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Variability in Distribution of Macrobenthos on Rocky Shores at Elba Island

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Abstract

The distribution patterns of macrobenthic assemblages on rocky subtidal shores of the promontory and bay of Fetovaia (Elba Island, Tyrrhenian Sea) were investigated by visual estimates of species percent cover. Orientation and the nature of the substrata were investigated at two spatial scales and two depths. Species distribution showed high levels of heterogeneity at both the investigated spatial scales. Heterogeneities observed at the scale of tens of metres were comparable to those observed between sites separate by hundreds of metres and with different geographic orientation. Differences in distributions of several species and in the overall assemblages were observed between the two shores of the bay. Furthermore assemblages found on the promontory were more variable than those occurring in the bay. Although the distribution of most taxa did not appear to be related to differences in the substratum mineralogy, some evidence of the influence of the substratum type on the distribution of macrobenthic assemblages were found at 3 metres in depth. However, in the study area, distribution of species and assemblages was affected mainly by geographic orientation, rather than by substratum mineralogy.

In September 1999 distribution of branched coralline algae, *Codium bursa*, *Halimeda tuna*, *Padina pavonica*, and massive sponges, didn't show any difference in abundance at different sites and areas (Table 1). *Peyssonnellia* spp., encrusting coralline algae, *Flabellia petiolata*, filamentous algae, hydroids, encrusting sponges, serpulids, and bryozoans showed a significant heterogeneity of abundance among areas. Only *Dasycladus vermicularis* showed significant difference in abundance among the three sites around the promontory and a homogeneous distribution among areas. In particular *D. vermicularis* was more abundant at site C (SNK site A=B<C).

In June 2000 most of the analysed taxa showed a significant heterogeneity of abundance among areas (Table 1). Abundance of both encrusting and massive sponges was homogeneous among areas but differ significantly among sites, being more abundant on the southern side of the bay (sites 3 and 4), rather than on the northern side of the bay (sites 1 and 2) (SNK site 1=2<3=4). *Acetabularia acetabulum*, *Flabellia petiolata*, and filamentous algae showed significant difference in abundance among sites and areas. *A. acetabulum* and filamentous algae were more abundant on the northern side of the bay (sites 1 and 2), while *F. petiolata* was more abundant on the southern side of the bay (sites 3 and 4).

Table 1: Summary of the ANOVA on percent covers data of all analysed taxa found in first and second study analysing different spatial scales in the Fetovaia bay (*: $p < 0.05$; **: $p<0.01$; ns: not significant, -: not analysable).

	September 1999		June 2000	
Taxa	**Area(Site)**	**Site**	**Area(Site)**	**Site**
Peyssonnellia spp.	*	ns	**	ns
Branched coralline algae	ns	ns	**	ns
Encrusting coralline algae	*	ns	**	ns
Acetabularia acetabulum	-	-	**	**
Codium bursa	ns	ns	*	ns
Halimeda tuna	ns	ns	**	ns
Flabellia petiolata	**	ns	*	*
Dasycladus vermicularis	ns	*	**	ns
Padina pavonica	ns	ns	*	ns
Filamentous algae	**	ns	**	**
Hydroids	**	ns	-	-
Encrusting sponges	*	ns	ns	**
Massive sponges	ns	ns	ns	**
Serpulids	*	ns	*	ns
Bryozoans	**	ns	ns	ns

In third study the analysis of epibenthic assemblages occurring on the two different typologies of rock was extended to 20 taxa (Table 2). Most of the analysed taxa (branched coralline algae, *Laurencia* sp., *Dasycladus vermicularis,* other erected algae, algal turf, serpulids, barnacle, and bryozoans) showed a heterogeneous distribution of abundance between sites within each combination of depth and substratum. These results are in agreement with the small-scale heterogeneity observed in the previous studies. The abundance of *Acetabularia acetabulum* was homogeneous among sites but varied between the different combination of depth and substratum. The distribution of some erected algae (e.g. *Laurencia* sp., Dictyotaceae) and of the encrusting sponges was affected by depth. Only *D. vermicularis* showed a variation in relation to the substratum type: it was more abundant on the igneous rocks than on the metamorphic.

Distribution of macrobenthic assemblages

The MDS plot (Fig. 2) showed a clear separation among the epibenthic assemblages sampled in the first and second study. In the first survey there were significant differences among the assemblages of the areas within each site but there were no differences among sites, as indicated by NPMANOVA (Table 3).

