



Epibiotic and endobiotic polychaetes of *Geodia cydonium* (Porifera, Demospongiae) from the Mediterranean Sea

M. Gherardi, A. Giangrande¹ & G. Corriero

Dipartimento di Zoologia, Via Orabona 4, 70125 Bari, Italy

¹Dipartimento di Biologia, Via Prov.le Lecce-Monteroni, 73100 Lecce, Italy

Received 19 January 2000; in revised form 10 October 2000; accepted 30 October 2000

Key words: polychaetes, Porifera, *Geodia cydonium*, Mediterranean Sea

Abstract

Polychaete assemblages associated to the sponge *Geodia cydonium* were investigated at two sampling sites in the Mediterranean Sea: Porto Cesareo Basin (Apulia) and Marsala Lagoon (Sicily), both characterized by sheltered hydrodynamic conditions. Samples were seasonally performed during 1997, in order to compare the assemblages coming from the two localities studied, considering separately the internal and external tissues of the sponge, and with the aim of evaluating the influence of sponge size on polychaete colonization. The examined sponge is characterized by a peculiar stratification of its tissues: an external thick and hard layer, the cortex, and an internal softer one, the choanosome. Statistical analysis showed that this was the main factor controlling polychaete assemblage, with the internal tissue, less rich and diversified, appearing impoverished with respect to the external layer. A similarity in species composition was observed between sites, even though some differences were evidenced in the abundance of some species, mainly reflecting differences in local environmental conditions. Species richness and density increased with the increasing sponge size. Such a situation is particularly evident at Porto Cesareo, where sponges are covered by an algal layer which is particularly rich on the largest specimens, thus suggesting that most of the species of polychaetes were linked more to the neighbouring environment than to the sponge itself.

Introduction

Sponges represent a complex living space for many associated taxa which can use the sponge as a space for living, or can have a commensal or parasitic habit. Among these, polychaetes are an important component (Santucci, 1922; Pansini, 1970; Dauer, 1973; Rützler, 1976; Amoureux et al., 1980; Pansini & Daglio, 1980; Peattie & Hoare, 1981; Westinga & Hoetjes, 1981; Alos et al., 1982; Koukouras et al., 1985, 1992, 1996; Voultziadou-Koukoura et al., 1987; Ilan et al., 1994; Pascual et al., 1996; Carrera-Parra & Vargas-Hernandez, 1996–1997). However, a large number of polychaete species living on sponges are also common on other substrates. This suggests that the composition of polychaete assemblage associated to sponges is related to the polychaete fauna of the immediate area, more than to the sponge itself (Long, 1968; Peattie & Hoare, 1981; Alos et al., 1982; Koukouras

et al., 1985, 1996). As far as the whole faunal assemblage is concerned, Voultziadou-Koukoura et al. (1987) found no characteristic or exclusive species for *Verongia* (= *Aplysina*) *aerophoba*, defining only 'constant' or 'rare' forms. By contrast, Westinga & Hoetjes (1981) and Koukouras et al. (1985) pointed out that taxa related to several sponges constitute a real 'ecological community' characterized by a quite constant composition, where, however, inter-relationships were still not clear. Among polychaetes, few species seem to be more related to sponges and may be considered associated forms (Martin et al., 1992; Magnino & Gaino, 1998), even though works dealing with the real relationships, through benefits/costs analysis, have never been performed. In a recent review (Martin & Britayev, 1998), many polynoid species are considered typical commensal of the sponges, as well as the species *Potamilla symbiotica*, *Hydroides spongicola*, *Sphinter acuticus*, and some spionids and

syllids, while the species *Dorvillea sociabilis*, *Bran-chiosyllis exilis*, *B. oculata*, *Haplosyllis spongicola* and *Boccardia androgyna* are considered parasitic forms having some morphological adaptations to the life inside the sponge. Tsurumi & Reiswig (1997) analyzing the relationship between *H. spongicola* and *Aplysina cauliformis* suggested that a coupling of partner reproductive patterns could be an indication of the kind of association. They defined this polychaete as having a quite benign parasitic/micropredatory action, but the real impact of its removing host biomass remained unknown. Finally, some species of *Exogone* have also been found feeding on host sponge as well, suggesting that, also within the genus *Exogone*, the relationship could be occasionally parasitic (Pascual et al., 1996).

The present work deals with a quantitative study of the polychaetes associated to the Atlantic-Mediterranean demosponge *Geodia cydonium* (Jameson), a species characterized by a peculiar well developed cortical layer which maintains separate the choanosomal body from the external environment. Polychaetes associated to *G. cydonium* were already investigated by Santucci (1922) and Koukouras et al. (1985) for North Adriatic and Aegean Sea, respectively.

In particular, the purpose of this work was to compare polychaete assemblages of *G. cydonium* coming from two different localities of the Mediterranean Sea, considering separately the internal and external tissues of the sponge and to evaluate the influence of sponge size on polychaete colonization.

Description of sites studied

Marsala Lagoon (see Fig. 1) (NW Sicily, 37° 14' N; 12° 40' E) covers an area of 20 km², with a depth ranging between 0.2 and 2.5 m (Magazzù, 1977). It is characterized by a high water exchange with the sea, mainly through the southern opening, which reduces the thermohaline oscillations. However, the presence of 'reefs' of *Posidonia oceanica* (L.) Delile (Calvo & Fradà Orestano, 1984) greatly decreases the wave action even in the outermost part of the lagoon (Corriero, 1989). Hard substrates, mainly represented by algal or animal calcareous concretions and by the rhizomes of *P. oceanica*, are very scant. Sponges represent a heavy component of the macrozoobenthos, being represented by 43 species and high biomass values (Corriero, 1990).

Porto Cesareo is a smaller basin (SW Apulia, 40° 15' N; 17° 54' E) (see Fig. 1) covering an area of about 2 km², with a maximum depth of 2.5 m (Passeri, 1974). The basin is connected to the sea through a channel system that allows a considerable inflow of sea water. The water movement within the basin, however, is significantly lower than in the open sea (Corriero, 1990). The bottom of the basin is primarily constituted by mixed sands, but calcareous boardings, rocks and pebbles are also present. Thirty-two species of sponges occur in the basin, with high cover values (Corriero et al., 1996).

