

Epibiontic sponges on the bivalve *Pinna nobilis*

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ABSTRACT: Epibiontic Porifera on shells of the bivalve mollusc *Pinna nobilis* were studied along the coast of Montecristo Island, Italy. Thirty-five species were found; 6 on more than 30% of the examined molluscs, the others sporadic in occurrence. The per cent area covered varied from 0 to 68% and the number of species per specimen of *P. nobilis* varied from 0 to 11. The number of epizoic individuals and the number of species per mollusc was highly correlated with the age of the host showing that the population is still developing throughout the host's life-span. The shell of *P. nobilis* does not seem to be selectively settled by Porifera. The sponge population differs structurally on the 2 valves of the same mollusc specimen. Small shell size and distance from the rocky coast probably limit sponge settlement opportunities. The colonization pattern by sponges on *P. nobilis* shells conforms to the facilitation model in its first stages and later to the inhibition model.

INTRODUCTION

A diverse fauna including Porifera, Cnidaria, Bryozoa and Tunicata settle on the shells of bivalve and gastropod molluscs. The shells can either be covered by many species of epibionts that compete for the substratum, or colonized by 1 or 2 species that almost completely cover the surface of the mollusc shells.

Porifera of the genera *Cliona* (Cobb 1969), *Mycale*, *Lissodendoxia* and *Suberites* (Annandale 1914) do not seem to prefer any particular shelled mollusc species with which to associate. Others, such as *Stelletta grubii* and *Clathria* sp., have more specific substratum requirements; the former is often associated with the oyster *Ostrea permollis* (Forbes 1964), whereas the latter settles on shells of the gastropod *Murex trunculus*, either living or inhabited by hermit crabs (Pourbaix 1931).

Literature sources provide little information about the timing and environmental conditions necessary for shell colonization by Porifera, and there are no data on the structure and temporal evolution of such epibiontic populations. Owing to the generally slow settlement rates by sponges (Pansini & Pronzato 1981), the host species must have a long life-span and large size to allow the establishment of a rich and plentiful fauna. *Pinna nobilis* L. is the largest bivalve mollusc in the Mediterranean area and the outer surfaces of its valves

are generally covered by several sessile organisms, often showing population stratification (Zavodnik 1963). Because of its long life-span (more than 20 yr according to Vicente et al. 1980), this mollusc is one of the most suitable living substrata for the settlement of sponges, particularly demosponges.

The purpose of this work was to increase our knowledge of sponge epibionts on mollusc shells, through an evaluation of possible substratum selectivity, relation between age of host and sponge population, and competition for substratum.

MATERIALS AND METHODS

Fifteen individuals of *Pinna nobilis* were collected by SCUBA at a depth of 15 to 21 m along the coast of Montecristo Island in the Tyrrhenian Sea, Tuscan Archipelago. The bottom in the sampling area consisted of coarse sand mixed with detritus with large patches of the sea grass *Posidonia oceanica*.

The total height, height of the portion emerging from the sediment, and maximum length of each valve were measured. Settled sponges were mapped by drawing a diagram of each shell (Fig. 1), and the surfaces of both shells and sponges were measured with a Salmoiraghi planimeter, model 236. The approximate ages of *Pinna nobilis* individuals were evaluated by applying the equation used by Vicente et al. (1980):

