



The cumacean community associated with a seaweed as a bioindicator of environmental conditions in the Algeciras Bay (Strait of Gibraltar)

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Abstract: In order to know the spatio-temporal distribution of a cumacean community and its role as a bioindicator of different environmental conditions, a representative seaweed (*Halopteris scoparia*), with which cumaceans are associated, was sampled in different stations in Algeciras Bay during one year. Five stations were sampled seasonally, and eight environmental factors were tested (temperature, hydrodynamism, silting, dissolved organic matter, organic matter in silt, suspended solids, compactness index, and interstitial volume). The physico-chemical study showed that the bay comprised an internal and an external areas, while the spatio-temporal study revealed the presence of three cumacean species, *Cumella limicola*, *Nannastacus unguiculatus* and *Scherocumella longirostris*. There was a clear difference in the distribution and the abundance of these species. In fact, *C. limicola* was more abundant in the inner area of the bay, whereas *N. unguiculatus* was more abundant in the outer area. Multivariate analyses were performed to explain the structure of this community along the different stations of the bay. The segregation was significantly related to hydrodynamism and algal parameters (interstitial volume and compactness index).

Résumé : La distribution spatio-temporelle de la communauté des cumacés associés aux algues et son rôle comme bio-indicateur des conditions environnementales dans la Baie d'Algeciras (Déroit de Gibraltar)

Une étude a été faite pendant un an, par le prélèvement d'une algue *Halopteris scoparia* avec laquelle les cumacés sont associés. Cinq stations ont été échantillonnées et huit facteurs environnementaux mesurés dans la baie d'Algeciras (température, hydrodynamisme, taux de sédimentation, matière organique dissoute, matière organique en suspension, solides en suspension, indice de compacité et volume interstitiel des algues). L'étude physico-chimique a permis de distinguer dans la baie une zone externe et une zone interne et l'étude spatio-temporelle a révélé la présence de trois espèces, *Cumella limicola*, *Nannastacus unguiculatus*, and *Scherocumella longirostris*. Ces trois espèces montrent des différences nettes de distribution et d'abondance. *Cumella limicola* est plus abondante dans la zone interne de la baie alors que *Nannastacus unguiculatus* est plus abondante dans la zone externe. L'analyse multivariée a été utilisée pour exprimer la structure de la communauté dans les différentes stations de la baie d'Algeciras. La ségrégation est significativement liée à l'hydrodynamisme et aux paramètres des algues (indice de compacité et volume interstitiel).

Keywords: Cumacea, Algeciras Bay, seaweed, spatio-temporal distribution, bioindicator.

Introduction

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Cumacea are benthic peracarid crustaceans found worldwide from the intertidal zone to abyssal depths (Jones,

1969). Although found in all ocean depths, they are most abundant in the littoral zone. There are more than 1100 known species in the world. This group lives in all kind of benthic habitats, muddy bottom, sand and gravel, on natural rock formations associated with algae or to sessile invertebrates.

Crustaceans in general and especially peracarids associated with arborescent substrata have often been studied (Colman, 1940; Chapman, 1955; Kito, 1975, etc.), and amphipods and isopods are the most abundant taxa (Hagerman, 1966; Mukai, 1971; Taylor & Cole, 1994). Cumacean fauna is always poorly represented, so it is difficult to know its dynamic and other populational data (Conradi, 1995; Sanchez-Moyano, 1996). Arntz (1971, 1974) found that few benthic animals (cumacean among them) constitute the main component of the food of demersal fish in Kiel Bay. Moreover, most of the works about the dynamics of cumacean population have been done on sediment inhabiting species (Corey, 1969; Roccatagliata, 1991) since this taxon is abundant in soft bottoms. On the other hand, little information exists about cumacean dynamics in the arborescent substratum e.g. algae or bryozoans. Therefore, more research in this area is needed in order to improve our knowledge of the real role of cumacean as mobile fauna associated with these particular habitats.

Macrophytes constitute a very important substratum in benthic communities. They have greater species richness, abundance and biomass of associated fauna than unvegetated habitats (Edgar, 1990). Macrophytes provide protection against desiccation in mediolittoral zones, against wave impact and hydrodynamic forces (Hicks, 1980; Buschmann, 1990), and give protection to predators, especially fishes (Stoner, 1980; Edgar, 1990; Russo, 1991). They are also used as a food source for several small invertebrates, which may achieve high densities (Nicotri, 1980; Shacklock & Croft, 1981). Depending on algal growth forms, they retain different quantities of sediment and variations in the surface or shape of the plant have an effect on the composition and abundance of their epiphytes (Arrontes, 1990). Therefore, macrophytes constitute a very complex system.