Materials and methods

Species studied

Geodia cydonium (Jameson, 1811) is a well known Atlantic-Mediterranean demosponge, very common in sciaphilous environments (Uriz, 1981). At both the study sites, rich populations of large specimens occur (Corriero, 1990; Mercurio et al., 1997a, b), but with different morphology: irregularly globose at Marsala and flattened/massive at Porto Cesareo. In Marsala Lagoon, *G. cydonium* primarily settles on *P. oceanica* rhizomes at depth ranging between 0.5 and 2 m (Corriero, 1990) and its surface results covered by a thin layer of sediment. In Porto Cesareo Basin, the species mainly settles on rocky calcareous substrates at a depth of 1–2 m in the middle part of the basin where, together with a thick layer of sediment, a dense frondose algal covering also occurs on its surface (Corriero et al., 1984; Mercurio et al., 1997a, b). As previously mentioned, this species is characterized by a peculiar stratification of its tissues. A thick external coriaceous tissue called cortex, and a more protected and soft internal tissue called choanosome. The sponge is also characterized by very large aquiferous canals. The cortex is always thinner than the choanosome and the cortex/choanosome rate decreases with the increasing sponge size.

Sampling protocol

Data collection was limited to areas and substrates where the species had been observed during previous research (Corriero et al., 1984; Corriero, 1989; Corriero, 1990; Mercurio et al., 1997a, b). Samples of *G. cydonium* were performed using SCUBA equipment, by scraping off the specimens from the substrate, after cleaning roughly the surface from macroalgal

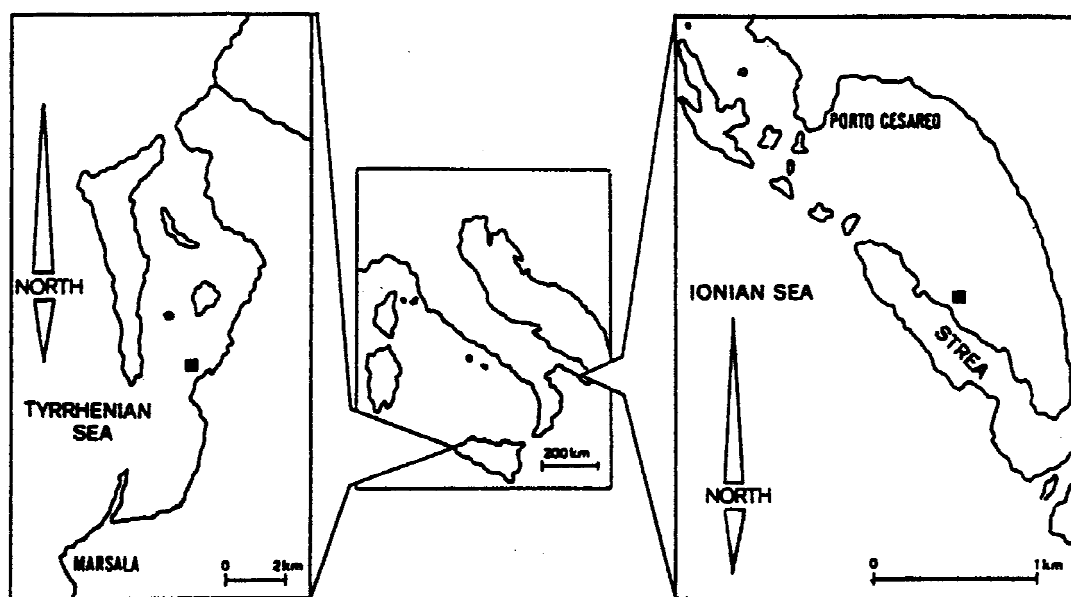


Figure 1. Map of the study area.

Table 1. Cortical and choanosomal volumes (ml) of *Geodia cydonium* relative to the sampling period

		Winter	Spring	Summer	Autumn
Porto Cesareo	cortex	420	340	385	380
	choanosome	630	565	690	705
Marsala	cortex	407	395	360	390
	choanosome	745	675	620	800

cover. At both sites (Marsala and Porto Cesareo), samples were collected with seasonal frequency (January, April, June and October, 1997). Each sample consisted in a variable number of specimens of different size, to be selected after volume measurement. After collection, the specimens were dissected to separate cortex from choanosome. The obtained fragments were enveloped with a plastic film for volume estimation, carried out by dipping them into a water-containing graduated beaker. Volume estimation allowed us to choose three individuals of sponge among the collected ones, corresponding to three sizes defined as small (mean volumes of cortical and choanosomal layers: 53.7 ± 24.9 ml and 53.7 ± 46.1 ml, respectively, at Porto Cesareo; 71.7 ± 22.5 ml and 86.2 ± 24.3 ml at Marsala), medium (103.7 ± 53.7 ml and 155 ± 84.7 ml at Porto Cesareo; 107.5 ± 46.6 ml and 246.2 ± 93.4 ml at Marsala) and large (232.5 ± 71.3

ml and 438.7 ± 152.9 ml at Porto Cesareo; 208.7 ± 60.9 ml and 377.5 ± 26.3 ml at Marsala). Such size categories were used in order to analyze, for both sites, the influence of sponge size on polychaete colonization. By contrast, size categories were not taken into account in comparing the seasonal differences in polychaete assemblages at each site and between the two sampling sites. The total volume of each seasonal sample is given in Table 1.

Fragments were transported to the laboratory in tanks containing sea water. Extraction of polychaetes from sponge tissues was obtained using the method by Pansini & Daglio (1981), keeping sponges in 1% formaldehyde for about 1 h. Polychaetes came out were isolated by filtering the solution with a mesh of 0.5 mm, and fixed with 4% formaldehyde in sea water. After this first treatment, sponge fragments were also cut under stereomicroscope to separate specimens that remained inside the tissue.

All the fragments were considered for polychaete extraction and no subsamples were performed.

For the most abundant polychaete species, *Exogone dispar* and *Branchiosyllis exilis*, the length from the prostomium segment to the 10th setiger was measured by a stereomicroscope micrometer, to obtain frequency histograms.

Statistical analysis

Quantitative data obtained following the procedure above reported were analysed without transformation, using PRIMER program of Plymouth Marine Laboratory. Classification was performed on Bray–Curtis similarity matrix by using the average linkage clustering technique (Bray & Curtis, 1957). The contribution of individual species to the similarity measure used was examined by R-mode analysis. Diversity was estimated by the Shannon–Weaver index.

Results

Comparison between sites

In total, 6867 individuals belonging to 51 taxa, 42 of which identified at specific level, were collected (see Table 2). The two examined polychaete assemblages showed a qualitative similarity, sharing 64.7% of the species. Species richness and abundance were higher at Porto Cesareo than at Marsala, for both cortical and choanosomal layers. By contrast, at Porto Cesareo, the cortical layer shows a lower diversity index.

