Isopods, tanaids and cumaceans (Crustacea, Peracarida) associated to the seaweed *Stypocaulon scoparium* in the Iberian Peninsula

Isópodos, tanaidáceos y cumáceos (Crustacea, Peracarida) asociados al alga *Stypocaulon scoparium* en la Península Ibérica

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Palabras clave: Peracáridos, distribución, ecología, España, Portugal

ABSTRACT

The distribution and abundance patterns of isopods, tanaids and cumaceans (Crustacea: Peracarida) associated with the alga *Stypocaulon scoparium* (L.) Kützing were studied. Fourteen stations were selected along the Iberian Peninsula and five environmental factors were measured (seawater temperature, conductivity, dissolved oxygen, turbidity and pH). The Atlantic coast was characterised by lower temperature and conductivity and higher values of oxygen and turbidity than the Mediterranean coast. Cover of *S. scoparium* was higher in the Strait of Gibraltar than in the remaining stations, coinciding with maximum values of number of peracaridean species. Twenty three species were collected (15 isopods, 4 tanaids and 4 cumaceans). Isopods were more abundant in Atlantic stations of the Iberian Peninsula while tanaids and cumaceans were dominant in the Mediterranean coast. The classification of species in geographical distribution groups showed that most species had an Atlantic-Mediterranean distribution (76%) and only 9% were endemic Mediterranean species. Multivariate analysis showed that distribution of species was mainly correlated to temperature, conductivity and oxygen, although the cover of *S. scoparium* also influenced the abundances of some taxa.

RESUMEN

Se estudiaron los patrones de distribución y abundancia de isópodos, tanaidáceos y cumáceos (Crustacea: Peracarida) asociados al alga *Stypocaulon scoparium* (L.) Kützing. Se seleccionaron catorce estaciones a lo largo de la Península Ibérica y se midieron cinco variables ambientales (temperatura del agua, conductividad, oxígeno disuelto, turbidez y pH). La costa atlántica mostró valores más bajos de temperatura y conductividad y valores más altos de oxígeno y turbidez que la costa mediterránea. La cobertura de *S. scoparium* fue superior en el Estrecho de Gibraltar que en las estaciones restantes, coincidiendo con los valores máximos del número de especies de peracáridos. Se recolectaron 23 especies (15 isópodos, 4 tanaidáceos y 4 cumáceos). Los isópodos fueron más abundantes en las estaciones atlánticas de la Península Ibérica mientras que tanaidáceos y cumáceos fueron dominantes en la costa mediterránea. La clasificación de las especies en grupos biogeográficos mostró que la mayoría de especies tenían distribución atlántico-mediterránea (76%) y sólo un 9% fueron endemismos del Mediterráneo. Los análsisis multivariantes mostraron que la distribución de las especies estuvo correlacionada fundamentalmente con la temperatura, conductividad y oxígeno, aunque la cobertura de *S. scoparium* también influyó en la abundancia de algunos taxones.

INTRODUCTION

Peracarid crustaceans are among the most diverse and numerically dominant organism of benthic faunas (Dauby *et al*., 2001). Furthermore, peracarids play an important role in the structuring of benthic assemblages, they are a source of food for other benthic animals and fishes of commercial importance and they are important contributors to benthic production (see Moreira *et al*., 2008). On the other hand, peracarids have been often used as marine boindicators (e.g. Conradi *et al*., 1997; Sánchez-Moyano & García-Gómez, 1998; Conradi & López-González, 2001; Guerra-García & García-Gómez, 2001; Ohji *et al*., 2002).

