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Polychaete assemblages on non-encrusting infralittoral algae from the Chafarinas Islands (SW Mediterranean)

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Abstract: The present study describes polychaete assemblages from the Chafarinas Islands (SW Mediterranean) and their relationships with different infralittoral communities of non-encrusting algae. Thirty-one samples were taken from the following infralittoral algal communities: Photophilic Algae in Exposed Water (PEW), Photophilic Algae in Calm Water (PCW), Sciaphilic Algae in Calm Water (SCW), and Hemiphotophilic Algae (HP). A total of 177 polychaete species was recorded. Each assemblage was characterized by a set of constant and dominant species. Diversity (Shannon index) for this taxocoenosis in every assemblage was high, ranging from 3.23 to 4.04. Evenness (Pielou index) values were also high, ranging from 0.61 to 0.72. One-way ANOSIM (Analysis of similarities) and ordination analyses showed that polychaete assemblages inhabiting different algal communities differed slightly. They also exhibited an environmental gradient with PEW at one extreme and HP and SCW at the other. The gradient was also apparent in the study of diversity, evenness and trophic guilds of each assemblage, especially with respect to numbers of filter-feeders.

Resumé : *Peuplements d'Annélides Polychètes des communautés algales non-encroûtantes infralittorales des Iles Zaffarines (Méditerranée sud-occidentale).* Nos résultats portent sur les peuplements de polychètes vivant dans les algues infralittorales non encroûtantes des Iles Zaffarines. 31 récoltes ont été réalisées dans les communautés algales infralittorales suivantes: algues photophiles en mode agité (PEW), algues photophiles en mode calme (PCW), algues sciaphiles en mode calme (SCW) et algues semi-photophiles (HP). 177 espèces de polychètes ont été récoltées. Chaque entité est caracterisée par un ensemble d'espèces dominantes et constantes. Les valeurs de la diversité (indice de Shannon) pour la taxocénose de chaque entité varient entre 3,23 et 4,04 et celles de l'équitabilité (indice de Pielou) entre 0,61 et 0,72. L'ANOSIM à une voie (l'analyse de similarité) et l'ordination par MDS montrent que les peuplements de polychètes présents dans les différents communautés algales diffèrent légèrement ; en outre, il y a un gradient écologique entre les communautés PEW- PCW-SCW/HP. Ce gradient existe aussi pour la diversité, l'équitabilité et les groupes trophiques de chaque peuplement, particulièrement en relation avec le nombre de filtreurs.

Keywords. Polychaete, assemblages, Mediterranean, hard bottom.

Introduction

There is a rich body of literature concerning polychaetous annelid assemblages inhabiting Mediterranean hard bottoms, those of Bellan (1964, 1969), Bellan-Santini

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(1966), Laubier (1966), Cantone (1971), Katzmann (1971), Kokatas (1976), Martín (1987), Cardell & Gili (1988) and San Martín & Aguirre (1991) being some of the most important. Thus, it is tempting to regard our general knowledge of these assemblages and their relationships with different algal communities to quite comprehensive. However, this view is biased; while many studies have been of communities from the northern Mediterranean coast, many fewer have been carried out on the southern coasts. Among them, those by Cantone et al. (1978), Zghal & Ben Amor (1980), Bitar (1987), or Menioui (1988) stand out. This makes the study of polychaete fauna from poorly studied or previously unstudied particular localities of necessity, to establish ecological models that are reliable for the whole Mediterranean basin.

The Chafarinas Islands (fig. 1) are a group of three small islands (Congreso, Isabel II, and Rey Francisco) of volcanic origin, close to the Mediterranean coast of Morocco. They are located between 35º10'33''N and 35º11'09''N and between 2º24'57''W and 2º26'32''W. From February 1991 to July 1993, research teams from the Universidad Autónoma de Madrid and the Universidad de Alcalá de Henares carried out several sampling expeditions to these islands.

The objective of the present study is to characterize polychaete assemblages and their variation with respect to depth and phytal canopy differences on the Chafarinas Islands. It was undertaken in the same manner as in the studies carried out in Italy by Fresi et al. (1983, 1984), Abbiati et al. (1987, 1991) and Giangrande (1988) or in the Balearic Islands by Sardá (1991), although our work differs from these by the study and characterization of the polychaete assemblage inhabiting Hemiphotophilic algae community. The work of Tena (1996), which includes some additional data on polychaete ecology on the Chafarinas Islands, is complementary to ours.

Material and methods

1. Study area.

The NW shore of Congreso, the N shore of Isabel II and the E shore of Rey Francisco are formed by high cliffs which reach depths of 30 m. Below this depth, bottoms are typically muddy. These shores face the open sea and thus are very exposed. The remaining shores of the Chafarinas are also rocky, but much shallower and more sheltered; bottoms are generally sandy below a depth of 6 m and, on some localities, they are covered by a *Posidonia oceanica* (L.) Delile, 1813 meadow.

Algal communities were characterized following the classification established by Meinesz et al. (1983), updated for the Chafarinas Islands by Tena (1996). The shallowest shores around the islands are covered by a belt of algae belonging to a Photophilic Alga in Exposed Water community (PEW) with different facies dominated by *Cystoseira tamariscifolia* (Hudson) Papenfuss, 1950, *Corallina elongata* Ellis and Solander, 1786 or *Laurencia obtusa* (Hudson) Lamouroux, 1813. Communities of this type are found from surface level to depths of 0.5-3 m, depending on the degree of exposure; they form wider belts on exposed coasts. Below them, a community of Photophilic Algae in Calm Water (PCW) can be found, in which *Stipocaulon scoparium* Kützing, 1813 dominates. This community may occur at variable depths: deeper on south-facing stations and shallower on north-facing ones. Small patches of this community are occasionally found at more than 12 m depth (sample D/1). Where the rocky bottom is deepest (10-25 m), there is a third community type, that of Hemiphotophilic Algae (HP), with two main facies dominated by *Cystoseira spinosa* Sauvageau, 1912 or *Halopteris filicina* (Grateloup) Kützing, 1843. On this community, algae were usually observed to be covered by a layer of fine sediment. The community of Sciaphilic Algae in Calm Water (SCW) can be found on shady surfaces at any depth. It is dominated by *Peyssonnelia squamaria* (Gmelin) Decaine, 1841 or by *Udotea petiolata* (Turra) Boergesen, 1925.