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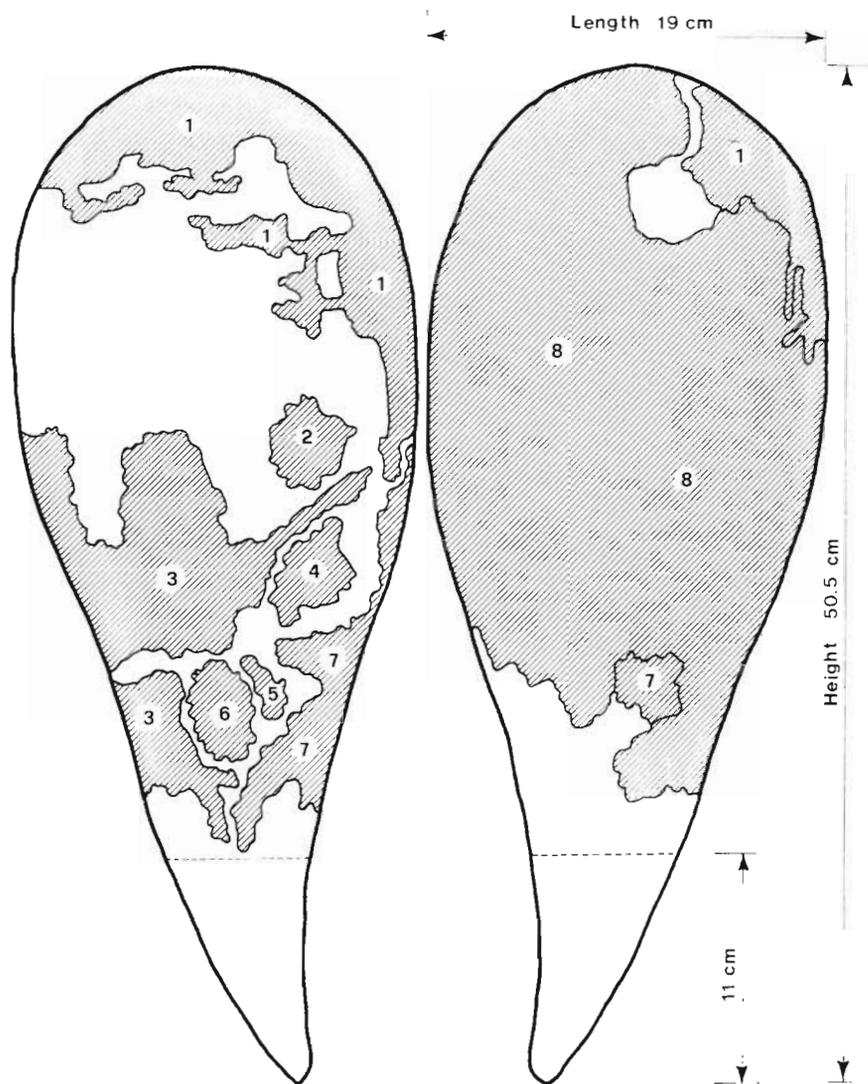


Fig. 1. *Pinna nobilis*, Specimen no. 6. Diagram showing mapping of epibiotic sponge specimens. (1) *Halichondria* sp. 1; (2) *Leptolabis exilis*; (3) *Stylopus dujardini*; (4) *Batzella inops*; (5) *Dysidea fragilis*; (6) *Aplysilla rosea*; (7) *Hymedesmia pansa*; (8) *Hymedesmia* sp.

$$x = 0.222 - \frac{\ln \left[1 - \frac{Ht}{86.33} \right]}{0.525} \quad (1)$$

where x = age (mo) of the individual; and Ht its total height (cm).

RESULTS

The collected specimens of *Pinna nobilis* were completely covered by stratified epibionts, mostly algae, Porifera, Bryozoa and colonial ascidians.

Both animal and algal covering of *Pinna nobilis* varied widely from shell to shell. Algae, branched Bryozoa, small bivalve molluscs and colonial ascidians prevailed on younger specimens. In the older ones there were fewer algae and an increase in sponges,

while encrusting Bryozoa began to occur and massive ascidians such as *Halocynthia papillosa* and *Microcosmus sulcatus* joined the encrusting epibionts.

Only the smallest specimen of *Pinna nobilis* examined, with an estimated age of 41 mo, showed no sponge settlement. Thirty-five species of Porifera were found on the remaining 14 *Pinna nobilis*. Six species of Porifera were present on more than 30% of the analyzed shells, while the remaining species were present sporadically. The per cent area cover of the shell by sponges varied from a minimum of 0.7% to a maximum of 68%. The number of sponge species per shell varied between 2 and 11, the number of individuals varying from 3 to 32 (Table 1). The data concerning number of species, per cent area covered, number of individuals found on the shells and diversity index (Shannon & Weaver 1949) were analyzed by several techniques: linear, logarithmic and exponential