In spite of their interest, the knowledge of peracarid crustaceans associated to algae along the coasts of the Iberian Peninsula is still scarce, and most of the research has been focused in the Strait of Gibraltar. Sánchez-Moyano & García-Gómez (1998) and Sánchez-Moyano *et al*. (2007) studied the whole crustacean community associated to *Stypocaulon scoparium* and *Caulerpa prolifera* respectively, from Algeciras Bay. Guerra-García *et al.* (2009) used the intertidal peracarids associated to the seaweed *Corallina elongata* to show that the north side of the Strait of Gibraltar is more diverse than the south side. Castelló & Carballo (2001) revised the isopod species inhabiting the Strait of Gibraltar, and Alfonso *et al.* (1998) used the cumacean community associated with *S. scoparium* as a bioindicator of environmental conditions. Several amphipod (gammarids and caprellids) studies have been also undertaken during the last decade in the Strait of Gibraltar (e.g. Conradi et al., 1997; Guerra-García, 2001; Guerra-García 2 Takeuchi, 2002; Guerra-García *et al*., 2000a, 2000b, 2001). Jimeno & Turón (1995) studied the ecological distribution of Gammaridea and Caprellidea from the northeast coast of Spain, and Pereira *et al.* (2006) studied the biogeographical patterns of intertidal peracarids, including isopods, tanaids and cumaceans, and their associations with macroalgal distribution along the Portuguese coast. However, information dealing with distribution, diversity and abundance patterns of peracarids along the whole Iberian Peninsula is scarce (Jimeno & Turón, 1995; Bellan-Santini & Ruffo 1998).

Among peracarids, amphipods are the dominant group and it usually monopolizes the interest of many authors. The other non-amphipod pera-carideans, such as isopods, tanaids and cumaceans frequently receive less attention than amphipods in ecological and taxonomical studies and their knowledge is even scarcer for these groups.

Stypocaulon scoparium (L.) Kützing is present in the Atlanic, Indian and Pacific Oceans and the Adriatic, Mediterranean and Black Seas (see Sánchez-Moyano, 1996). It occurs on rocky platforms and puddles on the coast few meters deep. It is characterised by shrub-like thallus with a brown colouration and about 20 cm high. It binds itself to the substrate with a fibrous and sponge-like basal disk. Its ramification is dense, irregularly alternate and distichous. Due to morphological features and environmental versatility *S. scoparium* is considered an excellent alga to host epifitic communities of associated macrofauna (Sánchez-Moyano & García-Gómez, 1998; Sánchez-Moyano *et al*., 2000a, 2000b, 2002)

For the present study we selected *Stypocaulon scoparium* as a substra-te to study the distribution and abundance patterns of the non-amphipod peracarids along the whole coasts of the Iberian Peninsula and to explore their relationships with environmental variables such as water temperature, conductivity, pH, oxygen and turbidity.

MATERIAL AND METHODS

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

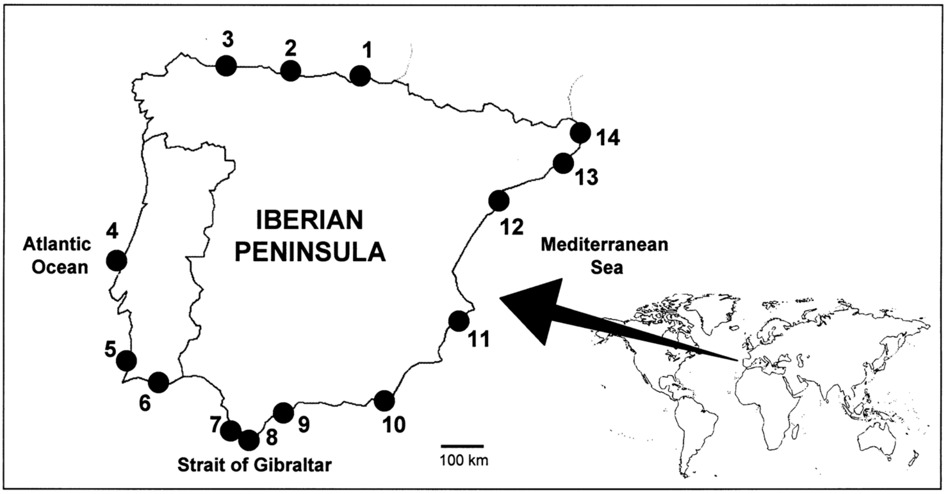

Fig 1.—Study area showing the sampling stations. Ogella (1), Oyambre (2), Cetarea (3), Playa Azul (4), Vale dos Homens (5), Castelo (6), Bolonia (7), Isla de Tarifa (8), Torreguadiaro (9), Cabo de Gata (10), Cala del tío Ximo (11), Torrent del Pi (12), Cala de Sant Françesc (13), L'Estartit (14).
Fig.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

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 turbidy in nephelometric turbidy units (ntu) using a turbidimeter WTW 335 IR.