Among the 17 families found, the best represented for number of species were at both sites Syllidae, Sabellidae and Nereididae, even though Syllidae were clearly dominant (see Fig. 2). *Exogone dispar* resulted the most abundant species. It was dominant at Porto Cesareo, and one of the most abundant species at Marsala, together with *Branchiosyllis exilis*, *Syllis armillaris* and *S. prolifera*. *E. dispar* is commonly found on deep hard bottoms or in coarse sediments, whilst *B. exilis* is typical of sciaphilous environments, often reported as symbiont of different marine invertebrates (Martin & Britayev, 1998). Other abundant species were: *Syllis prolifera*, *Ceratonereis costae*, *Amphiglena mediterranea*, *Amphicorina armandi*, *Syllis armillaris* and *Grubeosyllis clavata*. *S. armillaris* and *S. variegata*, together with *Pseudosyllides balearica*, were exclusive or more abundant at Marsala, and are typical of sciaphilous environments. By contrast, the species *S. prolifera*, *C. costae*, *A. mediterranea* and *G. clavata*, more typical of photophilous environments, were abundant at Porto Cesareo.

On the whole, most of the collected species are commonly found on hard substrate with rich algal cover, both photophilous and sciaphilous, (Bellan, 1964, 1969, 1980; Bellan-Santini, 1969; Katzmann, 1971; Camp, 1976; Fresi et al., 1983a, b; Desrosiers et al., 1984; Cantone, 1985; Villalba & Vieitez, 1985;

Abbiati, 1987; Sardà-Borroy, 1987; Giangrande, 1988; Somaschini, 1988), or they are interstitial forms such as *Parapionosyllis gestans*. Soft-bottom species such as *Notomastus latericeus*, *Clymenura clipeata*, *Armandia cirrhosa* and *Nainereis laevigata* were especially found at Porto Cesareo, even though in most cases they were represented by few individuals. On the contrary, the species *Pontogenia chrysocoma*, which is considered particularly linked to *Posidonia oceanica*, was exclusively found at Marsala. *Micromaldane ornithochaeta* was found for the first time in the Mediterranean area. This species is reported for hard bottoms, probably living within crevices. However, its taxonomic position is still under investigation.

Several of the collected species, especially Syllidae, are reported to be associated to sponges (Amoureux et al., 1980; Pansini & Daglio, 1980; Alos et al., 1982; Carrera-Parra & Vargas-Hernandez, 1996–1997; Koukouras et al., 1996). In particular *C. costae* seems to be very abundant in different species of sponges, including *G. cydonium* (Santucci, 1922; Koukoura et al., 1985; Voultziadou-Koukoura et al., 1987), and can be defined as ‘constant form’ sensu Voultziadou-Koukoura et al. (1987) and Cinar & Ergen (1998). However, only *B. exilis* and *H. spongicola* were considered strictly associated to sponges and classified as facultative and obligatory parasite, respectively (Martin & Britayev, 1998).

As far as the trophic aspect is concerned, it must be stressed the lack of information on basic biology, especially about Syllidae (Giangrande et al. 2000), which was one of the most represented families. Therefore, only some notes are here reported. Filter-feeders were well represented at both sites, even though by different species, with *A. mediterranea* at Porto Cesareo and *A. armandi* at Marsala. Herbivores, such as *C. costae* and *G. clavata*, and limivores such as *N. latericeus*, *A. cyrrhosa*, *C. clypeata* and *N. laevigata*, were more abundant at Porto Cesareo, whilst detritivores such as *S. variegata* and *P. balearica* were linked to Marsala. Finally, *S. prolifera*, which can be classified as omnivore (Giangrande et al., 2000), was abundant at both sites. No data on feeding biology of the most represented species, *E. dispar*, are available, even though preliminary observations seem to indicate that it is not herbivore. Finally, *B. exilis* and *H. spongicola* are considered parasites/micropredators (Martin & Britayev, 1998).

Table 2. List of species found on *Geodia cydonium* (abundance is expressed as annual mean of individuals)

Species	Porto Cesareo				Marsala			
	Cortex		Choanosome		Cortex		Choanosome	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
ORBINIIDAE								
<i>Naineris laevigata</i> (Grube, 1855)			1.00	2.00				
<i>Phylo foetida</i> (Claparède, 1870)	1.00	2.00						
<i>Protoaricia oerstedii</i> (Claparède, 1864)	3.25	3.95			3.75	3.30		
Orbiniidae sp.								
SPIONIDAE								
Spionidae sp.	1.25	2.50						
CIRRATULIDAE								
<i>Dodecaceria concharum</i> Oersted, 1843					1.00	2.00		
CAPITELLIDAE								
Capitellidae sp.	2.00	4.00	0.25	0.50	1.25	1.89		
<i>Notomastus latericeus</i> Sars, 1851			1.00	2.00	2.00	4.00		
MALDANIDAE								
<i>Clymenura clypeata</i> (Saint Joseph, 1894)	2.00	4.00	0.25	0.50				
<i>Micromaldane ornithochaeta</i> Mesnil, 1897	9.25	18.50			16.50	19.12		
OPHELIIDAE								
<i>Armandia cirrhosa</i> (Philippi, 1865)	8.00	10.61	1.00	2.00	3.25	3.59	0.25	0.50
<i>Polyophthalmus pictus</i> (Dujardin, 1839)	1.75	3.50	0.50	0.58	2.25	4.50		
PHYLLODOCIDAE								
Phyllodocidae sp.	7.50	8.70	0.50	1.00	2.00	2.31		
HESIONIDAE								
<i>Ophiodromus agilis</i> (Ehlers, 1864)	3.50	4.73	1.75	2.06				
SYLLIDAE								
<i>Brania pusilla</i> (Dujardin, 1839)	12.00	18.76	0.25	0.50	20.75	15.95	0.25	0.50
<i>Exogone dispar</i> Webster, 1879	473.75	307.51	34.25	25.38	59.75	48.40	5.25	5.38
<i>Grubeosyllis clavata</i> (Claparède, 1863)	71.25	31.11	6.75	4.79	6.75	9.00		
<i>Parapionosyllis gestans</i> (Pierantoni, 1903)	17.50	3.54			14.75	7.63	1.25	1.89
<i>Sphaerosyllis hystrix</i> Claparède, 1863	4.00	8.00			11.25	6.18	0.25	0.50
<i>Sphaerosyllis pirifera</i> Claparède, 1868	7.00	4.36	1.75	2.87	14.25	11.32	0.50	0.58
<i>Branchiosyllis exilis</i> (Gravier, 1900)	48.50	21.95	9.25	3.86	97.00	60.50	11.75	11.27
<i>Haplosyllis spongicola</i> (Grube, 1855)	6.00	7.66			6.25	11.84	7.75	15.50
<i>Pseudosyllides balearica</i> San Martin, 1982	4.75	6.60	1.25	1.50	8.50	9.98	0.25	0.50
<i>Syllis armillaris</i> O.F.Müller, 1771	15.00	30.00	1.25	2.50	83.25	43.29	7.50	6.61
<i>Syllis columbretensis</i> Campoy, 1982	4.50	5.74	0.25	0.50				
<i>Syllis garciai</i> Campoy, 1982	18.25	19.60	2.50	3.70	6.25	5.56	0.50	1.00
<i>Syllis gracilis</i> Grube, 1840	3.75	6.24	0.75	0.96	2.00	4.00		
<i>Syllis hyalina</i> Grube, 1840	8.50	10.63	4.50	7.72	6.00	7.12	1.00	2.00
<i>Syllis krohnii</i> Ehlers, 1864	2.25	3.86	0.25	0.50				
<i>Syllis prolifera</i> (Krohn, 1852)	61.00	19.97	4.50	5.26	58.25	31.48	5.75	5.91
<i>Syllis torquata</i> (Marion & Bobretzky, 1875)	1.00	2.00	0.25	0.50				

Continued on p. 92

Table 2. contd.