Bellan-Santini (1981) determined that the crustacean populations associated with different macrophytes were very sensitive to environmental disturbances (domestic and industrial wastes). This faunal community may thus be considered as a good bioindicator of environmental conditions. According to Corbera & Cardell (1995) cumaceans are very sensitive to environmental stress and may be used for environmental monitoring. Ledoyer (1997) also thinks that cumaceans are probably excellent bioindicators.

The main objectives of the present work were, first a spatio-temporal study of the cumacean community associated

with a macrophyte well represented in the Algeciras Bay (Southern Spain) and second an analysis of the cumacean community as a bioindicator of some environmental conditions (hydrodynamism, suspended solids, silting, dissolved organic matter and organic matter in silt).

Material and Methods

I. Study Site

Algeciras Bay (strait of Gibraltar) is characterized by a number of patches of small homogeneous environments, and along its 30 Km coastline there is an extended industrial area with chemical industries, refineries, thermal power plants, ironworks, paper mills, and shipyards alongside a major port. The amount of urban sewage corresponds to a population of approximately 205,000 inhabitants; industrial contamination corresponds to 150,000 inhabitants (Wait et al. 1990). Two rivers flow into the bay's centre, the Palmones and the Guadarranque, each one with an amount of sewage corresponding to 15,000 inhabitants, and industrial contamination corresponding to 15,000 inhabitants for the former and 2,500 for the latter (Wait et al. 1990).

The population of *Halopteris scoparia* (L) Sauvage is present all the year round throughout Algeciras Bay and is one of the most abundant macrophyte species. It is an amphiatlantic alga with latitudinal distribution from the coast of Norway to Nigeria. However, it has also been found in the Red Sea, the Caspian Sea and in the north-west Pacific (Cabioc'h et al., 1995). It has been found in the Mediterranean at 5 m depth (Boudouresque, 1971), while Sanchez-Moyano (1996) found it up to 15 m depth in Algeciras Bay and so its bathymetry depends on the physico-chemical characteristics of the environment.

H. scoparia was sampled in Algeciras Bay on a spatio-temporal scale, in order to define its role as a substratum for the associated cumacean community. The sampling stations were chosen on the basis of the heterogeneity of the environment (Fig. 1). Two different groups of stations were defined in the bay, in relation to two abiotic factors, hydrodynamism and sedimentation (Conradi & Cervera, 1995; Carballo et al., 1996; Conradi et al., 1997). The first group had a slight hydrodynamism and a low sedimentation by comparison with the second group, and included two stations situated in the outer area of the bay, Isla de las Palomas (IPA) and San García (SGA). These stations correspond to a hard natural substratum. Three other stations, with a lower hydrodynamism and a higher sedimentation are mainly artificial harbours located in the intermediate area for Cucareo (CUC) and in the internal area of the bay for Guadarranque (GUA) and Crinavis (CRI) (Fig. 1).

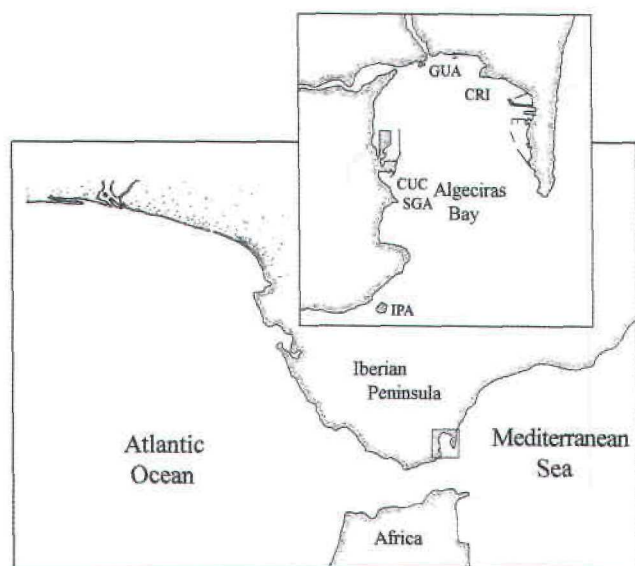


Figure 1. Studied area of Algeciras Bay which shows the sampling stations: outside the bay, Isla de las Palomas (IPA) and San Garcia (SGA) and inside the bay, Cucareo (CUC), Guadarranque (GUA) and Crinavis (CRI).