2. Sample collection.

All samples were collected by SCUBA diving, scraping off a 25 x 25 cm area of rocky bottom. The whole scraped material was treated with dilute formaldehyde (0.1%) in order to force animals to leave the algae, and then sieved (0.5 mm gauge mesh). The specimens obtained were preserved in 10% formaldehyde in seawater. This material was subsequently sorted into higher taxonomic groups (usually to class level) and polychaetes were identified to species level when possible.

Thirty-one samples from non-encrusting infralittoral algae were collected from 15 stations (Fig. 1). Their data (depth, community and facies, number of species and individuals, diversity, evenness) are presented in table 1; additional information can be found in López et al. (1996). Due to the different area covered by each community, the number of studied samples from each community type differed: 11 from PEW, 8 from PCW, 5 from SCW, and 7 from HP.

3. Data analysis.

A species abundance matrix was created, summarizing the actual numbers of individuals of each species. Statistical analysis was carried out using the PRIMER statistical package (Carr et al., 1993; Clarke & Warwick, 1994). A second matrix was derived from the abundance matrix, showing the similarity between samples by means of the Bray-Curtis coefficient, after data had been log-transformed (X=log (x+1)) to limit the influence of the most dominant

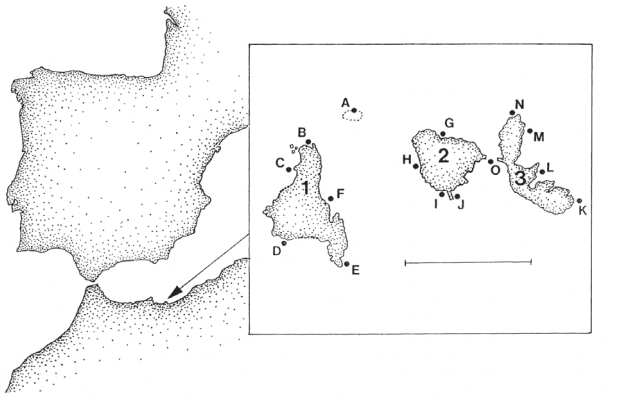

Figure 1. Map of the Chafarinas Islands, showing their situation in the Western Mediterranean and the location of sampling sites. 1: Congreso Island; 2: Isabel II Island; 3: Rey Francisco Island. (Scale bar = 1000 m).

Figure 1. Localisation des îles Zaffarines en Mer Méditerranée occidentale et répartition des lieux de récoltes. 1 : île Congreso ; 2 : île Isabel II; 3 : île Rey Francisco. (échelle = 1 000 m).

species. The matrix was used to carry out a one-way ANOSIM (Analysis of Similarity), in order to compare the four sample groups corresponding to different algal communities. A non-metric multidimensional scaling (MDS) ordination was also performed.

The species richness, as number of species, the Shannon diversity index, and the Pielou evenness index were computed for each sample and mean values were obtained for each algal community. Similarly, each community was characterized by its constant species (species which occurred in more than 75% of the samples within any particular community) and dominant species (species which comprised > 1% by number of the total specimens collected in any particular community, Picard, 1965), and by its trophic guild structure. Polychaete species were classified into trophic guilds according to the classification of Fauchald & Jumars (1979), taking into account the suggestions of Gambi & Giangrande (1985) and Sardá (1991) in order to reduce number of considered guilds. Thus, the considered trophic guilds are carnivores, herbivores, filter-feeders, surface deposit-feeders, omnivores, and sub-surface deposit-feeders. In several cases, there are strong disagreements in the literature concerning the inclusion of particular species in trophic guilds, so many inclusions were tentative. For this reason, all data referring to this subject must be considered cautiously.

Results

The study of the 31 samples gave an abundance matrix featuring 177 species from 29 families. Faunistic details of these samples have been presented in a series of taxonomic papers devoted to the polychaete fauna of the Chafarinas Islands (López, 1995; López & San Martín, 1996; 1997; López et al., 1996; 1997; López & Tena, 1999). Several of the recorded species have been recently described (*Harmothoe notochaetosa* López & San Martín, 1996, *Pionosyllis serratisetosa* López, San Martín & Jiménez, 1996, *Autolytus longoprimicirratus* López, San Martín & Jiménez, 1996 and *Amphicorina triangulata* López & Tena,

Table 1. Data on studied samples. H': Shannon diversity index. J': Pielou evenness index. N Ind: number of individuals / sample (= 625 cm²). SpR: Species richness

Tableau 1. Données sur les récoltes étudiées. H ': indice de Shannon. J : indice de Pielou. N Ind: nombre d'individus/prélèvement (= 625 cm²). SpR : richesse spécifique.