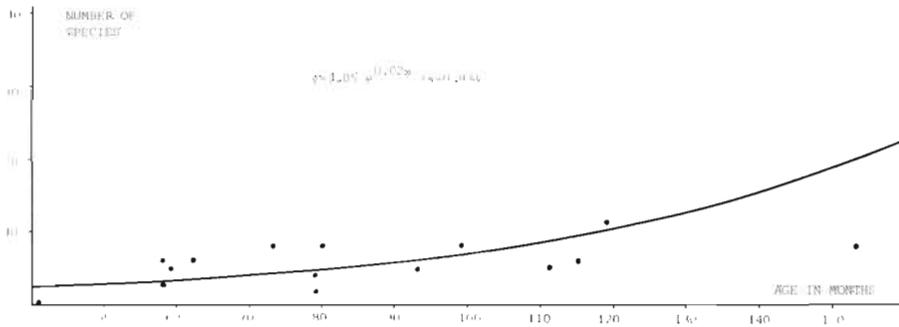


Fig. 2. Exponential regression curve between the age of *Pinna nobilis* specimens and the number of species of settled Porifera

regressions (exponential gave the best fit with our data), similarity index (Sørensen 1948) and R. Q. multivariate analysis (Hathaway 1971). The analyses were made by considering either each mollusc as a single entity or each valve separately. In the case of both valves the exponential regression curves show significant correlations between the age of the mollusc and both the number of species (Fig. 2) and the number of settled sponge specimens (Fig. 3). Conversely, the correlations between the age of the host and both the per cent area cover of Porifera and the Shannon-Weaver diversity index were not significant. The similarity indices and the R. Q. analysis show no significant correspondence between the structure of the settled sponge population and the age of the substratum. Similarity analysis (Fig. 4) shows that the populations established on specimens of *Pinna nobilis* of varying ages are associated at levels higher than 0.5. The ordination model of the R. Q. multivariate analysis displays no significant difference among the populations of each mollusc, and the variance explained by the first 2 axes is very low (first axis = 15.2%; second axis = 14.3%).

A similar analysis for each valve shows that the

sponge population is structurally different on the right and left valve of each specimen. The similarity indices (Fig. 5) only occasionally associate the valves of the same individual to high values. Also the R. Q. analysis shows no significant affinity among couples of populations settled on the valves of the same individual. In this case too, the variance explained by the first 2 axes is low (first axis = 8.7%; second axis = 8.5%).

Finally, the lengths of the boundaries of contiguous sponges were measured. Out of a total of 143 detected individuals, 33 cases of contiguity were found. Even though contiguity involved 23 out of 35 species, repetition of contiguity among the same species was sporadically observed. Furthermore, the length of the contiguous tracts typically measured only a few centimeters.

DISCUSSION

Pinna nobilis does not seem to be a selective substratum for Porifera. Indeed, most of the species were occasional, and the most frequent one, *Cliona viridis*, is attracted to the calcareous nature of the substratum. Moreover, this sponge requires an environment (such