Figure 1. Zone étudiée de la baie d'Algeciras indiquant les stations échantillonnées : à l'extérieur de la baie, Isla de las Palomas (IPA) et San Garcia (SGA) et à l'intérieur de la baie, Cucareo (CUC), Guadarranque (GUA) et Crinavis (CRI).

II. Sampling and analytical methods

Each station was sampled five times a year (from September 92 to September 93) by SCUBA diving. The specimens of *Halopteris scoparia* were collected and fixed in the laboratory with 10% formalin-sea water solution. All samples were sorted under a dissecting microscope, the cumacean were separated, preserved in 4% formalin-sea water solution, then identified to species and counted. Cumacean densities were expressed for 100 g dry weight of algae.

Maximum height, diameter and volume in each alga specimen were measured. The real volume (V_R) was

measured in sea water by displacement in a graduated cylinder. Assuming that *H. scoparia* has a paraboloid geometrical form, its theoretic volume was calculated (V_T). It is defined by height and diameter. With the two volumes (V_R and V_T) the interstitial volume ($VI = V_R - V_T$), which is the space where the epiphyte fauna lives was estimated. In this way we were able to calculate the Compactness Index ($IC = V_T/V_R$) (see Sanchez-Moyano, 1996).

The physico chemical data indicated here are part of a broader study undertaken five years ago by the Laboratorio de Biología Marina of the University of Sevilla on the benthic communities of Algeciras Bay. The research was focused on faunistic and ecological aspects of the main benthic invertebrate groups, cumaceans among them. Physico-chemical factors measured were, temperature (T^a), hydrodynamism (H), suspended solids (S.S.), silting (T.S.), dissolved organic matter (D.O.M.) and organic matter in silt (O.M.S.). These variables were measured as described in Carballo et al. (1996).

Cumacean abundance data were double square-root transformed so that the ensuing classification and ordination were not determined only by the most dominant species (Clarke & Green, 1988). Cluster analyses, employing the Bray Curtis index of dissimilarity (Bray & Curtis, 1957), were used to relate the different stations to both the distribution of the species and the physico-chemical factors. This index was chosen as it does not consider double absences. Bi- and tridimensional nonmetric multi-dimensional scaling ordinations (MDS) were made as the stress decreases as the dimension of the ordination increases (Clarke, 1993).

The cluster analysis, MDS was done with the NTSYS program. A non-parametric test of correlation (coefficient of Spearman) as BIO-ENV from the software package PRIMER and Canonical Correspondence Analysis (CCA) were used to link biological abundance data to environmental conditions. A Montecarlo permutation test was used to determine the statistical significance of CCA.

Table 1. Annual mean values of physico-chemical factors measured at each station.

Tableau 1. Valeurs moyennes annuelles des facteurs physico-chimiques mesurés à chaque station.

	Silting (g m ⁻²)		O.M. in silt (%)		Suspended Solids (mg l ⁻¹)		Dissolved O.M. (mg l ⁻¹)		Temperature (°C)		Hydrodynamism (V)		Compactness Index		Interstitial Volume (ml)	
	\bar{X}	SE	\bar{X}	SE	\bar{X}	SE	\bar{X}	SE	\bar{X}	SE	\bar{X}	SE	\bar{X}	SE	\bar{X}	SE
IPA	4,53	1,94	14,26	1,37	13,1	2,4	3,29	0,79	16,62	0,62	6,62	0,60	67,34	7,54	683,10	58,26
SGA	5,57	1,18	11,78	1,92	11,31	1,1	3,27	0,66	16,11	0,52	6,14	0,89	64,42	15,53	529,40	93,13
CUC	17,5	6,23	11,93	1,39	10,75	1,39	3,36	0,62	16,38	0,56	6,03	1,08	54,76	6,23	661,36	48,62
GUA	9,87	1,65	10,55	0,39	13,48	2,35	3,38	0,67	17,02	0,46	3,73	0,61	36,20	6,36	311,94	32,19
CRI	4,63	1,17	11,49	0,44	9,87	1,06	3,12	0,63	16,17	0,65	7,08	0,52	32,34	5,57	333,10	55,06

