Abundance patterns of macrofauna associated to marine macroalgae along the Iberian Peninsula

Patrones de abundancia de la macrofauna asociada a macroalgas marinas a largo de la Península Ibérica

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Palabras clave: Macrofauna, distribución, biogeografía, España, Portugal.

ABSTRACT

The distribution and abundance patterns of the macrofauna associated to macroalgae were studied on a spatial scale along the Iberian Peninsula. Nineteen stations and four dominant algae were selected (intertidal zone: *Corallina elongata* and *Asparagopsis armata*; subtidal zone: *Stypocaulon scoparium* and *Cladostephus spongiosus*). Five environmental factors were also considered (seawater temperature, conductivity, dissolved oxygen, turbidity and pH). The Atlantic coast was characterized by lower temperature and conductivity as well as higher values of oxygen and turbidity than the Mediterranean coast. A total of 106274 macrofaunal specimens were sorted and examined (68% arthropods, 27% molluscs, 4% annelids and 1% echinoderms). Crustaceans were the dominant group in all the macroalgae (ca. 80% in *C. elongata* and *A. armata*, ca. 50% in *S. scoparium* and *C. spongiosus*) followed by molluscs, which were more abundant in the subtidal algae (ca. 40%) than in intertidal ones (ca.10%). Abundance patterns of macrofauna along the Iberian Peninsula were similar in the four studied algae. Most of crustaceans belonged to the order Amphipoda, which showed high densities (>1000 ind/1000 ml algae) along the whole Peninsula; isopods showed the highest abundances in the Atlantic, while tanaids, cumaceans and decapods were more abundant in the Mediterranean. Among molluscs, gasteropods showed highest abundances along the Atlantic coasts, whereas bivalves showed higher densities along the Mediterranean. Taking into account that all selected stations were characterised by absence of anthropogenic influence, the abundance patterns obtained for macrofauna could be explained on the basis of natural differences in water temperature, oxygen, conductivity and turbidity between Mediterranean and Atlantic, existing a transitional gradient between warm-water (from north Africa and Mediterranean Sea) and cold-water taxa (from the North Sea and the Arctic).

RESUMEN

Se llevó a cabo un estudio espacial de los patrones de abundancia y distribución de la macrofauna asociada a macroalgas a lo largo de la Península Ibérica. Se seleccionaron 19 estaciones y 4 algas dominantes (zona intermareal: *Corallina elongata* y *Asparagopsis armata*; zona submareal: *Stypocaulon scoparium* y *Cladostephus spongiosus*). Se consideraron también cinco variables ambientales (temperatura del agua, conductividad, oxígeno disuelto, turbidez y pH). La costa atlántica se caracterizó por valores más bajos de temperatura y conductividad, y más altos de oxígeno y turbidez. Se examinaron 106274 individuos de la macrofauna (68% artrópodos, 27% moluscos, 4% anélidos y 1% equinodermos). Los crustáceos fueron dominantes en todas las macroalgas (alrededor del 80% en *C. elongata* y *A. armata*, y en torno al 50% en *S. scoparium* y *C. spongiosus*), seguidos por los moluscos, que fueron más abundantes en el submareal (40%) que en el intermareal (10%). Los patrones de abundancia de la macrofauna a lo largo de la Península Ibérica fueron similares en las cuatro algas estudiadas. La mayoría de los crustáceos pertenecieron al orden Amphipoda, que mostró densidades muy altas (>1000 ind/1000 ml alga) en toda la Península; los isópodos mostraron las mayores densidades en el Atlántico, mientras que los tanaidáceos, cumáceos y decápodos fueron más abundantes en el Mediterráneo. Entre los moluscos, los gasterópodos mostraron abundancias mayores en el Atlántico, mientras que los bivalvos dominaron en el Mediterráneo. Teniendo en cuenta que todas las estaciones seleccionadas no tenían influencia antrópica importante, los patrones de abundancia obtenidos podrían explicarse en base a diferencias naturales en la temperatura del agua, oxígeno, conductividad y turbidez, existiendo un gradiente transicional entre taxones de aguas más cálidas (del norte de Africa y del Mediterráneo) y taxones de aguas más frías (del Mar del Norte y el Ártico).

INTRODUCTION

Studies dealing with marine macrofauna associated to macroalgae are very scarce, probably due to the considerable time and efforts required to sort and identify all the material. However, faunistic information obtained from this kind of studies is essential, not only as baseline for future ecological and biogeographical studies, but also as bioindicator tool in marine monitoring programmes (e.g. Sánchez-Moyano & García-Gómez, 1998; Dauvin & Ruellet, 2007; Guerra-García *et al.*, 2009a).

The presence of vegetation allows a greater species diversity and abundance of individuals than unvegetated habitats (Sánchez-Moyano *et al*., 2007) providing suitable microhabitats, nutritional resources and protection from predators. Marine algae are known to provide habitats for a wide range of animal species (Williams & Seed, 1992). Crustaceans, molluscs and polychaetes are the major animal taxa associated with macrophytes (Taylor & Cole, 1994), and information about their spatial and temporal patterns of abundance is necessary to properly understand marine ecosystems. Nevertheless, few attempts have been made to investigate the relation between geographical changes in algae composition and patterns of macroinvertebrate diversity and abundance (Russo, 1997; Pereira *et al*., 2006).

The Iberian Peninsula is especially interesting from the biogeographical point of view. It is located in the southwest of Europe, being the westernmost of the three major southern European peninsulas. Its coasts are washed by the Mediterranean on the eastern side and Atlantic on the northern and western side, converging at the Strait of Gibraltar. In spite of its privileged location, studies focused on invertebrates associated to marine macroalgae are scarce and the majority of contributions have been conducted in the Strait of Gibraltar: molluscs (Sánchez-Moyano *et al*., 2000), annelids (Sánchez-Moyano *et al*., 2002; Sánchez-Moyano & García-Asencio, 2009) and crustaceans (Sánchez-Moyano & García-Gómez, 1998; Sánchez-Moyano *et al*., 2007; Guerra-García *et al*., 2009b,c). Although a variety of studies have dealt with macrofauna associated to algae in different areas of the Iberian Peninsula (e.g. Jimeno & Turón, 1995; Viejo, 1999; Pereira *et al*., 2006; Vázquez-Luis *et al*., 2008), these studies have been focused in particular groups or are restricted to specific sites.

