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Mollusca fauna from infralittoral hard substrate assemblages in the North Aegean Sea

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ABSTRACT. The spatial distribution of the molluscan fauna from infralittoral hard substrate assemblages in the North Aegean Sea was studied during summer 1997 and 1998. Material was collected from six stations located in Chalkidiki peninsula, plus one in Kavala Gulf. Samples were collected by means of SCUBA diving (5 replicates with a quadrate sampler covering the surface of 400cm^2). Examination of the 10917 living molluscs collected revealed 111 species, belonging to three different classes (five Polyplacophora, 85 Gastropoda and 21 Bivalvia). *Skeneopsis planorbis*, *Trapania maculata* and *Limapontia capitata* are reported for the first time as elements of the molluscan fauna in the Eastern Mediterranean or the Aegean Sea, and *Callistochiton pachylasmae*, *Raphitoma leufroyi*, *Polycera quadrilineata*, *Phyllaplysia lafonti* and *Petalifera petalifera* as elements in the North Aegean Sea. Multivariate analyses (Cluster and MDS), discriminate the sampling stations into four main groups, indicating, that apart from the rough dispersion of the molluscs, a more homogenous pattern is detectable at the middle part of the lower infralittoral zone.

KEY WORDS : *Keywords* : *Molluscs, infralittoral, Aegean Sea, hard substrate, biodiversity*

INTRODUCTION

The term 'biodiversity' is recently defined as the collection of genomes, species and ecosystems occurring in a geographically defined region (CBDMS, 1995). Its value as an indicator of environmental health is now largely recognized (Gaston & Spicer, 1998 ; Bianchi & Morri, 2000) and species diversity, i.e. composition, recognised as an important indicator of diversity across spatial scales and habitats. A considerable amount of information concerning the biodiversity of Mediterranean ecosystems has been organised and presented with reference to the classification of benthic biocenoses (Pérès, 1967) or organismic assemblages (Pérès, 1982), since this scheme has been considered as appropriate for that basin (Augier 1982).

Considering molluscs, available information during the earlier parts of the 20th century came mainly from general ecological and faunal surveys in the Eastern Mediterranean (e.g. Pérès & Picard, 1958 ; Ledoyer, 1969 ; Strack, 1988). Throughout the last ten years, records of molluscs were included in almost all research surveys carried out in Greek waters, mainly in the Aegean and the Ionian Seas, and information is summarized in Koutsoubas (1992), Delamotte & Vardala-Theodorou (1994), Zenetos (1997), Koutsoubas et al. (2000a). However, a biotope approach, based on the molluscan fauna distributed along the continental shelf of the Greek Seas and using numerical taxonomic methods, has been attempted in very few cases and even those cover only the soft substrate assemblages (e.g. Zenetos et al., 1991, 1997 ; Koutsoubas et al. 2000b).

When considering hard substrate within the infralittoral zone, three different ecological sub-zones can be recognized : a high one, which extends from 0 to 2m and is characterized by the assemblage of photophilic algae, an intermediate one extending from 2 to approximately 12m and dominated by several hydrozoans species, and a low one extending to almost 40m, where the sciaphilic algal assemblage occurs (Marinopoulos, 1988). Biodiversity aspects in these three sub-zones are rather well studied in the Western and Central Mediterranean (Biggs & Wilkinson, 1966 ; Bellan-Santini, 1969 ; Hong, 1983 ; Richards, 1983 ; Poulicek, 1985 ; Giangrade, 1988) and the neighbouring Atlantic Ocean (e.g. the North Sea - Kluijver, 1997), but less so for the Eastern Mediterranean (Pérès & Picard, 1964 ; Augier, 1982 ; Dauvin, 1993 ; Bellan-Santini et al., 1994).

The present study discusses in detail the molluscan diversity, and qualitatively illustrates its spatial dispersion in the lower infralittoral hard substrate assemblages in the North Aegean Sea.

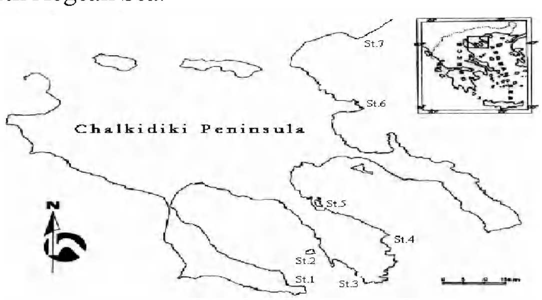


Fig. 1. – Map of the study area, showing the location of sampling sites.