Table 2: Summary of the ANOVA on percent covers data of all taxa found in third study analysing species distribution in relation to substratum type and depth (*: $p < 0.05$; **: $p<0.01$; ns: not significant, -: not analysable).

	Site(SxD)	SxD	Depth (D)	Substratum (S)
Bacterial film	-	-	-	-
Peyssonnellia spp.	ns	ns	ns	ns
Branched coralline algae	**	ns	ns	ns
Encrusting coralline algae	ns	ns	ns	ns
Acetabularia acetabulum	ns	*	**	*
Laurencia sp.	**	ns	*	ns
Codium bursa	ns	ns	ns	ns
Halimeda tuna	ns	ns	ns	ns
Flabellia petiolata	ns	ns	ns	ns
Dasycladus vermicularis	**	ns	ns	*
Dictyotaceae	ns	ns	*	Ns
Padina pavonica	ns	ns	ns	Ns
Other erected algae	*	ns	*	Ns
Algal turf	*	ns	ns	Ns
Hydroids	-	-	-	-
Encrusting sponges	ns	ns	*	Ns
Massive sponges	ns	ns	ns	Ns
Serpulids	**	ns	ns	Ns
Barnacle	**	ns	ns	Ns
Bryozoans	*	ns	ns	Ns

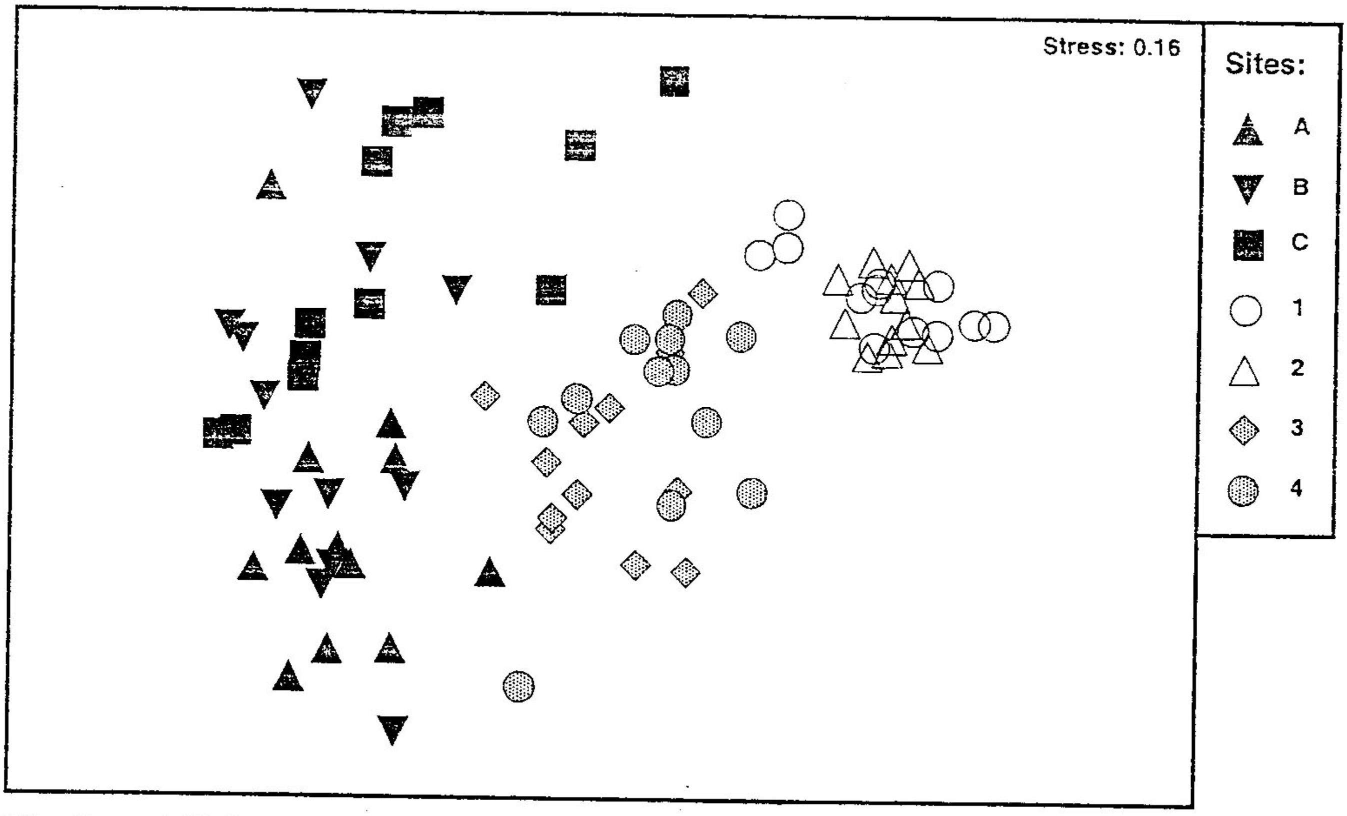

Fig. 2: MDS plot on percent cover data of epibenthic assemblages observed in the first (sites A, B, and C) and second survey (sites 1, 2, 3, and 4) comparing different spatial scales in the Fetovaia bay.

Table 3: Non-parametric multivariate analysis of variance on percent cover data of the assemblages found in the first and second survey: site (random), area (random and nested in site).

	Source	DF	SS	MS	F	P	F versus
September 1999	**Site**	2	10136.65	5068.327	1.5091	0.1898	Area(Site)