To avoid problems caused by pooling data from diverse substrate types, sampling efforts were limited to a well-defined habitat (alga *Stypocaulon scoparium* in this case) (see Thiel, 2002). Algal samples were taken from shallow waters (1-3 meters deep) by snorkeling. At each station, *S. scoparium* was collected by hand from different rocks to avoid effect of patchiness and to adequately sample caprellid diversity, until a volume of approximately 200 ml of seaweed was completed (see Thiel *et al.*, 2003; Guerra-García *et al.*, 2009). Samples were preserved in 70% ethanol. To estimate the cover of *S. scoparium* 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).

In the laboratory, the samples were washed over a sieve with 0.5 mm mesh size, and all isopods, tanaids and cumaceans were sorted from the algae and identified to species level. Density of animals was expressed as number of individuals per volume of algae (see Guerra-García *et al*., 2009), which was estimated as the difference between the initial and final volume when placed into a graduated cylinder with a fixed amount of water (see Pereira *et al*., 2006).

Species were classified in geographical distribution groups (see also Conradi & López-González, 1999; Guerra-García *et al*., 2009). Four groups were considered: I (Endemic Mediterranean), II (Atlantic and Mediterranean), III (Atlantic, Mediterranean and Indo-Pacific) and IV (Cosmopolitan).

The total number of species and total abundances were calculated for each station. The affinities among stations based on the environmental parameters were established through cluster analysis using UPGMA (unweighted pair group method using arithmetic averages) and euclidean distances. The relationships between environmental measures and isopods, tanaids and cumaceans assemblages were studied by Canonical Correspondence Analysis (CCA). Multivariate analyses were carried out using the PRIMER package (Clarke & Gorley, 2001) and the PC-ORD programme (McCune & Mefford, 1997).

RESULTS AND DISCUSSION

Environmental measures and cover of S. scoparium

The Mediterranean coast was characterised by higher seawater temperature and conductivity and lower values of oxygen concentration and turbidity (Fig. 2). Atlantic stations are much more exposed and this contributes to increase the turbidity and oxygen due to the larger waves breaking in the seaside. Values of pH were rather similar in all stations, ranging between 8-8.5. Temperature was negatively correlated with oxygen ($r=-0.63$, $p<0.05$) and turbity ($r=-0.44$, $p<0.05$) and positively with conductivity ($r=0.64$, $p<0.05$). The cluster elaborated using all the physicochemical measures clearly separated two groups of stations: one group was formed by the Atlantic stations (1-6) together with the Strait of Gibraltar sites (7-9), and the other group clustered all the Mediterranean stations (10-14). According to the measured parameters, the Strait showed more similarity with the Atlantic than with