MATERIAL AND METHODS

Sampling sites

Seven stations were set at different locations in the North Aegean Sea (Fig. 1). They were chosen for their dispersion in this specific biogeographical zone and their hard substrate extension and inclination (ranging from 45 to 90°). According to the maximum depth of hard substrate at each station, one to three substations were set (a-15 meters, b-30 meters and c-40 meters) in order to cover bathymetrically the entire range of the lower infralittoral zone. Basic characteristics of all stations are given in Table 1.

TABLE 1

Physical and biotic characteristics of sampling stations.

Station	Slope (°)	Maximum Depth (m)	Prevailing Winds	Substations	Biotic Characteristics
1 Kakia Skala	90	65	N, NE, SE	a - 15m	*Womersleyella setacea*
				b - 30m	*Womersleyella setacea*
				c - 40m	*Lithophylum* sp., *Peysonellia* sp.
2 Kelyfos	70	35	S, SW, SE, NW	a - 15m	*Padina pavonica, Codium bursa*
				b - 30m	*Womersleyella setacea*
3 Porto Koufo	90	50	SW	a - 15m	*Womersleyella setacea*
				b - 30m	*Womersleyella setacea*
				c - 40m	*Lithophylum* sp., *Peysonellia* sp.
4 Armenistis	50-60	35	NE	a - 15m	*Womersleyella setacea, Padina pavonica*
				b - 30m	*Womersleyella setacea*
5 Vourvourou	55	18	N, SE	a - 15m	*Pseudolithophylum expansum, Gelidium pectinatum, Cladocora caespitosa*
6 Eleftheronissos	70	30	NE, SE, N, S	b - 30m	*Lithothamnion* sp., *Polysiphonia* sp.
7 N.Iraklitsa	65	35	NE, NW, SE	a - 15m	*Cutleria multifida, Gelidium pectinatum*
				b - 30m	*Cutleria multifida, Gelidium pectinatum*

Sampling techniques

Physico-chemical factors

At each station measurements of the main abiotic parameters of the water column, i.e. temperature, salinity, conductivity, dissolved O_2 and pH, were carried out along the column of the water using the WTW salinity-conductivity-O_2 meter and Lovibond Checkit (pH meter) microelectronic equipment. Water clarity was also detected using the Secchi disc.

Data collection

Sampling was carried out by means of scuba diving using a modified quadrate sampler, covering a surface of 400cm^2, which is the minimum necessary for a statistically sound investigation on hard substrate benthic communities (Weinberg 1978 ; Stirn 1981). Five replicate samples (Bellan-Santini, 1969 ; Marinopoulos, 1988), were taken at each substation. All samples (75 overall) were collected by the same divers (authors), during summer months (July, August). At St.3 one more sampling attempt was performed at the depth of 30m, after one year, in order to identify annual changes in the structure of the fauna. During sampling the physiognomic aspects of the biotopes were registered by means of an underwater camera. All the samples were sieved through a 0.5mm mesh, fixed in 10% neutralized formalin and preserved in ethyl alcohol (70%). All living molluscs, after sorting, were identified to species level and counted.

Data analysis

Common biocoenotic methods were employed to analyze the data (Guille 1970 ; Hong 1983, Bakus, 1990 and others). Thus, the molluscan community structure was analysed by means of total number of species (S), average density (D - mean number of individuals/m^2), Shannon-Weaver diversity (H', log_2 basis), Margalef's species richness (d) and Pielou's evenness (J') indices.

Molluscs were classified according to their distribution to organismic assemblages (summarized in Table 2) based on information derived from Pérès & Picard, 1958; Fretter & Graham, 1962; Ledoyer, 1969; SMECKEL & Portmann, 1982; Ros & Gili, 1985; Zenetos, 1993, 1997; Strack, 1988; Cattaneo-Vietti et al., 1990; Koutsoubas, 1992; Delamotte & Vardala-Theodorou, 1994).

The multivariate analysis was based on presence/absence data per sampling substation, in order to equalize the contribution of each species. Thus, cluster analysis (group average) and non-metric multidimensional scaling, based on the Bray-Curtis similarity, were performed, using PRIMER package (Clarke & Green 1988; Clarke & Warwick 1994; Digby & Kempton 1994).