	Depth	Community	SpR	N Ind	H'	J'
A/1	25 m	SCW *(Udotea petiolata)*	70	811	4.51	.74
A/2	15 m	HP *(Cystoseira spinosa)*	66	1934	4.03	.67
B/1	12 m	HP *(Cystoseira spinosa)*	47	444	4.08	.73
B/2	6 m	SCW *(Peyssonnelia squamaria)*	33	122	4.35	.86
C/1	25 m	HP *(Cystoseira spinosa)*	39	265	3.96	.75
C/2	20 m	HP *(Cystoseira spinosa)*	63	619	4.61	.77
C/3	12 m	PCW *(Stypocaulon scoparium)*	55	4592	2.04	.35
C/4	1 m	PEW *(Corallina elongata + Asparagopsis armata)*	38	1273	3.35	.64
D/1	18 m	PCW *(Stypocaulon scoparium)*	42	843	3.13	.58
D/2	7 m	PCW *(Stypocaulon scoparium)*	35	1124	2.7	.53
D/3	0 m	PEW *(Cystoseira tamariscifolia)*	20	233	3.14	.73
E/1	1 m	PCW *(Stypocaulon scoparium)*	59	1418	4.04	.69
F/1	8 m	PCW (Mixed facies of photophilic algae)	91	3385	3.52	.54
F/2	6 m	SCW *(Udotea petiolata)*	56	1236	3.42	.59
G/1	25 m	HP *(Halopteris filicina)*	55	498	4.3	.74
G/2	10 m	PCW *(Stypocaulon scoparium)*	46	920	3.8	.69
G/3	0.5 m	PEW *(Corallina elongata)*	39	4707	0.87	.16
H/1	8 m	SCW *(Peyssonnelia squamaria)*	50	738	4	.71
H/2	0.5 m	PEW *(Cystoseira tamariscifolia)*	35	1002	3.68	.72
I/1	0.5 m	PEW *(Laurencia obtusa + Asparagopsis armata)*	59	2908	3.73	.63
J/2	0 m	PEW *(Corallina elongata)*	32	1252	3.17	.63
J/3	0 m	PEW *(Cystoseira tamariscifolia)*	43	1206	3.25	.60
K/1	12 m	HP *(Cystoseira spinosa)*	36	321	3.68	.71
K/2	0.5 m	PEW *(Laurencia obtusa + Asparagopsis armata)*	35	958	3.87	.75
K/3	0 m	PEW *(Corallina elongata)*	34	2866	3.39	.66
L/1	6 m	PCW *(Stypocaulon scoparium)*	28	222	3.74	.78
L/2	0.5 m	PEW *(Laurencia obtusa + Asparagopsis armata)*	48	1009	4.02	. 7 2
M/1	0.5 m	PEW *(Laurencia obtusa)*	31	332	3.04	.61
N/1	12 m	HP *(Cystoseira spinosa)*	67	841	4.55	.75
N/2	6 m	PCW *(Stypocaulon scoparium)*	42	434	3.87	.72
0/1	3 m	SCW *(Udotea petiolata)*	71	1522	4.53	.74

HP: Hemiphotophilic Algae. PCW: Photophilic Algae in Calm Waters. PEW: Photophilic Algae in Exposed Waters. SCW: Sciaphilic Algae in Calm Waters.

HP : Algues Semi-photophiles. PCW : Algues Photophiles en Mode Calme. PEW : Algues Photophiles en Mode Agité. SCW : Algues Sciaphiles en Mode Calme.

1999). *Eunice* cf. *cariboea* Grube, 1856 and *Polydora socialis* (Schmarda, 1861) were first recorded from the Mediterranean Sea while *Platynereis nadiae* Abbiati & Castelli, 1992 and *Demonax langerhansi* Knight-Jones, 1983 are new records for the Spanish and Morocco fauna.

A one-way ANOSIM test was computed from the similarity matrix data. It confirmed that the samples from the four algal community showed statistically significant differences with respect to their polychaete faunal composition (R= 0.49; $p < 0.1\%$).

The result of the MDS ordination is shown in figure 2. The analysis stress is not high (0.16), so it can be considered to be very reliable. The sample points form a large unique group, showing that differences in faunal composition are slight, and only sample B/2 is somewhat isolated from the remainder. However, a pattern of differentiation in communities is recognizable. Samples taken from the PEW community occur on the left side of the ordination model, those from the PCW community are located centrally, and those from HP and SCW communities occupy positions on the right. Samples D/1 and F/1 are the only exceptions. Both belong to the PCW community and are placed with those from the HP and SCW communities, in the upper-right part of plot.

Polychaete diversity (H'), evenness (J') and species richness (SpR) were calculated for each sample (tab. 1) and mean values were computed for every assemblage (tab. 2).

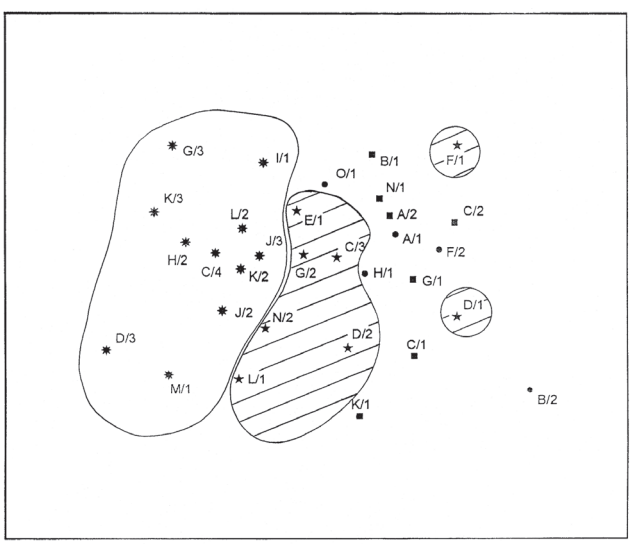

Figure 2. Results of Multi-Dimensional Scaling analysis (✷: PEW, Photophilic Algae in Exposed Waters. ★: PCW, Photophilic Algae in Calm Waters. ●: SCW, Sciaphilic Algae in Calm Waters. ■: HP, Hemiphotophilic Algae).

Figure 2. Résultats de l'analyse MDS (Multi-Dimensional Scaling). (✷ : PEW, Algues Photophiles en Mode Agité. ★ : PCW, Algues Photophiles en Mode Calme. ● : SCW, Algues Sciaphiles en Mode Calme. ■ : HP, Algues Semi-photophiles).