The main objective of the present study was to explore the abundance patterns of the main groups of macrofauna along the Iberian Peninsula, comparing the data obtained in four dominant algae along the coasts of Spain and Portugal: *Corallina elongata* J. Ellis & Solander, *Stypocaulon scoparium* (L.) Kützing, *Cladostepus spongiosus* (Hudson) Agardh and the invasive *Asparagopsis armata* Harvey.

MATERIAL AND METHODS

Nineteen stations were selected along the Atlantic and Mediterranean coasts, including the Strait of Gibraltar (Fig. 1). We chose relatively undisturbed enclaves with low human pressures to avoid the effect of anthropogenic influence on the natural biogeographical and ecological patterns of species.

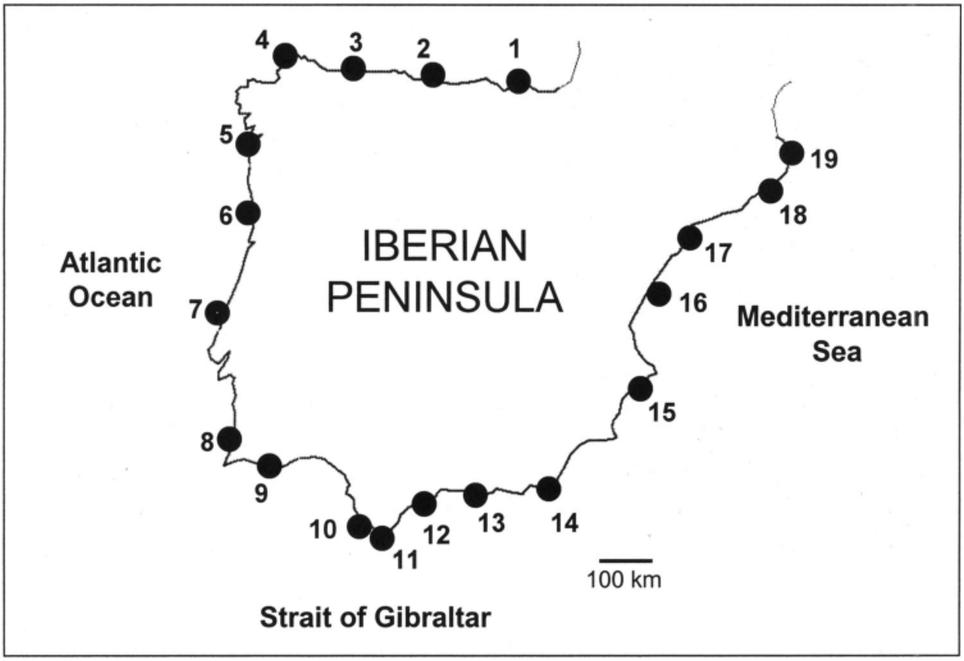

Fig. 1.—Study area showing the sampling stations. Ogella (1), Oyambre (2), Cetarea (3), Baleo (4), Cabo Silleiro (5), Labruge (6), Playa Azul (7), Vale dos Homens (8), Castelo (9), Bolonia (10), Isla de Tarifa (11), Torreguadiaro (12), Cerro Gordo-Herradura (13), Cabo de Gata (14), Cala del tío Ximo (15), Benicassim-Oropesa (16), Torrent del Pi (17), Cala de Sant Françesc (18), L'Estartit (19).
Fig. 1.—Área de estudio mostrando las estaciones de muestreo. Ogella (1), Oyambre (2), Cetarea (3), Baleo (4), Cabo Silleiro (5), Labruge (6), Playa Azul (7), Vale dos Homens (8), Castelo (9), Bolonia (10), Isla de Tarifa (11), Torreguadiaro (12), Cerro Gordo-Herradura (13), Cabo de Gata (14), Cala del tío Ximo (15), Benicassim-Oropesa (16), Torrent del Pi (17), Cala de Sant Françesc (18), L'Estartit (19).

Sampling was conducted in summer 2008 (from 5th June to 5th August). The following environmental parameters were measured "in situ" at each sampling site: water temperature, pH, conductivity, dissolved oxygen and turbidity. Five measurements were made for each parameter and mean values and standard deviation were calculated. Conductivity and pH were measured using a conductivimeter-pHmeter CRISON MM40, temperature and oxygen concentration with an oxymeter CRISON OXI 45P, and turbidity in nephelometric turbidy units (ntu) using a turbidimeter WTW 335 IR.

The algae *Corallina elongata*, *Stypocaulon scoparium*, *Cladostephus spongiosus* and *Asparagopsis armata* were selected as substrates since they are among the dominant algae along the whole Iberian Peninsula (pers. observ.). *Corallina elongata* was present in all stations (19) whereas *S. scoparium* was present in 14 stations, *A. armata* in 11 and *C. spongiosus* in 9. *Corallina elongata* and *A. armata* were collected from the low zone of the intertidal area, whereas *S. scoparium* and *C. spongiosus* were taken by snorkeling from shallow waters (0-5 m deep) along the subtidal. Hence, two algae were selected to characterise the intertidal zone and other two to explore the macrofaunal patterns in the shallow subtidal. At each station, macroalgae were collected by hand from different rocks to avoid effect of patchiness and to adequately sample macrofaunal diversity, until a volumen of approximately 200 ml of each algae was completed (see Thiel *et al.*, 2003; Guerra-García *et al.*, 2009b,c). The samples were preserved in ethanol 70-80%, brought to laboratory and sieved using a mesh size of 0.5 mm. All macrofauna were sorted and separated to general groups: arthropods (including Crustacea, Pycnogonida and Chironomida), Molluscs, Annelids and Echinoderms. Crustaceans were also separated in Amphipoda, Isopoda, Tanaidacea, Decapoda and Cumacea, and molluscs in Gastropoda, Bivalvia and Polyplacophora. Abundance of each faunal group was expressed as number of individuals/1000 ml and maps of distribution were elaborated per groups and algae.