Species	Porto Cesareo				Marsala			
	Cortex		Choanosome		Cortex		Choanosome	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
<i>Syllis variegata</i> (Grube, 1860)	0.50	1.00			11.50	19.21	0.50	1.00
<i>Trypanosyllis zebra</i> (Grube, 1860)	0.50	1.00	0.50	1.00	1.00	2.00		
<i>Autolytus inermis</i> Saint Joseph, 1887	0.50	1.00						
<i>Procerea</i> sp.			0.25	0.50				
NEREIDIDAE								
<i>Ceratonereis costae</i> (Grube, 1840)	88.50	42.21	17.75	8.06	7.75	11.15	1.50	1.91
<i>Perinereis cultrifera</i> (Grube, 1840)	0.25	0.50						
APHRODITIDAE								
<i>Pontogenia chrysocoma</i> (Baird, 1865)					1.50	1.91	0.50	0.58
LUMBRINERIDAE								
<i>Lumbrineris coccinea</i> (Renier, 1804)	1.50	3.00						
<i>Lumbrineris funchalensis</i> (Kinber, 1865)	1.00	2.00			2.50	3.79		
<i>Lumbrineris</i> sp.					0.50	1.91		
ARABELLIDAE								
<i>Arabella iricolor</i> (Montague, 1804)							0.50	1.00
FLABELLIGERIDAE								
<i>Flabelligera affinis</i> M.Sars, 1829					0.25	0.50		
TEREBELLIDAE								
<i>Terebella lapidaria</i> Linnaeus, 1767	0.50	1.00	3.00	6.00	0.50	1.00	0.50	1.00
Terebellidae sp.	3.75	3.86	1.00	2.00	4.25	7.85		
SABELLIDAE								
<i>Fabricia sabella</i> Grube, 1850	13.25	15.44			15.00	17.15	0.25	0.50
<i>Amphiglena mediterranea</i> (Leydig, 1851)	120.75	93.39	3.75	1.71	22.75	30.93	2.00	3.37
<i>Amphicorina armandi</i> (Claparède, 1864)	4.50	9.00			52.75	42.67	1.00	2.00
<i>Chone collaris</i> Langerhans, 1880	6.00	12.00	0.75	1.50				
SERPULIDAE								
Serpulidae sp.					2.25	2.63		
H'	2.79	0.61	2.92	0.33	3.50	0.31	2.31	0.56

Comparison between layers

Comparing cortical and choanosomal tissues heavy differences were found, being the former richer and more diversified (see Table 2). A large number of species is exclusive of the cortical layer, while almost all the species found in the choanosome are those showing the highest number of individuals in the cor-

tex. The only species which is more abundant in the choanosome is *H. spongicola*.

In both layers, however, the species collected were characterized by small sized individuals throughout the period of study. This was particularly evident analyzing the population structure of the most abundant species, *E. dispar* and *B. exilis*, which revealed the

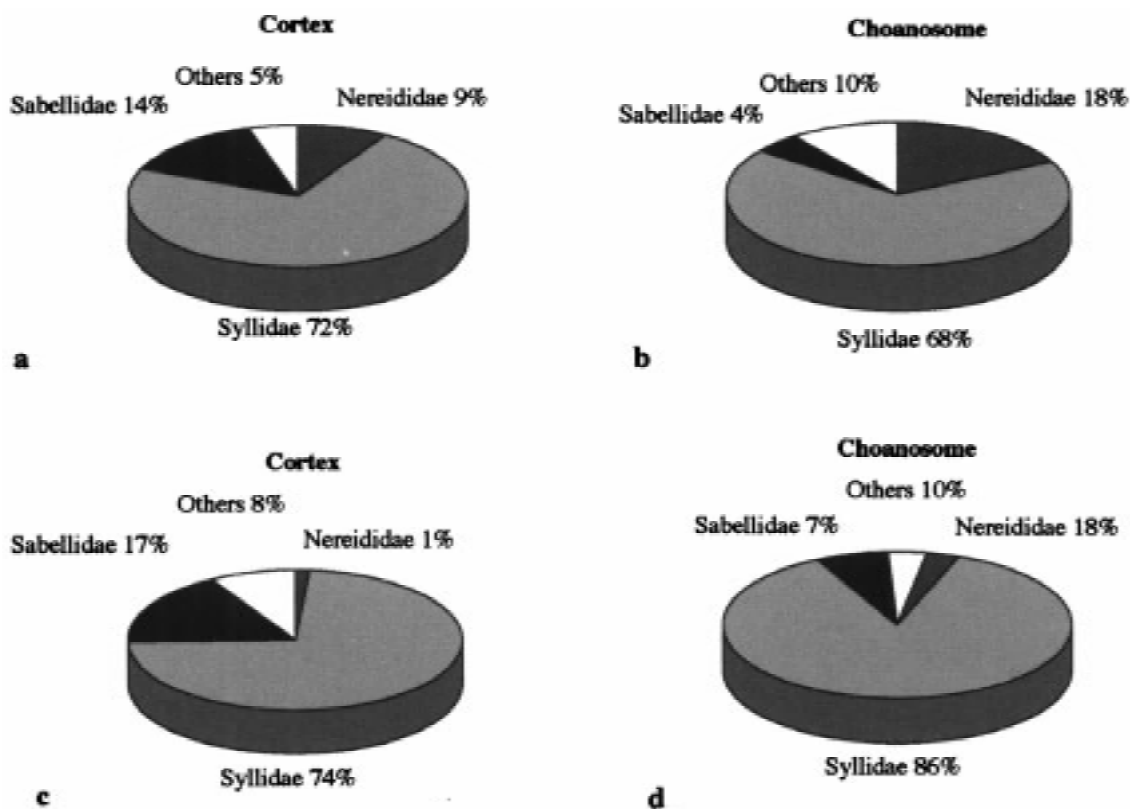


Figure 2. Percentage of individual abundance among polychaete families found, relative to the choanosome and cortex: (a, b) Porto Cesareo, (c, d) Marsala.

presence of numerous small size classes and only a few large size ones (see Fig. 3a,b). In both species, larger individuals were found almost exclusively during Spring. The histograms showed in Figure 3a,b are referred to the cortical layer of the population from Porto Cesareo, but a similar pattern was observed also for Marsala. Lastly, it was interesting the finding within *B. exilis* of a large amount of specimens whose morphology suggests the presence of asexual reproduction, and for which a more detailed population analysis is still under investigation.