Table 2. Faunistic assemblage characterization in the four communities studied (PEW: Photophilic Algae in Exposed Waters, PCW: Photophilic Algae in Calm Waters, SCW: Sciaphilic Algae in Calm Waters, HP: Hemiphotophilic Algae). H': Shannon diversity index. J': Pielou evenness index. SpR: Species richness.

Tableau 2. Caractérisation faunistique des peuplements dans les quatre communautés étudiées (PEW : Algues Photophiles en Mode Agité, PCW : Algues Photophiles en Mode Calme, SCW : Algues Sciaphiles en Mode Calme, HP : Algues Semi-photophiles). H' : indice de Shannon. J : indice de Pielou. SpR : richesse spécifique.

	PEW	PCW	SCW	HP
H'	3.23 (±0.84 S.D.)	3.39 (± 0.74 S.D.)	4.16 (±0.47 S.D.)	4.04 (±0.48 S.D.)
J'	0.62 (±0.16 S.D.)	0.61 (± 0.15 S.D.)	0.72 (±0.09 S.D.)	0.71 (±0.06 S.D.)
SpR	37.6 (±10.04 S.D.)	50.85 (± 20.7 S.D)	56 (±15.7 S.D.)	44.37 (±20.4 S.D.)

It is noteworthy that both SCW and HP show not only higher evenness values but also lower S.D. values than PEW or PCW.

The main results of the relative frequency analysis are presented in table 3, where constant species are recorded. In the Chafarinas Islands, 40 species are constant in at least one community; of these, 11 are constant in all communities. The SCW community type is the best characterized on the basis of its dominant species (13 species are constant exclusively in this community), followed by the HP (5 species) and PEW (4 species) communities. The community with the poorest characterization is PCW, which has no exclusive constant species. SCW and HP communities share the highest number of constant species (16), although only two of these (*Syllidia armata* and *Sphaerosyllis taylori*) are exclusive, as constant species, to this pair of communities. Three other species (*Sphaerosyllis austriaca*, *Polyophthalmus pictus*, and *Amphicorina armandi*) are constant in this pair of communities and in PCW, but not in PEW. It may be pointed out that with respect to constant species, the PCW community seems to be more similar to SCW or HP communities than to PEW communities.

Similarly, 9 species are dominant in the four communities (tab. 3, in bold) while 25 species are dominant in at least one community. Dominant species are not always constant. Thus, the cases of *Janua pseudocorrugata* (which shows high abundance values in PEW and PCW communities, but is not constant) and *Protoaricia oerstedi* (the same for PEW) are of particular note. PEW is the best-characterized community type, with five species that are dominant exclusively in this community. Furthermore, six species dominant in the four studied communities have dominance values in PEW that clearly differ from those in the other communities, especially in SCW and HP: *Grubeosyllis vieitezi*, *Sphaerosyllis austriaca*, and *Syllis prolifera* have much higher dominance values, while *Exogone naidina*, *Sphaerosyllis hystrix*, and *Sphaerosyllis*

Table 3. List of dominant and/or constant species in each community. Numbers express dominant abundances; constant species are indicated with *.

Tableau 3. Liste des espèces dominantes et/ou constantes dans chaque communauté. Les nombres expriment les dominances; * indique les espèces constantes.

	Communities				Tr. Guild
	PEW	PCW	SCW	HP	
Amphicorina armandi (Claparède, 1864)	3.2	5.6*	12.6*	6.5*	FTF
Amphicorina eimeri eimeri (Langerhans, 1880)	1.3		1.2		FTF
Amphiglena mediterranea Leydig, 1851	6.4*	3.5*	7.4*	4.4*	FTF
Autolytus edwarsi Saint-Joseph, 1887	*				CNV
Autolytus quindecimdentatus Langerhans, 1884	*	*	*	*	OMN
Brania pusilla (Dujardin, 1839)	*		1.5		OMN
Chrysopetalum debile (Grube, 1855)				*	CNV
Ehlersia ferrugina Langerhans, 1881			*		CNV
Eurysyllis tuberculata Ehlers, 1864				*	CNV
Exogone naidina Oersted, 1845	2.4*	22.3*	19.5*	30.2*	OMN
Exogone verugera Claparède, 1868			*		OMN
Fabricia sabella (Ehrenberg, 1836)			*		FTF
Fabriciola tonerella Banse, 1959			1.8*		FTF
Filograna implexa Berkeley, 1828			*		FTF
Grubeosyllis clavata (Claparède, 1868)	3.0*	4.1*	2.6*	6.7*	OMN
Grubeosyllis limbata (Claparède, 1868)	1.3*	*	3.9*	5.9*	OMN
Grubeosyllis vieitezi (San Martín, 1984)	7.7*	2.3*	2.5*	2.9*	OMN
Haplosyllis spongicola (Grube, 1855)			*		CNV
Janua pseudocorrugata (Bush, 1904)	26.7	25.0			FTF
Josephella marenzelleri Caullery & Mesnil, 1896			1.7*		FTF
Lumbrineris funchalensis (Kinberg, 1855)	*			*	OMN
Micromaldane ornitochaeta Mesnil, 1897			*		SSF
Micronereis variegata Claparède, 1864				*	CNV
Nereis funchalensis (Langerhans, 1880)	3.6*				OMN
Nicolea venustula (Montagu, 1818)					SDF
Odontosyllis ctenostoma Claparède, 1868			*		CNV
Odontosyllis fulgurans (Audouin & M. Edwards, 1863)			*		CNV
Odontosyllis gibba Claparède, 1863				*	CNV
Perinereis cultrifera (Grube, 1840)	1.9				HBV
Pionosyllis lamelligera Saint-Joseph, 1856			4.6*	1.7*	SDF
Pionosyllis pulligera (Krohn, 1852)	1.1*	1.7*	*	2.2*	CNV
Platynereis dumerilii (Audouin & M. Edwards, 1833)	2.4*	5.0*	*	4.9*	HBV
Polyophthalmus pictus (Dujardin, 1839)		*	1.1*	4.9*	OMN
Protoaricia oerstedi (Claparède, 1864)	3.9				SSF
Sphaerosyllis austriaca Banse, 1959	4.2	1.1*	1.3*	1.7*	HBV
Sphaerosyllis hystrix Claparède, 1863	2.3*	3.2*	6.9*	7.5*	HBV
Sphaerosyllis pirifera Claparède, 1868	1.2*	5.0*	10.0*	9.9*	HBV
Sphaerosyllis taylori Perkins, 1981			*	*	HBV
Syllidia armata Quatrefages, 1865			*	1.8*	CNV
Syllis columbretensis (Campoy, 1982)	1.1*		*		HBV
Syllis compacta Gravier, 1900	1.1				CNV
Syllis gracilis Grube, 1840	*				HBV
Syllis prolifera Krohn, 1852	16.8*	3.0*	3.2*	3.6*	OMN
Syllis variegata Grube, 1870			*		SDF
Trypanosyllis coeliaca Claparède, 1868			*		CNV