The significance of the multivariate results was assessed with ANOSIM test (CLARKE, 1993).

RESULTS

Abiotic factors

The pattern of the main abiotic parameters showed slight variation in relation to bathymetry or the location of the sampling sites. Temperature values fluctuated with depth, ranging from a minimum of 16.1°C at 40m to 27.5°C at water surface. The seasonal thermocline, due to summer (sampling was performed at the end of July- beginning of August), was detected at all stations at the average depth of 25m (end of July- first days of August), with the exception of St.5 (Vourvourou), possibly due to its shallow depth (18m). Salinity and conductivity showed similar variations. Their values ranged from 29.1 to 37.8 psu and 41.1 to 51.6 μS/cm respectively, with no really significant change in relation to depth, except from St.7 (N. Iraklitsa), where a notable decrease was observed (29.1 psu). The pH values were almost constant in relation to depth in all stations (8.5 at St.1 and St.7; 7.5 at St.4 and 8.2 at the rest of the stations). Dissolved oxygen values were generally high (from 6.5-10 mg/l) with an average value of 7.5 mg/l. Water clarity exceeded 20m in all sampling sites apart from st.5 (Vourvourou), where it was reduced to 12m, probably due to the increased presence of suspended particulate organic matter in the area.

Faunal composition and zoogeographical Remarks

Examination of the collected living material (10917 individuals), revealed 111 mollusc species. Gastropoda dominate in species number (85 species) followed by Bivalvia (21 species) and Polyplacophora (five species). Within Gastropoda the taxonomic groups with the highest number of species and individuals were the prosobranch families Trochidae, Rissoidae, Cerithiidae, Muricidae and Turridae and the heterobranch family Pyramidellidae. A complete list of the species in phylogenetic order within major taxa is presented in Table 2. The total number of species ranged from 64 at St.1 to 17 at St.5. Stations 1, 2, 3 and 4 were the most species rich, with stations 5, 6 and 7 the most poor.

TABLE 2

Molluscs reported from the hard substrata infralittoral assemblages. The numerical abundance is estimated from the total number of replicates per each substation (number of individuals per $0.2m^2$). The ecological status of each species (EC), is given by HS for hard substrate, C for coralligenous, PA for photophilic algae, HP for *Posidonia oceanica* meadows, DC for detritic costs, G for caves, SS for soft sediments, VTC for coastal terrigenous mud and U for unknown demands.

taxa	EC	St.1 15m	St.1 30m	St.1 40m	St.2 15m	St.2 30m	St.3 15m	St.3 30m	St.3 40m	St.3 30'm	St.4 15m	St.4 30m	St.5 18m	St.6 30m	St.7 15m	St.7 30m
Polyplacophora																
Callistochiton pachylasmae (Monterosato, 1878)	C					1										
Callochiton septemvalvis (Montagu, 1803)	HS		1											1		1
Lepidochiton monterosatoi Kaas & Van Belle, 1981	HS	1				1	1								1	
Chiton olivaceus Spengler, 1797	HS														1	1
Acanthochitona fascicularis (Linnaeus, 1767)	HS	1									1			1	1	1
Bivalvia																
Arca tetragona Poli, 1795	HS		2	2	2	2	10	6	2	4	1	8	2	6	2	6
Barbatia pulchella (Reeve, 1844)	HS								1							
Barbatia scabra (Poli, 1795)	C	1														
Striarca lactea (Linnaeus, 1758)	HS													1		1
Musculus costulatus (Risso, 1826)		2	3			1	3	3		3	1	1				
Lithophaga lithophaga (Linnaeus, 1758)	HS											1			4	2
Modiolus barbatus (Linnaeus, 1758)	HS,HP	1	27	13	9	42	3	12	16	7	4	11		4		
Modiolus adriaticus (Lamarck, 1819)	DC,SS	23	19	1	165	49	85	28		29	97	38	6	15	6	3
Chlamys varia (Linnaeus, 1758)	HS,SS	1				3						1				3
Lima lima (Linnaeus, 1758)	HS,C					1										
Limatulla subovata (Jeffreys, 1876)	HS,DC,C				4	3		1		3	3	6				
Anomia ephippium Linnaeus, 1758	HS				1			1	2		1					
Lucinella divaricata (Linnaeus,1758)	SS	17	4			1			2		8	12				
Myrtea spinifera (Montagu, 1803)	SS						1			1	2	24		1		
Chama (Psilopus) gryphoides Linnaeus, 1758	HS	1			1		1								4	2
Acanthocardia aculeata (Linnaeus, 1758)	SS	1	2		8	4	1			2	20	21	1	4		
Acanthocardia tuberculata (Linnaeus, 1758)	SS						2	2		1			2			
Dosinia exoleta (Linnaeus, 1758)	SS	1	16			2		4		4		37				
Irus irus (Linnaeus, 1758)	C	1	1	1	3	1	4	1		2	3	21				
Lentidium mediterraneum (CostaO.G.,1839)	SS	1	7	2		2	5	11		3	3	66				
Hiatella arctica (Linnaeus, 1767)	HS,C	17	10	6	78	49	38	31	10	20	38	24	34	59	28	11
Gastropoda																
Acmaea virginea (Mueller O.F., 1776)	HS,PA				1	2										
Emarginula adriatica CostaO.G., 1829	HS,M			1												
Emarginula octaviana Coen, 1939	HS		1				1					2		1	1	1
Emarginula huzardii (Payraudeau, 1826)	HS								2							
Anatoma crispata Fleming, 1828	DC		7	3		2	1	13	5	13		1		1		
Clanculus corallinus (Gmelin, 1791)	PA	1	1					1				1				
Clanculus jussieui (Payraudeau, 1826)	PA		1													
Gibbula magus (Linnaeus, 1758)	DC	15	34	2	5	2	18	14	1	15	2	3			3	
Gibbula adansonii (Payraudeau, 1826)	SS,HP							1								
Jujubinus exasperatus (Pennant, 1777)	C	1	10	1	3	8	6	13	1	4		6			1	2
Homalopoma sanguineum (Linnaeus, 1758)	HP,C		2			5		3	5	2					1	
Tricolia pullus pullus (Linnaeus, 1758)	PA,HP						1		6							