Results

I. The cumacean community.

During the whole survey, a total of 2058 cumacean individuals were counted associated with *H. scoparia* in Algeciras Bay. They belonged to three species: *Cumella limicola* Sars, 1879 (1429 individuals), *Nannastacus unguiculatus* (Bate, 1859) (621 individuals), and *Scherocumella longirostris* (Sars, 1879) (8 individuals), all of them included in the Family Nannastacidae. In the following comparison the number of cumaceans will be expressed for 100 gr DW alga. *Cumella limicola* was the dominant species associated with this macrophyte (74.34%), followed by *N. unguiculatus* (35.34%) while *S. longirostris* was poorly represented (0.31%). (Fig 2).

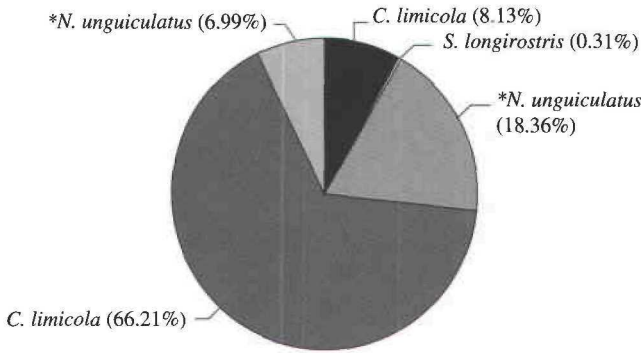


Figure 2. Relative abundance of Cumacean species within and *outside the bay of Algeciras.

Figure 2. Abondance relative des espèces de Cumacés à l'intérieur et *à l'extérieur de la baie d'Algeciras.

II. Spatial distribution.

Concerning the distribution of the three cumacean species in the sampling sites (Fig. 3), *S. longirostris* was only found in two out of the five stations (IPA and SGA) and in small numbers. This species represented less than 0.5% of the total cumacean abundance (19 specimens in IPA and 6 in SGA). *Cumella limicola* and *N. unguiculatus* were present in all the studied stations. *Cumella limicola* was more abundant in CUC, GUA and CRI, stations located in the intermediate and inner area of the bay, representing about 65% (527 individuals), 99% (3866 individuals) and 81% (1065 individuals) of the total cumacean abundance in each station respectively. *N. unguiculatus* was dominant in IPA and SGA, stations located in the outer area of the Bay representing 58% of the total cumacean abundance (665 individuals) and 84% (847 individuals), in these stations respectively.

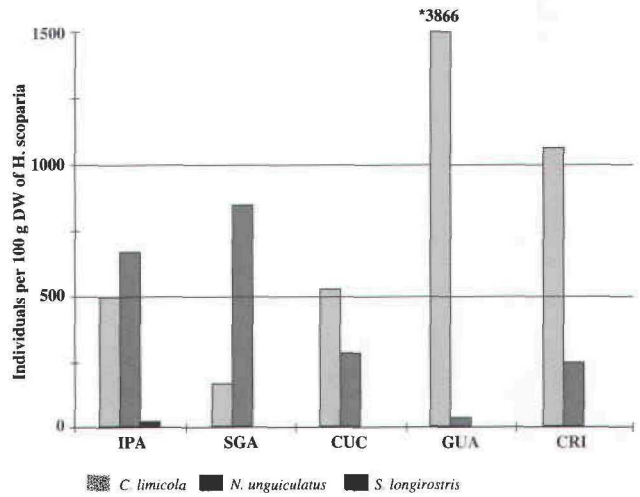


Figure 3. Number of individuals per species at each station. It is worth noting that *C. limicola* reaches a number of 3866 individuals at GUA station.

Figure 3. Nombre d'individus par espèce pour chaque station. Remarquer que *C. limicola* atteint le nombre de 3866 individus à la station GUA.

The three stations in the inner area of the Bay (CUC, GUA and CRI) had 73.2% of the total cumacean abundance, *C. limicola* represented 66.2% and *N. unguiculatus* 6.99%. In the outer area (IPA and SGA) *N. unguiculatus* represented 18.36%, *C. limicola* represented 8.13% and *S. longirostris* 0.31%.

