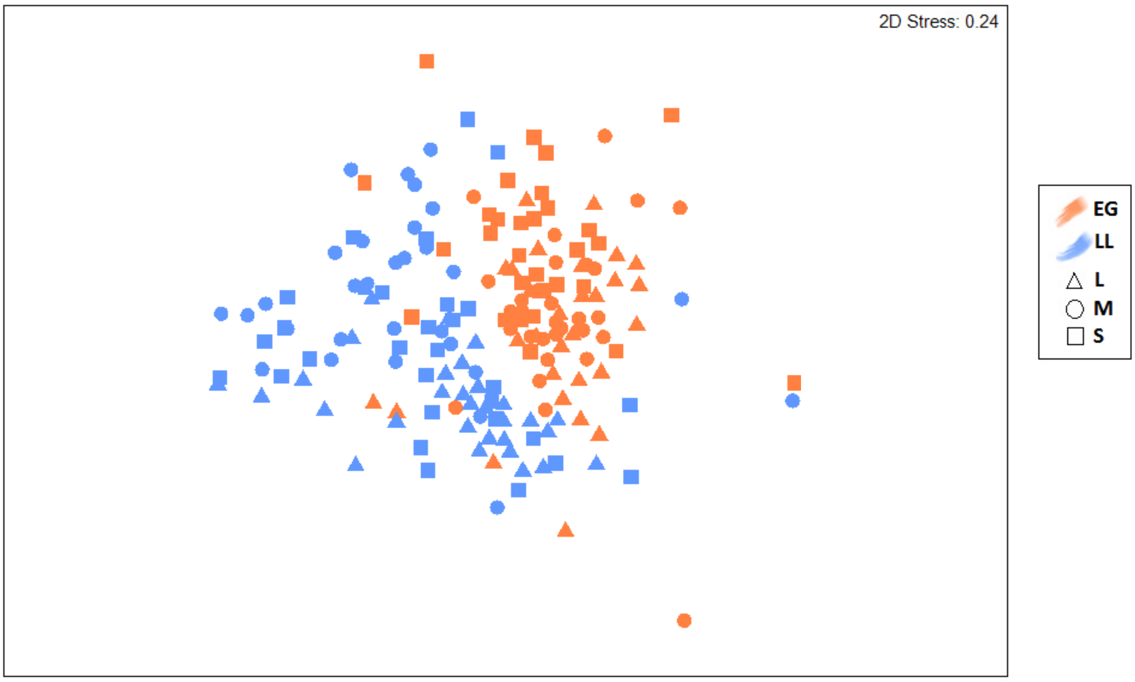

Figure 6. Multidimensional scaling of the samples of *Eunicella gazella* (EG) and *Leptogorgia lusitanica* (LL) using Bray-Curtis similarity. S – small. M – medium. L – large

3.2.1. *Eunicella gazella*

3.2.1.1 Effect of colony size on biodiversity patterns

In *Eunicella gazella* the attendant epifaunal assemblages were dominated by polychaetes, bivalves and Turbellaria sp., an undetermined species of Platyhelminthes (small-sized colonies, Polychaeta 79%; Turbellaria *sp.* 2%, Bivalvia 1%; medium-sized colonies, Turbellaria sp. 50%; Polychaeta 24%; Bivalvia 12%; large-sized colonies - Turbellaria sp. 56%; Polychaeta 16%; Bivalvia 13%). Concerning species richness, arthropods, molluscs and annelids were the most diverse groups in all colonies of *E. gazella.* However, within medium- and large-sized colonies, echinoderms were also relevant for the total species richness observed (Figure 7).

The number of individuals per colony, as well as the species richness (i.e. the number of taxa per colony), generally increased from small- (1050 individuals; 59 taxa) to large-sized colonies (8445 individuals; 107 taxa) (Table 3). While for the species richness there was a steady increase with colony size, for abundance, an abrupt increase in the number of individuals was observed from medium- to large-sized colonies.

Table 3. Abundance and biodiversity data on the attendant faunal assemblages of *Eunicella gazella* (EG) *per* colony size (Sm – small; M – medium; L – large) and time. n – number of colonies; N - number of individuals per colony; S - number of taxa per colony; *J'*- Pielou's evenness; *H'*- Shannon-Wiener diversity; $ES_{(50)}$ - Hurlbert's expected number of species per 50 individuals; $ES_{(100)}$ - Hurlbert's expected number of species per 100 individuals.

		n	N	S	*H'*	*J'*	$ES_{(50)}$	$ES_{(100)}$
Sm								
	July 2010	6	92	22	2.65	0.86	17.16	-
	November	6	153	22	2.17	0.70	13.28	18.13
	March 2011	6	39	19	2.65	0.90	-	-
	June	6	371	27	1.33	0.40	9.31	13.88
	August	6	395	31	2.16	0.63	12.80	17.67
M								
	July 2010	6	670	38	2.55	0.70	14.26	19.01
	November	6	356	27	1.91	0.58	10.24	14.47
	March 2011	6	76	28	2.89	0.87	22.09	
	June	6	755	36	1.58	0.44	8.95	13.18
	August	6	687	55	2.44	0.61	15.56	23.10
L								
	July 2010	6	363	45	2.63	0.69	17.48	25.51
	November	6	301	36	2.22	0.62	14.01	20.54
	March 2011	6	192	32	2.33	0.67	15.85	23.40
	June	6	6887	50	0.85	0.22	5.32	7.31
	August	6	702	73	2.97	0.69	20.76	31.22
	Sm	30	1050	60	2.31	0.56	14.18	20.53
	M	30	2544	85	2.48	0.56	14.53	21.39
	L	30	8445	110	1.53	0.32	9.17	13.70
	July 2010	18	1125	63	2.76	0.67	16.65	23.37
	November	18	810	54	2.22	0.56	12.94	18.94
	March 2011	18	307	50	2.79	0.71	19.24	28.60
	June	18	8013	66	1.16	0.28	6.28	8.73
	August	18	1784	89	2.74	0.61	17.65	26.89
	EG	90	12039	132	2.08	0.43	11.67	17.33

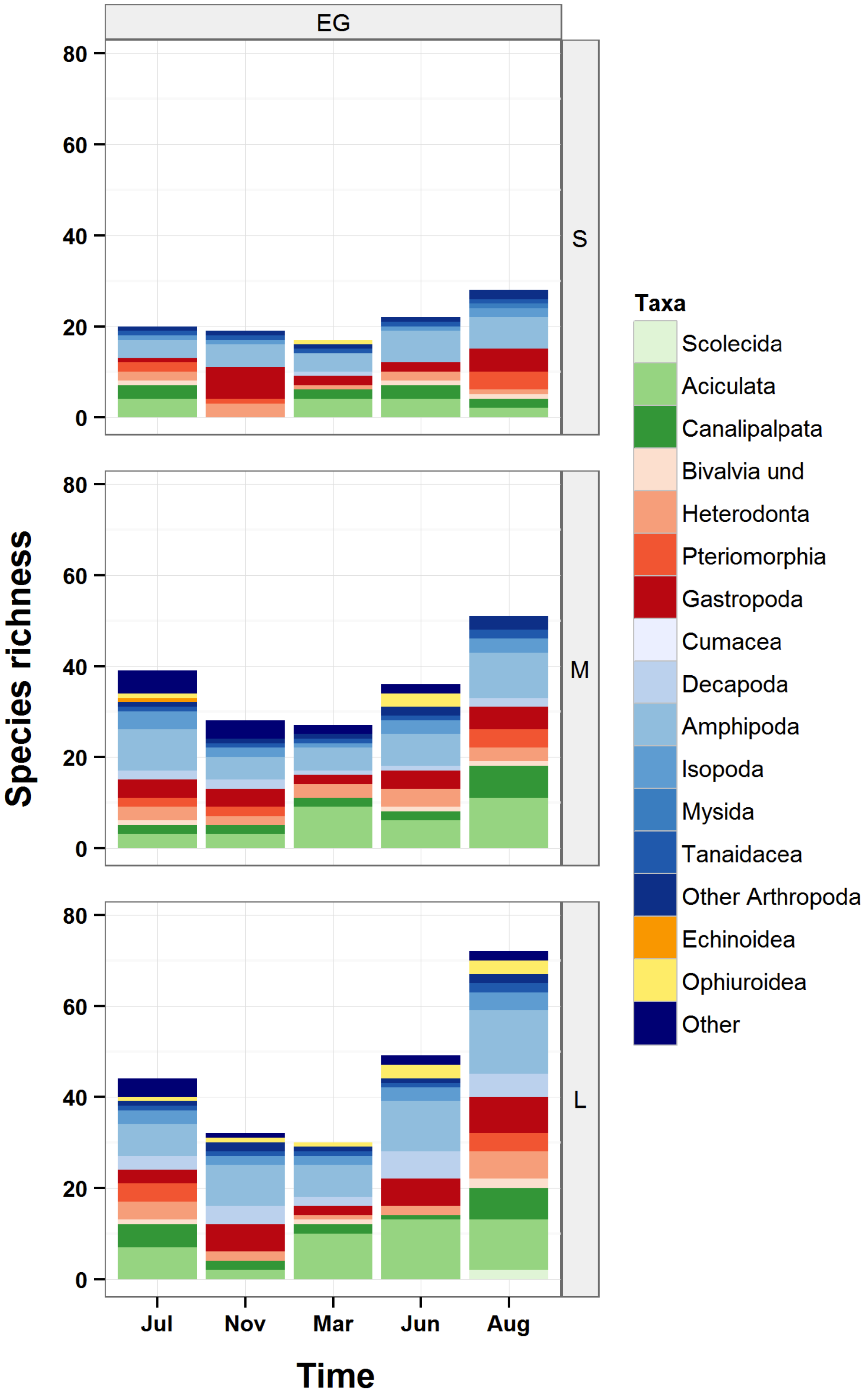

Figure 7. Species richness of the attendant faunal assemblages *Eunicella gazella* (EG). The contribution of major taxonomic groups in the pooled samples by colony size (S – small, M – medium, L – large) in each sampling occasion (from July 2010 to August 2011) are shown. Other – Ascidiacea, Nematoda, Nemertea, Phoronida, Polyplacophora, Porifera, Sipuncula, Turbellaria sp.

The value of $ES_{(50)}$ for pooled samples per colony size ranged from 9.17 to 14.53, while $ES_{(100)}$ ranged from 13.70 to 21.39. Lower and higher values were observed for large- and medium-sized colonies, respectively (Table 3). Small- and medium-size colonies of *E. gazella* had the highest ES values. *J'* values were generally lower within larger colonies, and the high abundance in June (one order of magnitude higher than in the other occasions) coupled with a very low evenness (J' - 0.22) had a strong effect on the low overall value for large-sized colonies. Small – and medium-sized colonies possess higher slopes, close to the overall rarefaction curve for *E. gazella*, which is only slightly affected by the lower rarefaction values of large-sized colonies (Figure 8).

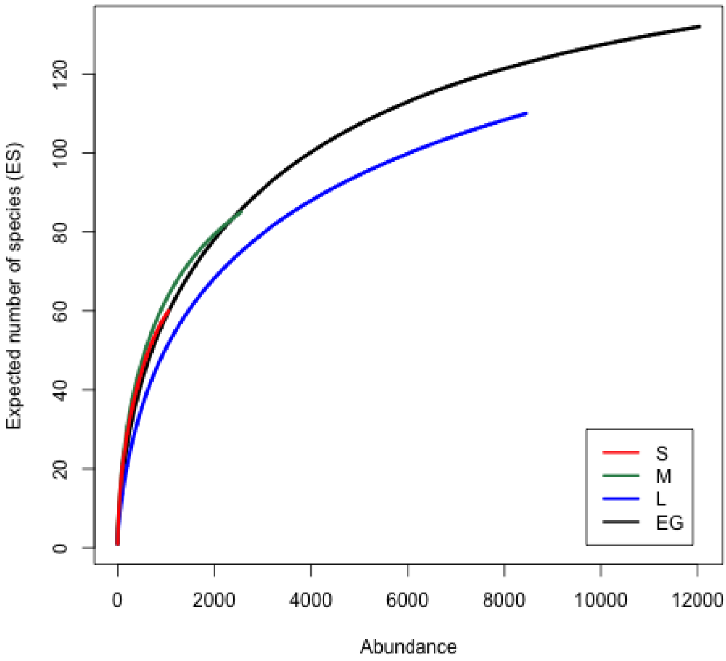

Figure 8. Comparison of rarefaction curves (Hurlbert's expected number of species) in *Eunicella gazella* (EG) assemblages for different colony size classes. S- small, M- medium, L- large

Table 4. *Eunicella gazella*: results of two-way ANOVA for the abundance (N, no. individuals per colony), number of taxa (S, no. of taxa per colony), Pielous' evenness (J') and Shannon-Wiener diversity (H'). Post-hoc comparisons based on Tuckey test are also given. *p<0.05; **p<0.01; ***p<0.001; ns - not significant.

	df	N		S		J'		H'	
		MS	F	MS	F	MS	F	MS	F
Size=Si	2	509666	1.496ns	388,9	8.328***	0.0824	4.863*	0.6567	2.168ns
Time=Ti	4	561379	1.648ns	392,5	8.405***	0.3432	20.254***	2.1005	6.935***
Si x Ti		435035	1.277ns	26,6	0,507	0.0367	2.164*	0.3077	1.016ns
res		340576		46,7		0.0169		0.3029	
Post-hoc comparisons									
Size				M=L>S					
Time				Aug>Jul=Jun=Mar=Nov				Jun≠Jul; Aug; Mar≠Aug	
Post-hoc time Size x Time									
For levels within factor Size									
S						Jun<Jul; Jun<Mar			
M						Jun<Mar			
L						Jun<Nov=Mar=Jul=Ago			
For levels within factor time									
July 2010						S>L			
November									
March 2011									
June									
August									

The ANOVA results showed significant differences for species richness, evenness, but not for abundance nor Shannon-Wiener diversity (Table 4). No significant differences were detected for Shannon-Wiener diversity in relation to the Size factor, probably resulting from the relatively steady values observed in all colony sizes (H': 2.3-2.6) (Tables 3 and 4). Small-sized colonies presented significantly lower number of taxa than medium- and large-sized colonies.

Except for Pielou's evenness, all the biological variables analysed showed that effects of colony size were consistent in time (Table 4). Only in July, there was a significant difference in Pielou's evenness between large- and small-sized colonies that presented high values, and in June throughout all sizes when the lowest values occurred (Table 3 and 4).

3.2.1.2. Temporal variability

The attendant epifaunal assemblages associated with *E. gazella* were numerically dominated by crustaceans and Turbellaria *sp.*, throughout the sample period, except in June 2011, where the Canalipalpata polychaetes numerically dominated the attendant assemblages (Figure 9 and Table 4). This increase in the abundance of polychaetes is largely due to an abrupt increase in the number of *Filograna implexa* in a single replicate, which strongly affects the rarefied biodiversity observed in this month (June in Figure 9). On the other hand, arthropods (mainly amphipods), polychaetes and molluscs were the most diverse groups throughout the study period (Figure 9).