Figure 4 shows the seasonal variations of number of species and abundance for both the studied sites. Seasonal fluctuations resulted more evident at Porto Cesareo (see Fig. 4a,b), with a marked summer decrease especially regarding abundance values, more evident in the cortex than in the choanosome, where the highest species richness was recorded during Spring. By contrast, fluctuations at Marsala seemed to be more evident in the choanosome (see Fig. 4c,d), with a marked spring increase in number of species.

Statistical analysis showed a clear separation between cortical and choanosomal assemblages (see Fig. 5), even though within each of the two resulting clusters polychaete assemblages were mainly grouped according to the study sites. By contrast, seasons seemed to be of minor importance in determining the similarity pattern, excluding for cortical assemblages at Marsala, which appeared to be more affected by seasonal variations. Indeed, cortical samples from Marsala are clearly grouped in couples – Spring/Summer and Winter/Autumn. Finally, cortical assemblages resulted more homogeneous than choanosomal ones.

Relationship between sponge size and polychaete abundance

An increase in number of individuals within polychaete assemblages could be observed with the increasing sponge size. This was particularly evident in the cortical layer (see Fig. 6b,d). An increase in number of species with the increasing sponge size was

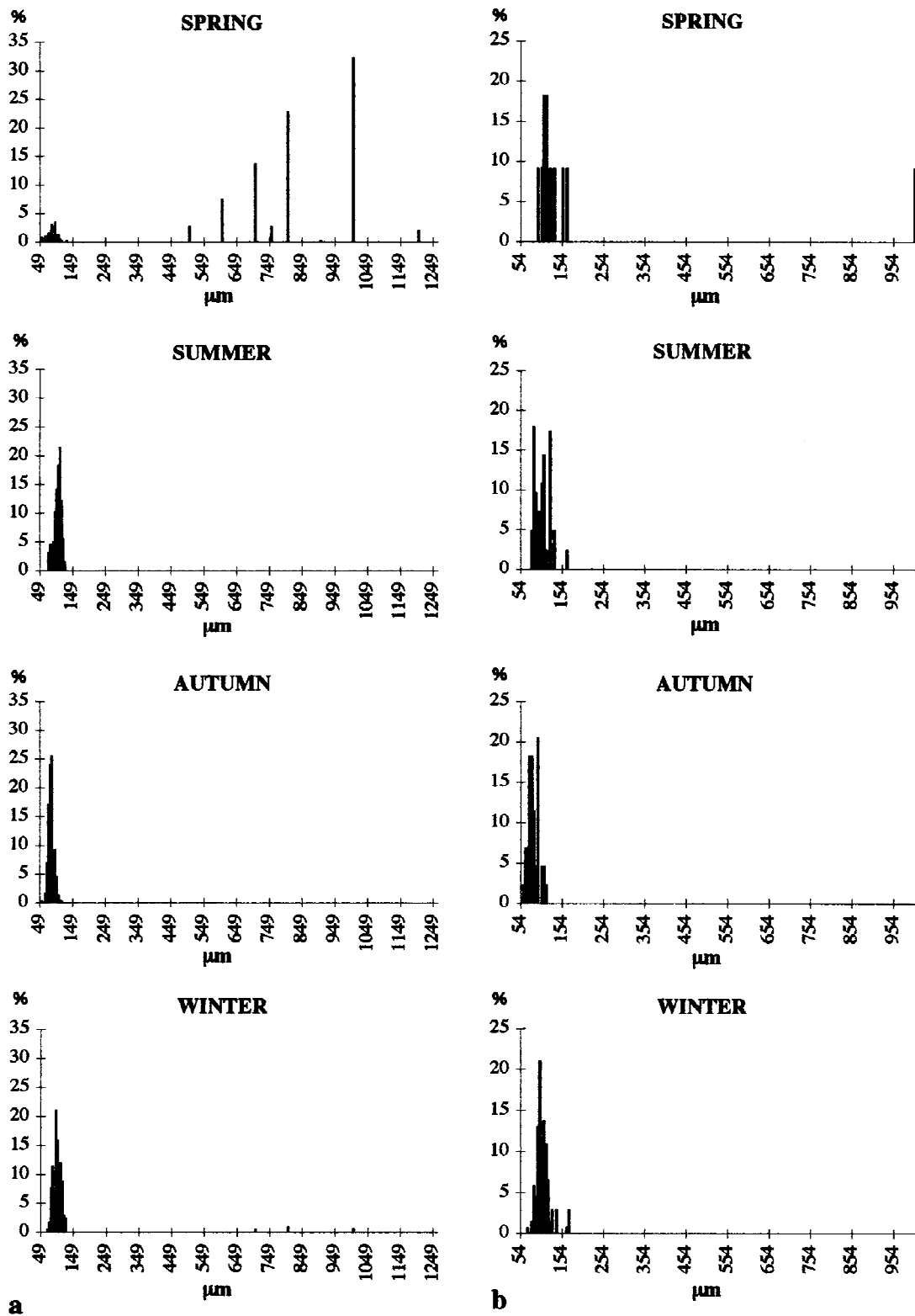


Figure 3. Seasonality and size frequency histograms of *Exogone dispar* (a) and *Branchiosyllis exilis* (b) relative to Porto Cesareo site.