To estimate the cover of each algal species in each locality, we used five random quadrats of 50 x 50 cm subdivided into 25 square units of 10 x 10 cm with thick fishing line. The presence/absence of the species was recorded for each unit and data were expressed as cover percentage (mean ± SD of the 5 replicates).

RESULTS AND DISCUSSION

The Mediterranean stations showed higher values of temperature and conductivity, as well as lower values of oxygen concentration and turbidity than the stations along the Atlantic coast (Fig. 2). Oppositely, pH maintained similar values amongst the surveyed sites, with an average of 8.16, ranging from 8 (station 6) to 8.33 (station 10). Temperature was negatively correlated with oxygen ($r=-0.69$, $p<0.01$) and turbidity ($r=-0.54$, $p<0.05$) and positively with conductivity ($r=0.73$, $p<0.01$). Station 6 showed abnormal characteristics when compared with the rest of the stations, with the maximum value of turbidity and minimum value of conductivity and temperature, probably due to river influence.

When focusing on the abundance patterns of macroalgae, cover of the four species showed lower values in Mediterranean stations than in the Atlantic

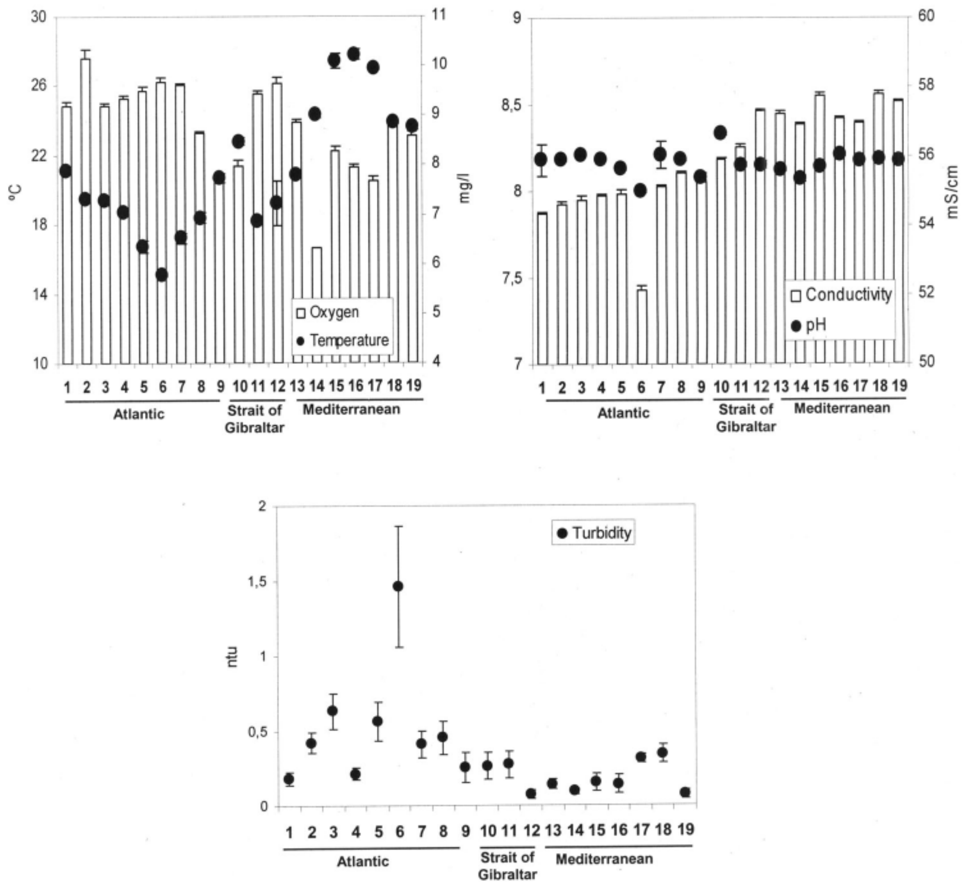

Fig. 2.—Abiotic variables measured in each station (Mean ± SD)
Fig. 2.—Variables abióticas medidas en cada estación (Media ± DE)

(Fig. 3). This pattern was more evident in the intertidal *Corallina elongata* and *Asparagopsis armata* (in fact this algae was absent in Mediterranean stations) while it was not so clear in the subtidal *Stypocaulon scoparium* and *Cladostephus spongiosus*. Lower algal abundances in Mediterranean stations can be probably explained by higher seawater and air temperatures. Other factors could also affect this distribution, such as tides, which affects the Atlantic coast; in Atlantic coast some species are adapted to grow up with specific conditions, while in the Mediterranean Sea, the competition among species for substrate is very high due to the lack of tidal effect. In general terms, the most important species in terms of cover was *C. elongata*,