TABLE 2 (cont.)

Molluscs reported from the hard substrata infralittoral assemblages. The numerical abundance is estimated from the total number of replicates per each substation (number of individuals per 0.2m^2). The ecological status of each species (EC), is given by HS for hard substrate, C for coralligenous, PA for photophilic algae, HP for *Posidonia oceanica* meadows, DC for detritic costs, G for caves, SS for soft sediments, VTC for coastal terrigenous mud and U for unknown demands.

taxa	EC	St.1 15m	St.1 30m	St.1 40m	St.2 15m	St.2 30m	St.3 15m	St.3 30m	St.3 40m	St.3 30'm	St.4 15m	St.4 30m	St.5 18m	St.6 30m	St.7 15m	St.7 30m
Truncatella subcylindrica (Linnaeus, 1767)	SS							1								
Benthonella tenalla (Jeffreys, 1856)	VP						3									
Bolma rugosa (Linnaeus, 1767)	PA,C							2								
Cerithium vulgatum (Bruguiere, 1792)	PA	2			1			1	2	3	8	10				1
Bittium latreillii (Payraudeau, 1826)	PA,C	1131	1880	121	340	400	414	547	90	629	254	1510	2	138	80	26
Pirenella conica (Blainville, 1826)	SS			1		1							1			
Alvania aspera (Philippi, 1844)	PA	1														
Alvania cimex (Linnaeus, 1758)	PA	8	31	2	2	1	9	23	6	5		11	3	2	5	3
Alvania discors (Allan, 1818)	SS,HP										5	4				
Alvania mamillata Risso, 1826	PA	18	88	10	3	7	12	34	16	17		23		3	3	
Alvania semistriata (Montagu, 1808)	PA						2				1			2		
Manzonia crassa (Kanmacher, 1798)	HP	2	7				1	3	1	2		1		2		
Pusillina radiata (Philippi, 1836)	PA	16	56	8	4	17	48	74	7	32	6	14	1	3	1	2
Setia turriculata Monterosato, 1884	PA		7				2			10			3			
Setia sp. juveniles	PA						8		3							
Skeneopsis planorbis (Fabricus, 1780)	U							1								
Rissoina bruguieri (Payraudeau, 1826)	HP	9	38	4	4	2	14	18		7	1	1		1	1	3
Caecum trachea (Montagu, 1803)	DC	38	33	2	4	44		20		27	45	88	5	7		
Luria lurida (Linnaeus, 1758)	PA							1								
Pseudosimnia carnea (Poiret, 1789)	C,G		1					1								
Erato voluta (Montagu, 1803)	DC						1									
Euspira macilenta (Philippi, 1884)	SS		2	1	1											
Payraudeautia intricata (Donovan, 1804)	HP				2							1				
Monophorus perversus (Linnaeus, 1758)	PA,HP	2	5									1				
Metaxia metaxae (Delle Chiaje, 1828)	HP										1	3				
Cerithiopsis tubercularis (Montagu, 1803)	DC	2	4		1	1	3	1	1	1	1	4				1
Epitonium commune (Lamarck, 1822)	PA	1														
Melanella polita (Linnaeus, 1758)	SS,HP	1	1				1	1				1				
Hadriana oretea (De Gregorio, 1885)	SS,DC							1								
Muricopsis cristata (Poiret, 1883)	PA		3													
Ocinebrina aciculata (Lamarck, 1822)	PA								1							
Buccinulum corneum (Linnaeus, 1758)	PA,DC	1														
Engina leucozona (Philippi, 1843)	PA	1														
Fasciolaria lignaria (Linnaeus, 1758)	PA								1							
Fusinus pulchellus (Philipi, 1884)	C,G				1	1										