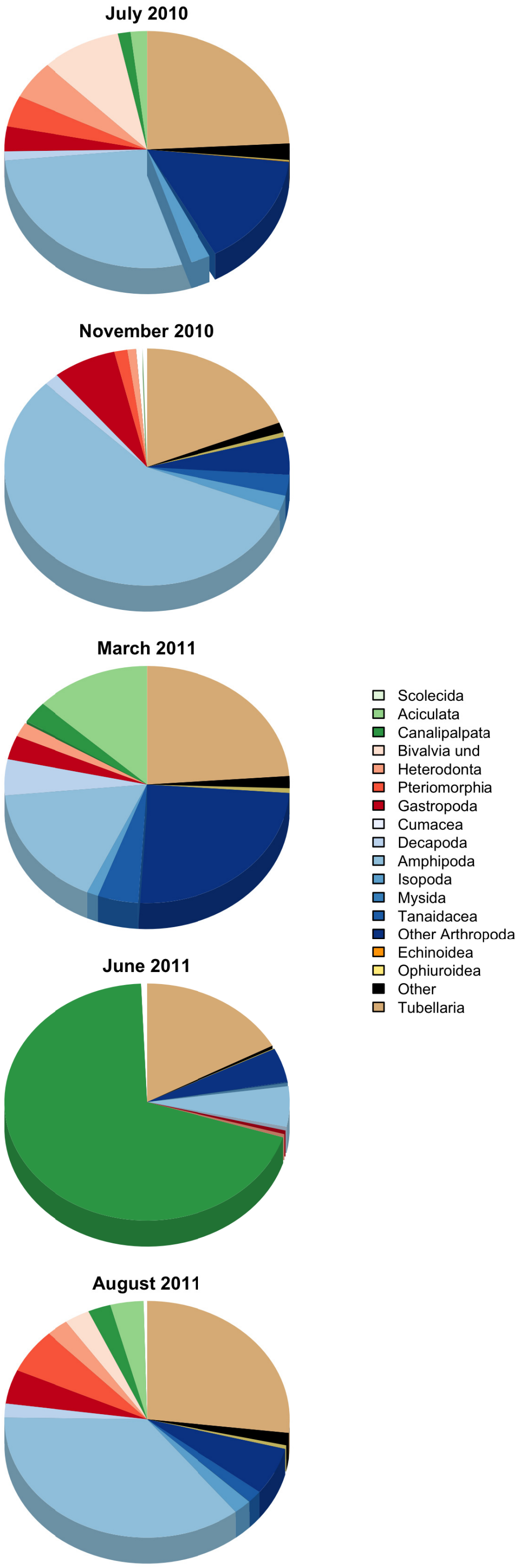

Figure 9. Community structure of the attendant faunal assemblages in *Eunicella gazella* at different sampling occasions. The relative abundance of the main taxonomic groups is shown. Other Arthropoda – Pycnogonida and Ostracoda; Other – Ascidiacea, Nematoda, Nemertea, Phoronida, Polyplacophora, Porifera, Sipuncula.

In general, species richness and abundance were higher during late spring and summer with minimum values observed in March, irrespectively to the colony size (Figure 7 and 9; Tables 4 and 5). Despite these trends, no significant temporal differences were detected in abundance, while in the number of taxa, values observed in August were significantly higher than in the remaining months (Table 1 and 2). On the other hand, significantly lower values of diversity, equitability and expected number of species were generally observed in June (Table 1 and Figure 8), particularly when compared to those observed in August (Table 1 and 2).

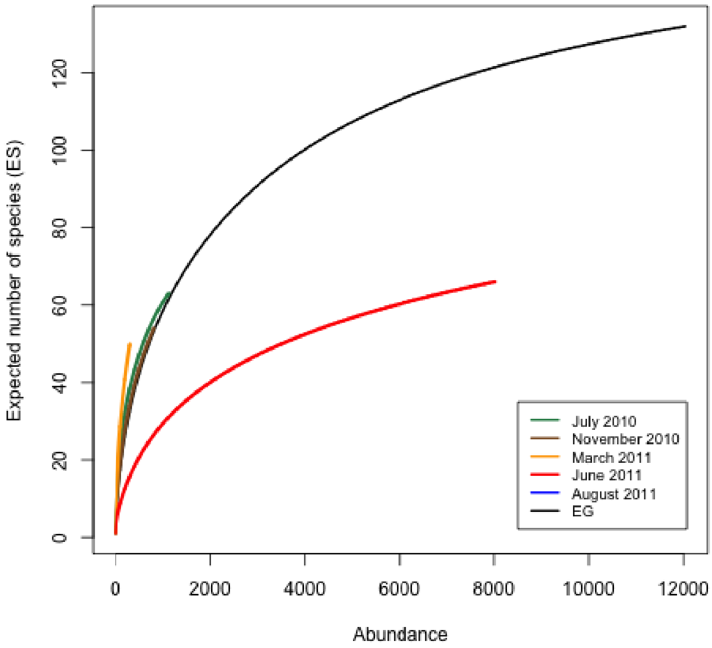

Figure 10. Comparison of rarefaction curves (Hurlbert’s expected number of species) in *Eunicella gazella* (EG) assemblages for the different sampling periods.

Table 5. *Eunicella gazella*: average (± standard deviation) of the abundance of main taxonomic groups at different sampling periods.

	July 2010	November	March 2011	June	August
Scolecida	-----	-----	-----	-----	0.13±0.702
Aciculata	0.05±0.353	0.01±0.107	0.09±0.358	0.13±0.553	0.17±0.626
Canalipalpata	0.06±0.296	0.02±0.186	0.03±0.269	18.20±327.743	0.16±0.789
Bivalvia	1.13±4.023	-----	0.01±0.105	0.02±0.148	0.57±1.629
Heterodonta	0.18±1.143	0.02±0.155	0.02±0.135	0.11±0.720	0.14±0.621
Pteriomorphia	0.33±1.257	0.08±0.695	-----	-----	0.76±2.216
Gastropoda	0.08±0.537	0.12±0.645	0.02±0.051	0.08±0.537	0.16±0.729
Amphipoda	0.58±4.561	0.82±5.854	0.10±0.543	0.80±5.337	1.15±10.493
Decapoda	0.05±0.341	0.004±0.181	0.05±0.509	0.14±1.480	0.12±1.150
Isopoda	0.18±0.662	0.12±0.669	0.02±0.153	0.25±1.250	0.24±0.871
Mysida	-----	-----	-----	-----	0.03±0.167
Ostracoda	9.61±15.812	2.28±2.866	4.22±6.486	20.67±43.830	5.83±4.502
Other Arthropoda	0.11±0.000	0.03±0.993	0.19±0.799	0.17±0.605	0.57±1.039
Echinoidea	0.06±0.236	-----	-----	-----	-----
Ophiuroidea	0.01±0.118	0.06±0.471	-----	0.08±0.325	0.10±0.449
Turbellaria	15.11±12.247	8.50±8.424	4.06±4.165	76.17±92.606	26.61±21.415
Other	0.14±0.675	0.06±0.302	0.03±0.225	0.18±1.239	0.17±0.802

When taxa were classified as residents, occasional and rare, an interesting pattern emerged (Table 6). Residents numerically dominated the attendant assemblages, except in June, when rare species presented the highest abundance (Table 6). However, this is the effect of a single species (*Filograna implexa*) that massively colonized a single large colony sampled in June. Therefore, this exception in the overall pattern is biased by the presence of *F. implexa*. On the other hand, November 2010 presented the highest dominance with 91% of total individuals being residents (Table 6). The abundance of occasional taxa was higher in late spring and summer, while rare species (44 taxa) largely contributed to the peak of taxa richness observed in August (total of 89 taxa; Table 6).

Table 6. Number of taxa (S), total (N) and relative abundance (%N) of resident, occasional and rare species for *Eunicella gazella* attendant assemblage during the sample period.

	Residents			**Occasional**			**Rare**		
	N	**%N**	**S**	**N**	**%N**	**S**	**N**	**%N**	**S**
July 2010	809	72%	20	268	24%	25	48	4%	18
November	740	91%	20	46	6%	19	24	3%	15
March 2011	236	77%	20	59	19%	20	12	4%	10
June	2300	29%	20	118	1%	31	5594	70%	15
August	1361	76%	20	259	15%	25	164	9%	44

3.2.1.3. β-diversity

Turnover values for faunal composition were generally below 20% irrespectively of the colony size, except for the spring-summer transition (June to August), where turnover were above 30% (Figure 11). Turnover values from November to March decreased both in small- and large-sized colonies, in opposition to medium-sized colonies. Turnover values increased in the transition from March to June and further again in June to August. Except for the transition from November to March, the assemblages of small-sized colonies showed higher turnover values than those inhabiting medium- and large-sized colonies (Figure 11).

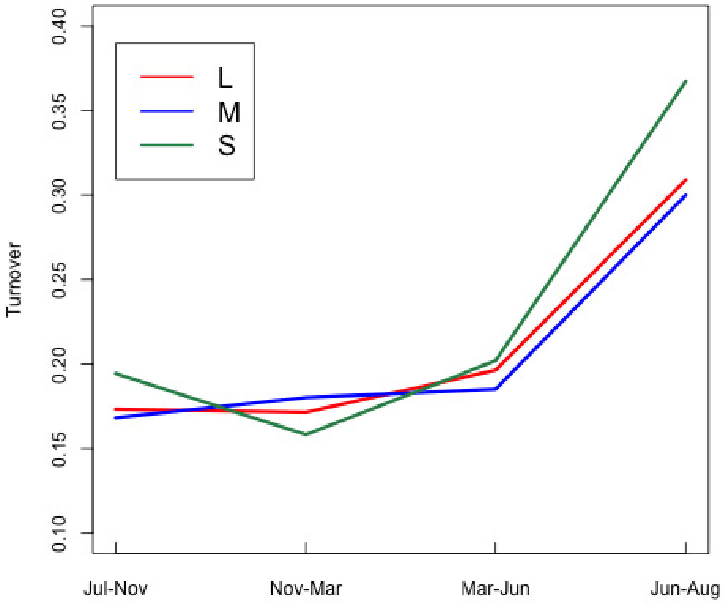

Figure 11. Comparison of turnover values in *Eunicella gazella* assemblages for different colony size classes.

As expected, Bray-Curtis dissimilarity showed the lowest values for samples taken within the same colony size and time period (Figure 12). Increased variability in colony size increased dissimilarity only slightly (2nd boxplot compared to 1st and 4th compared to 3rd) while the effect of temporal variability was stronger (3rd and 4th boxplots compared to 1st and 2nd). Unlike all other 3 cases, the dissimilarity values from "same Time, different Size" were skewed towards high values evidencing more dispersion in the samples with high dissimilarity values (Figure 12).

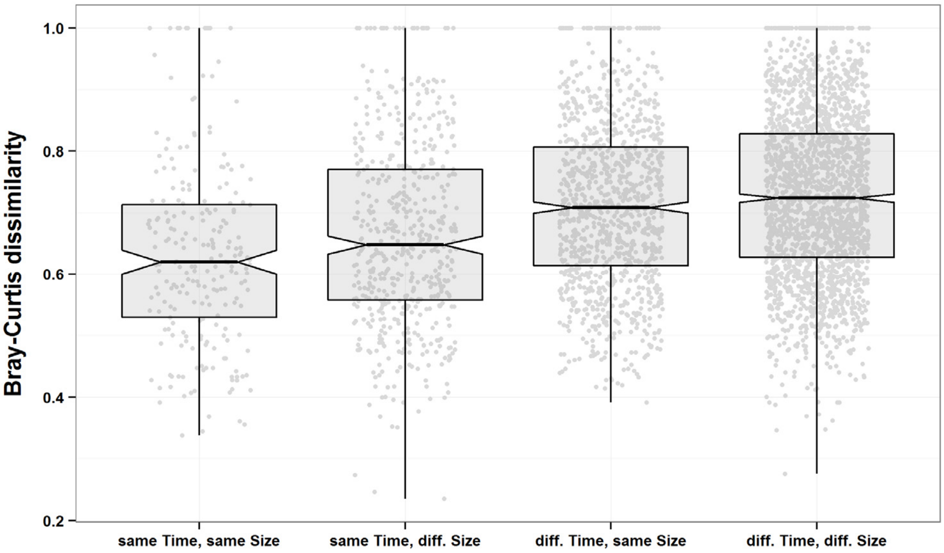

Figure 12. Boxplots of dissimilarity values between samples of *Eunicella gazella* with: same time and same size; same time and different size; different time and same size; and different time and different size. Different angles of the notches indicate difference between the medians.

3.2.1.4. Community structure

The results of the MDS plot for *Eunicella gazella* (Figure 13) showed a slight segregation of the autumn samples (November). According to the ANOSIM tests performed for factor Time (Table 4), the composition and structure of the attendant assemblages significantly differed with time. Although the MDS plot does not allow for a clear visualisation in what concerns colony sizes, the ANOSIM analysis indicated significant differences between assemblages from small- and medium-sized colonies, small and large-sized colonies, but not between the medium- and large-sized colonies (Table 7).

In the attendant assemblages of *Eunicella gazella*, the five most abundant taxa, despite some rank shifts, were fairly constant throughout the study period (Table 8). The undetermined Tubellaria species was always present in the two first ranks of all colony sizes and months. Besides, Ostracoda, the amphipods *Ericthonius punctatus* and *Gammaropsis* cf. *crenulata*, as well as the gastropod *Simnia spelta* were always well represented in the assemblages (Table 8). Although not dominant in medium- and large-sized colonies, the bivalve *Musculus* sp1 was relatively abundant and frequently observed in small-sized colonies (Table 8).

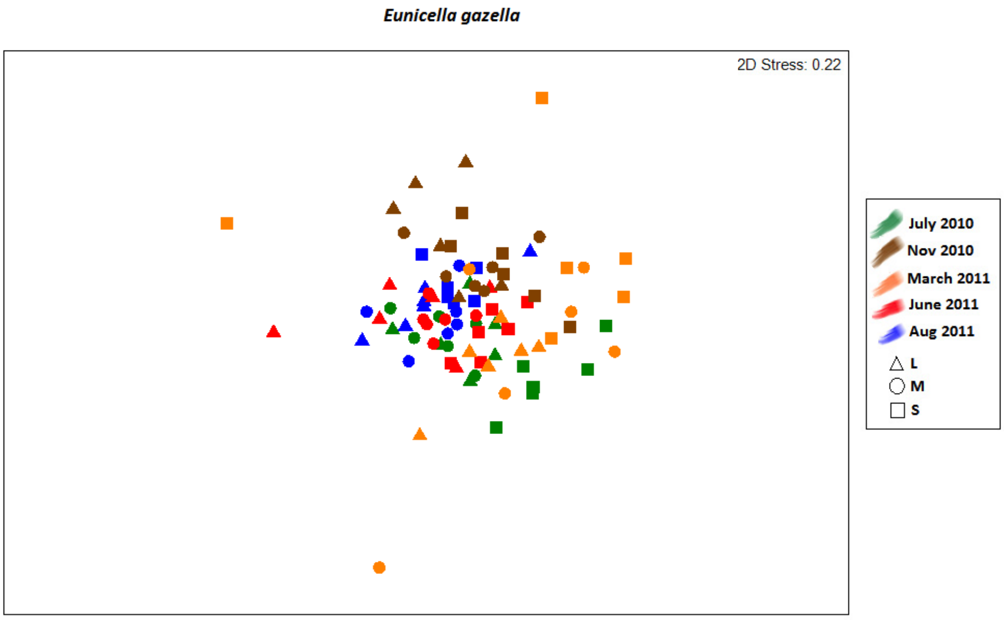

Figure 13. Multidimensional scaling of the samples of *Eunicella gazella* using Bray-Curtis coefficient. S- small, M- medium, L- large

Table 7. Results of the ANOSIM global and pairwise tests on the attendant assemblages of *Eunicella gazella*. Two-way analysis with Time and Size. 9999 permutations used in all tests. *p<5%; **p<1%; ***p<0.1%; ns - not significant.