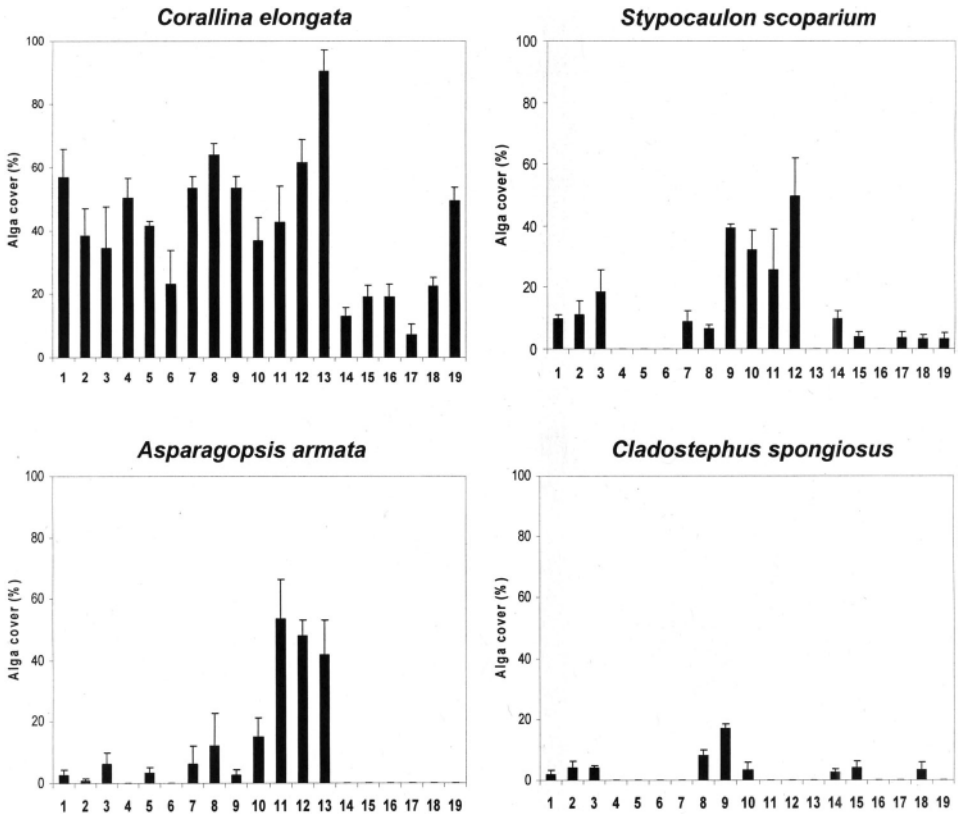

Fig. 3.—Cover percentage of the four algae studied (Media ± SD) in each station.
Fig. 3.—Cobertura en porcentaje de las cuatro algas estudiadas (Media ± DE) en cada estación.

followed by *S. scoparium*. Cover of *C. spongiosus* was lower than 20% in all the stations.

Concerning the fauna, a total of 106274 specimens were sorted and examined, out of which 68% were arthropods (mainly crustaceans), 27% molluscs, 4% annelids and 1% echinoderms. Arthropods (basically crustaceans) were the dominant phyla in the four algae. In fact, in the intertidal algae *C. elongata* and *A. armata*, arthropods represented more than 80%. In the subtidal algae *S. scoparium* and *C. spongiosus*, arthropods were also dominant, but molluscs were also significantly represented (Fig. 4). This general pattern is normally maintained in all the sampled stations (Fig. 5). Crustaceans were the dominant group in *C. elongata* and *A. armata* in all the sites. In the case of *S. scoparium* and *C. spongiosus*, crustaceans were

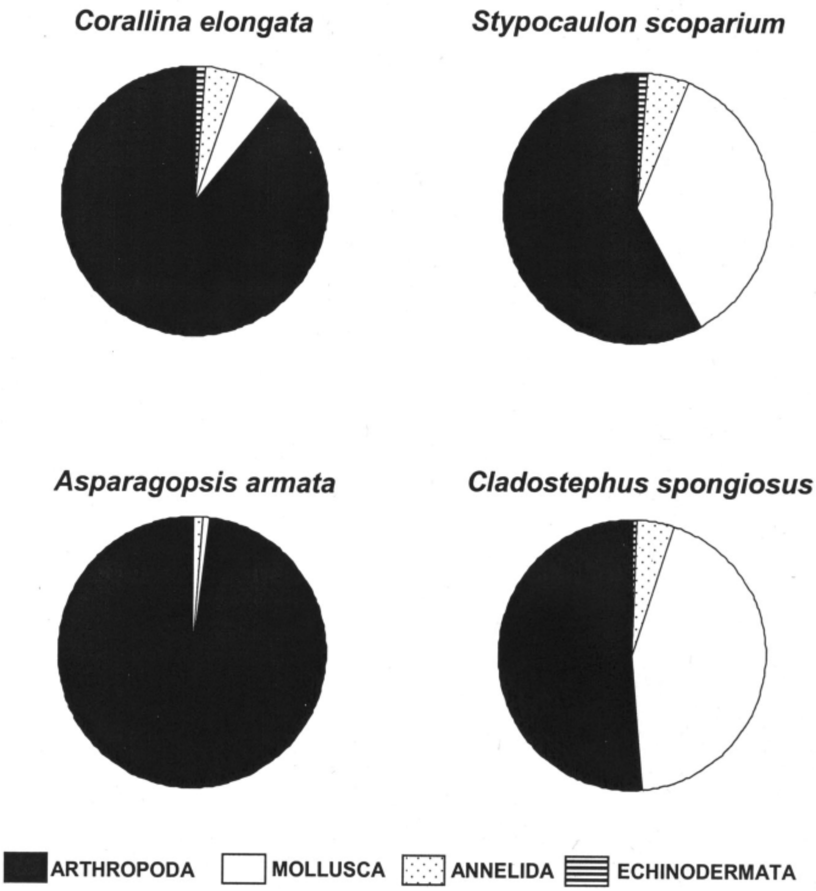

Fig. 4.—Total abundance percentages of arthropods, molluscs, annelids and echinoderms measured in each algal species

Fig. 4.—Porcentajes de abundancia total de artrópodos, moluscos, anélidos y equinodermos medidos en cada especie de alga.

also dominant in most stations, except for stations 7 and 8 (*S. scoparium*) and stations 1 and 15 (*C. spongiosus*), where molluscs represented more than 70% of the total abundance. Annelids and echinoderms were always the less important group in terms of abundance. Sánchez-Moyano (1996) studied the macrofauna associated to *S. scoparium* in 13 stations of Algeciras Bay, Southern Spain (3-10 m deep); in this case, arthropods were also the dominant group, followed by annelids, which were more abundant in Algeciras Bay (20-50%) than in the stations sampled during the present study (<10%). This could be probably due to the degree of anthropogenic influence in Algeciras Bay, which favoured polychaetes in comparison with