	Area(Site)	9	30225.63	3358.403	5.3524	0.0002	Res
	Residual	24	15058.94	627.456			
	Total	35	55421.22				

	Source	DF	SS	MS	F	P	F versus
June 2000	**Site**	3	26759.6	8919.866	6.1776	0.0002	Area(Site)
	Area(Site)	12	17326.84	1443.903	5.5987	0.0002	Res
	Residual	32	8252.86	257.902			
	Total	47	52339.29				

In the second survey the assemblages of the northern side of the bay (sites 1 and 2) were well distinct from those present in the southern side (sites 2 and 3; Fig. 2). This was confirmed by NPMANOVA, which detect high significant difference at both spatial scales (among areas within sites, and among sites; Table 3), and by the pair-wise post hoc comparisons, which clearly separate the assemblages of the two different sides of the bay (1 = 2 □ 3 = 4). Overall, the assemblages found in the second survey on the northern side of the bay appear more homogeneous rather than those present on the promontory in both seasons.

In the third study, the MDS showed some separation between the assemblages found at the two different depths (-3 metres vs. -10 metres; Fig. 3). Moreover, at the shallowest depth it is possible to see some separation between the assemblages colonising different substrata (igneous vs. metamorphic). These patterns were not confirmed by NPMANOVA, which detect high heterogeneity among sites within each combination of depth and substratum (Table 4).