		Sample statistic (R)	Significant statistic	Significance level
Time				
	Global Test	0.336	0	0.01%***
	Pairwise Tests			
	July, Nov	0.419	0	0.01%***
	July, Mar	0.376	0	0.01%***
	July, Jun	0.390	0	0.01%***
	July, Aug	0.379	0	0.01%***
	Nov, Mar	0.270	0	0.01%***
	Nov, Jun	0.296	0	0.01%***
	Nov, Aug	0.309	0	0.01%***
	Mar, Jun	0.387	0	0.01%***
	Mar, Aug	0.432	0	0.01%***
	Jun, Aug	0.281	0	0.01%***
Size				
	Global Test	0.143	0	0.02%***
	Pairwise Tests			
	Small *vs* Medium	0.191	9	0.1%**
	Small *vs* Large	0.230	0	0.01%***
	Medium *vs* Large	0.041	1946	19.5 *ns*

Table 8. First five dominant species for *Eunicella gazella* attendant assemblages. S – small. M – medium. L – large.

	July 2010	November	March 2011	June	August
S	Turbellaria sp.	*Ericthonius punctatus*	Turbellaria sp.	Turbellaria sp.	*Ericthonius punctatus*
	Hiatella arctica	Turbellaria sp.	*Leptochelia savygni*	Ostracoda	Turbellaria sp.
	Ostracoda	Ostracoda	*Gammaropsis* cf. *crenulata*	*Ischyrocerus inexpectatus*	Ostracoda
	Tritoniidae	*Leptochelia savygni*	*Simnia spelta*	*Ericthonius punctatus*	*Musculus* sp1
	Musculus sp1	*Musculus* sp1	*Ischyrocerus inexpectatus*	*Hiatella arctica*	*Gammaropsis* cf. *crenulata*
M	Turbellaria sp.	*Ericthonius punctatus*	Turbellaria sp.	*Turbellaria sp.*	*Ericthonius punctatus*
	Ostracoda	Turbellaria sp.	Ostracoda	*Ostracoda*	Turbellaria sp.
	Ericthonius punctatus	*Gammaropsis* cf. *crenulata*	*Ischyrocerus inexpectatus*	*Gammaropsis cf. crenulata*	*Gammaropsis* cf. *crenulata*
	Stenothoe spp.	Ostracoda	*Syllidia armata*	*Ericthonius punctatus*	Ostracoda
	Bivalvia sp1	*Simnia spelta*	*Leptochelia savygni*	*Astacilla sp.*	*Musculus* sp1
L	Turbellaria sp.	*Ericthonius punctatus*	*Ostracoda*	*Filograna implexa*	Turbellaria sp.
	Ostracoda	Turbellaria sp.	Turbellaria sp.	*Turbellaria sp.*	*Ericthonius punctatus*
	Bivalvia sp1	*Gammaropsis* cf. *crenulata*	*Pisidia* af. *bluteli*	*Ostracoda*	Ostracoda
	Ericthonius punctatus	Ostracoda	*Ischyrocerus inexpectatus*	*Gammaropsis cf. crenulata*	*Gammaropsis* cf. *crenulata*
	Stenothoe spp.	*Simnia spelta*	*Gammaropsis* cf. *crenulata*	*Ericthonius punctatus*	Bivalvia sp1

3.2.1.5. Relationships between biological and environmental data

The dbRDA always explains over 30% of the total variation regardless of the size class. In general, the environmental parameters (mainly PAR and chl *a*, but also temperature for medium-sized colonies), together with colony attributes (mainly area, but also number of branches and width) all contributed significantly for explaining the associated patterns of the fauna (Table 9). The ordination diagrams (Figure 14) generally separate the samples from November and March from the remaining sampling occasions along the first dbRDA axis that explains a large percentage of the variation. This separation mainly results from the lower values of temperature and PAR during autumn-winter months. Chl *a* presents the opposite pattern with lower values in warmer periods, while morphometric variables separate colonies within each period.

Table 9. *Eunicella gazella*: results of the distance-based redundancy analysis (dbRDA) for the fitted model relating a set of variables (morphometrical: colony area, width and number of branches; environmental: chl *a*, PAR and temperature), where amounts explained by each set added to the model is conditional on sets of variables already in the model. %Var: percentage of variance in species data explained by that set of variables and Cum. %: cumulative percentage of variance explained.

	Parameters	%Var	Cum(%)	*F*
S	Area	17.41	17.4	1.79*
	Width	23.33	40.7	2.40**
	no. branches	8.03	48.8	0.83ns
	Chl *a*	19.00	67.8	1.96*
	PAR	17.77	85.5	1.83*
	Temperature	14.43	100	1.49ns
M	Area	16.49	16.5	1.83*
	Width	13.82	30.3	1.54ns
	no. branches	12.27	42.6	1.36ns
	Chl *a*	25.07	67.7	2.79**
	PAR	16.39	84.0	1.82*
	Temperature	15.98	100	1.78*
L	Area	8.41	8.4	0.81ns
	Width	12.98	21.4	1.25ns
	no. branches	7.85	29.2	0.75ns
	Chl *a*	22.27	51.5	2.14**
	PAR	31.74	83.2	3.05***
	Temperature	16.74	100	1.61ns

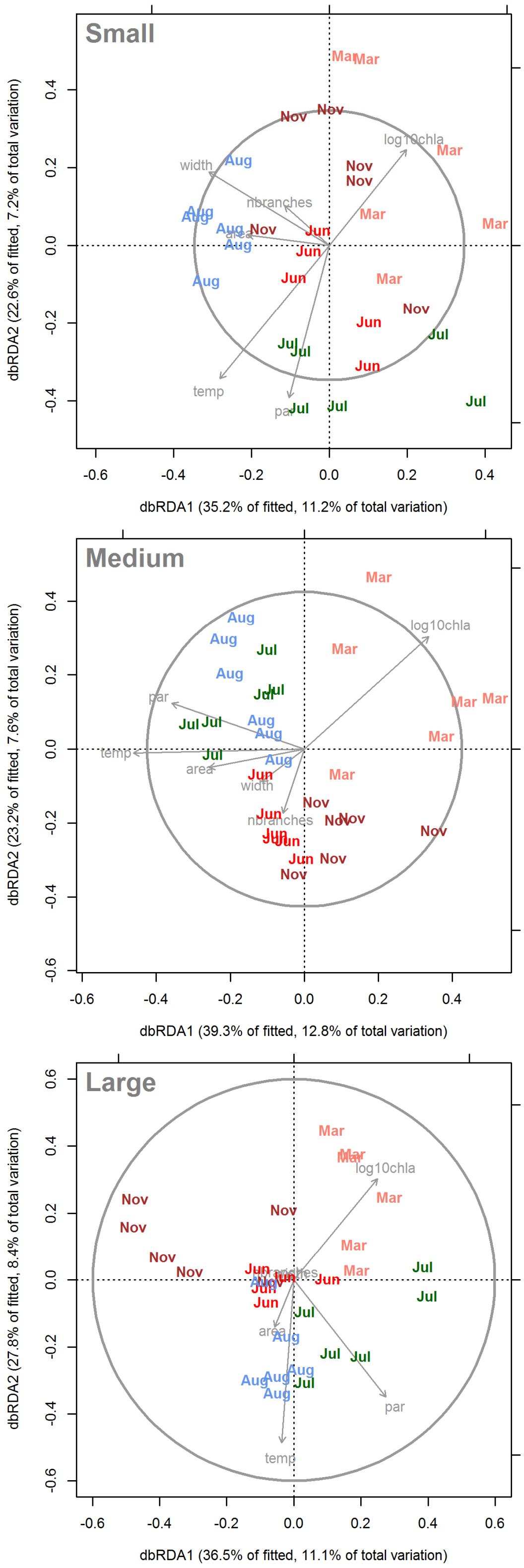

Figure 14. *Eunicella gazella*: distance based Redundancy analysis (dbRDA) ordination biplot for July (Jul), November (Nov), March (Mar), June (Jun) and August (Aug) samples. The vector lines represent the relationship of environmental data (seawater temperature, temp; irradiance, par; chlorophyll *a*, chla) and colonies attributes (area, width and no. of branches) to the ordination axes; their length is proportional to their relative significance.

3.2.2. *Leptogorgia lusitanica*

3.2.2.1 Effect of colony size

In *Leptogorgia lusitanica*, the assemblages are mostly dominated by polychaetes, followed by gastropods and amphipods, overall accounting for 57% and 64% of total abundance in large and medium-sized colonies, respectively. In small-sized colonies polychaetes were also dominant, but were followed by amphipods and the gastropods, overall accounting for 64% of total abundance .

Table 10. Abundance and biodiversity data on the attendant faunal assemblages of *Leptogorgia lusitanica* (LL). Data are pooled by colony size (S – small, M – medium, L – large) and sampling occasion or host species. n - number of colonies; N - number of individuals per colony; S - number of taxa per colony; *ES(50)* - Hurlbert's expected number of species per 50 individuals; *ES(100)* - Hurlbert's expected number of species per 100 individuals.

		n	N	S	*H'*	*J'*	*ES(50)*	*ES(100)*
Sm								
	July 2010	6	306	27	2.40	0.73	13.15	17.18
	November	6	97	14	1.17	0.44	9.55	-
	March 2011	6	105	27	2.69	0.82	18.09	26.32
	June	6	53	13	2.10	0.82	12.71	-
	August	6	246	34	2.63	0.75	16.45	22.96
M								
	July 2010	6	1343	79	3.05	0.70	19.29	27.32
	November	6	167	12	0.75	0.30	6.55	9.67
	March 2011	6	382	34	2.26	0.64	12.76	18.31
	June	6	113	40	3.40	0.92	27.34	38.15
	August	6	320	62	3.40	0.82	24.77	36.02
L								
	July 2010	6	1126	60	2.08	0.51	13.14	19.17
	November	6	500	44	1.48	0.39	11.59	18.74
	March 2011	6	597	49	2.91	0.75	17.66	23.84
	June	6	772	57	2.77	0.69	18.08	25.99
	August	6	1038	75	3.06	0.71	20.26	28.44
	S	30	807	63	2.93	0.71	17.40	24.03
	M	30	2325	111	3.36	0.71	22.07	31.21
	L	30	4033	127	3.11	0.64	19.40	28.06
	July 2010	18	2775	96	2.90	0.63	17.89	25.24
	November	18	764	51	1.38	0.35	10.75	17.57
	March 2011	18	1084	66	2.95	0.70	17.85	24.64
	June	18	938	68	2.97	0.70	19.84	28.88
	ugust	18	1604	96	3.25	0.71	21.56	30.89
	LL	90	7165	156	3.31	0.65	21.12	30.08

The patterns of abundance, species richness, and rarefaction biodiversity (Table 10 and Figure 15) generally mirrored those described for *Eunicella gazella*, i.e. an increase in the number of individuals and taxa with increasing colony size. However, in the case of *L. lusitanica*, the number of individuals per colony was significantly lower in small- than large-sized colonies, while for the species richness, significant differences were detected between all size classes (Table 11). Pielou's evenness was lower at large-sized colonies (Tables 10 and 11).

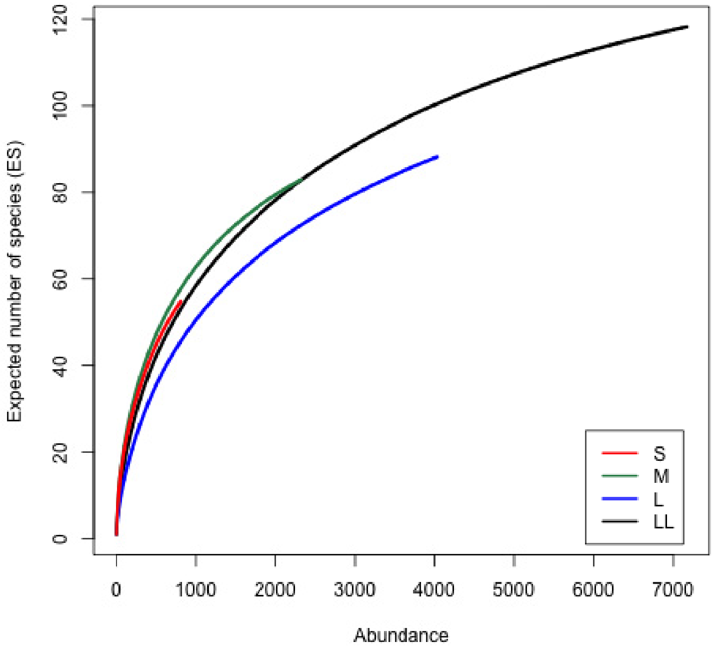

Figure 15. Comparison of rarefaction curves (Hurlbert's expected number of species) in *Leptogorgia lusitanica* (LL) assemblages for different colony size classes.

Table 11. *Leptogorgia lusitanica*: Results of two-way ANOVA for the abundance (N, no. individuals per colony), number of taxa (S, no. of taxa per colony), Pielous' evenness (J') and Shannon-Wiener diversity (H'). Post-hoc comparisons based on Tuckey test are also given. *$p<0.05$; **$p<0.01$; ***$p<0.001$; ns - not significant.

	df	N		S		J'		H'	
		MS	F	MS	F	MS	F	MS	F
Size=Si	2	86826	9.821***	1242.4	21.916***	0.1551	8.128***	2.097	9.470***
Time=Ti	4	36730	4.154**	695.9	12.276***	0.3544	18.575***	6.312	28.500***
Si x Ti		9829	1.112ns	114.6	2.022ns	0.0303	1.590ns	0.461	2.083*
res		8841		56.7		0.0191		0.221	
Post-hoc comparisons									
Size		L≠S		L>M>S		L≠S		L=M>S	
Time				Aug=Jul>Jun=Mar=Nov		Aug=Mar=Jun=Jul>Nov			
Post-hoc time Size x Time									
For levels within factor Size									
S								Aug=Mar=Jul>Nov	
								Aug=Jul=Jun>Nov; Mar>Nov;	
M								Aug>Mar	
L								Aug=Mar=Jun>Nov	

Table 12. *Leptogorgia lusitanica*: mean (±standard deviation) abundance of main taxonomic groups at different sample periods in *Leptogorgia lusitanica* assemblages.

	July 2010	November	March 2011	June	August
Scolecida	0.09±0.293	-----	-----	-----	0.04±0.191
Aciculata	0.18±0.673	0.01±0.096	0.20±1.008	0.21±0.742	0.27±1.220
Canalipalpata	0.12±0.596	0.03±0.166	0.06±0.515	0.10±0.709	0.10±0.404
Bivalvia und	1.47±5.022	0.11±0.436	0.04±0.256	0.09±0.386	0.61±1.953
Heterodonta	0.70±5.259	0.03±0.313	0.04±0.219	0.10±0.766	0.15±0.941
Pteriomorphia	0.54±3.081	0.04±0.233	0.01±0.083	0.05±0.216	0.80±2.932
Gastropoda	0.17±0.892	1.26±7.707	0.22±1.482	0.09±0.750	0.45±1.983
Amphipoda	2.42±17.575	0.10±0.782	1.00±6.183	0.41±2.330	1.08±7.506
Cumacea	0.06±0.236	0.11±0.323	-----	-----	0.06±0.236
Decapoda	0.09±0.481	0.05±0.423	0.15±0.967	0.02±0.176	0.03±0.193
Isopoda	0.94±3.115	0.09±0.456	0.47±1.613	0.23±0.695	0.47±1.845
Mysida	-----	-----	0.03±0.167	-----	-----
Ostracoda	24.22±23.285	-----	7.33±8.246	10.11±15.526	9.17±14.093
Other Arthropoda	0.38±1.723	0.08±0.436	0.13±0.627	0.50±1.899	0.75±2.378
Echinoidea	0.11±0.323	-----	-----	0.06±0.236	-----
Ophiuroidea	0.056±0.371	0.01±0.118	0.04±0.262	0.03±0.236	0.11±0.396
Other	0.97±5.162	0.02±0.246	0.26±2.990	1.32±11.671	0.60±3.783

3.2.2.2. Temporal variability

The attendant fauna of *Leptogorgia lusitanica* was numerically dominated by crustaceans in all sampling occasions except for November 2010, when molluscs, namely gastropods, predominated (Figure 16 and Table 12). This exception is due to the increase in abundance of *Simnia spelta* in a single replicate. Similarly to the pattern observed in *Eunicella gazella*, polychaetes, molluscs and crustaceans were the most diverse groups throughout the study period.