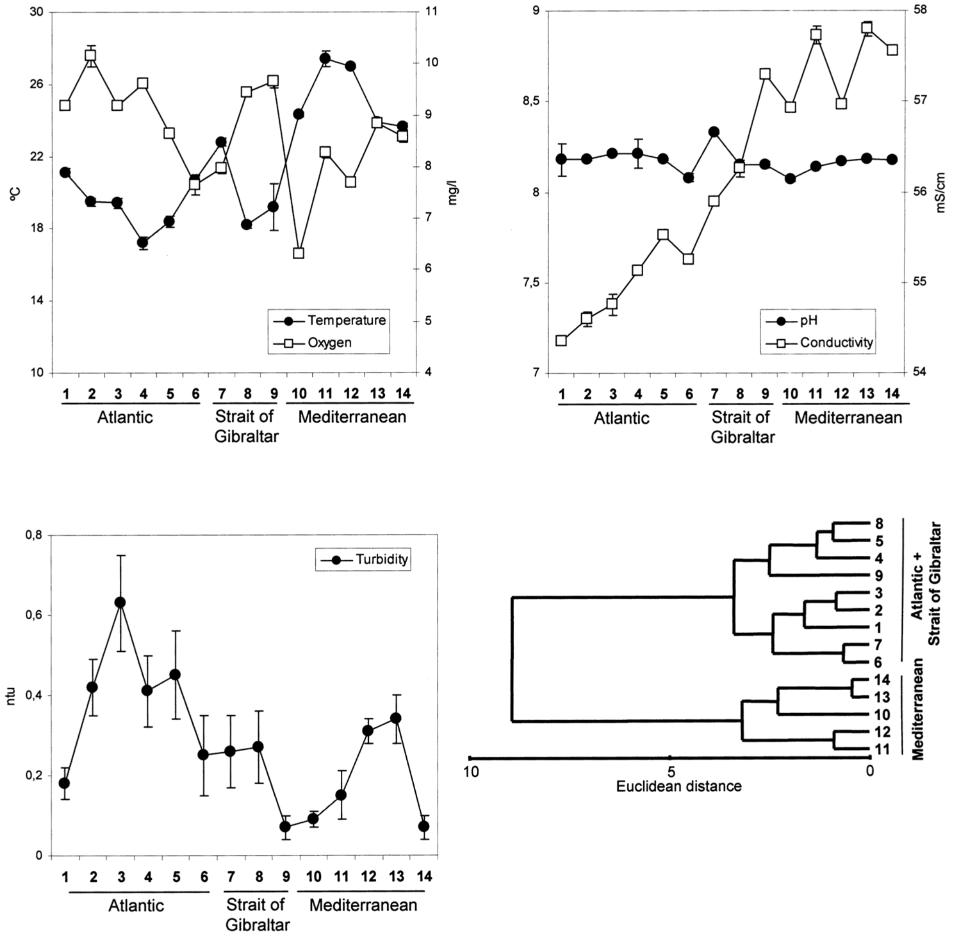

Fig. 2.—Abiotic variables measured in each station (Mean ± SD) and Cluster analysis based on the abiotic data.
Fig. 2.—Variables abióticas medidas en cada estación (Media ± SD) y análsis de Cluster basado en los datos abióticos.

the Mediterranean. However, cover of *S. scoparium* showed the highest values in the Strait of Gibraltar (20-50%) than in the Atlantic (7-18%) and Mediterranean (<10%) (Fig. 3). Consequently, other factors differing from temperature, oxygen, conductivity, pH and turbidity should be used to explain the cover patterns. Probably, the current dynamics around the Strait of Gibraltar could be involved.