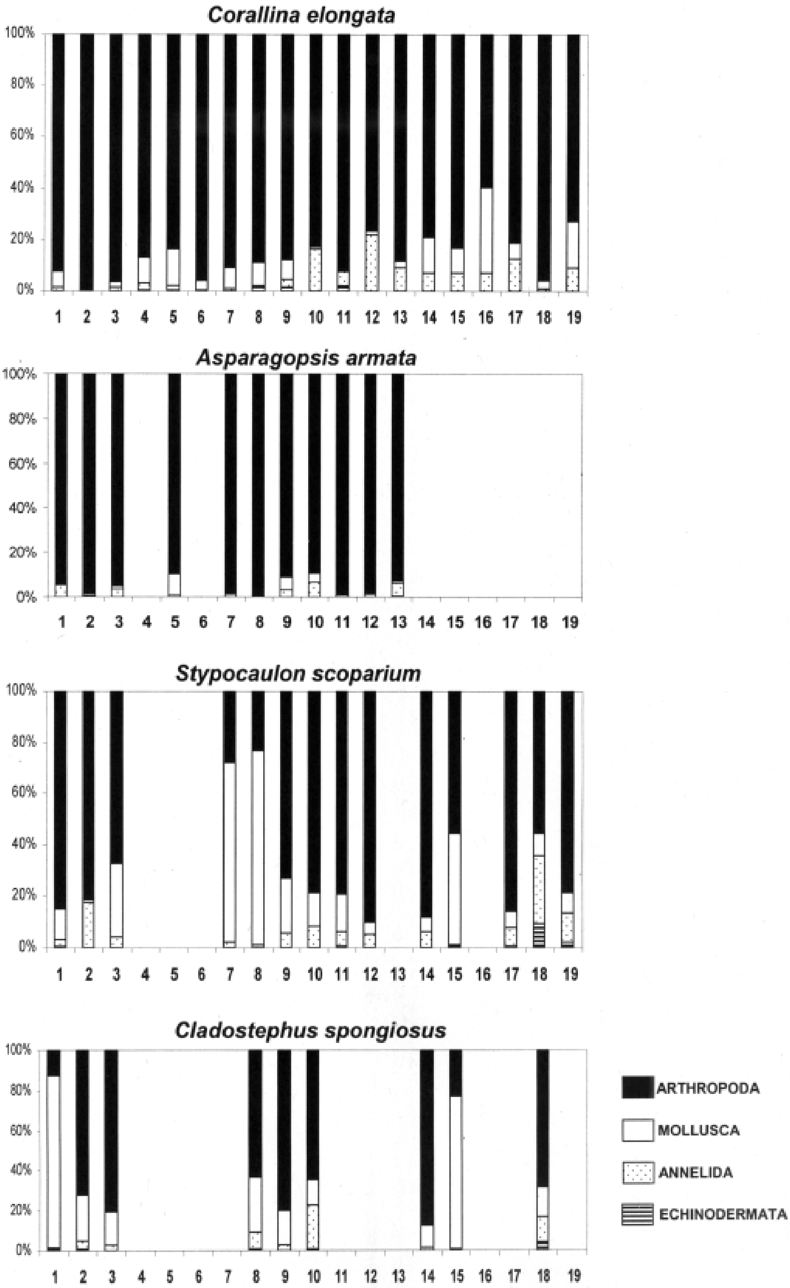

Fig. 5.—Abundance percentages of arthropods, molluscs, annelids and echinoderms in each station for the four algae sampled.
Fig. 5.—Porcentajes de abundancia de artrópodos, moluscos, anélidos y equinodermos en cada estación para las cuatro algas muestreadas.

other groups (Sánchez-Moyano, 1996). Sánchez-Moyano *et al*. (2001) also conducted a detailed study of the macrofauna associated with the seaweed *Caulerpa prolifera* (2-5 m deep) in Algeciras Bay, Southern Spain, and found that molluscs were dominant in most of the stations, followed by arthropods and annelids. In fact annelids were much more abundant in *C. prolifera* (around 15-30%) than in the algae collected during the present study (<10%). Annelids can also be the dominant epifaunal group in seagrasses ecosystems (Jagtap *et al*., 2003). Anyway, arthropods, especially crustaceans are usually the most abundant group of associated fauna on algae and seagrasses (Fredriksen *et al*., 2005) and have been traditionally the most used in associated fauna studies to establish the environmental guides that control epifaunal communities (Aoki & Kikuchi, 1990). In this sense, the crustacean communities have been considered as one of the most sensitive to the changes produced by environmental variables (see Sánchez-Moyano & García-Gómez, 1998).

In connection with the distribution patterns of the different macrofaunal groups (Figs. 6, 7 and 8), crustaceans are clearly the dominant group, distributed along the whole Iberian Peninsula, with values higher than 1000 ind/1000 ml of algae in the four studied algae (Fig. 6). Pycnogonida were more abundant in *C. elongata*, and especially *S. scoparium*; on this alga, the abundances were higher along the Mediterranean than along the Atlantic coasts. Chironomida was absent in *A. armata*, restricted to the Strait of Gibratar in *S. scoparium*, but distributed along the whole Iberian Peninsula in *C. elongata* and *C. spongiosus*. Molluscs were scarce in *A. armata*, but very common in *S. scoparium* and *C. spongiosus*. Most of crustaceans belonged to the order Amphipoda, which showed high densities along the whole Peninsula (Fig. 7). Isopoda showed the highest abundances in the Atlantic, while Tanaidacea, Decapoda and Cumacea were more abundant in the Mediterranean. Isopods and tanaids were dominant in *C. elongata* and *S. scoparium*, whereas decapods had higher densities in *C. spongiosus*. In molluscs, as a phylum, there is no clear distribution pattern, but if the different classes are consider (Fig. 8), we can observe that Gastropoda seems to be more abundant in the Atlantic coast, whereas Bivalvia show higher abundances along the Mediterranean. The different faunal composition on each substrate could be due to the different algal morphology. However, apparently, the observed geographical differences in epifaunal groups were not related with differences in dominant algae, and, in general, similar patterns were obtained for the four algal species considered. These observations are in agreement with those of Pereira *et al.* (2006) obtained for peracarids along the Portuguese coasts, but differs from those described by Arrontes & Anadón (1990) for northern Spain. Guerra-García *et al*. (2009b) and