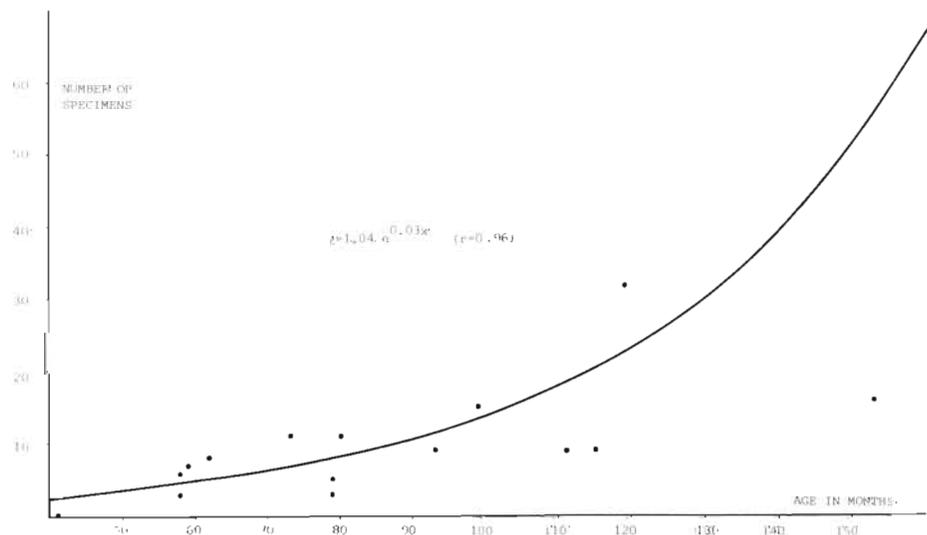


Fig. 3. Exponential regression curve between the age of *Pinna nobilis* specimens and the number of specimens of settled Porifera

as tunnels dug under the outer surface) (Cobb 1969) where few competitors are present.

The long life-span of *Pinna nobilis*, with the oldest bivalve examined in the study being almost 13 yr old, allows an evaluation of the colonization and the development of sponge populations.

The settlement of demosponges on open substrates takes a relatively long time. Pansini & Pronzato (1981) and Vacelet (1981) observed that almost 2 yr of immer-

sion are needed in order to get over the initial stage of colonization. The initial stage is characterized by a rapid succession of different populations, including the calcareous sponges, until an early equilibrium is achieved. Demosponges appear at a later stage and can come to cover much of the available space.

Due to the slow colonization, epibiontic Porifera may be lacking on the youngest specimens of *Pinna nobilis*. Calcareous sponges do not disappear after initial col-

Table 1. Porifera distribution on the shells of *Pinna nobilis*. Total surface area of each shell was computed by considering only the part emerging from the substratum. For each species, the covering values (%) and the number of specimens (in parentheses) are reported. A: right valve; B: left valve

	<i>Pinna nobilis</i> specimens											
	1		2		3		4		5		6	
Total surface area of shells (cm ²)	2096.8		2106.6		1900.0		1260.0		1283.4		1466.6	
Age (mo)	119		115		99		62		59		73	
Porifera species	A	B	A	B	A	B	A	B	A	B	A	B
1. <i>Clathrina contorta</i> (Bowerbank)												
2. <i>Sycon cibatum</i> (Fabricius)								0.53 (3)				
3. <i>Sycon elegans</i> (Bowerbank)							0.26 (1)					
4. <i>Leuconia aspera</i> (Schmidt)												
5. <i>Corticium candelabrum</i> Schmidt								0.26 (1)				
6. <i>Plakina monolopha</i> Schulze												
7. <i>Terpios fugax</i> Duchassaing & Michelotti	0.16 (1)											
8. <i>Cliona lobata</i> Hancock	0.63 (1)											
9. <i>Cliona viridis</i> (Schmidt)		20.10 (2)	0.63 (1)	2.05 (2)	1.13 (1)							
10. <i>Timea fasciata</i> Topsent	8.70 (4)	0.89 (3)				5.88 (2)						
11. <i>Batzella inops</i> (Topsent)												1.00 (1)
12. <i>Halichondria</i> sp. 1										1.55 (1)	3.64 (1)	16.36 (1)
13. <i>Halichondria</i> sp. 2				0.63 (1)								
14. <i>Mycale setifera</i> Topsent			0.16 (1)					20.36 (1)				
15. <i>Mycale tunicata</i> (Schmidt)												
16. <i>Yvesia</i> sp.												
17. <i>Himedesia pansa</i> Bowerbank									1.29 (3)	1.36 (1)	7.26 (1)	
18. <i>Himedesia</i> sp.											81.37 (1)	
19. <i>Leptolabis exilis</i> (Topsent)												2.04 (1)
20. <i>Stylopus dujardini</i> (Bowerbank)												19.77 (2)
21. <i>Stylopus</i> sp.												
22. <i>Anchinoe paupertas</i> (Bowerbank)		0.16 (1)		0.16 (1)		2.63 (1)						
23. <i>Stylostichon</i> sp.		0.47 (1)										
24. <i>Microciona</i> sp.									1.29 (1)			
25. <i>Haplosclerida</i> sp. 1										1.04 (1)		
26. <i>Haplosclerida</i> sp. 2												
27. <i>Spongia virgulosa</i> (Schmidt)	0.80 (3)	0.32 (2)										
28. <i>Cacospongia mollis?</i> Schmidt	0.47 (2)	1.34 (6)			0.17 (1)							
29. <i>Cacospongia scalaris</i> Schmidt												
30. <i>Ircinia spinosula</i> (Schmidt)												
31. <i>Ircinia variabilis</i> (Schmidt)		0.63 (3)	0.16 (1)									
32. <i>Dysidea fragilis</i> (Montague)	0.16 (1)			0.16 (1)		1.96 (2)	0.25 (1)					0.45 (1)
33. <i>Dysidea incrustans</i> (Schmidt)		0.32 (2)				10.50 (3)						
34. <i>Aplysilla rosea</i> (Barron)					0.35 (2)	0.70 (1)	0.25 (1)					2.04 (1)
35. <i>Plezaplysilla mauchium</i> Topsent					8.25 (2)				3.01 (1)			
Cover values	10.92	24.23	0.95	3.00	9.91	21.67	0.78	21.15	4.40	3.88	86.37	48.92
Number of specimens	32		8		15		8		7		11	
Number of species	11		6		8		6		5		8	
Diversity index (Shannon-Weaver)	1.83		1.82		2.41		0.48		2.19		1.80	