Nassarius incrassatus (Stroem, 1768)	PA,SS		1		1									1	3	5
Nassarius limata (Chemnitz, 1795)	PA,SS		1													
Stramonita haemastoma (Linnaeus, 1758)	PA													1	1	1
Vexillum tricolor (Gmelin, 1791)	PA	1	3		1			2		1		2				
Vexillum littorale (Philippi, 1843)	PA	1														
Mitra cornicula (Linnaeus, 1758)	PA,SS,HP								1							
Conus mediterraneus *Hwass in Bruguiere, 1792*	PA		1													
Mangelia attenuata (Montagu, 1803)	SS								1							
Mangelia vauquelini (Payraudeau, 1826)	HP						2		1			1			1	
Clavus maravignai (Bivona, 1838)	SS		1													
Haedropleura septangularis (Montagu, 1803)	SS								1							
Mitrolumna olivoidea (Cantraine, 1835)	PA	1	1	1				1		1						
Raphitoma echinata (Brocchi, 1814)	C	4	22	3		3	5	10	8	1		4	2			
Raphitoma concinna (Scacchi, 1836)	PA,C								1							
Raphitoma leufroyi (Michaud, 1828)	C	2	2		2					2	1	1			1	
Philbertia densa (Monterosato, 1884)	PA										1					
Pseudotorinia architae (Costa O.G., 1841)	DC									1						
Omalogyra atomus (Philippi, 1841)	SS	1	1		1								1			
Chrysallida doliolum (Philippi, 1844)	SS	4	5							1	1	2				
Folinella excavata (Philippi, 1836)	SS	2	11	1	1	1	5	12		2		2		2		2
Odostomia conoidea (Brocchi, 1814)	SS,HP		3												1	1
Turbonilla lactea (Linnaeus, 1758)	SS		2		1			1								
Cylichnina umbilicata (Montagu, 1803)	VTC	2				1					1		1			1
Haminaea navicula (Da Costa, 1778)	SS	3	9			2	1	4		5	2					
Philine catena (Montagu, 1803)	SS,HP,DC												1			
Ascobulla fragilis (Jeffreys, 1856)	HP								1							
Limapontia capitata (Mueller, 1774)	U												1			
Umbraculum umbraculum (Roeding, 1798)	C,DC		1													
Pleurobranchus membranaceus (Montagu, 1815)	DC				1											
Phyllaplysia lafonti (Fischer P., 1798)				2												
Petalifera petallifera (Rang, 1828)	U				1											
Trapania maculata Haefelfinger, 1960				1												
Hypselodoris webbi (D'Orbignyi, 1839)	PA							1								
Discodoris atromaculata Bergh, 1880	PA,C,G									1						
Paradoris indecora Bergh, 1881	PA										1					
Polycera quadrilineata (Mueller, 1876)				1												
Dendrodoris sp.	PA												1			

The dominant species in terms of average density was the prosobranch gastropod *Bittium latreillii* (2520 individuals/m^2), followed by the bivalves *Modiolus adriaticus* (215 individuals/m^2) and *Hiatella arctica* (175 individuals/m^2), the prosobranch gastropods *Caecum trachea* (120 individuals/m^2), *Pusillina radiata* (110 individuals/m^2) and *Alvania mammilata* (90 individuals/m^2), the bivalve *Modiolus barbatus* (60 individuals/m^2) and finally the prosobranch gastropods *Gibbula magus* (45 individuals/m^2) and *Alvania cimex* (40 individuals/m^2).