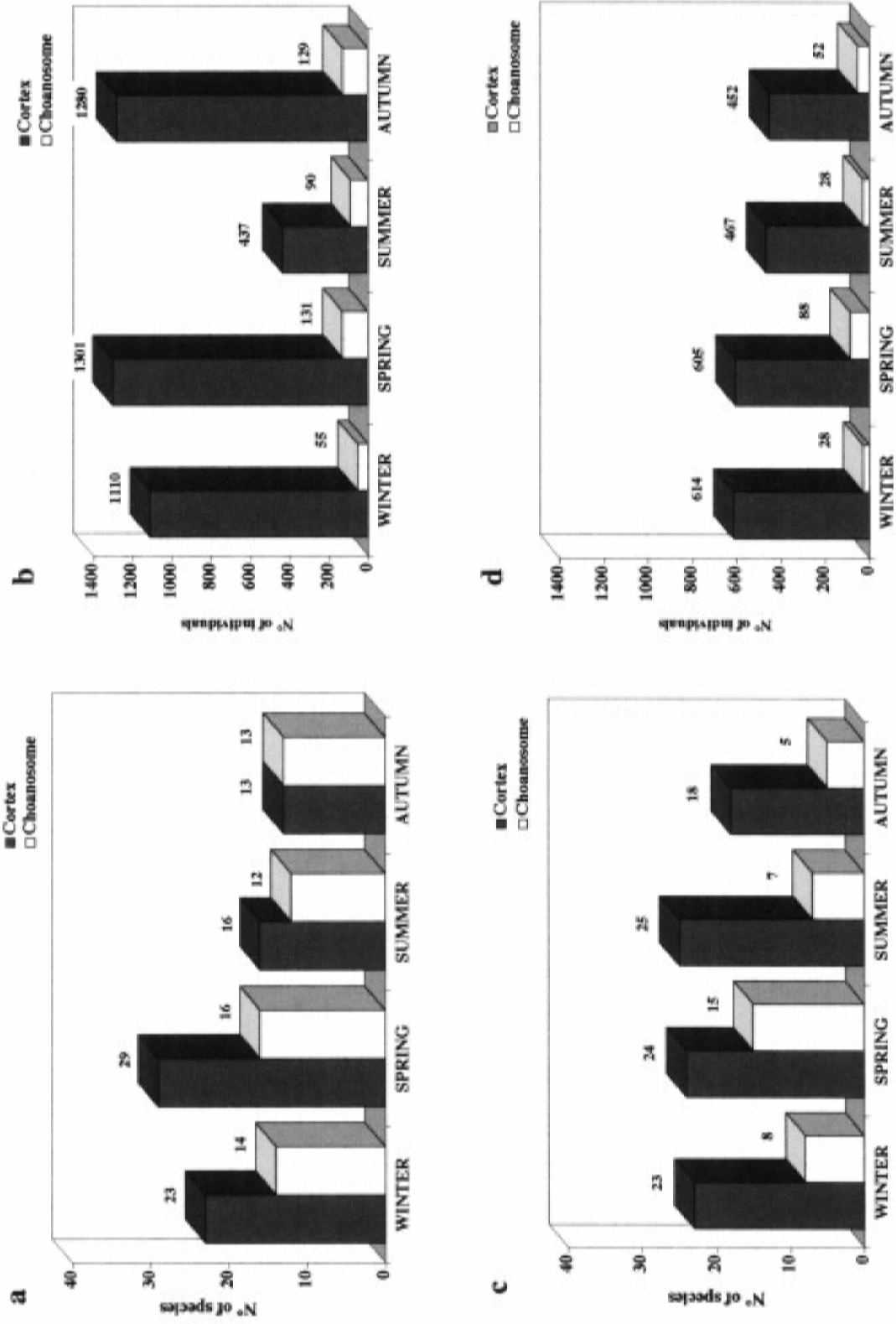


Figure 4. Seasonal trends in number of species and abundance observed at Porto Cesareo (a, b) and Marsala (c, d).

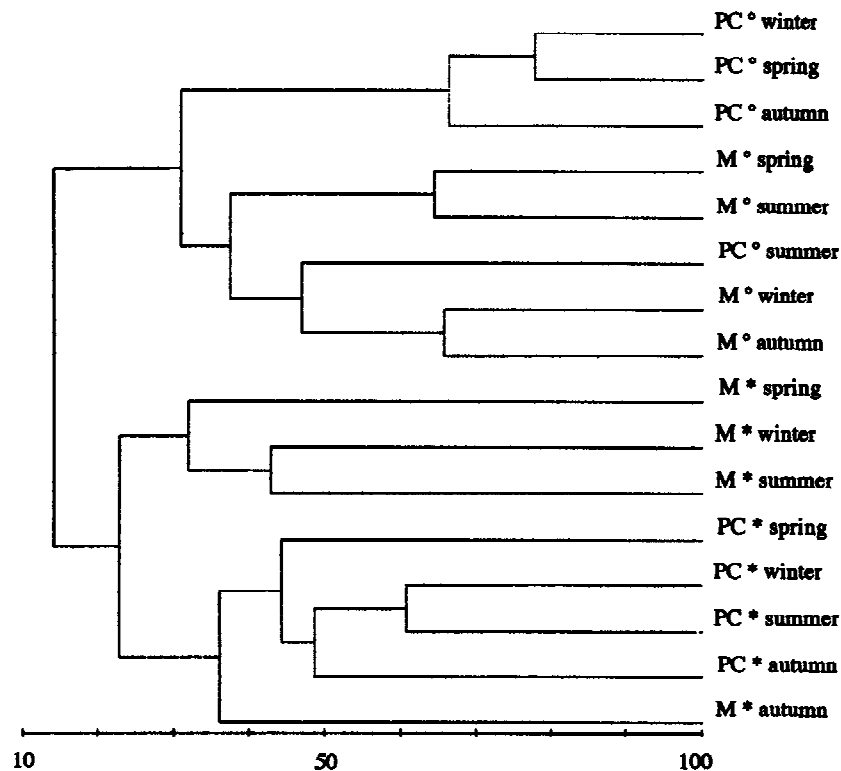


Figure 5. Dendrogram comparing the two studied sites: PC, Porto Cesareo; M, Marsala; (°), cortex; (*), choanosome.

also observed at Porto Cesareo (see Fig. 6a), contrasting with a very slight increase in number of species observed at Marsala (see Fig. 6c).

Table 3 reports the species of sponges where relationships between sponge size and number of species or density of polychaetes were up to now studied. A positive correlation was found for 71.4% and 59.1%, respectively, of the sponge species studied. However, density of endobiont polychaetes was almost always dependent on size of aquiferous canals for all the sponge species studied.

Discussion

Even though polychaete assemblages inhabiting *G. cydonium* showed a high similarity in species composition between the two investigated sites, most of the species found are common also on other substrates (Castelli et al., 1988; Cicciari et al., 1996). This suggests that polychaetes utilize the sponge as a substrate without any specificity, and that the affinity between the two assemblages reflects mainly the simi-

arity between the environmental conditions of the two sites.

This is in accordance with most of the previous studies conducted on different sponge species (Long, 1968; Peattie & Hoare, 1981; Alos et al., 1982; Koukouras et al., 1985, 1996), which stressed the similarity of sponge host communities to the neighbouring environment (see Table 3). In particular, Alos et al. (1982) pointed out the similarity between polychaete assemblages on sponges and polychaetes from sciaphilous biocoenoses.