onization, and individuals of *Sycon ciliatum* can occasionally be found on shells up to 10 yr old. The rate of settlement by Porifera is probably related to the distance from the shore and to mollusc size. Sponge larvae are short-lived and they are unable, by swimming in the plankton, to cover long distances unless they are transported by currents. As a consequence, isolated substrata far from the coast are not easily accessible to sponge larvae (Vacelet 1981).

Jackson (1977) and Keough (1984a) suggested that the valves of *Pinna bicolor* and other isolated hard

substrata can be utilized as a refuge by taxa with good colonizing possibilities and weak competition abilities. Accordingly, in *Pinna nobilis*, when surfaces become suddenly available, such as inner valves of dead specimens, they are promptly occupied by bryozoans and serpulids (Harmelin 1977). In this case the presence of refuge-seekers should often originate populations in which sponges are later settlers (Keough 1984b). The sponge population associated with each specimen of *P. nobilis* showed some particular development features. The low correlation between

Table 1 (continued)

	<i>Pinna nobilis</i> specimens																	
	7		8		9		10		11		12		13		14		15	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
	1470.0		746.6		1016.8		2960.0		2193.2		1123.4		1693.4		1730.0		1550.0	
	79		41		58		153		111		58		80		93		79	
1.					0.33 (1)								0.40 (2)	0.57 (1)				0.22 (1)
2.	0.23 (1)	0.23 (1)							0.15 (1)		0.30 (1)				0.19 (2)			
3.																		
4.											0.30 (1)							
5.																		
6.													0.29 (1)					
7.																		
8.							1.57 (1)	19.59 (1)	4.71 (1)	1.66 (1)								
9.																		43.32 (1)
10.																		
11.					1.96 (1)		10.92 (1)			0.75 (1)					7.13 (2)	7.31 (1)	3.97 (1)	4.94 (1)
12.																		
13.												4.14 (1)						
14.							5.90 (1)											
15.							0.98 (1)											
16.														3.54 (1)				
17.																		
18.																		
19.																		
20.							0.33 (1)											
21.															1.57 (1)			
22.																		
23.																		
24.																		
25.																		
26.														0.98 (1)				
27.							0.67 (2)	0.33 (1)						0.59 (1)				
28.	0.91 (1)				0.33 (1)	1.97 (3)	0.11 (1)						0.88 (2)	0.20 (1)				
29.						0.22 (1)										7.31 (1)		
30.							0.22 (1)											
31.																		
32.							0.22 (1)											
33.							6.75 (3)		1.06 (1)				0.79 (1)					
34.								2.88 (1)	7.92 (3)						11.75 (1)	0.19 (1)		0.22 (1)
35.	1.14	0.23			1.96	7.87	15.35	27.22	7.59	11.54	0.30	4.44	6.48	2.76	19.64	14.81	3.97	48.70
	3				6		16		9		3		11		9		5	
	2				6		8		5		3		8		5		4	
	0.86				1.81		1.87		1.46		0.51		2.54		1.68		0.73	