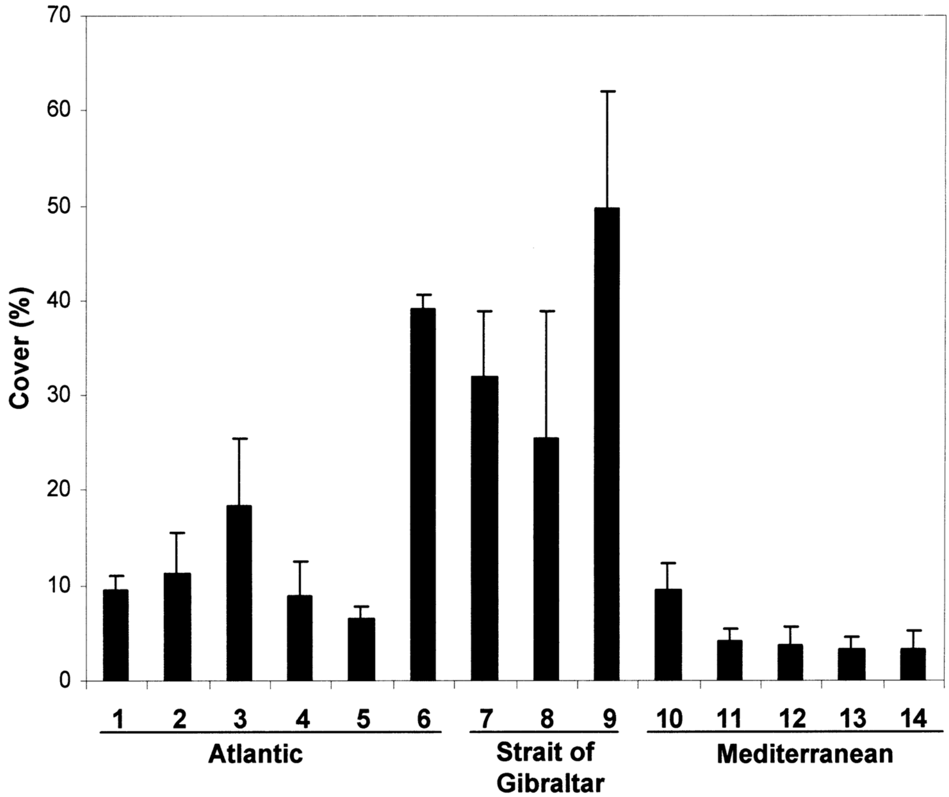

Fig. 3.—Cover percentage of *S. scoparium* (Media ± SD) in each station.
Fig. 3.—Cobertura en porcentaje de *S. scoparium* (Media ± SD) en cada estación.

Faunal assemblages

A total of 1016 specimens of isopods (15 species), 1771 tanaids (4 species) and 27 cumaceans (4 species) were examined (Table 1). The most common species associated to *S. scoparium* were the isopods *Cymodoce truncata*, *Dynamene magnitorata*, *Paranthura nigropunctata* and *Synisoma capito*, and the tanaids *Leptochelia dubia* and *Tanais dulongii*. The highest values of number of species were registered around the Strait of Gibraltar (Fig. 4). Isopods were more abundant in Atlantic stations of the Iberian Peninsula while tanaids and cumaceans were dominant in the Mediterranean coast (Fig. 5).

The classification of species in geographical distribution groups showed that most species have an Atlantic-Mediterranean distribution (76%). Only two species, the isopod *Astacilla axeli* and the cumacean *Cumella limicola*

Table 1. Abundance of species of isopods, tanaids and cumaceans associated to *Stypocaulon scoparium* along the Iberian Peninsula (ind/ 1000 ml seaweed). BG, biogeographical region (see text).

Tabla 1. Abundancia de las especies de isópodos, tanaidáceos y cumáceos asociados a *Stypocaulon scoparium* a lo largo de la Península Ibérica (ind/ 1000 ml de alga). BG, región biogeográfica (ver texto):

	BG	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Isopoda:															
Astacilla axeli Castelló, 1992	I	0	0	0	0	0	0	0	0	0	0	0	0	29	0
Cymodoce truncata Leach, 1814	II	67	11	43	0	17	12	73	0	23	60	37	0	0	0
Cymodoce sp.		0	0	0	44	0	33	0	9	0	0	0	0	143	24
Dynamene edwardsi (Lucas, 1849)	II	333	0	6	8	0	58	38	31	90	20	0	9	0	6
Dynamene magnitorata Holdich, 1968	II	600	32	6	108	567	65	4	6	87	0	0	0	0	0
Dynamene sp.		100	0	0	0	0	33	0	9	27	0	0	0	0	0
Idotea pelagica Leach, 1815	II	0	0	0	52	17	0	0	0	0	0	0	0	0	0
Ischyromene lacazei Racovitza, 1908	II	0	0	0	0	0	14	0	3	3	0	11	0	0	0
Jaeropsis brevicornis Koehler, 1885	II	0	0	0	0	0	0	0	0	0	0	0	291	0	0
Janira maculosa Leach, 1814	II	0	0	0	0	0	0	4	0	0	0	0	0	0	0
Munna cf. *limicola* Sars, 1866	II	0	0	0	0	50	14	0	0	0	0	0	0	0	0
Paranthura nigropunctata (Lucas, 1849)	II	200	58	46	4	0	51	77	34	90	0	5	48	43	100
Synisoma lancifer (Miers, 1881)	II	0	11	0	0	0	0	0	0	0	0	0	0	0	0
Synisoma capito (Rathke, 1837)	II	0	0	3	4	83	221	488	254	17	280	147	78	14	47
Zenobiana prismatica Risso, 1826	II	100	0	0	12	0	0	0	0	0	0	0	0	0	0
Tanaidacea:															
Apseudes talpa (Montagu, 1808)	II	0	0	0	0	0	0	0	3	3	0	0	0	0	0
Leptochelia dubia (Krøyer, 1842)	IV	0	0	0	0	0	9	4	0	0	20	116	187	57	12
Tanais dulongii Audouin, 1826	III	167	0	11	8	33	186	88	143	3063	280	0	2530	0	24
Zeuxo normani (H.Richardson, 1905)	III	0	0	0	4	0	9	0	0	0	40	0	0	0	0
Cumacea:															
Cumella limicola Sars, 1879	I	0	0	0	0	0	0	0	0	17	0	0	0	71	0
Cumella pygmaea Sars, 1865	II	0	0	0	0	0	12	0	0	3	0	0	4	14	0
Nannastacus unguiculatus (Bate, 1859)	II	0	0	0	0	0	0	0	0	0	0	0	4	43	6
Pseudocuma cf. *longicornis* (Bate, 1858)	II	0	0	0	0	0	0	0	0	0	0	0	0	57	0