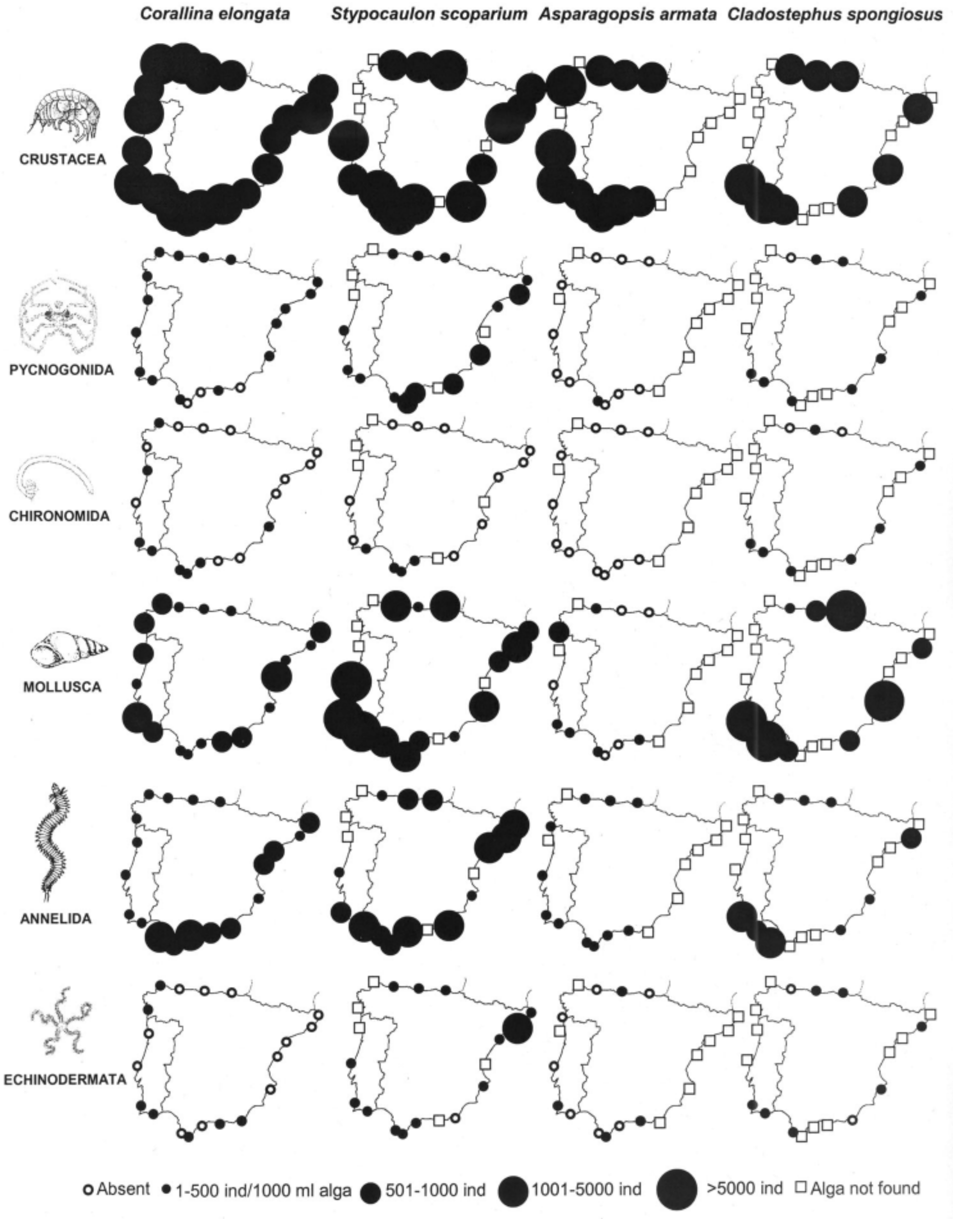

Fig. 6.—Abundance patterns of arthropods (Crustacea, Pycnogonida and Chironomida), molluscs, annelids and echinoderms along the Iberian Peninsula.
Fig. 6.—Patrones de abundancia de artrópodos (Crustacea, Pycnogonida y Chironomida), moluscos, anélidos y echinodermos en la Península Ibérica.