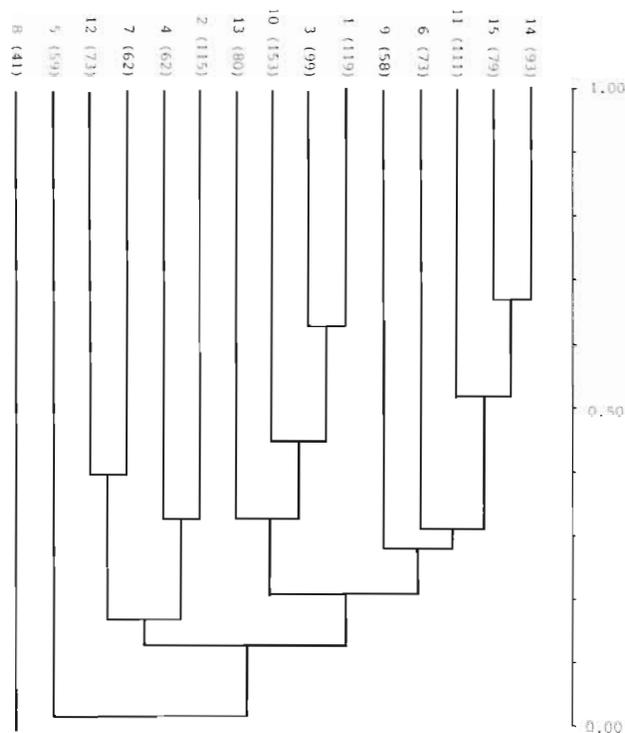


Fig. 4. Similarity (according to Sørensen 1948) among Porifera populations settled on *Pinna nobilis* specimens. Numbers refer to the specimens in Table 1, with (in parentheses) their age in mo

the host age and both diversity index and per cent area cover suggests that the first larval settlement is random and results in a colonization pattern which is not referable to a single model, as evidenced by R. Q. analysis.

The high correlation between the age of the host and the number of species and specimens of sponge shows that the population is still developing as the host mollusc ages and that new sponge larvae continue to settle on it. The presence of many adjacent sponges suggests a further stage of population development compared to that described by Pansini & Pronzato (1981) in 4 yr old populations, where no adjacents were observed. The absence of preferential contiguities among sponge species suggest that, at least in this stage of population development, competition prevails over cooperation (Sarà 1970).

Massive and erect sponges are lacking among the epibiotic fauna of *Pinna nobilis*. This could be related to the reduced size of the available substratum and the short time available for colonization. Clausade (1969) reported mostly encrusting sponges on small stones collected from muddy bottoms. Small substrata located far from rocky coasts can be more successfully exploited by sponges showing an encrusting growth, because they are most efficient in competition for the substratum (Vacelet 1980).

A comparison between the sponge population of *Pinna nobilis* and those of other Mediterranean environments is possible (Table 2). The species richness of the *P. nobilis* sponge population is similar to that recorded from other habitats (such as *Posidonia* meadows, artificial substrata or polluted zones) where unfavourable conditions limit the growth of sponge communities. Consequently, the shells of *P. nobilis* are probably 'limiting' environments for sponges.