Molluscs were among the dominant taxa, accounting for 60% of the mean density of the macrofauna in the sampling sites (polychaetes accounted for 20% and crustaceans 15%) and were also the richest group in terms of species composition (ANTONIADOU & CHINTIROGLOU, unpublished data).

Three of these species namely : *Skeneopsis planorbis, Limapontia capitata* and *Trapania maculata* are reported for the first time as elements of the molluscan fauna in the Eastern Mediterranean or the Aegean Sea. Five other species, namely : *Callistochiton pachylasmae*, *Raphitoma leufroyi, Phyllaplysia lafonti*, *Petalifera petalifera* and *Polycera quadrilineata*, are reported for the first time in the North Aegean Sea. For the species that are new records for the Eastern Mediterranean or the Aegean Sea some taxonomic, ecological and zoogeographical information is given below.

New Records for the Eastern Mediterranean or the Aegean Sea

GASTROPODA

PROSOBRANCHIA

Family : Skeneopsidae

Skeneopsis planorbis (Fabricius O., 1780)

Skeneopsis planorbis, FRETTER & GRAHAM 1962 : 550, Fig. 290.

Material : Station 3 (Porto-Koufo), 1 specimen, 30m, bottom covered with the Rhodophycea *Womersleyella setacea*

Distribution : Mediterranean : various areas of the Western and Central Mediterranean (SABELLI et al., 1990) ; Eastern Atlantic : Boreal region (FRETTER & GRAHAM 1962).

OPISTHOBRANCHIA

Family : Stiligeridae

Limapontia capitata (O.F. Mueller, 1773)

Limapontia nigra, PRUVOT-FOL 1954 : 205, Fig. 79a-e.

Limapontia capitata, SCMECKEL & PORTMAN 1982 : 311, Abb. 3.1.

Material : Station 5 (Vourvourou), 1 specimen, 15m, bottom covered with the Rhodophycea *Pseudolithophylum expansum, Gelidium pectinatum*

Distribution : Mediterranean : various areas of the Western and Central Mediterranean (PRUVOT-FOL, 1954 ; SMECKEL & PORTMAN, 1982) and the coasts off Turkey (SWENNEN, 1961) ; Eastern Atlantic : European coast south to Marocco (SCMECKEL & PORTMAN, 1982).

Family : Goniodorididae

Trapania maculata Haefelfinger, 1960

Trapania maculata, CERVERA & GARCIA-GOMEZ 1988 : 166, Figs 1-5.

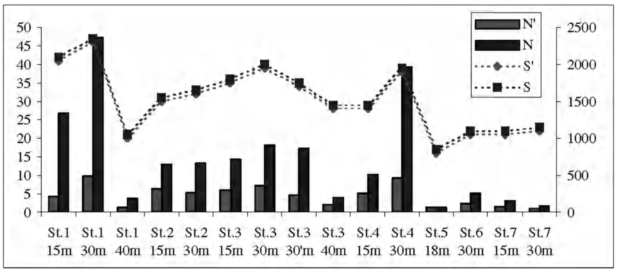
CATTANEO-VIETTI et al. 1990 : 45, Fig. 11, Pl.1 Fig. 7.

Material : Station 5 (Vourvourou), 1 specimen, 15m, bottom covered with the Rhodophycea *Pseudolithophylum expansum, Gelidium pectinatum*

Distribution : Mediterranean : various areas of the Western Mediterranean (CATTANEO-VIETTI et al., 1990) ; Eastern Atlantic : European coasts (BROWN & PICTON, 1976 ; CERVERA & GARCIA-GOMEZ, 1989).

Structural analysis

Diversity indices showed a variation in different sampling sites, with species richness (d) values ranging from 3.79 to 5.73, community diversity (H') values ranging from 1.28 to 3.62, and evenness (J') values from 0.24 to 0.79 (Fig. 2). The diversity values were quite low as a consequence of the great density values of the species *Bittium latreillii* recorded in most of the sampling stations. Furthermore, the high density of very few species (e.g. *Modiolus adriaticus, Hiatella arctica, Caecum trachea, Pusillina radiata, Alvania cimex, Modiolus barbatus, Gibbula magus, Alvania mammilata*) strongly influenced diversity indices values and in particular Shannon-Weaver's diversity and Pielou's evenness. However, the above calculations after the elimination of the species *Bittium latreillii* showed high values (Fig.2 red points-dash symbols), with d' ranging from 4.2 to 7.49, H' from 2.44 to 4.34 and J' from 0.5 to 0.86.