Although in medium- and large-sized colonies species richness appears to be clearly increasing from November to August (Figure 17), no significant differences were found between these sampling periods (Table 11). November 2010 showed the lowest values of Pielou's evenness, Shannon-Wiener diversity and expected number of species. Despite this trend, differences in *H'* diversity were only significant when size factor was taken into account, contrasting with J' that were always significant regardless of the colony size (Table 11). On the other hand, highest values for all biological variables were generally observed in August. Additionally, significantly high numbers of individuals and species were also observed in July (Table 11).

The comparison between rarefaction curves per sampling month shows that there was always some degree of complementarity in the assemblages along the year, as the pooled number of species of each month was always lower than the grand total (Figure 18).

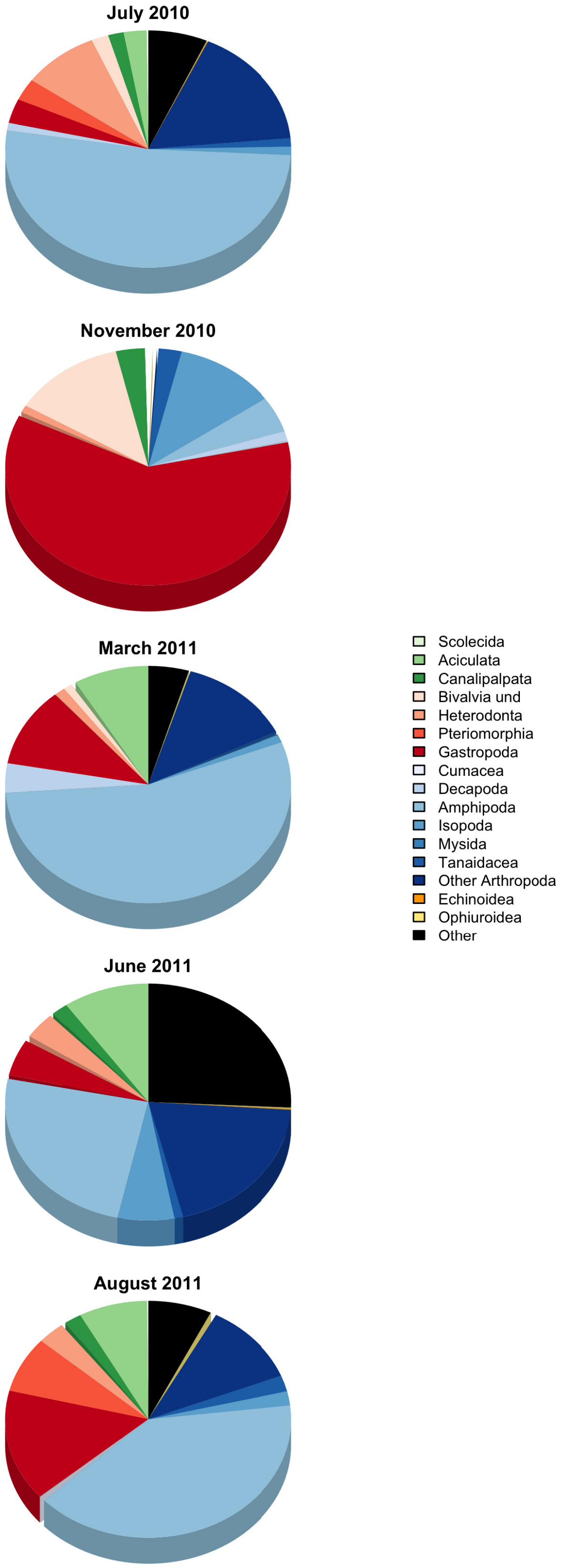

Figure 16. Community structure of the attendant faunal assemblages in *Leptogorgia lusitanica* at different sampling occasions. The relative abundance of the main taxonomic groups is shown. Other Arthropoda – Pycnogonida and Ostracoda; Other – Ascidiacea, Nematoda, Nemertea, Phoronida, Polyplacophora, Porifera, Sipuncula.

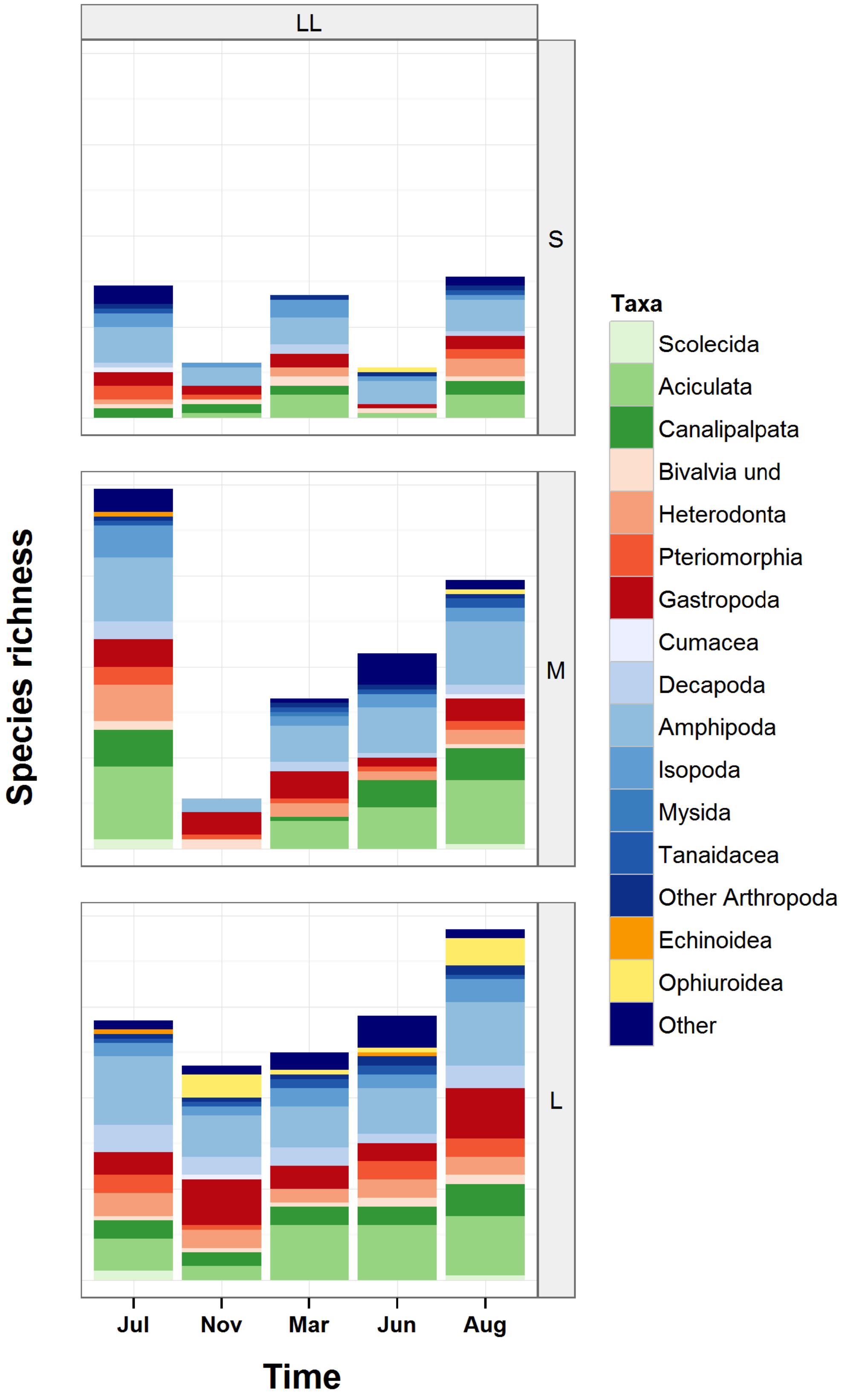

Figure 17. Species richness of the attendant faunal assemblages *Leptogorgia luitanica*. The contribution of major taxonomic groups in the pooled samples by colony size (S – small, M – medium, L – large) in each sampling occasion (from July 2010 to August 2011) are shown. Other – Ascidiacea, Nematoda, Nemertea, Phoronida, Polyplacophora, Porifera, Sipuncula, Turbellaria sp.

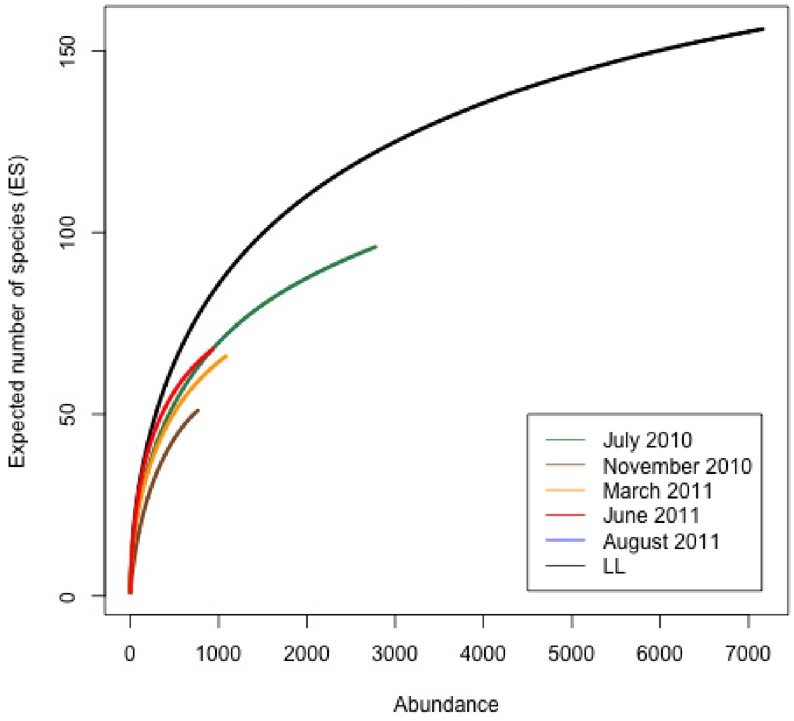

Figure 18. Comparison of rarefaction curves (Hurlbert's expected number of species) in *Leptogorgia lusitanica* (LL) assemblages for the different sampling periods.

Although the number of residents was higher in July 2010 (1741 individuals), the highest relative abundance occurred in November 2010 (90%), similarly to the assemblages of *E. gazella*. On the other hand, both total and relative abundance were lowest in June 2011 (360 individuals and 38%, respectively) (Table 13).

The highest relative abundance of occasional taxa occurred in June 2011, (58%, 33 different taxa). The lowest values for number of taxa (12), total (37) and relative abundance (5%) were observed in November 2010. All variables studied for rare taxa were highest in July (N – 179, %N – 6%, S - 42) and lowest in June 2011 (N – 29, %N – 3%, S – 12; Table 11).

Table 13. Number of taxa (S), total (N) and relative abundance (%N) of resident, occasional and rare species for *Leptogorgia lusitanica* attendant assemblage during the sample period.

	Residents			**Occasional**			**Rare**		
	N	**&N**	**S**	**N**	**&N**	**S**	**N**	**&N**	**S**
July 2010	1741	63%	23	855	31%	31	179	6%	42
November	689	90%	23	37	5%	12	38	5%	16
March 2011	771	71%	23	264	24%	27	49	5%	16
June	360	38%	23	546	58%	33	29	3%	12
August	1011	63%	23	513	32%	34	80	5%	39

3.2.2.3. β-diversity

Turnover of the attendant assemblages of *Leptogorgia lusitanica,* particularly in small-sized colonies, increased throughout the study period (Figure 19). Maximum turnover values were observed in the transition from June to August, regardless of the colony size. Bray-Curtis dissimilarity showed the same patterns as in *Eunicella gazella*. However, the effect of increased variability (both temporal and in colony size) was more clearly displayed by differences in themedian values of dissimilarity (Figure 20).

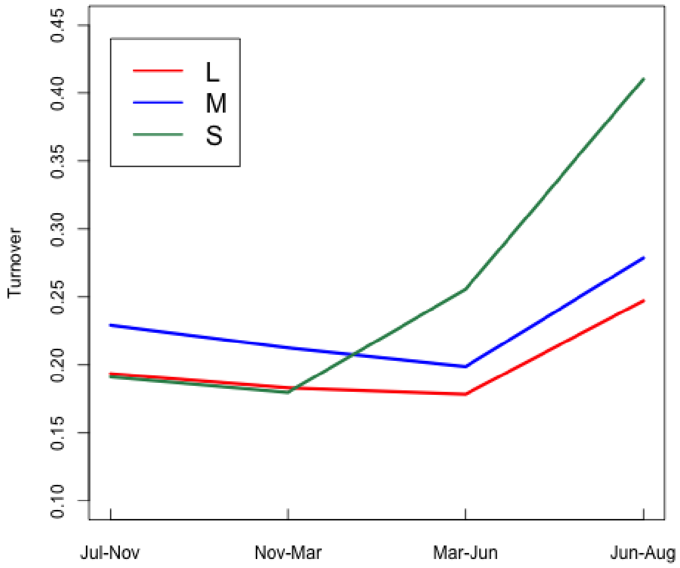

Figure 19. Turnover values of small (S), medium (M) and large (L) colonies of *Leptogorgia lusitanica* throughout the sample period.

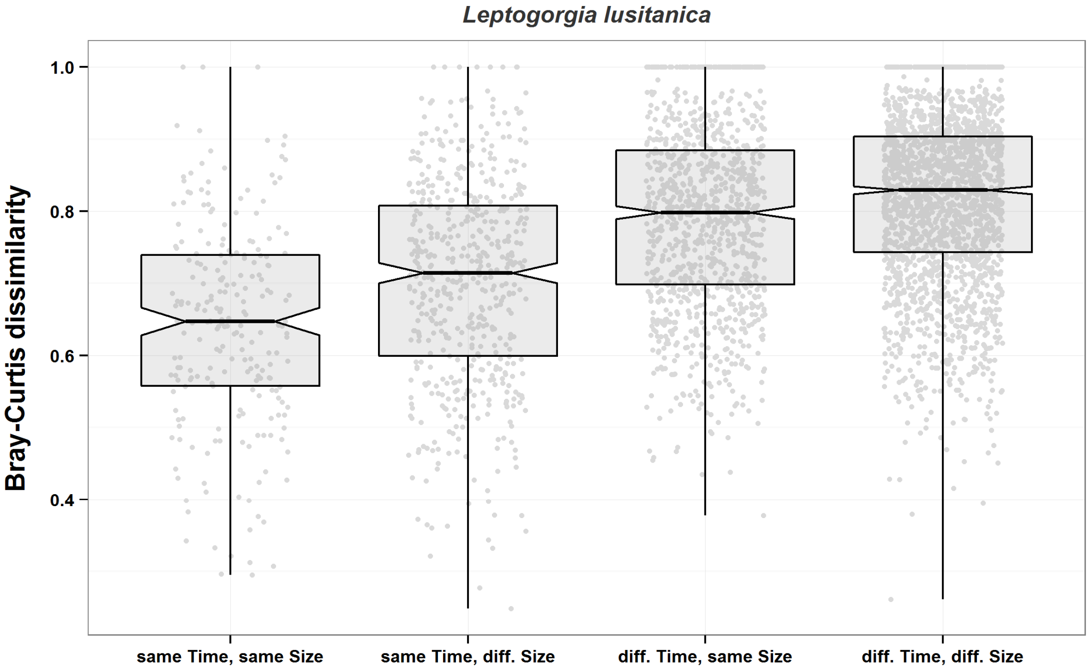

Figure 20. Boxplots of dissimilarity values between samples of *Leptogorgia lusitanica* with same time and same size; same time and different size; different time and same size; and different time and different size

3.2.2.4. Community structure

The MDS plot for *L. lusitanica* (Figure 21) shows that samples from November were segregated from the remaining sampling occasions. Also, samples from November, July and August presented less dispersion compared to those collected in March and June. The ANOSIM tests (Table 14) indicated that composition and structure of the attendant epifaunal assemblages differed significantly between all study periods. Although not clearly depicted in the MDS plot, the ANOSIM analysis indicated that there was a significant difference in community structure and composition between all colony size classes.