Sponges are abundant and varied in marine caves

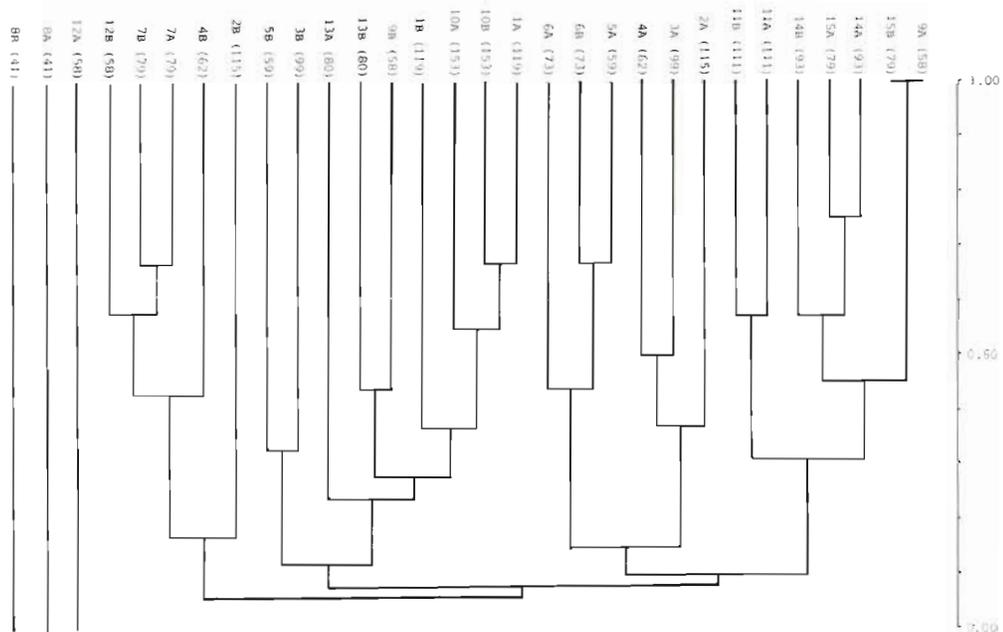


Fig. 5. Similarity (according to Sørensen 1948) among Porifera populations settled on each valve of *Pinna nobilis*. Numbers refer to the specimens in Table 1 with (in parentheses) their age in mo. A: right valve; B: left valve

Table 2. Number of species of Porifera found in some Mediterranean habitats

Habitat	Average no. of species in 1 sample	Total no. of species	Source
<i>Pinna nobilis</i>	5.4*	35	Present study
Artificial substrata	3.7*	23	Pansini & Pronzato 1981
Polluted environments	4.5**	31	Pansini & Pronzato 1975
<i>Posidonia</i> meadows	5.5**	30	Pansini & Pronzato 1985
Marine caves	10.0**	52	Pansini & Pronzato 1982
Littoral rocky walls	18.0**	74	Sarà et al. 1978

* Data standardized to a surface of 400 cm² using the area/species curve proposed by Pansini et al. 1977
** Data refer to a standard surface of 400 cm²

and even more so on littoral rocky walls. They probably find favourable conditions in environments with numerous micro-habitats. The high self-control potential of these communities and their persistence in time (Sarà in press) probably depend on the complex structure of the biocenoses and the innumerable interactions between environment and living organisms.

CONCLUSION

The settlement of Porifera both on artificial and natural substrata seems to be delayed within the development of the epibiontic community. This is probably due to the fact that Porifera need 'preparation' of the substratum by pioneer species. The 'facilitation model' (review in Dean & Hurd 1980) seems here confirmed, even though no climax is reached. Only the first stage of Porifera colonization is regular, with the early settlement of Calcispongiae. After this stage, no definite colonization pattern was found.

The 'inhibition model' also fits our data. In fact, a long-term study of a benthic community of Porifera (Pansini & Pronzato in press) shows that the larger specimens 'hold their position' for many years with few modifications in size and shape. The sponges settle randomly on the prepared substratum and are not replaced by other organisms. Further settlement of benthic organisms is prevented owing to the successful competition by sponges (Keough 1984b) and to the persistence of the community (Sarà in press). Only erect branching forms, such as hydroids, can settle on sponges (Boero 1984), usually without compromising their viability.

Porifera are one of the major settlers on natural hard substrata of Mediterranean coasts and the evolution of their populations first follows the facilitation and then the inhibition model. This pattern does not necessarily apply to overall community development. Other organisms, such as hydroids and many bryozoans, show a marked seasonality and their populations may

vary consistently throughout the year. Therefore, a single model of community development seems to be too restrictive, particularly as the ecology of many taxa is still scarcely known.

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