According to literature data, the only species which seem to be associated to the sponge itself are *H. spongicola* and *B. exilis*. These species, more abundant at Marsala, are considered commensal or parasitic forms (Martin & Britayev, 1998), even though they may occur on different species of sponges, thus lacking species specificity. Moreover, *B. exilis* may be found associated also with other invertebrates (Hendler & Meyer, 1982). In the present paper, *Haplosyllis spongicola* is the only species that, at least on Marsala site, is more abundant in the choanosome than in the cortex. The probable presence of asexual reproduction

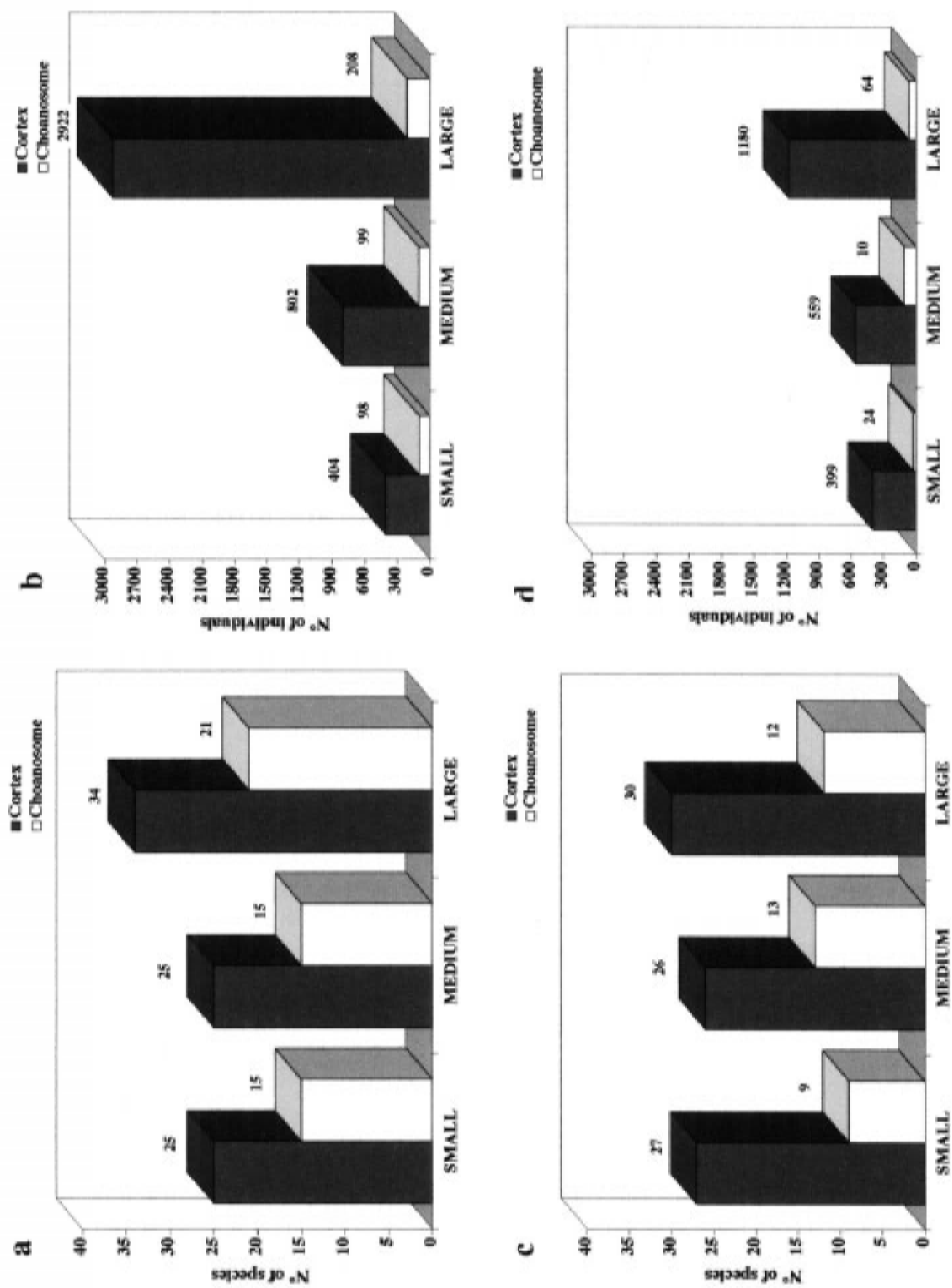


Figure 6. Trends in number of species and abundance with increasing sponge size relative to Porto Cesareo (a, b) and Marsala (c, d).

Table 3. Literature data relative to the investigated species of sponges were Polychaetes occur or exclusively to Polychaetes assemblage(*)

Species	Authors	Similarity inhabiting assemblage neighbouring assemblages	Relationship sponge size/ species	Relationship sponge size/ individuals	Relationship sponge size/ biomass	Relationship endobiont density/size of aquiferous canals
<i>Stellata grubii</i>	Labate & D'Addabbo (1974)			none		
<i>Geodia cydonium</i>	Santucci (1922)	low		none		
<i>Geodia cydonium</i>	Koukouras et al (1985)		none	none	none	none
<i>Suberites lata</i>	Long (1968)	high	positive	positive		positive
<i>Sphaeiospongia vesparia</i>	Westinga & Hoetjes (1981)	low	positive	positive	positive	
<i>Axinella cannabina</i>	Koukouras et al. (1996)	high	positive	none		positive
<i>Agelas oroides</i>	Koukouras et al. (1985)		none	none	none	positive
<i>Agelas oroides</i>	Koukouras et al. (1992)		positive	positive	none	positive
<i>Agelas oroides</i>	Koukouras et al. (1996)	high	positive	none		nothing
<i>Agelas oroides</i>	*Pansini & Daglio (1980)			none		
<i>Homaxinella</i> sp.	Long (1968)	high	positive	positive		positive
<i>Halichondria panicea</i>	Long (1968)	high	positive	positive		positive
<i>Halichondria panicea</i>	Peattie & Hoare (1981)	high				positive
<i>Crambe crambe</i>	*Pansini & Daglio (1980)			none		positive
<i>Microciona prolifera</i>	Long (1968)	high	positive	positive		positive
<i>Petrosia ficiformis</i>	Labate & D'Addabbo (1974)			none		
<i>Petrosia ficiformis</i>	Koukouras et al. (1985)		none	none	none	positive
<i>Petrosia ficiformis</i>	*Alos et al. (1982)	high				positive
<i>Petrosia ficiformis</i>	Koukouras et al. (1992)		positive	positive	none	positive
<i>Petrosia dura</i>	*Pansini & Daglio (1980)			none		positive
<i>Hippospongia communis</i>	Rützler (1976)	low		positive	none	positive
<i>Spongia officinalis</i>	Koukouras et al. (1985)		none	none	none	positive
<i>Spongia officinalis</i>	*Pansini & Daglio (1980)			none		
<i>Spongia zimocca</i>	Rützler (1976)	low		positive	none	positive
<i>Fasciospongia cavernosa</i>	*Amourex et al. (1980)	high				
<i>Ircinia foetida</i>	*Pansini & Daglio (1980)			none		positive
<i>Ircinia oros</i>	Rützler (1976)			none	positive	nothing
<i>Ircinia muscarum</i>	Rützler (1976)	low		positive	none	positive
<i>Ircinia muscarum</i>	Koukouras et al. (1985)		none	none	none	positive
<i>Sarcotragus(Ircinia) muscarum</i>	Cinar & Ergen (1998)		positive	positive		
<i>Ircinia fasciculata</i>	Rützler (1976)	low		positive	none	positive
<i>Ircinia fasciculata</i>	Koukouras et al. (1985)		none	none	none	positive
<i>Ircinia fasciculata</i>	*Alos et al. (1982)	high				
<i>Ircinia variabilis</i>	Rützler (1976)	low		positive	none	positive
<i>Ircinia variabilis</i>	Koukouras et al. (1992)		positive	positive	none	positive
<i>Ircinia variabilis</i>	*Pansini & Daglio (1980)			positive		positive
<i>Aplysina aerophoba</i>	Koukouras et al. (1992)		positive	positive	none	positive
<i>Aplysina aerophoba</i>	Koukouras et al. (1996)	high	positive	none		positive
<i>Aplysina aerophoba</i>	Koukouras et al. (1985)		none	none	none	positive
<i>Aplysina aerophoba</i>	Voultsiadou Koukoura et al. (1987)	high	none	none	none	
<i>Aplysina aerophoba</i>	*Alos et al. (1982)	high				
<i>Aplysina cavernicola</i>	*Pansini & Daglio (1980)			none		positive