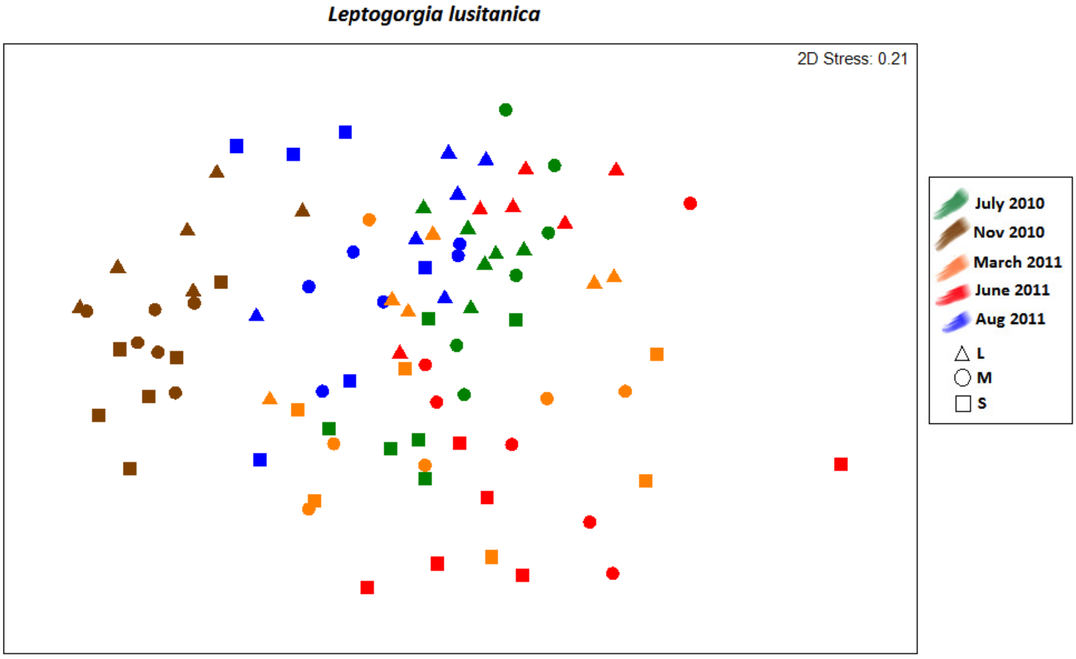

Figure 21. Multidimensional scaling of the samples of *Leptogorgia lusitanica* using Bray-Curtis coefficient. S- small, M- medium, L- large

In *Leptogorgia lusitanica*, the molluscs Tritoniidae and *Simnia spelta*, the amphipods G*ammaropsis* cf. *crenulata*, *Ischyrocerus inexpectatus* and *Ericthonius punctatus*, as well as the Ostracoda were frequently ranked in the top five abundant taxa regardless of the sampling time and colony size. Although not that frequent, the isopod *Astacilla* sp. was fairly constant in small-sized colonies throughout the study period, while the amphipod *Caprella fretensis* was mainly associated with large-sized colonies (Table 15).

Table 14. Results of the ANOSIM global and pairwise tests on the attendant assemblages of *Leptogorgia lusitanica*. two-way analysis with Time and Size factors. 9999 permutations used in all tests. **P<5%; **P<1%*; ****P<0.1%*; ns - not significant

	Sample statistic (R)	Significant statistic	Significance level
Time			
Global Test	0.565	0	0.01%***
Pairwise Tests			
July, Nov	0.971	0	0.01%***
July, Mar	0.388	0	0.01%***
July, Jun	0.373	0	0.01%***
July, Aug	0.406	1	0.02%***
Nov, Mar	0.722	0	0.01%***
Nov, Jun	0.909	0	0.01%***
Nov, Aug	0.838	0	0.01***
Mar, Jun	0.129	407	4.10%*
Mar, Aug	0.405	0	0.01%***
Jun, Aug	0.264	1	0.02%**
Size			
Global Test	0.269	0	0.01%***
Pairwise Tests			
Small, Medium	*0.194*	*4*	*0.05%****
Small, Large	*0.227*	*0*	*0.01****
Medium, Large	*0.040*	*43*	*4.00%**

Table 15. First five dominant species for *Leptogorgia lusitanica* per colony size class (S – small; M – medium; L – large) for each sampling period.

	July 2010	**November**	**March 2011**	**June**	**August**
S	*Caprella fretensis*	*Simnia spelta*	*Gammaropsis* cf. *crenulata*	*Gammaropsis* cf. *crenulata*	*Ericthonius punctatus*
	Ischyrocerus inexpectatus	Tritoniidae	Ostracoda	Ostracoda	*Gammaropsis* cf. *crenulata*
	Astacilla sp.	*Caprella fretensis*	*Astacilla* sp.	*Astacilla* sp.	Ostracoda
	Ostracoda	Nematoda	*Simnia spelta*	*Ischyrocerus inexpectatus*	Tritoniidae
	Tritoniidae	und. Nudibranchia	*Syllidia armata*	Tritoniidae	*Phtisica marina*
M	Ostracoda	*Simnia spelta*	*Ischyrocerus inexpectatus*	Ostracoda	*Caprella acanthifera*
	Gammaropsis cf. *crenulata*	Tritoniidae	*Lembos* cf. *websteri*	*Corynactis viridis*	*Syllis gracilis*
	Stenothoe spp.	*Musculus* sp1	*Ericthonius punctatus*	Sipuncula	af. *Scacchia zorni*
	Hiatella arctica	und. Nudibranchia	Ostracoda	*Ericthonius punctatus*	und. Nudibranchia
	Corynactis viridis	*Ischyrocerus inexpectatus*	*Simnia spelta*	*Astacilla* sp.	und. Ophiuroidea
L	*Caprella fretensis*	*Simnia spelta*	*Gammaropsis* cf. *crenulata*	*Corynactis viridis*	*Ericthonius punctatus*
	Ostracoda	*Ericthonius punctatus*	Ostracoda	Ostracoda	Ostracoda
	Bivalvia sp1	*Lembos* cf. *websteri*	*Caprella fretensis*	*Gammaropsis* cf. *crenulata*	*Corynactis viridis*
	Ischyrocerus inexpectatus	Tritoniidae	*Ischyrocerus inexpectatus*	*Caprella fretensis*	*Musculus* sp1
	Astacilla sp.	*Munna* sp.	*Ericthonius punctatus*	*Leptochelia savygni*	*Simnia spelta*

3.2.2.5. Relationships between biological and environmental data

The dbRDA always explains over 38% of the total variation, regardless of the *Leptogorgia lusitanica* size class. In general, the environmental parameters (especially PAR and temperature, but also chl *a* for large-sized colonies), together with colony attributes (number of branches or the also area and width, for large-sized colonies) all contributed significantly for explaining the associated patterns of the fauna (Table 16). In small-sized colonies, the ordination diagram generally separates the samples from November, mainly due to temperature and PAR during autumn-winter months (Figure 22). Within medium-sized colonies, three clusters are observed, one comprising the samples from November, another one with samples from March and June, and the third comprising the samples from July and August. The samples of March and June are associated to higher values of chl *a*, while morphometric variables separate colonies within each period. In large-sized colonies, samples of July and August were associated to higher values of temperature and PAR. In opposition, November samples, which form a clear cluster, were associated to lower values of both environmental variables. Some of the differences found between samples from November and those of March and June seem to be related to the area and to the number of branches of the colony.

Table 16. *Leptogorgia lusitanica*: Results of the distance-based redundancy analysis (dbRDA) for the fitted model relating a set of variables (morphometrical: colony area, width and number of branches; environmental: chl a, PAR and temperature), where amounts explained by each set added to the model is conditional on sets of variables already in the model. %Var: percentage of variance in species data explained by that set of variables and Cum. %: cumulative percentage of variance explained.

	Parameters	**%Var**	**Cum.(%)**	**F**
S	Area	8.67	8.67	1.22ns
	Width	5.64	14.31	0.79ns
	no. branches	17.10	31.41	2.39**
	log10 Chla	12.67	44.08	1.77ns
	PAR	27.91	71.99	3.90**
	Temperature	28.00	99.99	3.91*
M	Area	6.45	6.45	1.06ns
	Width	9.73	16.18	1.60ns
	no. branches	11.00	27.17	1.80*
	log10 Chla	10.17	37.34	1.66ns
	PAR	45.33	82.68	7.42**
	Temperature	17.33	100.01	2.84**
L	Area	15.34	15.34	2.04*
	Width	20.08	35.42	2.67**
	no. branches	10.73	46.15	1.43ns
	log10 Chla	15.24	61.39	2.03*
	PAR	24.30	85.69	3.24**
	Temperature	14.30	99.99	1.91*

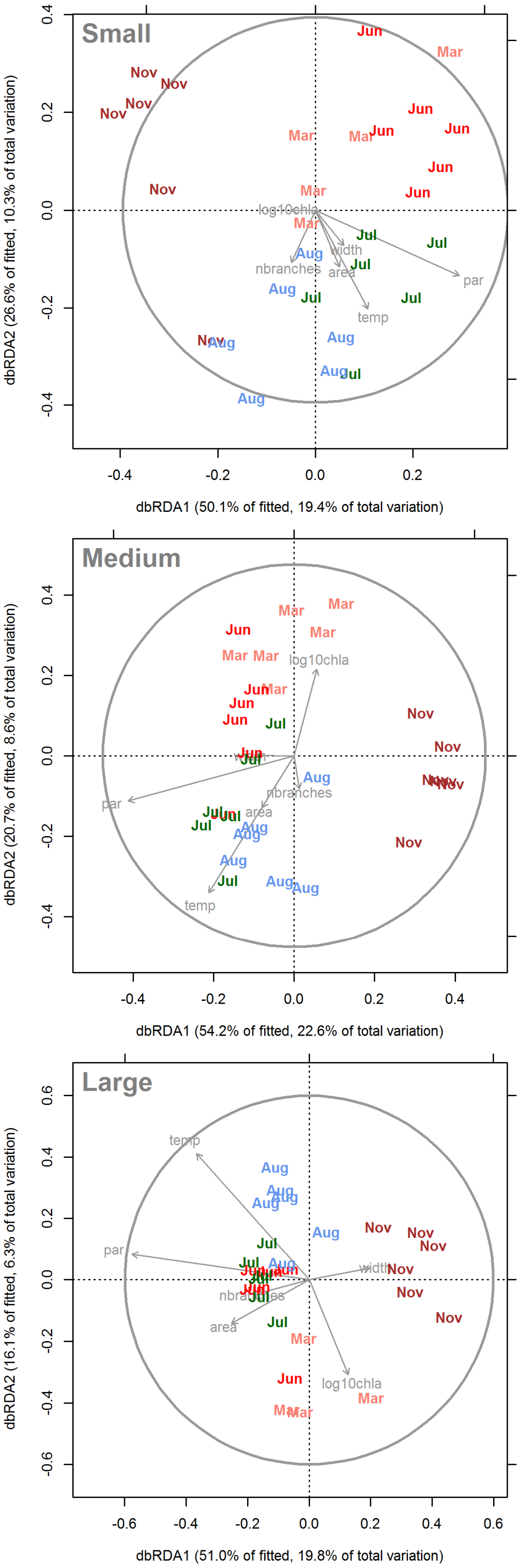

Figure 22. *Leptogorgia lusitanica*: Distance based Redundancy analysis (dbRDA) ordination biplot for July (Jul), November (Nov), March (Mar), June (Jun) and August (Aug) samples. The vector lines represent the relationship of environmental data (seawater temperature, temp; irradiance, par; chlorophyll *a*, chla) and colonies attributes (area, width and no. of branches) to the ordination axes; their length is proportional to their relative significance.

4. Discussion

4.1. Southern Portuguese gorgonian gardens

The epifaunal assemblages associated with *Eunicella gazella* and *Leptogorgia lusitanica* in the southern coast of Portugal encompassed a wide spectrum of taxa (178 taxa possibly more as most polychaetes were identified to family level), mainly crustaceans, polychaetes and molluscs. These high values are in agreement with data on gorgonian gardens from these (Cúrdia *et al.*, in press) and other regions (Goh *et al.*, 1999; Kumagai and Aoki, 2003; Greene, 2008). The overall community composition is also similar to those described for some other anthozoan species (Stella *et al.*, 2010; García-Matucheski and Muniain, 2011), but not for deep-sea gorgonians, where ophiuroids were dominant (Buhl-Mortensen *et al.*, 2010). Turbellaria specimens, apparently to belong to a single species, were very abundant and exclusively associated with *E. gazella* colonies. In a previous study, Cúrdia (2012) suggested that this strong association could rely upon a strategy to avoid predation. Flatworms are white coloured as are *Eunicella gazella* branches, and therefore the epibionts are probably taking advantage of crypsis as observed for other flatworms species (Goh *et al.*, 1999). However, this needs to be confirmed. On the other hand, a Tritoniid species (Mollusca: Nudibranchia) and also the gastropod *Simnia spelta*, associated both to *Eunicella gazella* and *Leptogorgia lusitanica*, may also have a close dependence on these particular habitats. The association of these taxa has been previously reported, as they are well-known octocoral predators (Oliverio *et al.*, 2009; García-Matucheski and Muniain, 2011). Therefore, in case of gorgonian gardens' degradation, this relationship may be disrupted with consequences for the populations of both predator species. Indeed, although the whole assemblages are important and need to be considered, the existence of exclusive species within these environments (and the knowledge on these relationships) is of utmost importance namely in the scenario of global warming and increasing disturbance pressure that coastal zones have been experiencing. Besides, taking into account the almost inexistent knowledge on the contribution of each species for ecosystem functioning, no species should be disregarded. By losing alpha diversity, we will eventually be losing beta diversity, and negatively impacting the ecosystem key functional traits (Chapin III *et al.*, 2000).