Tr. Guild: Trophic Guild. CNV: Carnivores. FTF: filter-feeders. HBV: Herbivores. OMN: Omnivores. SDF: Surface deposit-feeders. SSF: sub-surface deposit-feeders.

Tr. Guild: Groupe trophique. CNV : carnivores. FTF : filtreurs. HBV : herbivores. OMN : omnivores. SDF : déposivores de surface. SSF : déposivores de sub-surface.

pirifera have clearly lower ones. Three species are dominant exclusively in SCW and one in HP, whereas PCW has no exclusive dominant species. In qualitative terms of dominant species, the PCW community is more similar to PEW than to any other community, and HP and SCW are the most similar pair of community types (13 shared species).

Summarizing data on relative frequency and dominance, the polychaete assemblages belonging to each algal community can be characterized by means of the species that, besides being constant, have high dominance values or are dominant exclusively in this particular community. Thus, the characteristic polychaete species of PEW are *Syllis prolifera* (dominance value 16.8), *Grubeosyllis vieitezi* (7.7), *Amphiglena mediterranea* (6.4), *Nereis funchalensis* (3.6), *Grubeosyllis clavata* (3), and *Perinereis cultrifera* (1.9). The PCW assemblage is characterized by *Exogone naidina* (dominance value 21), *Amphicorina armandi* (5.3), *Platynereis dumerilii* (4.7), *Sphaerosyllis pirifera* (4.7), *Grubeosyllis clavata* (3.9), *Amphiglena mediterranea* (3.3), and *Sphaerosyllis hystrix* (3), while the SCW assemblage is characterized by *Exogone naidina* (dominance value 19.6), *Amphicorina armandi* (12.6), *Sphaerosyllis pirifera* (10.0), *Amphiglena mediterranea* (7.4), *Sphaerosyllis hystrix* (7), *Pionosyllis lamelligera* (4.9), *Grubeosyllis limbata* (3.7), *Syllis prolifera* (3.2), *Fabriciola tonerella* (1.8), and *Josephella marenzelleri* (1.7). Finally, the assemblage from HP is characterized by *Exogone naidina* (dominance value 30.2), *Sphaerosyllis pirifera* (10.0), *Sphaerosyllis hystrix* (7.5), *Grubeosyllis clavata* (6.7), *Amphicorina armandi* (6.5), *Grubeosyllis limbata* (5.9), *Platynereis dumerilii* (4.9), *Polyophthalmus pictus* (4.9), *Amphiglena mediterranea* (4.4), *Syllis prolifera* (3.6), and *Syllidia armata* (1.8).

The results of the trophic guild analysis are shown in figure 3. Proportions of carnivores (ranging from 4.1% in PEW to 7.6% in HP) and herbivores (from 14.8% in PEW to 22.2% in HP) vary little and are always moderate. Proportions of surface deposit-feeders (from 0.8% in PEW to 6.9% in SCW) and sub-surface deposit-feeders (from 0.4% in HP to 4.1% in PEW) vary from low to moderate. The largest variations occur in filter-feeders (from 14.3% in HP to 38.7% in PEW) and omnivores (from 36.5% in SCW to 49.6% in HP).