in *B. exilis* could be an indication of a symbiotic habit, being parasites often asexual reproducing.

Regarding *E. dispar*, which was the most common species found, no data on feeding biology are available. Generally, on hard substrates at low depth the dominant species is the congeneric *E. naidina*. This species characterized by an herbivorous habit was not found in our samples. *Exogone dispar* is a species more common in deeper hard substrates or in soft-bottoms. It is, therefore, interesting to investigate on its feeding habitus, considering that a rich population was found also in the choanosome, where light does not penetrate. It is possible that this species is actually associated to the sponge and that, like *H. spongicola*, it can feed on sponge tissue. However, *E. dispar* was found abundant at Porto Cesareo also in the surrounding soft substrates (Castelli et al., 1988), therefore it must be also hypothesized that the species is linked, more than to the sponge, to the high sedimentation rate recorded on *G. cydonium* at this site.

A prevalence of herbivorous and limivorous forms was recorded at Porto Cesareo, where the species typical of photophilic environment resulted more abundant, together with those typical of soft-bottoms. This was probably due both to the higher algal cover and once again to the higher sedimentation rate recorded on the sponge surface at this site. By contrast, species commonly found in more sciaphilous biotopes were abundant at Marsala, with a predominance of detritivorous forms, reflecting the presence of the leaves of *P. oceanica* acting like a filter against sunlight. Actually, the species *P. chrysocoma* was exclusive of this site. Finally, sossensivores were well represented at both sites, even though with different species.

In general, it could be easily supposed that filter-feeders find a suitable environment within canals of the sponge, while sossensivore forms are linked to the external layer. However, observations on functional aspects were limited by the lack of knowledge of the basic biology of many polychaetes and particularly of the family Syllidae, which is the best represented in *G. cydonium* from the study sites.

The polychaete assemblage of *G. cydonium* was characterized by very small individuals, thus leading to hypothesize a 'nursery' effect for most species, particularly evident in *E. dispar* and *B. exilis*. This was probably due to the effect of protection and shelter that the sponge can have. A utilization of sponge as a refuge was evidenced by Peattie & Hoare (1981) for *Halichondria* sp., having they found a complete food web strictly linked to the sponge, where the major-

ity of fauna found refuge from the mechanical stress caused by water-movement. The nursery effect was already observed by Alos et al. (1982) who hypothesized that the size of sponge canals may exert a selection on the species of polychaetes, but did not exclude the possibility that only juveniles could live inside the sponge, leaving it when they become adults. In this respect, *G. cydonium* is a very peculiar sponge, showing large canals which allow the penetration of very large species such as *Eunice siciliensis*, but also having very hard and rigid internal tissue, so supporting more the first Alos' hypothesis. However, the finding of adults during Spring, leads to suppose not only a size selection, but also the existence of a true shelter effect.

Polychaetes of *G. cydonium* are mainly found in the cortical layer, where the assemblage is richer and more diversified than in the choanosome. Moreover, the assemblage found in the choanosome seems to depend from the cortical one. Probably, the reason why the cortex resulted more colonized than the choanosome could be that, being a very hard tissue, it can act as a filter. Qualitative differences between polychaete assemblages of the two tissues are so heavy that statistical analysis points out them, even obscuring differences between sites. These latter, however, were represented as subclusters, where seasonality plays an important role, placing the Summer sample from Porto Cesareo close to that coming from Marsala, probably because of its paucity during Summer. This suggests again that the separation between sites reflects more quantitative differences than qualitative ones. Seasonality was in fact more evident at Porto Cesareo, with a marked Summer decrease both in number of species and in individuals. This was due to the peculiar environmental conditions existing at Porto Cesareo during Summer, when a sharp increase in water temperature occurred (Corriero, unpublished data). By contrast, at Marsala environmental conditions are more constant, as underlined once again by the presence of *P. oceanica* beds.

As regards the relationship between size of the host sponge and number of species or density of polychaetes, literature reports a positive correlation for 71.4% and 59.1%, respectively, of the sponge species studied. With regard to *G. cydonium*, no relationships have been pointed out (see Table 3). In the present studies, at both sites, polychaete abundance increased with the increasing sponge size, while number of species showed a positive correlation with the size of the sponge only at Porto Cesareo. Here, the increase in

species richness observed with the increasing sponge size could be explained considering that the largest specimens were covered by a richer algal layer, from which polychaetes could have migrated. This algal covering was not present at Marsala.

It's possible, therefore, to infer that the increasing of species richness and abundance in polychaete assemblages of *G. cydonium* follows a pattern commonly found on hard substrates, where the increasing in density but not species richness is linked to increasing of available area (Weinberg, 1978); thus indicating once again that there isn't a true selection of polychaete species associated to the sponge.

Acknowledgements

We wish to thank Prof. Guillermo San Martin (University of Madrid) for his help in some Syllidae identification, Dr C. Nonnis Marzano for the English revision of the manuscript and for her suggestions, Dr M. Mercurio for technical assistance. This research was financially supported by the Italian M.U.R.S.T. (ex 40% and 60% funds). All the experiments complied with current Italian laws.

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