4.2. Effect of colony size

Most of the biological variables increased with colony size, except for the Pielou's evenness that was generally high in assemblages from small-sized colonies. Although the number of taxa per colony, and abundance were generally lower at small-sized colonies, the expected number of species was usually higher than the observed for large-sized colonies, indicating that even small-sized colonies (EG, 7.6±1.4cm in height; LL, 7.9±1.6cm in height) have a high contribution for the biodiversity associated with gorgonian gardens. The occurrence of a variety of colony sizes may also have a role in the species-area effect in gorgonian gardens. It is expected that as sample area increases, biological variables such as abundance and species richness will also increase. This species-area effect was already reported for seagrass (Attrill *et al.*, 2000) and gorgonians (Cúrdia, 2012) but not for other corals (Vytopil and Willis, 2001). However, in the case of hard corals, the volume, more than the area, seems to be a reliable measure of the colony size. In what concerns to volume, Garcia *et al.* (2009) found that the number of individuals and non-colonial taxa showed a positive and significant relationship with the volume of *Millepora alcicornis* colonies. This relationship may reflect the increased availability of ecological niches (Attrill *et al.*, 1996; Kovalenko *et al.*, 2012) that allow the settlement of species with different ecological requisites (eventually in higher numbers). It can also promote refuges against predation, especially when associated with increased complexity (e.g. Gratwicke and Speight, 2005; Lingo and Szedlmayer, 2006).

The effect of colony size on the biodiversity and community structure patterns (more evident between small and large-sized colonies) was significant. However, temporal variation had a higher contribution to β-biodiversity, calculated either as a turnover index or as the Bray-Curtis dissimilarity.

4.3. Temporal variability

There is a general lack of studies regarding the distribution, abundance, community structure and dynamics of invertebrate assemblages associated with gorgonian gardens (also extensive to corals). This is severely hindering our understanding of the biodiversity and options for conservation and management of these valuable coastal habitats. Available information concerning the temporal variability associated with these putative patterns is even scarcer, thus limiting comparative analyses (Kumagai and Aoki, 2003). Nevertheless, previous studies on the associated fauna of other sensitive habitats, such us seagrass, meadows showed a clear seasonal variability pattern (Guidetti and Bussotti, 2000).

Temporal patterns of the epibenthic non-colonial invertebrate assemblages associated with the studied gorgonian species were generally consistent in both hosts. Species richness, abundance, diversity, and the expected number of taxa showed a temporal variation, with generally higher values recorded in the spring – summer period and lower values recorded in the autumn-winter period. Only Pielou’s evenness showed the reverse trend, as a result of an abundance peak observed for some species, such as *Caprella fretensis* and *Filograna implexa*, in the spring-summer period. However, it is worth noting that this peak of abundance mainly results from a single colony replicates. These general patterns match the ones observed in the seaweed or seagrass-associated peracarid fauna both in the strait of Gibraltar (Tarifa, southern Spain) (Guerra-García *et al.*, 2010), and NW Iberian Peninsula (Esquete *et al.*, 2011), and also in soft-bottom fauna of other temperate areas (Van Hoey *et al.*, 2007). On the other hand, they contrast to what has been reported from the Mediterranean (Delgado *et al.*, 2009) or NE Atlantic coastal lagoons (Carvalho *et al.*, 2011), where the peak of abundance and diversity was mainly occurring during autumn-winter or winter-spring periods. This difference probably results from the different dynamics of both open-coastal and transitional ecosystems, as the latter are much more influenced by human-induced eutrophication and subsequent oxygen depletion and changes in nutrient availability that occur mainly during summer (Pereira *et al.*, 2010).

The temporal variability pattern also indicated that higher turnover rates (i.e. changes in the number of taxa between two consecutive times) were consistently observed for the spring-summer periods, following the increase of seawater temperature. This period also corresponded to the maximum of diversity and abundance, probably resulting from higher food availability induced by the peak of phytoplankton observed in March 2011. Enhanced food availability following phytoplankton peak has been reported by several authors (Buchanan and Moore, 1986; Costa and Costa, 1999; Rees *et al.*, 2007; McArthur *et al.*, 2010; Schueckel *et al.*, 2010). Additionally, it has been suggested that food sources available in summer have a higher nutritional value (Danovaro and Fabiano, 1997). Indeed, the dbRDA analysis indicated that the temporal variability of epibenthic associated assemblages is significantly influenced by most of the environmental variables included in the model (seawater temperature, chlorophyll *a* and photosynthetic active reaction (PAR)). However, it is worth noting that morphometric attributes of the gorgonians also play a relevant role in the general ecological patterns. To what extent size effects can differ at different times of the year is beyond the subject of this work, but arises as an important question to be addressed in the future.

Turnover reflects a dynamic equilibrium between immigration and extinctions and therefore is likely to reflect the changes of species life cycles along the year. In this context, the highest turnover observed in the transition from June to August reflected an increase in the number of species mainly due to the contribution of many occasional and rare taxa. These were only observed during the spring and summer while the winter assemblages consisted mostly of resident taxa.

Although the total number of taxa identified in this study was 132 for *Eunicella gazella* and 156 for *Leptogorgia lusitanica*, the highest species richness (S) per colony was 55 and 45, respectively. In general, only a few taxa accounted for the majority of the abundance of the assemblages associated with each host. Most of these taxa were classified as residents, i.e. taxa that were present in all sampling dates, and among these, Nematoda, Sipunculida, the polychaetes *Syllidia armata*, the bivalve *Hiatella arctica*, the gastropods Tritoniidae and *Simnia spelta*, the amphipods *Ericthonius punctatus*, *Ischyrocerus inexpectatus*, *Gammaropsis* cf. *crenulata* and *Lembos* cf. *websteri*, the isopods *Astacilla* sp. and the tanaid *Leptochelia savygni* were common to both gorgonian species. With the exception of the known gorgonian predators *Simnia spelta*, and the Tritoniidae (even though the latter could not be identified to species), the remaining taxa are commonly observed in different habitats, especially (but not restricted to) artificial reefs and vegetated habitats (Sánchez-Jerez *et al.*, 1999; Bradshaw *et al.*, 2003; Boaventura *et al.*, 2006; Carvalho *et al.*, 2007; Moura *et al.*, 2008; Bedini *et al.*, 2011; Carvalho *et al.*, 2012). The relatively high number of resident taxa (20 in *E. gazella* and 23 in *L. lusitanica*) together with their high abundance also indicates that the assemblages are dominated by a "core" group of species during the year, and this is reflected in relatively low turnover rates (*E. gazella*, 11.5-22.1%; *L. lusitanica*, 10.4-34.8%). Previous studies concerning the reproductive cycles of benthic non-colonial invertebrates in Portugal showed that several species have continuous reproduction (despite one or two seasonal reproductive peaks) (Malaquias and Sprung, 2005; Pardal et al., 2000), which may support the maintenance of stable populations of "core" assemblages that persist throughout the year. The ANOSIM results suggest a high degree of seasonal variability, expressed by the existence of significant differences between all pairs of sampling occasions analysed. However, and besides this seasonal variability, the proximity of the samples collected in July 2010 and August 2011 in the multivariate analyses suggest that there is an annual cyclicity in the composition and structure of the faunal assemblages associated with gorgonians.

The present work suggests that the fauna associated with gorgonians is shaped by the morphometric of gorgonian colonies and shows a clear temporal variation linked to environmental parameters. In order to increase our understanding of the ecological role of gorgonian gardens, further studies in the region or elsewhere should continue to focus on the investigation of spatial and temporal patterns of their attendant assemblages.

5. Final remarks

The shallow sublittoral rocky habitats of the Algarve coast have been poorly studied until recently (Gonçalves *et al.*, 2008; Gonçalves *et al.*, 2010). These habitats present abundant and rich fauna and flora assemblages (Gonçalves *et al.*, 2008; Gonçalves *et al.*, 2010). The deeper infralittoral and especially the circalittoral rocky areas are dominated by dense gorgonian gardens formed by different species, such as *Eunicella labiata*, *Eunicella verrucosa*, *Eunicella gazella*, *Leptogorgia sarmentosa* and *Leptogorgia lusitanica* (Gonçalves *et al.*, 2010; Cúrdia, 2012). Gorgonian dominated biocenoses in south Portugal and Spain are included in the category of “coral gardens” and the conservation value of these habitats was recently recognized by their integration in the OSPAR (Convention for the Protection of the marine Environment of the North-East Atlantic) list of protected habitats (Anonymous, 2011). By assessing the temporal variability in composition and community structure of the epifaunal assemblages associated to gorgonian species, the present study adds important information on the ecology of these particularly valuable and sensitive environments.

Our results, based on community indices (both uni- and multivariate), reported the existence of temporal variability in the attendant epifaunal assemblages, which reflects differences in community structure and composition throughout the annual cycle, and a high turnover in the spring-summer period. The high turnover rates observed during this period are probably linked to increased immigration rates in spring, followed by high extinction rates at the end of the summer that may be related to: i) influence of temperature on species life cycles; ii) food availability during spring, plausibly promoted by the autumn-winter phytoplankton; iii) higher nutritional value of food during summer, as observed elsewhere (Danovaro and Fabianno, 2007).

Temporal patterns in the attendant epifaunal assemblages were linked to environmental conditions. The highly diverse and abundant assemblages encompassing a core of resident species accompanied by several occasional and more rare gorgonian inhabitants is observed during summer. The high mortality or emigration rates of the latter categories induce a strong decline on the abundance and species richness of the assemblages. The peak of phytoplankton (observed in March) and the seawater temperature increase during spring allows the re-establishment of the rich and abundant assemblages during summer.

The temporal variability observed on the epifaunal assemblages associated with gorgonian colonies in southern Portugal, documented in the present study, has important management implications: time is the main driver for the community dynamics of these assemblages, and therefore biomonitoring aiming the biodiversity assessment and the conservation of gorgonian gardens must take temporal variability into account. In fact, punctual studies may provide only incomplete snapshots of the more complex ecological patterns and result in inappropriate decisions for management actions. Monitoring surveys should also address a representative range of colony sizes for accurate estimates of biodiversity indices and community dynamics.

6. References

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Annex I

List of taxa found in the attendant assemblage of *Eunicella gazella*. Taxonomic data according WoRMS – World Register of Marine Species (http://www.marinespecies.org)

Phylum	**Class**	**Subclass**	**Order**			**July 2010**			**November 2010**			**March 2011**			**June 2011**			**August 2011**	
					S	**M**	**L**	**S**	**M**	**L**	**S**	**M**	**L**	**S**	**M**	**L**	**S**	**M**	**L**
Porifera																			
				Porifera spA	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cnidaria																			
	Anthozoa																		
				Corynactis viridis	0	2	10	2	0	1	0	2	0	2	1	18	0	1	6
Platyhelminthes																			
	Turbellaria																		
				Turbellaria und.	17	137	118	32	71	50	9	16	48	265	435	671	93	156	230
Nemertea																			
				Nemertea und.	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Nematoda																			
				Nematoda und.	0	2	2	1	0	0	1	0	0	2	0	0	1	16	4
Mollusca																			
	Polyplacophora																		
				Polyplacophora und.	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
	Gastropoda																		
				Gastropoda und.	0	0	0	1	0	1	0	0	0	0	0	0	2	0	1
				Gastropoda juv und.	0	0	0	0	0	1	0	0	1	0	0	0	2	1	2
		Vetigastropoda																	

			Calliostoma zizyphinum	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0
			Gibbula sp.	0	0	2	1	0	0	0	0	0	0	2	1	0	0	0
	Caenogastropoda																	
		[unassigned] Caenogastropoda																
			Bittium sp.	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
			Cerithiopsis sp.	0	0	0	0	1	3	0	0	0	0	0	0	0	0	0
			Mesalia sp.	0	0	0	0	0	0	0	0	0	0	0	0	2	1	6
		Littorinimorpha																
			cf. *Lamellaria* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
			Simnia spelta	0	1	1	8	14	11	2	3	0	3	2	3	3	2	4
			Rissoidae und.	0	3	0	0	1	1	0	0	0	0	0	1	0	0	0
		Neogastropoda	cf. *Chauvetia brunnea*	0	2	0	0	0	0	0	0	0	0	1	0	0	1	0
			Coralliophila panormitana	0	0	0	0	0	0	0	0	0	0	0	4	0	0	1
	Heterobranchia																	
			Chrysallida und.	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
			Omalogyra atomus	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
		Nudibranchia																
			Nudibranchia und.	0	0	1	0	0	0	0	0	0	0	0	0	0	3	0
			Tritoniidae und.	9	13	6	5	4	2	2	1	0	4	3	15	14	14	22
Bivalvia																		
			Bivalvia spB	4	59	39	0	0	0	0	0	0	0	1	0	11	13	26
			Bivalvia spA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
			Bivalvia und.	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
	Heterodonta																	
		Anomalodesmata																
			Thracia sp.	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
		Carditoida																
			Glans sp.	0	0	0	0	0	0	0	1	0	0	0	0	0	3	1
		[unassigned] Euheterodonta																

			Hiatella arctica	12	30	8	1	2	1	1	1	2	11	4	11	5	9	12
			Rocellaria dubia	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
		Lucinoida																
			Loripes sp.	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
			Lucinoma sp.	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0
			Thyasira sp.	1	2	2	0	0	0	0	0	0	0	0	0	0	0	0
		Veneroida																
			Abra sp.	0	0	0	1	0	1	0	0	0	1	2	0	0	0	0
			Bornia sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
			Epilepton clarkiae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
			Kellia sp.	0	0	0	1	0	0	0	1	0	0	0	0	0	5	5
			Kelliella miliaris	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0
			cf. *Kurtiella bidentata*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
			Tellina sp.	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
	Pteriomorphia																	
		Arcoida																
			Arca noae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
		Limoida																
			Limaria tuberculata	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
			Limaria loscombi	2	0	0	0	0	0	0	0	0	0	0	0	0	2	1
		Mytiloida																
			Modiolus sp.	0	0	0	0	1	0	0	0	0	0	0	0	3	17	13
			Musculus spA	7	14	3	8	3	0	0	0	0	0	0	0	26	18	25
			Rhomboidella sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
		Ostreoida																
			Ostrea edulis	0	10	3	0	0	0	0	0	0	0	0	0	1	0	0
		Pectinoida																
			Pectinoida und.	0	0	8	0	0	0	0	0	0	0	0	0	1	0	0
Sipuncula																		

				Sipuncula und.	0	5	1	0	4	1	0	2	0	0	2	2	0	0	2
Annelida																			
	Polychaeta																		
				Polychaeta und.	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
		Aciculata																	
			Eunicida																
				Lumbrineridae und.	0	0	1	0	0	0	0	0	1	0	1	1	0	1	0
			Phyllodocida																
				Autolytinae und.	0	0	0	0	1	0	0	1	2	0	1	2	0	0	0
				Brania pusilla	0	0	6	0	1	0	0	1	0	0	0	1	0	2	2
				Chrysopetalidae spA	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
				Exogone sp.	0	0	0	0	0	0	0	0	1	0	0	0	0	3	2
				Hesionidae und.	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0
				Nereididae und.	1	0	0	0	0	0	0	0	0	0	0	3	0	0	0
				Paleanotus cf. *debilis*	1	1	0	0	0	0	0	1	1	1	1	6	3	3	6
				Pholoe inornata	0	0	0	0	0	0	0	1	0	0	0	0	0	2	1
				Phyllodocidae und.	1	0	0	0	0	0	2	2	2	0	0	4	0	2	6
				Pionosyllis spp.	0	0	0	0	0	0	2	0	0	0	0	0	0	0	3
				Polynoidae und.	0	0	0	0	0	0	1	4	3	0	1	1	2	0	4
				Sphaerosyllis sp.	0	0	2	0	0	1	0	0	1	2	0	4	0	3	3
				Syllidae und.	2	0	0	0	0	0	0	1	3	2	5	5	0	3	4
				Syllidae epitoquia	0	0	0	0	0	0	0	0	1	0	0	1	0	1	1
				Syllidia armata	0	2	1	0	0	1	1	5	3	2	3	10	0	9	6
				Syllis gracilis	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
				Syllis sp.	0	0	2	0	1	0	0	0	0	0	0	2	0	0	0
		Canalipalpata																	
			Sabellida																
				Chone sp.	2	2	4	0	2	1	1	0	4	0	0	0	2	7	1
				Fabricia sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0