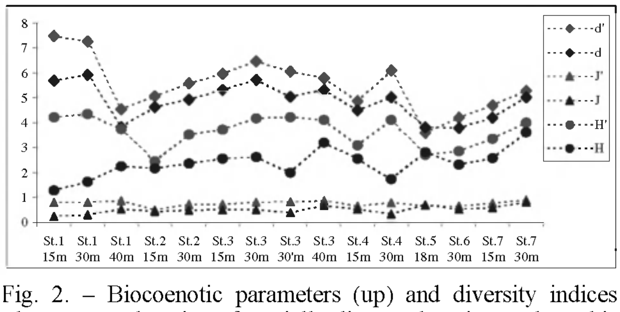


Fig. 2. – Biocoenotic parameters (up) and diversity indices (down) per substation of spatially-dispersed stations, where d is Margalef's richness, H is Shannon-Weaver index, J Pielou's evenness, S number of species/$0.2m^2$ and N number of individuals/$0.2m^2$. The dash (') indicates the above calculations after the elimination of the species *Bittium latreillii*.

Both multivariate analyses of the sampling sites, based on presence/absence data, indicate the separation of the samples in four main groups (Fig. 3). At about 40% similarity level, the samples from station 3 (c-40m) and the samples from station 5 form the first two single site groups. The third group includes the samples from stations 6 and 7 (a-15m & b-30m), while the fourth group matches the leftover stations at a 65% similarity level. The stress value for the two-dimensional MDS configuration is 0.13, so a useful picture is gained. However, a cross check of any conclusion by the superimposition of a cluster is suggested (Clarke & Warwick, 1994). The performance of a one-way ANOSIM test gave global R : 0.955 at a significance level of $p<0.1\%$, indicating an elevated degree of discrimination between the groups, confirming both Cluster and MDS. The discrimination of station 7 should probably be attributed to its slightly different abiotic characteristics (low salinity values). Its relatively moderate inclination places this station (St.7) near station 6, while the sharpest slope of stations 1, 2, 3 and 4 clusters them together. The substrate at St.5 is unique, formed by the coral *Cladocora caespitosa*. Furthermore a significant lowering in water clarity values discriminates this station from all others. At both stations 6 and 7 the sciaphilic algal assemblage is characterized by the occurrence of the Rhodophyceae *Gelidium pectinatum* and *Cutleria multifida*, while at all the other stations the dominant algae were the Rhodophyceae *Womersleyella setacea* and the Phaeophyceae *Padina pavonica* and *Codium bursa*. Furthermore at the third substation set at the depth of 40m, the dominant algae were the encrusting Rhodophyceae *Lithothamnion* sp., *Lithophyllum* sp. and *Peyssonnelia* sp.

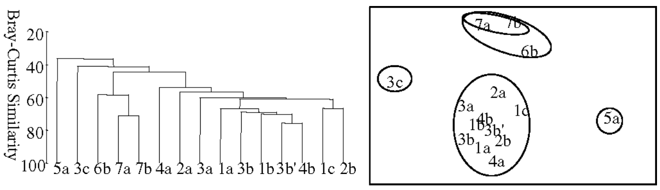


Fig. 3. – Spatial results of a cluster (left) and multidimensional scaling (right) based on Bray-Curtis similarity index on presence/absence data.

DISCUSSION

Generally speaking, Mollusca appear to be one of the most intensively studied taxa in marine habitats. However, as our revision shows, the knowledge concerning the abundance and the spatial dispersion of this taxon is very restricted. The study of hard substrate infralittoral assemblages in the North Aegean has revealed the presence of a rich molluscan community in this type of marine coastal ecosystem, while eight new records were set up for the N. Aegean molluscan fauna. These findings support previous authors' claims (e.g. Koutsoubas et al., 1997; Zenetos, 1997) that the marine biodiversity in Greek waters will be revealed to be even more rich when extended studies cover neglected geographical locations or habitats and contribute to the overthrow of the "impoverished Eastern Mediterranean theory" expressed earlier in this century (e.g. Pérès, 1967).