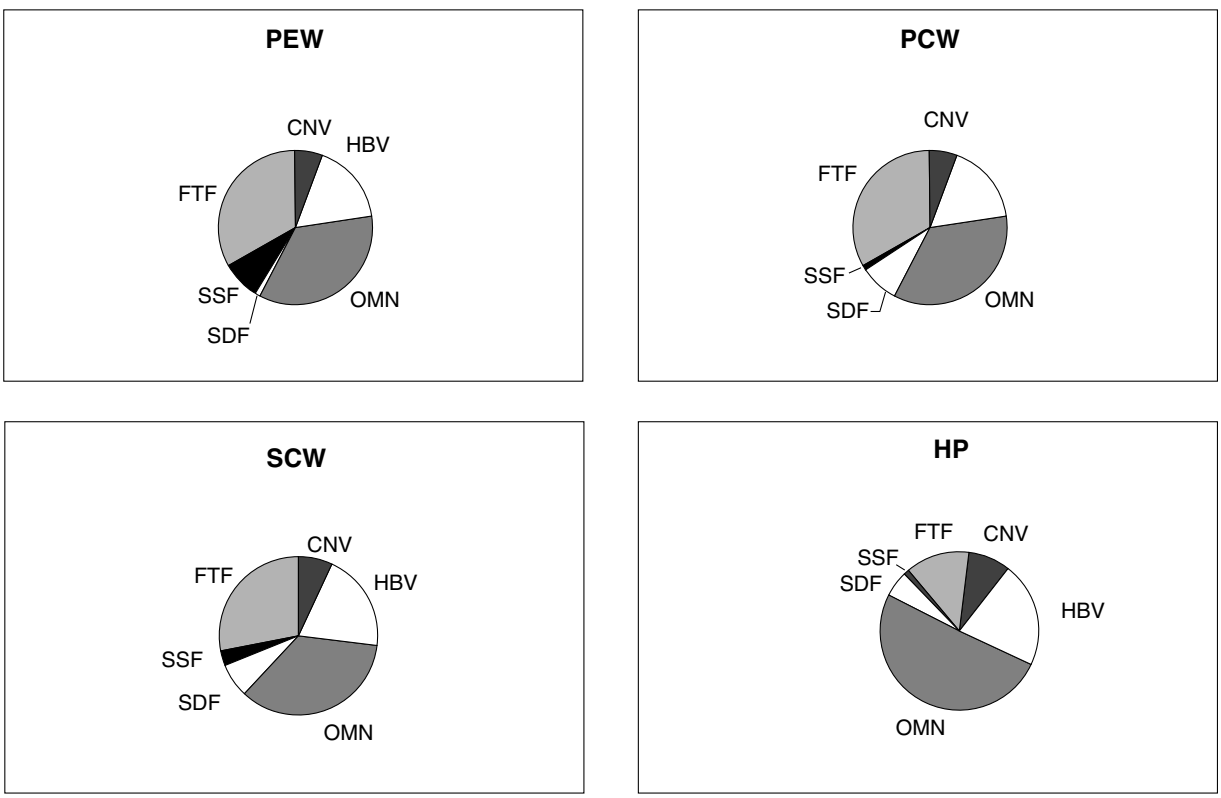

Figure 3. Relative proportion of the trophic guilds of polychaetes in the four communities studied (PEW, PCW, SCW, HP, as in Figure 2). CNV: Carnivores. FTF: filter-feeders. HBV: Herbivores. OMN: Omnivores. SDF: Surface deposit-feeders. SSF: sub-surface deposit feeders.

Figure 3. Proportion relative des groupes trophiques dans les quatre communautés étudiées (PEW, PCW, SCW, HP, comme dans la Figure 2). CNV : carnivores. FTF : filtreurs. HBV : herbivores. OMN : omnivores. SDF : déposivores de surface. SSF : déposivores de sub-surface.

Discussion and conclusions

Several authors (Abbiati et al., 1987; Sardá, 1991) have found clear correlations between algal communities and polychaete assemblages. Some of them consider polychaetes to be good "effective descriptors" of benthic communities (Abbiati et al., 1987) though Giangrande (1988) acknowledged the difficulty of characterizing algal communities by their polychaete fauna.

In our study, ANOSIM analysis reveals significant differences on polychaete assemblages in each algal community. However, sample point arrangement in MDS analysis suggests a gradual change of faunal composition, without sharp differences between assemblages, as mentioned by Giangrande (1988). There are no isolated groups and only PEW is clearly characterized on the plot, as all the samples belonging to this community are gathered on the left hand side of the graph. Samples from PCW are located centrally and those from SCW and HP occur together on the right hand side, showing that polychaete assemblages from these last two communities are very similar. Moreover, the arrangement of sample points suggests the existence of an ecological gradient where polychaete assemblages from PEW lie at one extreme and those from SCW and HP lie at the other, while polychaete fauna from PCW plays a transitional assemblage role.

The faunistic characterization of the four assemblages is consistent with this idea. The assemblage from PEW is clearly different from all other assemblages in terms of constant and dominant species, from both quantitative and qualitative point of view. The assemblages from SCW and HP have quite similar faunal characterizations. On the other hand, that from PCW is more similar to those from SCW and HP on the basis of constant and characteristic species but is closer to PEW in a qualitative consideration of the dominant species. The gradient is apparent from the variation in diversity (H') and, to a lesser extent, in evenness (J') indices, but not from species richness values. The proportional variation of most trophic guilds (omnivores and sub-surface deposit-feeders are the exceptions) is also consistent with the existence of this gradient, especially in the case of filter-feeders.

A few samples do not follow this pattern. Sample B/2 is the only one where *Miscellania dentata* was recorded and this could explain its isolated position on the plot, owing to the relatively high abundance of the species (14 specimens). The position of sample D/1 can be explained by its collection at a much greater depth than is usual for this community in the Chafarinas Islands; this may be due to the southern orientation of the sampling station and its subsequently greater light exposure. Sample F/1 was the only one collected from a mixed facies of algae and animal substrata, so some differences in polychaete fauna might be expected.

The factors that govern this ecological gradient were not clearly identified. Two possibilities may be mentioned: light, as in the model proposed by Pérès & Picard (1964), and/or wave and hydrodynamic exposure, as proposed by Riedl (1964). Both factors attain maximum values in PEW (very close to a depth of 0 m and where low sedimentation was observed) and minimum values in SCW (in very sheltered environments, such as caves and shady surfaces, irrespective of depth) and HP (close to circalittoral stage, where light penetration and hydrodynamics are restricted by depth and greater sedimentation is observed). However, we lack quantitative measurements of both factors to be able to determine which is the most important variable.

Some authors (Bellan, 1969; Sarà et al., 1978; Fresi et al., 1983; 1984; Boero & Fresi, 1986) consider hydrodynamics to be the most important physico-chemical variable determining epifaunal assemblages on Mediterranean hard bottoms. There is evidence to support this hypothesis from the Chafarinas Islands. Sample D/1, from a PCW community, was collected from a location where this community occurred at greater depths than usual as, due to its southerly orientation, it received more exposure to light. However, its polychaete fauna is more similar to that from the HP or SCW communities (fig. 2), suggesting that the distribution of polychaetes can be somewhat independent of light exposure. The progressive decrease of the proportion of filter-feeders (maximal on PEW and minimal on HP) and their replacement by an increasing number of surface deposit-feeders (minimal on PEW and maximal on SCW) may be related to the decrease in wave exposure and the subsequent increase of sedimentation rate. The most likely explanation is that of Abbiati et al. (1987) and Giangrande (1988), who proposed that both wave exposure and sedimentation rate act together indirectly on benthic animal populations, affecting the phytal canopy qualitatively and quantitatively. This makes the assessment of the role of each variable difficult.