				Filograna implexa	0	0	0	0	0	0	0	0	0	0	0	5563	0	1	8
				Oweniidae spA	0	0	0	0	0	0	0	1	0	0	0	0	0	0	10
				Sabellariidae und.	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2
				Sabellidae und.	1	0	1	0	0	0	0	0	1	1	2	0	0	1	0
				Serpulidae und.	0	0	2	0	2	0	0	0	0	0	0	0	0	0	0
			Spionida																
				Chaetopterus variopedatus	0	0	0	0	0	1	0	0	0	0	0	0	1	1	3
				Polydora hoplura	0	0	1	0	0	0	1	0	0	1	0	0	0	0	1
				Polydora sp.	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0
				Spionidae und.	0	0	0	0	0	0	0	1	0	0	1	0	0	2	1
			Terebellida																
				Terebellidae und.	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0
		Scolecida																	
				Micromaldane ornithochaeta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
				Nicomache sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Arthropoda																			
	Ostracoda																		
				Ostracoda und.	11	107	55	11	18	12	1	9	66	33	127	212	29	38	38
	Malacostraca																		
		Eumalacostraca																	
			Amphipoda																
				Ampelisca sp.	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
				Amphilochus sp.	0	0	0	0	1	0	0	0	0	0	1	2	0	1	1
				Amphipoda und.	0	0	0	0	0	0	0	0	0	0	0	3	0	0	1
				Atylidae und.	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
				Caprella acanthifera	0	0	0	0	0	0	0	0	0	0	0	6	12	0	0
				Caprella fretensis	2	4	0	0	0	0	0	0	7	1	0	0	0	0	0
				Colomastix pusilla	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4

	Epimeria cornigera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
	Ericthonius punctatus	0	101	19	55	137	124	1	4	2	11	24	47	145	244	84
	Gammaropsis cf. *crenulata*	0	25	9	3	70	33	3	4	7	5	81	179	15	43	29
	Gammaropsis sophiae	0	10	3	0	0	0	0	0	2	0	0	2	0	0	0
	Ischyrocerus inexpectatus	6	40	1	1	0	4	2	5	7	11	8	16	6	2	1
	Lembos cf. *websteri*	2	2	3	6	2	9	1	0	3	2	5	14	0	4	3
	Leptocheirus sp.	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0
	Leucothoe spinicarpa	0	0	0	0	0	1	0	0	0	0	0	6	0	0	6
	Lysianassidae spA	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1
	Megamphopus cornutus	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
	Microdeutopus gryllotalpa	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
	Photis sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
	Phtisica marina	5	8	5	2	0	2	0	1	0	3	3	3	1	8	3
	Stenothoe spp.	0	63	12	0	1	0	0	0	0	1	7	1	0	2	1
Isopoda																
	Anthuridae und.	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
	Astacilla sp.	1	6	7	0	10	0	0	1	1	1	13	6	0	3	2
	Cymothoidae und.	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0
	Gnathiidae und.	0	1	2	1	1	2	0	0	1	0	1	3	1	1	11
	Janira maculosa	0	0	0	0	0	4	0	1	0	0	0	0	0	1	9
	Munna sp.	0	2	0	0	0	2	0	0	0	0	4	3	1	1	9
Mysida																
	Erythrops elegans	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Tanaidacea																
	Apseudes talpa	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1
	Leptochelia savygnyi	0	3	4	9	3	11	5	4	5	1	1	8	6	8	14
Decapoda																
	Balssia sp.	0	1	8	0	0	2	0	0	2	0	0	0	0	8	4

			Eualus cranchii	0	0	0	0	1	2	0	0	0	0	0	22	0	0	18
			Hippolyte varians	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
			Hippolyte sp.	0	2	2	0	0	0	0	0	0	0	1	0	0	0	0
			Macropodia linaresi	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
			Paguridae und.	0	0	0	0	0	3	0	0	0	0	0	0	0	1	0
			Palaemonetes varians	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
			Pilumnus hirtellus	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1
			Pisa carinimana	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
			cf. *Pisa* sp.	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
			Pisidia cf. *bluteli*	0	0	0	0	0	4	0	0	10	0	0	12	0	0	1
			Xantho pilipes	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
	Pycnogonida																	
		Pantopoda																
			Achelia cf. *echinata*	0	0	0	0	0	1	0	0	0	0	2	0	1	6	2
			Anoplodactylus pygmaeus	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
Echinodermata																		
	Ophiuroidea																	
			Ophiuroidea und.	0	0	0	0	0	0	0	0	0	1	1	0	1	0	5
		Ophiurida																
			Amphipholis squamata	0	1	0	0	0	1	1	0	1	0	3	3	0	0	3
			Ophiacantha bidentata	0	0	1	0	0	4	0	0	0	0	0	1	0	0	0
	Echinoidea																	
			Echinoidea und.	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Chordata																		
	Ascidiacea																	
		Stolidobranchia																
			Molgula sp.	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0

Annex II

List of taxa found in the attendant assemblage of *Leptogorgia lusitanica*. Taxonomic data according WoRMS – World Register of Marine Species (http://www.marinespecies.org)

						July 2010			**November**			**March 2011**			**June**			**August**		
Phylum	**Class**	**Subclass**	**Superorder**	**Order**		**S**	**M**	**L**	**S**	**M**	**L**	**S**	**M**	**L**	**S**	**M**	**L**	**S**	**M**	**L**
Cnidaria																				
	Anthozoa																			
				Corallimorpharia																
					Corynactis viridis	1	86	21	0	0	0	0	0	40	2	10	206	1	14	76
Nematoda																				
					Nematoda und.	0	29	2	3	0	0	0	2	0	0	1	0	3	4	2
Mollusca																				
	Polyplacophora																			
					Polyplacophora und.	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
	Gastropoda																			
					Gastropoda juv und.	0	0	0	0	0	2	0	4	0	0	0	0	0	0	1
					Gastropoda spA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
					Gastropoda spB	0	0	0	0	1	0	1	0	0	0	0	0	0	1	2
		Vetigastropoda																		
					Calliostoma zizyphinum	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
					Gibbula magus	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0

		Gibbula sp.	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
		Jujubinus striatus	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0
Caenogastropoda																	
	[unassigned] Caenogastropoda																
		Bittium sp.	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
		Mesalia sp.	0	3	0	0	0	0	0	0	0	0	0	0	0	1	2
		Triphoridae und.	0	0	0	0	2	6	0	0	0	0	0	0	0	0	0
	Littorinimorpha																
		cf. *Alvania* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
		Littorina sp.	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
		Simnia spelta	4	3	25	72	142	367	10	27	47	0	2	8	10	41	59
		cf. Skeneopsis planorbis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
		Rissoidae und.	0	0	0	0	0	0	0	3	3	0	0	0	0	0	0
	Neogastropoda																
		cf. *Chauvetia brunnea*	1	0	1	0	0	2	0	1	0	0	0	1	0	0	3
		Coralliophila panormitana	0	0	3	0	2	0	0	2	1	0	0	1	0	0	1
		Nassarius nitidus	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
Heterobranchia																	
		Chrysallida sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
		cf. *Odostomia* sp.	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
		Omalogyra atomus	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
		cf. *Retrotortina* sp.	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	Nudibranchia																
		Euctenidiacea und.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
		Nudibranchia und.	0	0	1	3	3	1	0	0	0	0	0	1	1	0	0
		Platydoris argo	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
		Tritoniidae und.	21	10	10	6	6	9	1	5	5	4	5	25	27	31	42

	Patellogastropoda																	
			Tectura virginea	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Bivalvia																		
			Bivalvia sp1	3	69	59	0	1	0	0	0	0	0	0	3	6	14	34
			Bivalvia spE	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
			Bivalvia und.	0	0	0	1	2	6	1	0	1	1	0	4	0	0	0
			Bivalvia spC	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
	Heterodonta																	
		Anomalodesmata																
			Thracia sp.	0	0	8	0	0	0	0	0	0	0	0	0	1	0	0
		Carditoida																
			Glans sp.	0	0	0	0	0	1	2	0	0	0	2	2	0	0	0
			Parvicardium cf. *vroomi*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
		[unassigned] Euheterodonta																
			Hiatella arctica	16	130	30	0	0	3	1	2	1	0	2	22	4	11	18
		Lucinoida																
			Lucinoma sp.	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0
			Thyasira sp.	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
		Myoida																
			Corbula gibba	0	25	0	0	0	0	0	0	0	0	0	0	0	0	0
		Veneroida																
			Abra sp.	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0
			Bornia sp.	0	3	1	0	0	0	0	0	1	0	0	1	0	0	1
			Epilepton clarkiae	0	4	0	0	0	0	0	0	0	0	0	0	0	1	0
			Kellia sp.	0	2	1	0	0	5	0	0	0	0	0	4	5	1	1
			cf. *Kurtiella bidentata*	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0
			cf. *Pseudopythina macandrewi*	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0

				af. *Scacchia zorni*	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0
		Pteriomorphia																	
			Arcoida																
				Arca noae	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
			Limoida																
				Limaria loscombi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
			Mytiloida																
				Modiolus sp.	0	10	1	0	0	0	0	0	0	0	0	2	1	15	18
				Musculus spA	7	7	8	1	4	1	0	1	0	0	0	1	5	10	59
			Ostreoida																
				Ostrea edulis	1	38	2	0	0	0	0	0	0	0	0	0	0	0	0
			Pectinoida																
				Pectinoida und.	1	2	1	0	0	0	0	0	0	0	1	2	0	0	3
Sipuncula																			
				Sipuncula und.	4	5	2	0	0	2	0	1	4	0	7	7	2	2	2
Annelida																			
	Polychaeta																		
				Polychaeta und.	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0
		Aciculata																	
			Eunicida																
				Eunice spA	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
				Eunice spB	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
				Lumbrineridae und.	0	4	0	0	0	0	0	0	0	0	0	9	0	1	4
				Nematonereis unicornis	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0
				Ophryotrocha labronica	0	4	0	0	0	0	0	0	4	0	1	0	0	0	0
			Phyllodocida																
				Autolytinae und.	0	0	0	0	0	0	1	2	1	0	1	8	0	0	0

		Brania pusilla	0	3	2	0	0	0	0	0	1	0	0	1	0	1	1
		Exogone sp.	0	2	0	0	0	0	0	0	0	0	0	5	0	2	4
		cf. *Haplosyllis spongicola*	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
		Hesionidae und.	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
		Micronephthys sp.	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0
		Nereididae und.	0	1	0	0	0	1	0	0	0	0	0	0	0	2	10
		Paleanotus cf. *debilis*	0	4	1	0	0	0	0	0	4	0	2	11	3	2	14
		Pholoe inornata	0	2	1	0	0	0	0	0	0	0	0	1	0	1	4
		Phyllodocidae und.	0	5	0	0	0	0	0	2	3	0	1	2	1	2	3
		Pionosyllis spp.	0	0	0	0	0	0	0	0	0	0	1	0	0	1	2
		Polynoidae und.	0	1	0	0	0	0	1	4	24	0	2	2	0	3	3
		Sphaerosyllis sp.	0	5	0	0	0	0	1	0	5	0	2	11	0	1	6
		Syllidae und.	0	2	1	0	0	0	0	0	2	0	0	2	2	1	0
		Syllidia armata	0	15	1	1	0	1	9	2	13	0	4	16	0	4	29
		Syllis gracilis	0	4	0	0	0	0	1	0	0	0	0	3	4	0	2
		Syllis sp.	0	4	3	0	0	1	0	1	1	0	4	0	0	1	1
Canalipalpata																	
	Sabellida																
		Chone sp.	3	4	0	1	0	1	1	0	0	0	0	0	2	4	2
		Fabricia sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
		Oweniidae spA	0	0	1	0	0	0	0	0	0	0	1	0	0	4	2
		Sabellariidae und.	0	1	0	1	0	0	0	0	1	0	3	1	0	2	2
		Sabellidae und.	0	1	3	0	0	0	0	8	0	0	2	13	0	1	1
		Serpulidae und.	0	1	1	0	0	0	0	0	0	0	0	0	0	1	2
	Spionida																
		Chaetopterus variopedatus	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0
		Poecilochaetidae und.															

					Polydora hoplura	0	9	0	0	0	0	1	0	4	0	1	2	0	0	1
					Polydora sp.	0	4	3	0	0	0	0	0	1	0	0	0	0	0	0
					Spionidae und.	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0
				Terebellida																
					Acrocirridae und.	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
					Cirratulidae und.	0	0	0	0	0	0	0	0	0	0	1	3	0	0	2
					Flabelligeridae und.	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
					Pherusa sp.	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
					Terebellidae und.	0	1	0	0	0	0	0	0	0	0	2	0	0	0	0
		Scolecida																		
					Capitella sp.	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
					Micromaldane ornithochaeta	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
					Nicomache sp.	0	1	2	0	0	0	0	0	0	0	0	0	0	1	0
Arthropoda																				
	Ostracoda																			
					Ostracoda und.	28	221	187	0	0	0	17	42	73	11	12	159	31	37	97
	Malacostraca																			
		Eumalacostraca																		
			Peracarida																	
				Cumacea																
					Cumacea und.	1	0	0	0	0	2	0	0	0	0	0	0	0	1	0
				Amphipoda																
					Amphilochus sp.	0	2	2	0	0	0	0	1	0	0	0	2	0	0	0
					Amphipoda und.	0	0	0	0	0	0	0	2	0	0	0	2	0	2	1
					Apherusa bispinosa	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0
					Caprella acanthifera	1	0	0	0	0	0	0	0	0	0	0	0	8	0	2
					Caprella fretensis	68	46	560	3	1	0	0	2	66	2	2	45	0	3	22

	Cheirocratus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
	Epimeria cornigera	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
	Ericthonius punctatus	2	37	6	1	0	15	4	46	50	0	6	17	49	10	258
	Gammaropsis cf. *crenulata*	20	198	21	0	0	4	19	3	81	15	4	50	48	10	56
	Gammaropsis sophiae	4	5	1	0	0	0	0	0	0	0	1	0	0	1	9
	Iphimedia sp.	0	0	0	0	0	1	0	0	1	0	1	0	0	0	0
	Ischyrocerus inexpectatus	56	33	40	1	2	4	8	128	55	4	4	4	1	7	4
	Jassa sp.	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0
	Lembos cf. *websteri*	0	9	1	1	0	13	2	66	5	1	4	4	0	6	12
	Leucothoe spinicarpa	0	2	3	0	0	1	0	0	1	0	2	0	0	4	1
	Liljeborgia sp.	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	Maera sp.	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
	Megamphopus cornutus	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
	Perioculodes longimanus	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
	Photis sp.	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
	Phtisica marina	13	32	18	0	0	0	0	2	0	2	3	26	11	6	15
	Pseudoprotella phasma	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
	Stenothoe spp.	1	143	9	0	1	0	1	0	3	0	0	8	0	4	16
	Synchelidium sp.	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Isopoda																
	Anthuridae und.	0	1	0	0	0	0	0	0	0	0	0	0	0	0	2
	Astacilla sp.	45	16	34	0	0	2	11	12	25	8	5	1	8	8	7
	Cymothoidae und.	0	2	3	0	0	0	1	0	0	0	0	0	0	0	2
	Gnathiidae und.	0	2	8	0	0	0	1	0	2	0	4	4	0	5	3
	Janira maculosa	0	3	5	0	0	1	1	0	14	0	1	18	1	7	20
	Munna sp.	1	4	0	2	0	7	3	0	1	0	1	6	0	1	23
	Sphaeromatidae und.	0	1	0	0	0	0	0	0	2	0	0	0	0	0	0