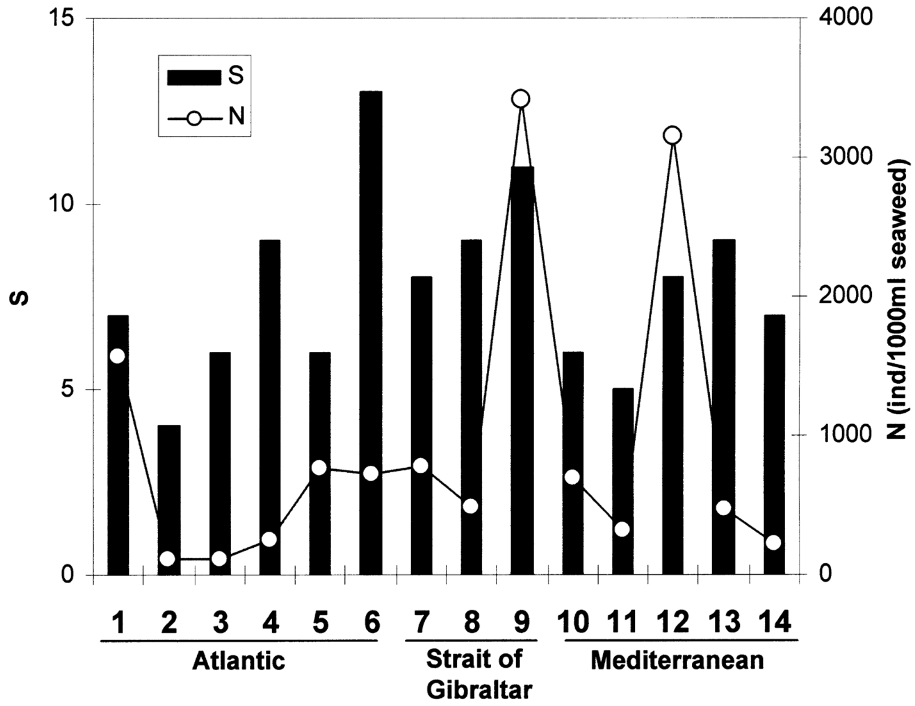

Fig. 4.—Number of non-amphipod peracaridean species (S) and abundance (ind/1000 ml seaweed) in each station.
Fig. 4.—Número de especies de peracáridos no anfípodos (S) y abundancia (ind/1000 ml alga) en cada estación.

are Mediterranean endemics. The tanaids *Tanais dulongii* and *Zeuxo normani* are also distributed in the Indo-Pacific, and *Leptochelia dubia* can be considered as cosmopolitan (Sanz, 1992)

During a study of macrofaunal assemblages associated to *S. scoparium* in the Strait of Gibraltar, Sánchez-Moyano & García-Gómez (1998) also reported the presence of the tanaids *Parapseudes latifrons* and *Zeuxo coralensis,* not found during the present study, although the most common species were also *Leptochelia dubia* and *Tanais dulongii*, as in the present work. *Tanais dulongii* is also one of the most common species distributed along the whole coast of Portugal (Pereira *et al.*, 2006). In connection with the cumaceans, *Cumella limicola* and *Nannastacus unguiculatus* are also the dominant species reported by Sánchez-Moyano & García-Gómez (1998) associated to *S. scoparium*. Alfonso *et al.* (1998) found a clear difference