Some authors have characterized polychaete fauna from PEW, PCW (Abbiati et al., 1987; Sardá, 1991), and SCW (Sardá, 1991) communities attending to the diversity, evenness and species richness. They found similar diversity values (differing from ours by less than 0.5). Evenness values given by Sardá are even closer for PEW and SCW but are clearly lower for PCW (0.35 vs 0.61). Species richness values for the Chafarinas Islands are similar to those given by these authors for PEW, similar to those given by Abbiati et al. for PCW and clearly higher than those given by Sardá for SCW (56 vs 37.7).

From the point of view of the characteristic species, PCW and PEW assemblages are consistent with other published studies. Thus, four of the six characteristic species of PEW assemblage, *Syllis prolifera*, *Amphiglena mediterranea*, *Grubeosyllis clavata*, and *Perinereis*

cultrifera and five of the seven characteristic species of the PCW assemblage, *Exogone naidina*, *Amphicorina armandi*, *Amphiglena mediterranea*, *Sphaerosyllis hystrix*, and *Grubeosyllis clavata*, had already been recorded as being characteristic of these assemblages (Bellan, 1964; 1969; Kokatas, 1976; Abbiati et al., 1987; Giangrande, 1988; Sardá, 1991). The greatest differences were found in the assemblage from the SCW community, in which the only species previously recorded as dominant is *Pionosyllis lamelligera* (Sardá, 1991).

The study of trophic guilds within each assemblage reveals little consistency between our data and that of other authors. Abbiati et al. (1987) found a much higher proportion of carnivores and lower proportions of filter-feeders and omnivores in PEW and PCW communities, and a higher proportion of herbivores in PEW communities. There are also clear differences with Sardá's (1991) data. He found that proportions of filter-feeders were lower in PEW communities, that proportions of omnivores and herbivores were lower in PCW and SCW communities, and that proportions of carnivores were much higher in PCW, PEW and SCW communities. It must be noted that some of these inconsistencies are difficult to evaluate, since they may be caused by the different size of samples and by the inclusion of the same species in different trophic guilds. The trophic strategies of polychaetes are still far from completely known, and this is especially problematical in the case of syllids. For example, Abbiati et al. (1987) included all exogoninae species, except those belonging to the genus *Sphaerosyllis*, within the carnivore guild. In the present study, they are considered to be omnivores, in accordance with recent studies (Sardá, 1991), and this affects more than 10,000 of our specimens. This is also the case of several species of *Syllis* which are herein considered omnivores or herbivores (Giangrande, pers. com.) instead of carnivores, as of customary.

Annexe. List of non-dominant and non-constant species with their trophic guilds.Tr. Guild: Trophic Guild (Abbreviations as in Table 3).

Annexe. Liste des espèces non-dominantes et non-constantes et indication sur leur groupe trophique. Tr. Guild: Groupe trophique (abréviations, voir tableau 3).

Species	Tr. Guild
Amblyosyllis dorsigera Claparède, 1864	CNV
Amblyosyllis inmatura Langerhans, 1879	CNV
Amblyosyllis madeirensis Langerhans, 1879	CNV
Amphicorina triangulata López & Tena, 1999	FTF
Aphelochaeta cf. *marioni* (Saint-Joseph, 1894)	SDF
Arabella iricolor (Montagu, 1804)	OMN
Autolytus benazzi Cognetti, 1953	CNV
Autolytus brachycephalus (Marenzeller, 1874)	CNV
Autolytus convolutus Cognetti, 1953	CNV
Autolytus sardai Alós, 1988	CNV
Branchiomaldane vincenti Langerhans, 1881	SSF
Branchiomma bombyx (Dalyell, 1853)	FTF
Branchiomma lucullana (Delle Chiaje, 1828)	FTF
Branchiosyllis exilis Ehlers, 1887	CNV
Brania arminii Langerhans, 1880	OMN
Capitomastus minimus (Langerhans, 1880)	SSF
Caulleriella alata (Southern, 1914)	SDF
Caulleriella bioculata (Keferstein, 1862)	SDF
Ceratonereis costae (Grube, 1840)	OMN
Chaetopterus variopedatus Reiner, 1804	FTF
Chone duneri Malmgren, 1867	FTF
Chone filicaudata Southern, 1914	FTF
Cirratulus cirratus (Müller, 1776)	SDF
Cirriformia tentaculata (Montagu, 1808)	SDF
Ctenodrilus serratus (Schmidt, 1857)	SDF
Dasybranchus gajolae Eisig, 1887	SSF
Dasybranchus sp.	SSF
Demonax brachychona (Claparède, 1870)	FTF
Demonax langerhansi Knight-Jones, 1983	FTF
Dodecaceria concharum Oersted, 1843	SDF
Dorvillea rubrovittata (Grube, 1855)	OMN
Ephesiella abysorum (Hansen, 1878)	SDF
Eulalia viridis (Linnaeus, 1767)	CNV
Eumida sanguinea (Oersted, 1843)	CNV
Eunice cf. *cariboea* Grube, 1856	OMN
Eunice harassii Audouin & M. Edwards, 1833	OMN
Eunice purpurea Grube, 1866	OMN
Eunice vittata (Delle Chiaje, 1828)	OMN
Euphrosine foliosa Audouin & M. Edwards, 1834	CNV
Eupolymnia nebulosa (Montagu, 1818)	SDF
Eusyllis assimilis Marenzeller, 1875	SDF
Eusyllis lamelligera Marion & Bobretzky, 1875	SDF
Exogone gambiae Lanera, Sordino & San Martín, 1994	OMN
Exogone rostrata Neville, 1933	OMN
Glycera tesselata Grube, 1863	CNV
Grubeosyllis euritmica (Sardà, 1984)	OMN
Harmothoe spinifera (Ehlers, 1864)	CNV
Hesione splendida Savigny, 1818	CNV
Hesiospina similis (Hessle, 1925)	CNV
Hydroides nigra Zibrowius, 1971	FTF
Hydroides pseudouncinata Zibrowius, 1971	FTF
Janua pagenstecheri (Quatrefages, 1865)	FTF
Jasmineira elegans Saint-Joseph, 1894	FTF
Lepidonotus clava (Montagu, 1808)	CNV
Lumbrineris coccinea (Reiner, 1804)	OMN
Lumbrineris gracilis (Ehlers, 1868)	OMN
Lumbrineris latreilli Audouin & M. Edwards, 1834	OMN
Marphysa fallax (Marion & Bobretzky, 1875)	OMN
Miscellania dentata Martín, Alós & Sardà, 1990	CNV
Myrianida pinnigera (Montagu, 1808)	CNV
Myxicola aesthetica Claparède, 1870	FTF
Nainereis laevigata (Grube, 1855)	SSF