The stations throughout Algeciras Bay exhibited quite different levels of cumacean abundance (Fig. 2 and 3). About 50% of all individuals collected were obtained from GUA (46.89% correspond to *C. limicola*) while CUC had the poorest representation (about 10%). From the species point of view the best representation of *N. unguiculatus* was in SGA (847 individuals). In contrast this species only reached 42% (35 individuals) in GUA. As mentioned above *C. limicola* exhibited its maximum abundance in GUA (3866 individuals). *Scherocumella longirostris* was only present in IPA and SGA and in small numbers.

III. Temporal distribution.

Cumacean abundance varied throughout the sampling seasons (Fig. 4). The first sample (September 92) had the highest number of cumaceans: *Cumella limicola*, the best represented species, dominated in GUA and CRI, whereas *Nannastacus unguiculatus* was dominant in IPA and SGA. In winter (December 92) cumacean populations went down in most station (however in SGA the *C. limicola* population was a little more abundant than in the previous season). Cumaceans were less abundant in GUA and *N. unguiculatus* was absent in CRI. In spring (March 93) individuals were more abundant in the inner area than in the outer area of the

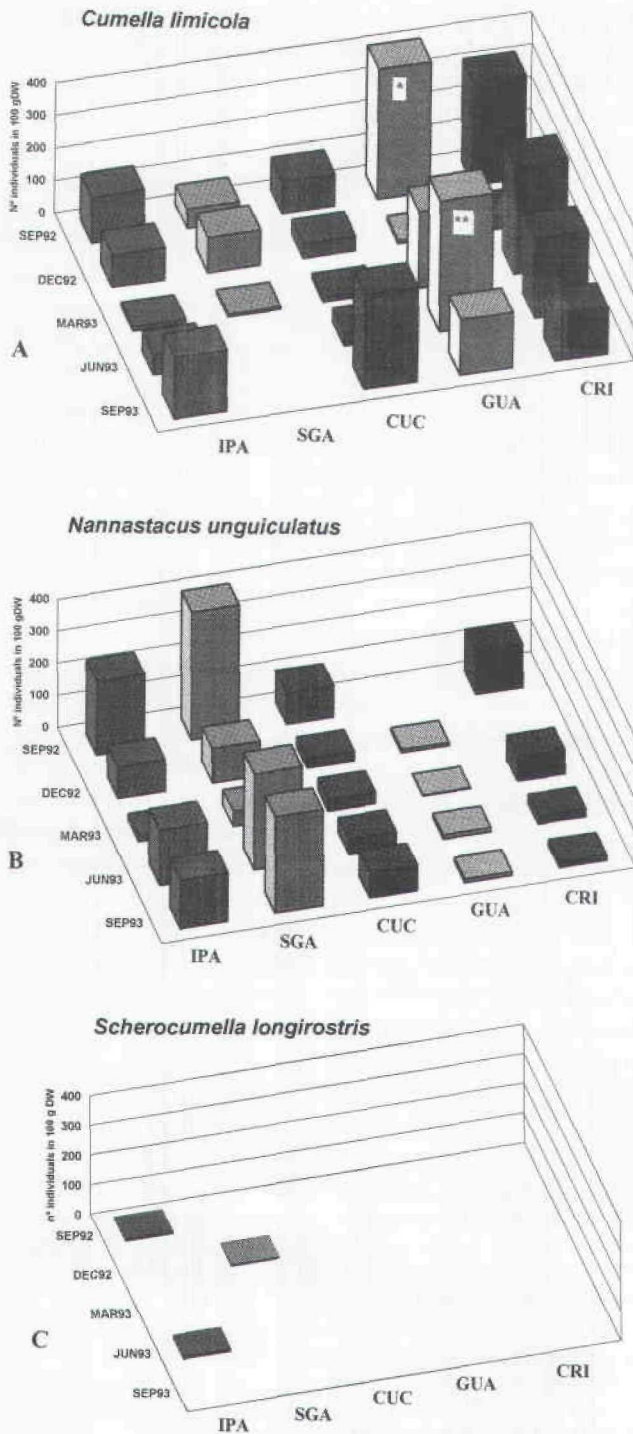


Figure 4. Temporal fluctuations of the species abundance at each sampled station. A: *Cumella limicola*; B: *Nannastacus unguiculatus*; C: *Scherocumella longirostris*. For *Cumella limicola*, maximal abundances (* and **) reach 2093 individuals in September 1992 and 1359 individuals in June 1993.