Comparing our results with the relevant reports from other investigators, we could focus to some major differences between the eastern and the western part of that semi-closed sea. Firstly the number of mollusc species found in this study (111) is higher than that reported from other areas of the Western and Central Mediterranean where quantitative sampling has been performed in hard substrate infralittoral assemblages [e.g. Banyuls Sur Mer (72 species) : Marinopoulos, 1988 ; Corsica (109 species) : Poulicek, 1985 ; Malta (44 species) : Richards, 1983]. The higher species richness (total number of species) found in the Aegean and Corsica, indicates that the survival ability of these assemblage is extremely high. According to Walker (1992), who expressed the hypothesis of 'over-species', the function of an ecosystem is little affected by the loss of species when there are always some representatives of all the basic functional groups in an assemblage (e.g. Gaston & Spicer, 1998). Secondly, the same also applies to density values, where 1200 individuals/m^2 had been reported from the photophilic algae assemblages off the coasts of Corsica (Poulicek, 1985). To a certain degree species with the maximum density in both aforementioned study areas *i.e.* North Aegean and Corsica, were either the same or congeneric (*Alvania mammilata, Pusillina radiata, Bittium latreillii, Hiatella arctica* – North Aegean Sea ; *Alvania cimex, Pusillina lineolata, Bittium reticulatum, Hiatella arctica* – Corsica). Thirdly a strong difference exists concerning the density of the species *Bittium latreillii.* This species was reported as one of the most abundant species from 20 meters downwards (Bellan-Santini 1969 ; Marinopoulos 1988), but as far as the western Mediterranean is concerned, it's normalized abundance (number of individuals per 5 replicates of 400cm^2) never exceeds 90, while at our stations it reached 1880. This is the case for the two upper substations (15 and 30 meters depth), while at the third substation (40 meters) and at stations 5, 6 and 7 the numerical abundance ranged from 2 to 138 individuals. The high values of *Bittium latreillii* abundance are probably related to the branching form of the dominant algae, which serves as an excellent ecological niche for this mollusc. This particular shape offers the opportunity for quantities of organic material to be trapped in the algae, thus offering suitable conditions for the species' trophic demands (herbivore-deposit feeder according to Gambi et al., 1992).

The majority of the molluscs collected during this study, including most of the dominant species, were ecologically classified as members of the photophilic algal assemblage in various areas of the Mediterranean and the Eastern Atlantic (e.g. Table 2). However, quite few of them have been recorded in soft sediments, submarine caves and sea-grass meadows. It seems that this specific habitat (rocky infralittoral) may be suitable for soft substrate and detritic species. The branching algae, which dominate the higher and middle layers of the infralittoral, offer suitable substrate for the settlement of most photophilic algal species. In-between the thallus of the algae and the hard substrate, an amount of soft sediment is trapped, leading to an increased occurrence of species demanding soft sediments. Our multivariate results revealed that the composition of the flora had a significant effect on the faunistic discrimination of the stations. They also indicate that molluscs are qualitatively distributed more evenly in terms of similarity at the middle part (20 to 30 meters) of the lower infralittoral zone. At that depth a high similarity in terms of the dominant species of flora is detectable. This demonstrates that hard substrate with either photophilic or sciaphilic algae may be a temporary, preferential site for various reasons, such as food demands, protection from predators, spawning, settlement and early development for individuals of many infralittoral or even circalittoral molluscs belonging to other assemblages. A similar statement has been made by POULICEK (1985) who noticed an increased presence of juveniles of mollusc species belonging to other assemblages in the photophilic algal communities of the coasts of Corsica over the reproduction period.

Therefore, we can imply that the complexity of the biotopes included in the hard substrate infralittoral zone, is not only insufficiently studied but also its importance is not well defined. The ecological approach of biodiversity, as GASTON & SPICER (1998) points out, is a firm component to its total definition. Consequently, the fact that these assemblages hold a very rich fauna (Mollusca in this specific case) of typical hard but also of soft substrate, reveals that they can play a key role for the maintenance of biodiversity of the broader geographical area.

Lack of knowledge on a quantitative basis makes it difficult to formulate general testimonials concerning the biogeography, although these would be valuable for building a broad picture of the biodiversity of the Mediterranean. These gaps were recently pointed out by STERGIOU et al. (1997), verifying that the problem of insufficient and piecemeal information applies not only for the phylum Mollusca, but also for the majority of the fauna in the Mediterranean.

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