			Mysida																
				Mysida und.	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
			Tanaidacea																
				Apseudes talpa	0	0	0	0	0	0	0	0	1	0	0	1	1	1	0
				Leptochelia savygnyi	1	18	8	0	0	4	0	1	7	0	3	29	0	11	38
		Eucarida																	
			Decapoda																
				Anapagurus sp.	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
				Balssia sp.	0	0	1	0	0	0	0	1	3	0	1	0	0	2	2
				Decapoda und.	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
				Eualus cranchii	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
				Eurynome aspera	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
				Hippolyte sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
				Hippolyte varians	0	1	7	0	0	0	0	0	15	0	0	0	0	0	0
				cf. *Homola barbata*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
				Palaemonetes varians	0	1	3	0	0	0	0	0	0	0	0	0	0	0	0
				Pilumnus hirtellus	0	2	1	0	0	0	0	0	0	0	0	0	0	0	1
				Pisa carinimana	0	0	1	0	0	0	2	0	2	0	0	0	0	0	0
				cf. *Pisa* sp.	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
				Pisidia cf. *bluteli*	1	8	0	0	0	2	2	2	14	0	0	2	0	0	1
				Xantho pilipes	0	0	0	0	0	8	0	0	0	0	0	2	0	0	0
	Pycnogonida																		
			Pantopoda																
				Achelia cf. *echinata*	0	0	0	0	0	0	0	0	0	0	0	3	0	0	3
				Anoplodactylus pygmaeus	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
Phoronida																			
				Phoronida und.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

Echinodermata																		
	Ophiuroidea																	
			Ophiuroidea und.	0	0	1	0	0	1	0	0	0	0	0	0	1	0	1
		Ophiurida																
			Amphipholis squamata	0	0	0	0	0	5	0	0	1	1	0	1	0	1	6
			Ophiacantha bidentata	0	3	0	0	0	0	0	0	0	0	0	0	0	3	0
			Ophiomyxidae und.	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
	Echinoidea																	
			Echinoidea und.	0	1	1	0	0	0	0	0	0	0	0	1	0	0	0
Chordata																		
	Ascidiacea																	
			Ascidiacea und.	0	25	0	0	0	0	0	0	0	0	0	0	0	1	0

Annex III

List of resident taxa in the attendant assemblage of *Eunicella gazella* (EG) and *Leptogorgia lusitanica* (LL)

EG		LL	
Group	**Taxon**	**Group**	**Taxon**
Anthozoan	*Corynactis viridis*	Sipuncula	**Sipuncula**
Platyhelminthes	Turbellaria und.	Nematoda	**Nematoda**
Sipuncula	**Sipuncula**	Polychaeta	***Syllidia armata***
Nematoda	**Nematoda**	Polychaeta	*Syllis* sp.
Polychaeta	*Brania pusilla*	Polychaeta	Sabellariidae und.
Polychaeta	***Syllidia armata***	Bivalvia	***Hiatella arctica***
Polychaeta	*Sphaerosyllis* sp.	Bivalvia	*Musculus* spA
Bivalvia	***Hiatella arctica***	Gastropoda	**Tritoniidae**
Gastropoda	**Tritoniidae**	Gastropoda	***Simnia spelta***
Gastropoda	***Simnia spelta***	Gastropoda	cf. *Chauvetia brunnea*
Ostracoda	Ostracoda	Gastropoda	*Coralliophila panormitana*
Amphipoda	***Ericthonius punctatus***	Amphipoda	***Ericthonius punctatus***
Amphipoda	***Ischyrocerus inexpectatus***	Amphipoda	*Stenothoe* spp.
Amphipoda	***Gammaropsis* cf. *crenulata***	Amphipoda	***Ischyrocerus inexpectatus***
Amphipoda	*Phtisica marina*	Amphipoda	***Gammaropsis* cf. *crenulata***
Amphipoda	***Lembos* cf. *websteri***	Amphipoda	*Leucothoe spinicarpa*
Isopoda	***Astacilla* sp.**	Amphipoda	***Lembos* cf. *websteri***
Isopoda	Gnathiidae	Amphipoda	*Caprella fretensis*
Tanaidacea	***Leptochelia savygnyi***	Isopoda	***Astacilla* sp.**
Ophiuroidea	*Amphipholis squamata*	Isopoda	*Munna* sp.
		Isopoda	*Janira maculosa*
		Tanaidacea	***Leptochelia savygnyi***
		Decapoda	*Pisidia* cf. *bluteli*

Annex IV

List of occasional taxa in the attendant assemblage of *Eunicella gazella* (EG) and *Leptogorgia lusitanica* (LL)

EG		**LL**	
Group	**Taxon**	**Group**	**Taxon**
Polychaeta	**Syllidae und.**	**Anthozoa**	*Corynactis viridis*
Polychaeta	*Paleanotus* cf. *debilis*	**Polychaeta**	*Chone* sp.
Polychaeta	**Phyllodocidae und.**	**Polychaeta**	**Sabellidae**
Polychaeta	**Lumbrineridae und.**	**Polychaeta**	***Polydora hoplura***
Polychaeta	Hesionidae und.	**Polychaeta**	Oweniidae spA
Polychaeta	*Syllis* sp.	**Polychaeta**	*Brania pusilla*
Polychaeta	Nereididae und.	**Polychaeta**	*Syllis gracilis*
Polychaeta	**Polynoidae und.**	**Polychaeta**	**Syllidae und.**
Polychaeta	Autolytinae und.	**Polychaeta**	*Sphaerosyllis* sp.
Polychaeta	*Chone* sp.	**Polychaeta**	**Phyllodocidae und.**
Polychaeta	**Sabellidae**	**Polychaeta**	**Polynoidae und.**
Polychaeta	***Polydora hoplura***	**Polychaeta**	**Lumbrineridae und.**
Polychaeta	Serpulidae und.	**Polychaeta**	*Pholoe inornata*
Polychaeta	*Polydora* sp.	**Polychaeta**	*Ophryotrocha labronica*
Polychaeta	Spionidae und.	**Polychaeta**	*Exogone* sp.
Bivalvia	**Bivalvia sp1**	**Polychaeta**	*Paleanotus* cf. *debilis*
Bivalvia	*Musculus* spA	**Bivalvia**	**Bivalvia sp1**
Bivalvia	***Kellia*** **sp.**	**Bivalvia**	***Kellia*** **sp.**
Gastropoda	Rissoidae	**Bivalvia**	*Bornia* sp.
Gastropoda	*Gibbula* sp.	**Bivalvia**	*Glans* sp.
Gastropoda	cf. *Chauvetia brunnea*	**Bivalvia**	Pectinoida und.
Gastropoda	*Calliostoma zizyphinum*	**Bivalvia**	*Modiolus* sp.
Amphipoda	*Stenothoe* spp.	**Gastropoda**	Nudibranchia und
Amphipoda	***Gammaropsis sophiae***	**Gastropoda**	Gastropoda sp1
Amphipoda	*Caprella fretensis*	**Ostracoda**	Ostracoda
Amphipoda	*Leucothoe spinicarpa*	**Amphipoda**	*Phtisica marina*
Amphipoda	*Janira maculosa*	**Amphipoda**	***Gammaropsis sophiae***
Amphipoda	***Amphilochus*** **sp.**	**Amphipoda**	*Iphimedia* sp.
Isopoda	*Munna* sp.	**Amphipoda**	***Amphilochus*** **sp.**
Decapoda	***Balssia*** **sp.**	**Isopoda**	Gnathiidae und.
Decapoda	*Pisidia* cf. *bluteli*	**Isopoda**	Cymothoidae und.
Decapoda	*Hippolyte varians*	**Tanaidacea**	*Apseudes talpa*
Decapoda	*Pilumnus hirtellus*	**Cumacea**	Cumacea und.
Decapoda	*Eualus cranchii*	**Decapoda**	***Balssia*** **sp.**
Pycnogonida	*Achelia* cf. *echinata*	**Ophiuroidea**	*Amphipholis squamata*
Ophiuroidea	*Ophiacantha bidentata*	**Ophiuroidea**	Ophiuroidea und.

Annex V

List of rare taxa in the attendant assemblage of *Eunicella gazella* (EG) and *Leptogorgia lusitanica* (LL)

EG		EG	
Group	**Taxon**	**Group**	**Taxon**
Porifera	Porifera	Hydrozoa	Aglaophenia sp.
Nemertea	Nemertea	Polychaeta	Polychaeta und.
Polychaete	*Syllis gracilis*	Polychaeta	Nereididae
Polychaete	*Pionosyllis* spp.	Polychaeta	Pionosyllis spp.
Polychaete	*Pholoe inornata*	Polychaeta	Nematonereis unicornis
Polychaete	*Exogone* sp.	Polychaeta	Autolytinae
Polychaete	Atylidae	Polychaeta	Hesionidae ind.
Polychaete	Chrysopetalidae spA	Polychaeta	Micronephthys sp.
Polychaete	Terebellidae ind.	Polychaeta	Eunice sp. B
Polychaete	Sabellariidae	Polychaeta	Eunice sp.
Polychaete	Oweniidae sp. A	Polychaeta	cf. Haplosyllis spongicola
Polychaete	*Filograna implexa*	Polychaeta	Serpulidae
Polychaete	*Chaetopterus variopedatus*	Polychaeta	Polydora sp.
Polychaete	*Fabricia* sp.	Polychaeta	Spionidae
Polychaete	*Nicomache* sp.	Polychaeta	Cirratulidae ind.
Polychaete	*Micromaldane ornithochaeta*	Polychaeta	Chaetopterus variopedatus
Bivalvia	Bivalvia A	Polychaeta	Terebellidae ind.
Bivalvia	*Thracia* sp.	Polychaeta	Pherusa sp.
Bivalvia	*Lucinoma* sp.	Polychaeta	Flabeligeridae/Poecilochaetidae
Bivalvia	*Kelliella miliaris*	Polychaeta	Fabricia sp.
Bivalvia	*Glans* sp.	Polychaeta	Acrocirridae sp.
Bivalvia	*Abra* sp.	Polychaeta	Nicomache sp.
Bivalvia	*Thyasira* sp.	Polychaeta	Micromaldane ornithochaeta
Bivalvia	*Loripes* sp.	Polychaeta	Capitella sp.
Bivalvia	*Tellina* sp.	Bivalvia	Bivalvia ind. C
Bivalvia	*Rocellaria dubia*	Bivalvia	Bivalvia E
Bivalvia	*Epilepton clarkiae*	Bivalvia	Thracia sp.
Bivalvia	cf. *Kurtiella bidentata*	Bivalvia	Epilepton clarkiae
Bivalvia	*Bornia* sp.	Bivalvia	Abra sp.
Bivalvia	*Ostrea edulis*	Bivalvia	Thyasira sp.
Bivalvia	Pectinoida und.	Bivalvia	Lucinoma sp.
Bivalvia	*Limaria loscombi*	Bivalvia	Parvicardium cf. Vroomi
Bivalvia	*Modiolus* sp.	Bivalvia	Corbula gibba
Bivalvia	*Limaria tuberculata*	Bivalvia	cf. Pseudopythina macandrewi
Bivalvia	*Rhomboidella* sp.	Bivalvia	cf. Mysella bidentata

Bivalvia	*Arca noae*
Gastropoda	Nudibranchia ind.
Gastropoda	*Omalogyra atomus*
Gastropoda	*Coralliophila panormitana*
Gastropoda	Gastropoda ind1
Gastropoda	*Chrysallida* sp.
Gastropoda	*Bittium* sp.
Gastropoda	*Mesalia* sp.
Gastropoda	cf. *Lamellaria* sp.
Gastropoda	*Cerithiopsis* sp.
Polyplacophora	Polyplacophora ind.
Amphipoda	Lysianassidae ind1
Amphipoda	*Microdeutopus gryllotalpa*
Amphipoda	*Caprella acanthifera*
Amphipoda	*Photis* sp.
Amphipoda	*Megamphopus cornutus*
Amphipoda	*Leptocheirus* sp.
Amphipoda	*Epimeria cornigera*
Amphipoda	*Colomastix pusilla*
Amphipoda	*Ampelisca* sp.
Isopoda	Cymothoidae
Isopoda	Anthuridae
Mysida	*Erythrops elegans*
Tanaidacea	*Apseudes talpa*
Decapoda	*Xantho pilipes*
Decapoda	*Pisa carinimana*
Decapoda	*Palaemonetes varians*
Decapoda	Paguridae ind.
Decapoda	*Macropodia linaresi*
Decapoda	*Hippolyte* sp.
Decapoda	cf. *Pisa* sp.
Decapoda	*Anoplodactylus pygmaeus*
Phoronida	Phoronida
Ophiuroidea	Ophiuroidea ind.
Chordata	*Molgula* sp.

Bivalvia	af. Scacchia zorni
Bivalvia	Ostrea edulis
Bivalvia	Limea loscombi
Bivalvia	Arca noae
Gastropoda	Mesalia sp.
Gastropoda	Rissoidae
Gastropoda	Gibbula sp.
Gastropoda	Triphoridae
Gastropoda	Tectura virginea
Gastropoda	Skeneopsis planorbis vs Omalogyra atomus
Gastropoda	Polyplacophora
Gastropoda	Platydoris argo
Gastropoda	Phanerobranchia
Gastropoda	Omalogyra atomus
Gastropoda	Nassarius nitidus
Gastropoda	Jujubinus striatus
Gastropoda	Gibbula magus
Gastropoda	Gastropoda spA
Gastropoda	Chrysallida sp.
Gastropoda	cf. Retrotortina sp.
Gastropoda	cf. Odostomia sp.
Gastropoda	cf. Alvania sp.
Gastropoda	Calliostoma zizyphinum
Gastropoda	Bittium sp.
Amphipoda	Pilumnus hirtellus
Amphipoda	Caprella acanthifera
Amphipoda	Apherusa bispinosa
Amphipoda	Synchelidium sp.
Amphipoda	Pseudoprotella phasma
Amphipoda	Photis sp.
Amphipoda	Perioculodes longimanus
Amphipoda	Megamphopus cornutus
Amphipoda	Maera sp.
Amphipoda	Littorina sp.
Amphipoda	Lillejborgia sp.
Amphipoda	Epimeria cornigera
Amphipoda	Cheirocratus sp.
Isopoda	Anthuridae
Isopoda	Sphaeromatidae
Isopoda	Jassa sp.
Mysida	Mysida
Decapoda	Hippolyte varians
Decapoda	Xantho pilipes
Decapoda	Pisa carinimana

Decapoda	Thoralus cranchii
Decapoda	Palaemonetes varians
Decapoda	Hippolyte sp.
Decapoda	Eurynome aspera
Decapoda	Decapoda
Decapoda	cf. Pisa sp.
Decapoda	cf. Homola barbata
Decapoda	Anapagurus sp.
Decapoda	Achelia cf. echinata
Pycnogonida	Anoplodactylus pygmaeus
Echinoidea	Echinoidea
Ophiuroidea	Ophiacantha bidentata
Ophiuroidea	Ophiomyxidae
Phoronida	Phoronida
Ascidiacea	Ascidiacea und.