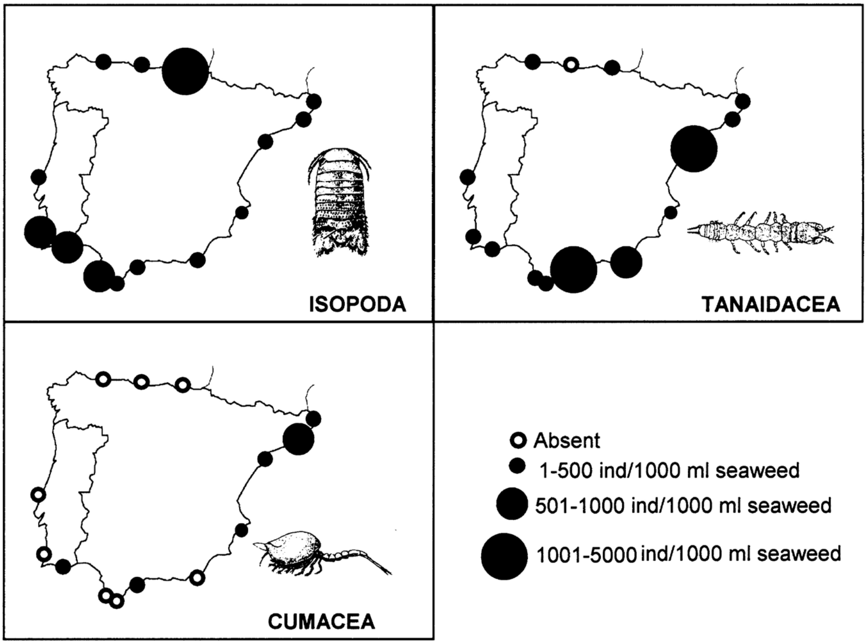

Fig. 5.—Abundance patterns of isopods, tanaids and cumaceans.
Fig. 5.—Patrones de abundancia de isópodos, tanaidáceos y cumáceos.

in the distribution and abundance of these two species in Algeciras Bay, Southern Spain: *C. limicola* was more abundant in the inner area of the bay, with lower hydrodinamism and higher sedimentation rate, while *N. unguiculatus* was more abundant in the outer area, with higher hydrodynamism. The isopods *Paranthura nigropunctata* and *Synisoma capito* were also one of the dominant species in the study of Sánchez-Moyano & García-Gómez (1998) based on material collected from Algeciras Bay. Pereira *et al*. (2006) also reported *Dynamene magnitorata* and *Synisoma capito* as one of the most common isopods along the Portuguese coasts, being more abundant in southern stations. The taxonomical status of *S. capito* and *S. nadejda* is still under debate (see Junoy and Castelló, 2003); in the present study we have identified the specimens as *S. capito*, following Sánchez-Moyano & García-Gómez (1998) and Pereira *et al*. (2006).

The faunal composition of isopods, tanaids and cumaceans associated to the alga *S. scoparium* is richer than the fauna collected from *Corallina elongata*, other dominant algae in intertidal and shallow waters in temperate ecosystems. Guerra-García *et al.* (2009) reported nine species of isopods, one species of tanaid and no cumaceans associated to *C. elongata* from the Strait of Gibraltar. Abundance patterns also differ between the two algal species. *Ischyromente lacazei* was clearly the dominant species in *C. elongata*, while its abundance in *S. scoparium* was very low, restricted to some specimens in a few stations.

Relationships between isopods, tanaids and cumaceans associated to S. scoparium *and abiotic variables*

Figure 6 and table 2 show the results of the Canonical Correspondence Analysis (CCA). Fist axis, which absorbed 24% of total variance, significantly correlated with the turbidity (positively) and temperature and conductivity (negatively). Species such as *Zenobiana prismatica*, *Dynamene magnitorata*, *Idotea pelagica*, *Synisoma lancifer* and *Munna* cf *limicola* were associated to lower values of temperature and conductivity, while the species *Leptochelia dubia*, *Jaeropsis brevicornis*, *Tanais dulongi* or *Cumella limicola* seem to prefer stations characterised by higher values of conductivity and temperature. Second axis was correlated with oxygen and turbidity (positively) and cover of alga (negatively). Consequently, in general, isopods showed preferences by Atlantic coast, characterised by higher values of oxygen and turbidy, while cumaceans and tanaids were dominant in Mediterranean localities, where temperature and conductivity is higher than in the Atlantic ones.