Nematonereis unicornis (Grube, 1840)	OMN
Nereiphylla pusilla (Claparède, 1870)	CNV
Nereiphylla rubiginosa (Saint-Joseph, 1888)	CNV
Nereis rava Ehlers, 1868	OMN
Nereis zonata Malmgren, 1867	OMN
Notomastus cf. *lineatus* Claparède, 1868	SSF
Octobranchus lingulatus (Grube, 1863)	SDF
Opisthosyllis brunnea Langerhans, 1879	CNV
Paleanotus chrysolepis Schmarda, 1861	CNV
Palola siciliensis (Grube, 1840)	OMN
Parapionosyllis brevicirra (Day, 1954)	CNV
Pholoe synophthalmica Claparède, 1868	CNV
Phyllodoce madeirensis Langerhans, 1880	CNV
Phyllodoce mucosa Oersted, 1843	CNV
Pileolaria militaris Claparède, 1860	FTF
Pionosyllis longocirrata Saint-Joseph, 1886	CNV
Pionosyllis serratisetosa López, S. Martin & Jiménez,1996	CNV
Pista cristata (Müller, 1776)	SDF
Platynereis nadiae Abbiati & Castelli, 1992	HBV
Podarke pallida Claparède, 1864	CNV
Polycirrus aurantiacus Grube, 1860	SDF
Polydora armata Langerhans, 1880	SDF
Polydora caeca (Oersted, 1843)	SDF
Polydora ciliata (Johnston, 1838)	SDF
Polydora quadrilobata Jacobi, 1833	SDF
Polydora socialis (Schmarda, 1861)	SDF
Prionospio multibranchiata Berkeley & Berkeley, 1927	SDF
Proceraea aurantiaca Claparède, 1868	CNV
Proceraea picta Ehlers, 1864	CNV
Protolaespira striata Quiévreux, 1963	FTF
Pseudomystides limbata (Saint-Joseph, 1888)	HBV
Pseudosyllis brevipennis Grube, 1863	CNV
Pterocirrus macroceros (Grube, 1860)	CNV
Sabella pavonina Savigny, 1822	FTF
Sabellaria alcocki Gravier, 1906	FTF
Sclerocheilus minutus (Grube, 1863)	SSF
Semivermilia cribrata (O.G. Costa, 1861)	FTF
Serpula concharum Langerhans, 1880	FTF
Serpula vermicularis Linnaeus, 1767	FTF
Sphaerodorium claparedii (Greeff, 1866)	SDF
Sphaerosyllis campoyi S. Martín, Acero, Contonente & Gómez, 1982	HBV
Sphaerosyllis cryptica Ben-Eliahu, 1977	HBV
Sphaerosyllis xarifae Hartmann-Schröder, 1960	HBV
Spirobranchus polytrema (Filippi, 1844)	FTF
Subadyte pellucida (Ehlers, 1864)	CNV
Syllides edentatus (Westheide, 1974)	CNV
Syllides fulvus (Marion & Bobretzky, 1875)	SDF
Syllis armillaris Müller, 1776	HBV
Syllis beneliahui (Campoy & Alquézar, 1982)	CNV
Syllis corallicola Verrill, 1900	HBV
Syllis ferrani Alós & San Martín, 1987	CNV
Syllis garciai (Campoy, 1982)	OMN
Syllis gerlachi (Hartmann-Schröder, 1960)	CNV
Syllis hyalina Grube, 1863	OMN
Syllis krohni Ehlers, 1864	OMN
Syllis lutea (Hartmann-Schröder, 1960)	SDF
Syllis schulzi (Hartmann-Schröder, 1960)	CNV
Syllis truncata cryptica Ben-Eliahu, 1977	OMN
Syllis vittata Grube, 1840	CNV
Syllis westheidei San Martín, 1984	CNV
Terebella lapidaria Linnaeus,1767	SDF
Thelepus cincinnatus Fabricius, 1780	SDF
Trypanosyllis aeolis Langerhans, 1879	CNV
Trypanosyllis sp.	CNV
Trypanosyllis zebra (Grube, 1860)	SDF
Umbellisyllis clavata (Langerhans, 1879)	CNV
Vermiliopsis striaticeps (Grube, 1862)	FTF
Websterinereis glauca (Claparède, 1870)	OMN
Xenosyllis scabra (Ehlers, 1864)	CNV

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