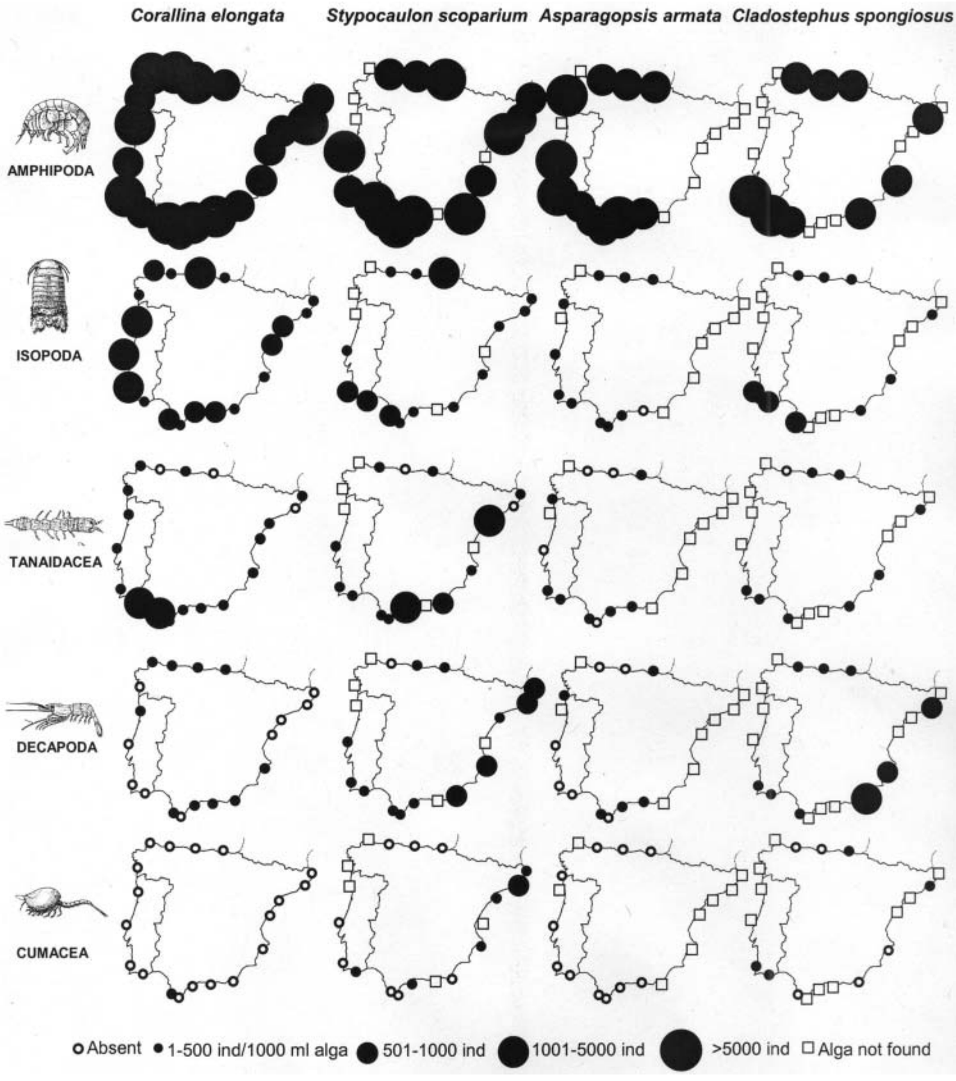

Fig. 7.—Abundance patterns of crustaceans (Amphipoda, Isopoda, Tanaidacea, Decapoda and Cumacea) along the Iberian Peninsula.
Fig. 7.—Patrones de abundancia de crustáceos (Amphipoda, Isopoda, Tanaidacea, Decapoda y Cumacea) en la Península Ibérica.

Guerra-García & Izquierdo (2010) studied the distributional and ecological patterns of caprellids (Crustacea: Amphipoda) associated with the algae *S. scoparium* and *C. elongata* along the Iberian Peninsula and found clear different pattern of abundances depending on the species, but this patterns

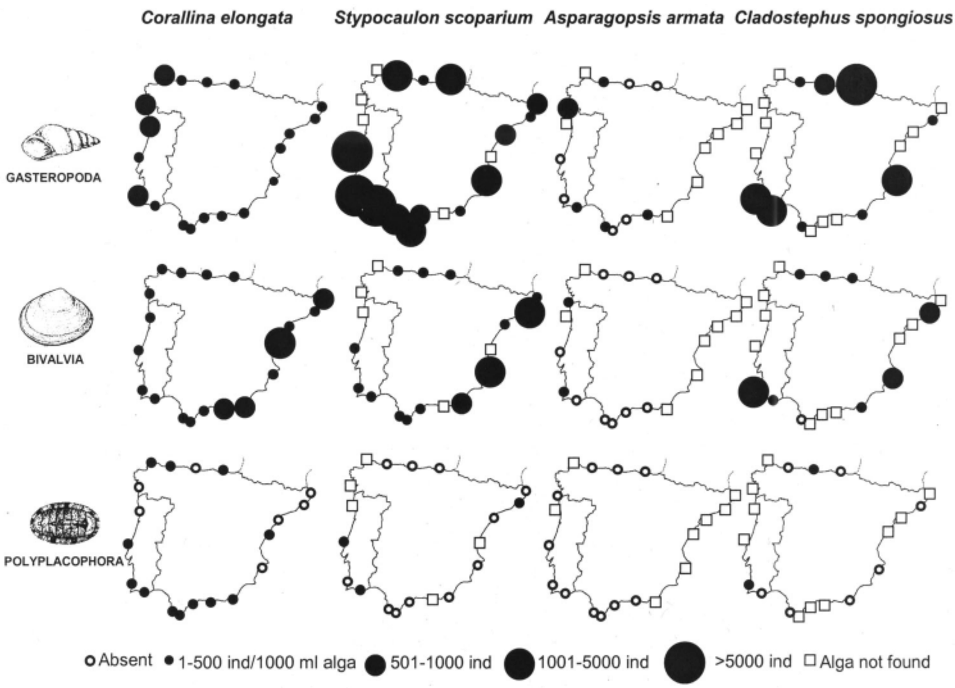

Fig. 8.—Abundance patterns of molluscs (Gastropoda, Bivalvia and Polyplacophora) along the Iberian Peninsula.
Fig. 8.—Patrones de abundancia de moluscos (Gastropoda, Bivalvia y Polyplacophora) en la Península Ibérica.

were similar in both algae: *Caprella penantis* was restricted to Atlantic waters while *C. hirsuta* and *C. grandimana* were distributed in the Strait of Gibraltar and Mediterranean coast. On the other hand, Izquierdo & Guerra-García (2011) using the Whittaker index, as measure of ß-diversity, found a different composition of peracarids between Mediterranean and Atlantic and a clear replacement of species along the coast, especially at the Strait of Gibraltar.

Taking into account that all the selected stations were characterised by absence of anthropogenic influence, the abundance patterns obtained for macrofauna could be explained on the basis of natural differences in water temperature, oxygen, conductivity and turbidity between the Mediterranean and Atlantic, which determine the ecological requirements of the different groups. The abundance gradients support the idea that there is a transition between warm-water (from north Africa and Mediterranean Sea) and cold-water taxa (From the North Sea and the Arctic) as described in earlier works (see Pereira *et al*., 2006). Other factors, such us population dynamics or patchy distribution of fauna could be also involved. Further studies dealing with the taxa identified to species level could dilucidate more precisely the biogeographical patterns of macrofauna associated to macroalgae.

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REFERENCES

AOKI, M. & KIKUCHI, T. 1990. Habitat adaptations of caprellid amphipods and the importance of epiphytic secondary habitats in a *Sargassum patens* bed in Amakusa, southern Japan. *Publications of the Amakusa Marine Biology Laboratory*, 10: 123-133.

ARRONTES, J. & ANADÓN, R. 1992. Seasonal variation and population dynamics of isopods inhabiting intertidal macroalgae. *Scientia Marina*, 54: 231-240.

DAUVIN, J. C. & RUELLET, T. 2007. Polychaete/amphipod ratio revised. *Marine Pollution Bulletin Special Issue*, 55: 215-224.

FREDRIKSEN, S., CHRISTIE, H. & SAETHRE, B. A. 2005. Species richness in macroalgae and macrofauna assemblages on Fucus serratus L. (Phaeophyceae) and Zostera marina L. (Angiospermae) in Skagerrak, Norway. *Marine Biology Research,* 1: 2-19.