Table 2.—Summary of the results of the CCA análisis. *p<0.05, **p<0.01, ***p<0.001
Tabla 2.—Resumen de los resultados del análisis CCA. *p<0.05, **p<0.01, ***p<0.001

	Axis 1	Axis 2	Axis 3
Eigenvalue	0.59	0.25	0.20
Species-environment correlation	0.97	0.75	0.81
Percentage of species variance	24.0	10.1	8.3
Correlation with environmental variables			
Temperature (ºC)	–0.77***	—	0.74**
pH	—	—	—
Oxygen (mg/l)	—	0.67**	—
Conductivity (mS/cm)	–0.83***	—	—
Turbidity (ntu)	0.54*	0.49*	—
Cover *S. scoparium* (g)	—	–0.50*	—

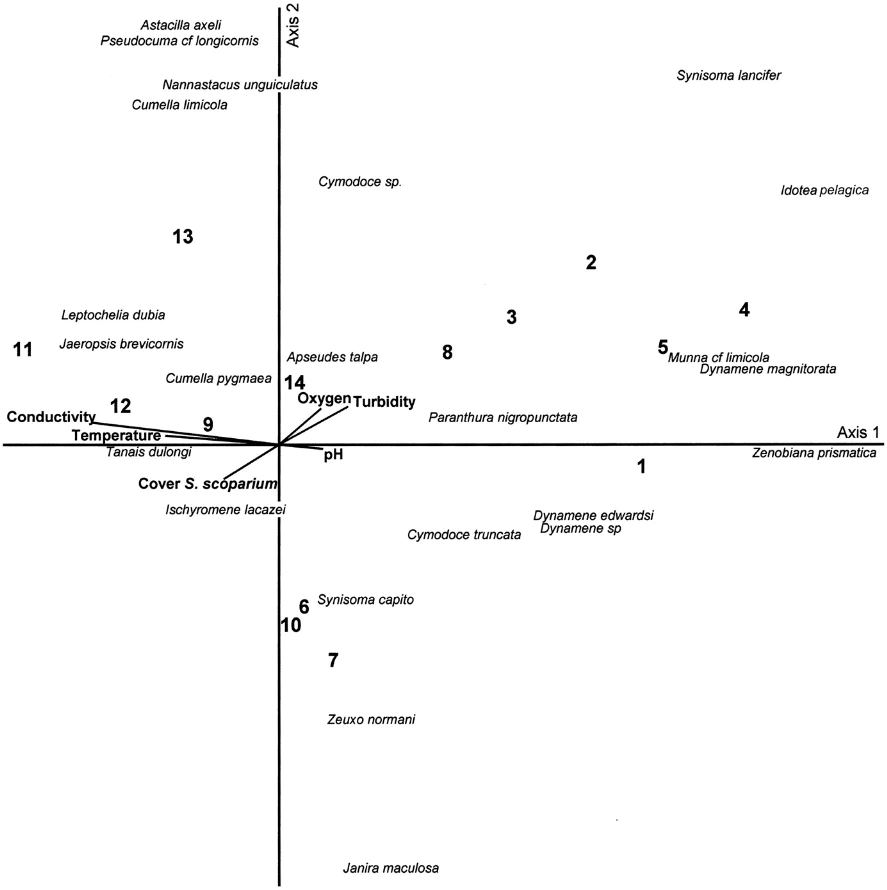

Fig. 6.—Graph representation of the stations and non-amphipod peracaridean species with respect to the first two axes of the Canonical Correspondence Analysis (CCA).
Fig. 6.—Representación gráfica de las estaciones y de las especies de peracáridos no-anfípodos con respecto a los dos primeros ejes del Análisis Canónico de Correspondencias (CCA).

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