Figure 4. Fluctuations temporelles de l'abondance des espèces à chaque station échantillonnée. A : *Cumella limicola* ; B : *Nannastacus unguiculatus* ; C : *Scherocumella longirostris*. *Cumella limicola* présente une abondance maximale (* et **) de 2093 individus en septembre 1992 et 1359 individus en juin 1993.

bay. *Cumella limicola* increased in GUA and CRI, whereas, in IPA and SGA populations went down. With the arrival of summer (June 93), cumacean population increased, except in CRI, so in June *C. limicola* and *N. unguiculatus* were more abundant than in March 93 (less in CRI where the cumacean populations went down). *N. unguiculatus* had a similar abundance in June 93 and September 93 in each sampled stations. On the other hand, *C. limicola* did not appear in SGA (September 93), increased in CUC and IPA, but it decreased in GUA and CRI. *S. longirostris* only appeared in IPA (September 92 and June 93) and was poorly represented in SGA (Dec. 92).

IV. Multivariate Analysis.

Taking into account environmental variables (See Table 1 and Fig 5), the cluster analysis showed the following association of stations: CRI and GUA were the most different stations, whereas CUC, SGA and IPA were the most related ones.

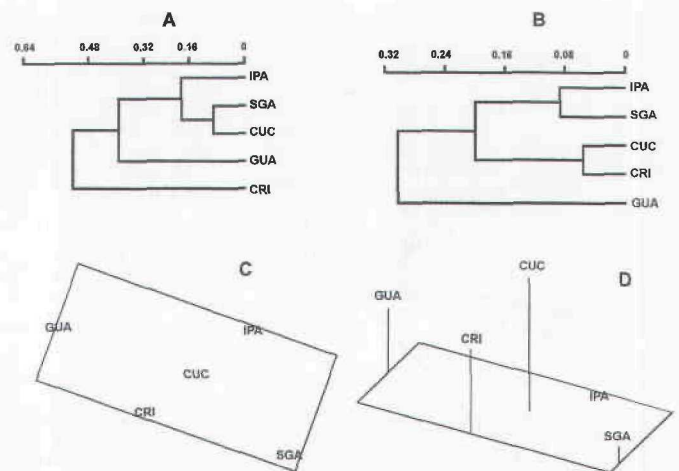


Figure 5. Dendrograms, bi- and tridimensional MDS ordination of Bray-Curtis similarity index. A, classification of the stations according to physico-chemical factors; B, classification of the stations according to species abundance; C and D, bidimensional and tridimensional MDS of stations derived from a matrix of the species abundance.

Figure 5. Dendrogrammes et distribution bi- et tridimensionnelles par MDS à partir de l'indice de similitude de Bray-Curtis. A, classification des stations en fonction des facteurs physico-chimiques ; B, classification des stations en fonction de l'abondance des espèces ; C et D, distribution en MDS des stations, C projection en 2D, D projection en 3D.

Cluster analysis based on species abundance separates GUA from the remaining stations (Fig. 5B). The remaining stations can be divided into two subgroups. In the first one are included IPA and SGA (the most external stations, see figure 1) and in the second subgroup CUC and CRI. Thus,

CUC may be considered an external station from a physico-chemical view-point, and an internal one from the cumacean abundance data.

However, when 2- and 3- dimensional MDS was performed based on species abundance, the relationship between the sampled stations became more evident (see Fig 5, compare C and D with B).

A factorial analysis (CCA) was carried out in order to clarify the relationships between abundance species distribution and environmental factors in Algeciras Bay (Fig. 6). Axis I separated stations into two groups: IPA and SGA situated in the outer area of the bay and CRI, CUC and