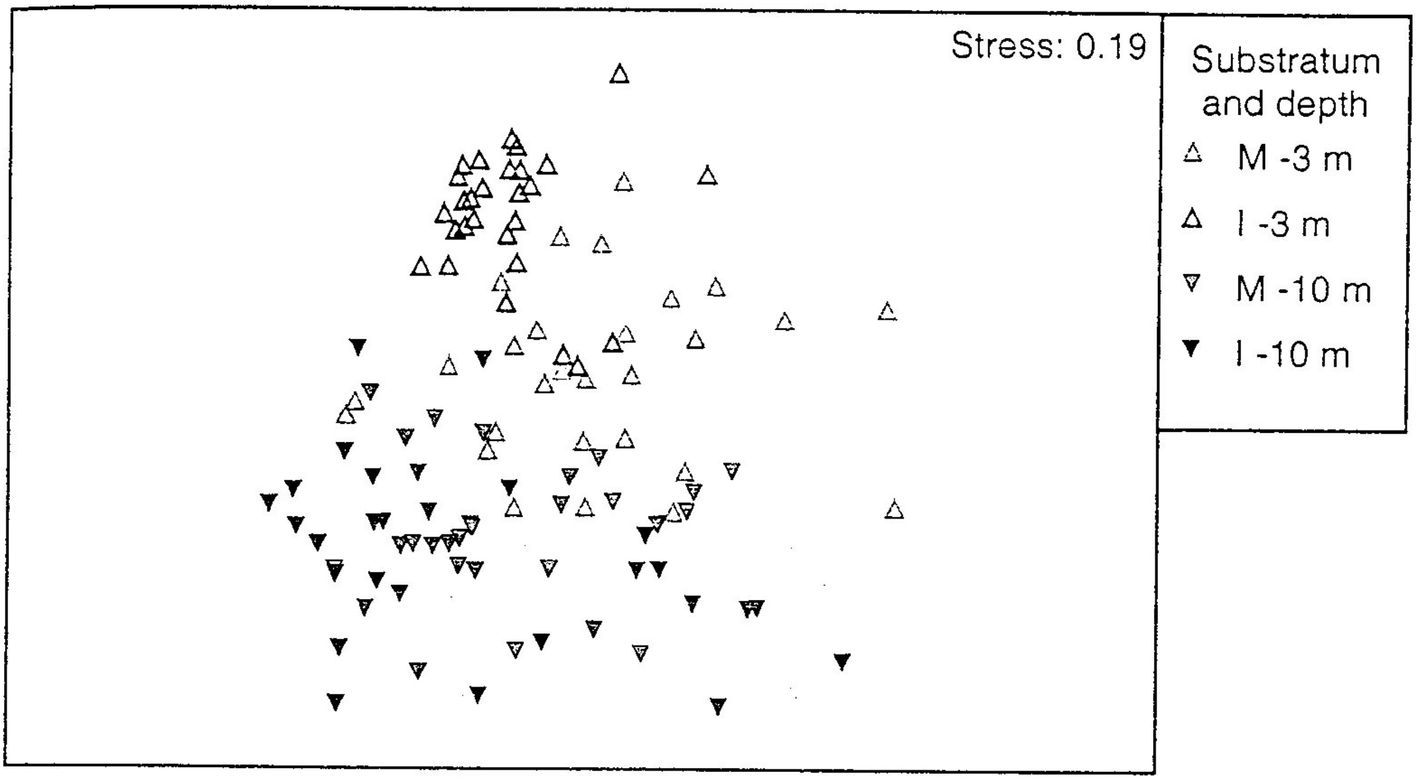

Fig. 3: MDS plot on percent cover data of epibenthic assemblages in June 2002. Symbols indicate the combinations of different substrata (black: igneous rocks; grey: metamorphic rocks) and depths (triangle toward up: 3 metre in depth; triangle toward down: 10 metres in depth).

Table 4: Non-parametric multivariate analyses of variance on percent cover data of the assemblages observed in June 2002: substratum (fixed), depth (fixed and orthogonal to substratum), site (random and nested in substratum and depth).

Source	DF	SS	MS	F	P	F versus
Substratum (S)	1	1.29260	1.29260	1.09017	0.39760	Site(SxD)
Depth (D)	1	0.47506	0.47506	0.40067	0.87940	Site(SxD)
SxD	1	0.32149	0.32149	0.27114	0.94200	Site(SxD)
Site(SxD)	4	4.74276	1.18569	11.57264	0.00020	Res
Residual	104	10.65545	0.10246			
Total	111	17.48737				

Conclusions

The results of the first two surveys showed a high heterogeneity of the epibenthic assemblages colonising the rocky subtidal shores of the promontory and bay of Fetovaia at both the investigated dates. Heterogeneities observed among areas, at a scale of tens of metres, were comparable to those observed between sites, separate by hundreds of metres and with different geographic orientation. The distributions of several species and of the overall assemblages showed clear differences between the two inner sides of the bay. Furthermore assemblages found on the promontory were more variable than those of the shores of the bay. The high level of heterogeneity observed among areas could be probably related to biotic and abiotic factors, like recruitment processes, inter- and intraspecific competition and predation, and substratum heterogeneity (Blanchard and Bourget, 1999). The observed difference between the assemblages of the two sides of the bay could be related to differences in geographic orientations, which involve different irradiation and hydrodynamic conditions.

Although the distribution of most taxa did not appear to be related to differences in substratum mineralogy, some evidence of substratum influence on the distribution of some species were found at 3 metres in depth. *Acetabularia acetabulum* is the only taxon that showed a clear preference for the igneous (granodiorites) rocks. This pattern was consistent with the previous study. *Dasycladus vermicularis*, although showed high variability at small spatial scale, appeared more abundant on the igneous rocks, but this pattern was not detected in previous studies. As expected, the effect of depth on the distribution of epibenthic taxa was more evident. The possible effects of substratum mineralogy on the overall assemblage are probably hidden by the observed high variability among areas, that increases with depth. Overall, in the study area, distribution of species and assemblages appeared affected mainly by geographic orientation, rather than by substratum mineralogy.

Description of patterns of species distribution in the macrobenthic assemblages on the rocky subtidal shore of the Fetovaia bay contribute to the knowledge of coastal biodiversity in the Tuscan Archipelago National Park. The results suggested that better understanding of the effects of substratum mineralogy on the macrobenthic assemblages requires further studies investigations including greater bathymetric ranges and wide number of substrata.

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