GUERRA-GARCÍA, J. M.; BAEZA-ROJANO, E.; CABEZAS, M. P.; DÍAZ-PAVÓN, J. J.; PACIOS, I. & GARCÍA-GÓMEZ, J. C. 2009a. The amphipods *Caprella penantis* and *Hyale schmidtii* as biomonitors of trace metal contamination in intertidal ecosystems of Algeciras Bay, Southern Spain. *Marine Pollution Bulletin,* 58: 765-786.

GUERRA-GARCÍA, J. M.; SÁNCHEZ, J. A. & ROS, M. 2009b. Distributional and ecological patterns of caprellids (Crustacea: Amphipoda) associated with the seaweed *Stypocaulon scoparium* in the Iberian Peninsula. *Marine Biodiversity Records,* 2: 1-8.

GUERRA-GARCÍA, J. M.; CABEZAS, P.; BAEZA-ROJANO, E.; ESPINOSA, F. & GARCÍA-GÓMEZ, J. C. 2009c. Is the north side of the Strait of Gibraltar more diverse than the south side? A case study using the intertidal peracarids (Crustacea: Malacostraca) associated to the seaweed *Corallina elongata*. *Journal of the Marine Biological Association of the UK,* 89: 387-397.

GUERRA-GARCÍA, J. M. & IZQUIERDO, D. 2010. Caprellids (Crustacea: Amphipoda) associated with the intertidal alga *Corallina elongata* along the Iberian Peninsula. *Marine Biodiversity Records,* 3: 1-7.

IZQUIERDO, D. & GUERRA-GARCÍA, J. M. 2011. Distribution patterns of the peracarid crustaceans associated with the alga *Corallina elongata* along the intertidal rocky shores of the Iberian Peninsula. *Helgoland Marine Research*, 65: 233-243.

JAGTAP, T. G., KOMARPANT, D. S. & RODRIGUES, R. S. 2003. Status of a seagrass ecosystem: an ecologically sensitive wetland habitat from India. *Wetlands*, 23: 161-170.

JIMENO, A. & TURÓN, X. 1995. Gammaridea and Caprellidea of the northeast coast of Spain: Ecological distribution on different types of substrata. *Polskie Archiwum Hydrobiologii*, 42: 495-516.

PEREIRA, S. G.; LIMA, F. P.; QUEIROZ, N. C.; RIBEIRO, P. A. & SANTOS, A. M. 2006. Biogeographic patterns of intertidal macroinvertebrates and their association with macroalgae distribution along the Portuguese coast. *Hydrobiologia*, 555: 185-192.

RUSSO, A. R. 1997. Epifauna living on sublittoral seaweeds around Cyprus. *Hydrobiologia*, 344: 169-179.

SÁNCHEZ-MOYANO, J. E. 1996. *Variación espacio-temporal en la composición de las comunidades animales asociadas a macroalgas como respuestas a cambios en el medio. Implicaciones en la caracterización ambiental de las áreas costeras*. Doctoral thesis, University of Sevilla, 407 pp.

SÁNCHEZ-MOYANO, J. E.; ESTACIO, F. J.; GARCÍA-ADIEGO, E. M. & GARCÍA-GÓMEZ J. C. 2000. The molluscan epifauna of the alga *Halopteris scoparia* in southern Spain as a bioindicator of coastal environmental conditions. *Journal of Molluscan Studies*, 66: 431-448.

SÁNCHEZ-MOYANO, J. E.; GARCÍA-ADIEGO, E. M.; ESTACIO, F. J. & GARCÍA-GÓMEZ, J. C. 2001. Influence of the density of *Caulerpa prolifera* (Clorophyta) on the composition of the macrofauna in a meadow in Algeciras Bay (Southern Spain). *Ciencias Marinas*, 27: 47-51.

— 2002. Effect of environmental factors on the spatial variation of the epifaunal polychaetes of the alga *Halopteris scoparia* in Algeciras Bay (Strait of Gibraltar). *Hydrobiologia*, 470: 133-148.

SÁNCHEZ-MOYANO, J. E.; GARCÍA-ASENCIO, I. M. & GARCÍA-GÓMEZ, J. C. 2007. Effects of temporal variation of the seaweed *Caulerpa prolifera* cover on the associated crustacean community. *Marine Ecology,* 28: 324-337.

SÁNCHEZ-MOYANO, J. E. & GARCÍA-ASENCIO, I. M. 2009. Distribution and trophic structure of annelid assemblages in a *Caulerpa prolifera* bed from southern Spain. *Marine Biolgoy Research,* 5: 122-132.

SÁNCHEZ-MOYANO, J. E. & GARCÍA-GÓMEZ, J. C. 1998. The arthropod community, especially Crustacea, as a bioindicator in Algeciras Bay (Southern Spain) based on a spatial distribution. *Journal of Coastal Research,* 14: 1119-1133.

TAYLOR, R.B & COLE, R.G. 1994. Mobile epifauna on subtidal brown seaweeds in northeastern New Zealand. *Marine Ecology Progress Series*, 115: 271-282

THIEL, M.; GUERRA-GARCÍA, J. M.; LANCELLOTTI, D. A. and VÁSQUEZ, N. 2003. The distribution of littoral caprellids (Crustacea: Amphipoda: Caprellidea) along the Pacific coast of continental Chile. *Revista Chilena de Historia Natural*, 76: 297-312.

VÁZQUEZ-LUIS, M.; SÁNCHEZ-JEREZ, P. & BAYLE-SEMPERE, J. T. 2008. Changes in amphipod (Crustacea) assemblages associated with shallow-water algal habitats invaded by *Caulerpa racemosa* var *cylindracea* in the western Mediterranean Sea. *Marine Environmental Research*, 65: 416-426.

VIEJO, R. M. 1999. Mobile epifauna inhabiting the invasive *Sargassum muticum* and two local seaweeds in northern Spain. *Aquatic Botany*, 64: 131-149.

WILLIAMS, G. A. & SEED, R. 1992. Interactions between macrofaunal epiphytes and their host algae. In: JOHN, S. H. D. M & PRICE, J. H. (Editors). *Plant-animal interactions in the marine benthos*. Clarendon Press, Oxford: 189-211.