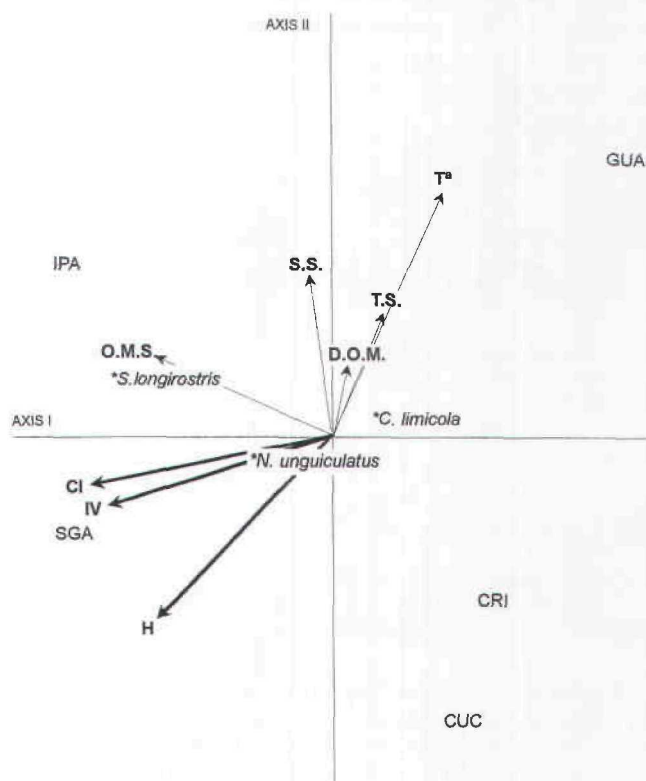


Figure 6. Species-factors biplot based on Canonical Correspondence Analysis (CCA). Bold arrows represent the factors which were significantly cross-correlated, using a Montecarlo permutation test. (confidence interval 0.05%). Temperature (T^a); siltation (T.S.); Dissolved organic matter (D.O.M.); Organic matter in silt (O.M.S.); Compactness index (C.I.); Interstitial volume (I.V.); suspended solids (S.S.) and Hydrodynamism (H).

Figure 6. Projection des espèces et des facteurs explicatifs sur les axes I et II de l'analyse canonique de correspondances (CCA) obtenue à partir de la matrice d'abondances des espèces dans les stations échantillonnées. Les flèches en gras illustrent les facteurs significativement corrélés (Seuil 0,05 %) en utilisant le test de permutation de Montecarlo. Température (T^a); taux de sédimentation (T.S.); Matière organique dissoute (M.O.D.); Matière organique en suspension (M.O.S.); Indice de compacité (C.I.); Volume interstitiel (I.V.); Solides en suspension (S.S.) et Hydrodynamisme (H).

GUA in the inner area. Localities situated inside the bay could be separated from those situated outside the bay. The former group of localities had a little more content of organic matter and silt (Table 1), and was characterized by the dominance of *C. limicola*. The second group of localities had lower contents of organic matter and silt, and was characterized by the dominance of *N. unguiculatus*. The distribution of the cumacean species was significantly correlated (F-ratio = 57.33; $p < 0.05$) with a set of three environmental factors (hydrodynamism, compactness Index, interstitial volume). The I and II axes explain 99.4% of total variance in the data.

Table 2 shows the combination of environmental variables which give rise to the largest rank correlation (ρ_s) between biotic and environmental sample dissimilarities using the BIO-ENV procedure. When all species are considered, the best correlation is the 2-variable combination: hydrodynamism and compactness index ($\rho_s = 0.62$). The best 3-variables combination is hydrodynamism, compactness index and interstitial volume ($\rho_s = 0.58$). This test is in agreement with the results of the CCA, showing that among both the environmental and biological factors measured, the structure of algae and the hydrodynamism are the two principal factors related to the distribution of Cumacean species. Using only the two more abundant species (*C. limicola* and *N. unguiculatus*) higher values of ρ_s are reached. The best 2-variable combination is hydrodynamism and compactness index ($\rho_s = 0.80$). Moreover, there is a good correlation between hydrodynamism and interstitial volume ($\rho_s = 0.78$). Algal variables and hydrodynamism are the most important factors in the distribution of the cumacean species.

Table 2. Largest correlations (ρ_s) between biotic and environmental factors, calculated from the Spearman coefficient, using combinations of 2 to K variables. Bold indicates the best r value obtained from the overall set of data. Interstitial volume (I.V.) and Compactness index (C.I.).

Tableau 2. Corrélations (ρ_s) entre les facteurs biotiques et environnementaux par utilisation du coefficient de Spearman, obtenues par des combinaisons de 2 à K variables. La meilleure valeur de r obtenue par combinaison est indiquée en gras. Volume interstitiel (I.V.) et Indice de compacité (C.I.).

K	Best variable combinations (ρ_s)	
1	Hydrodynamism (0.697)	Temperature (0.539)
2	Hydrodynamism-CI (0.806)	Hydrodynamism-I.V. (0.782)
3	Hydrodynamism-CI-I.V. (0.673)	

Discussion

Cumacean species associated with *Halopteris scoparia* in Algeciras Bay (present study) may be compared with other previously published data on cumaceans from different arborescent substrata, such as green algae *Caulerpa prolifera* (Forsskal), and *Codium* spp. (see Sanchez-Moyano, 1996), and the bryozoan *Bugula neritina* (see Conradi & Cervera, 1995). All these arborescent substrata had similar species composition and spatio-temporal distribution throughout Algeciras Bay. Nevertheless, total cumacean abundance was larger in *H. scoparia* than in any other considered substrata, and algal substrata were preferred to animal ones.

Arborescent substrata in Algeciras Bay provided a low number of cumacean species in comparison with soft bottom, where a higher species diversity in cumaceans inhabiting sediments was found (Bandera et al., unpublished).

Different types of public works determine the heterogeneity of the stations investigated in Algeciras Bay. So stations such as IPA, SGA and CUC (the latter protected from hydrodynamism) are considered more preserved from antropogenic activities, while other stations were under other stress, such as river influence in GUA and shipyards in CRI. This heterogeneity between internal areas subjected to environmental stress (GUA and CRI) and external areas without such a stress (IPA, SGA and CUC), conditioned the species abundance.

If we consider the species abundance, CUC has similar characteristics to those stations situated in the inner area because *C. limicola* is the most abundant species (Fig. 5B). However, if the physico-chemical factors are considered, CUC is more similar to SGA and IPA (inner area) (Fig. 5A). In fact, CUC is a fluctuating station, exhibiting characteristics of both an inner station and an outer station at different times throughout the sampling period (Fig. 5).

Three species of cumacean were associated with *Halopteris scoparia*: two of them (*C. limicola* and *N. unguiculatus*) were always present, while *S. longirostris* was only found in IPA and SGA, so the community was actually characterized by the presence of *C. limicola* and *N. unguiculatus*. There was a clear difference between inner and outer areas of the Bay, concerning both the quantitative and qualitative composition of the cumacean community inhabiting *H. scoparia*. The population of *H. scoparia* located inside the Bay supported a greater abundance of cumacean species than those located outside the Bay. This can be explained by the continuous river sediment contributions, which probably favour a food enrichment and then the permanence of a dense cumacean population, mainly *C. limicola*.

On the other hand, a clear segregation was observed between *C. limicola* and *N. unguiculatus*, the two best represented species in the population of *H. scoparia*. This can probably be explained by the nature of the organic matter in the sediments retained by this alga in each sampled station, and the clear differences in the structure parameters of the alga.

Hagerman (1966) noted two groups of factors responsible for the composition of epifauna associated with macrophytes: first those related to physical environment (e.g. hydrodynamism, temperature, silting), and second the physical characteristics of macrophytes (e.g. scrub-like algae, leaf-like algae). The combination of some factors from these two environmental groups are also responsible for the amount and nature of the sediment retained at the surface and in the interstitial space of algae. Within the term "nature" of the sediment we include the detritus factor pointed out by Dahl (1948) together with the inorganic factor. Moore (1972) emphasized that the main factors were hydrodynamism, silting, turbidity (suspended solids), feeding and macrophyte morphology. The results obtained in the present work are in agreement with Moore's assessment: the distribution of the two mainly represented cumacean species were significantly influenced by hydrodynamism and macrophyte morphology (see Table 1 and Fig. 6). Thus, *Cumella limicola* dominated in a station (GUA) characterized by a low hydrodynamism, a high sedimentation and high suspended solids. These factors favour the retention of quantities of sediment at the frond surface of plants, which provide food for cumacean species. Conversely, *N. unguiculatus* dominated in stations characterized by a high hydrodynamism, a low sedimentation and low suspended solids.

Scherocumella longirostris was poorly represented and never collected in previous studies carried out in Algeciras Bay (Conradi, 1995; Bandera et al., unpublished). This species probably prefers other physico-chemical characteristics of the environment and its scarce abundance in *H. scoparia* do not justify a discussion about its distribution according to these factors in the bay.

The "alternanz" concept introduced by Wieser (1952) means that different but closely related species may dominate in different samples at the same time and place. He also asserted that dominance of one species is the result of an interspecific competition for space with a closely related species. However, in the present work, *C. limicola* and *N. unguiculatus* are not two alternate species in the Wieser's sense, because they are dominant in different areas, they have not the same ecological requirements, and the same species is always dominant throughout the different samples at the same place in Algeciras Bay (*C. limicola* in one case and *N. unguiculatus* in other case).

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