# SMALL-SCALE DISTRIBUTION OF THE MACROBENTHIC FAUNA ON THE ROMANIAN ROCKY COAST OF THE BLACK SEA

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**ABSTRACT**

The present study describes the community structure and distribution of the macrobenthic fauna found on rocky shores along the Romanian coast of the Black Sea. A total of 23 macrobenthic species were identified. The pseudolittoral zone was dominated by vagile species such as *Sphaeroma pulchellum* (870 ind. $m^{-2}$), *Idotea balthica* (798 ind. $m^{-2}$) and *Echinogammarus olivii* (368 ind. $m^{-2}$). Macrofaunal biomass was dominated by sessile organisms such as the bivalve *Mytilaster lineatus* (52.9 g $m^{-2}$) and the sea-anemone *Actinia equina* (27.1 g $m^{-2}$). Species richness, evenness, Shannon-Wiener diversity *H'*, abundance, and biomass tended to increase from the supralittoral zone to the superior sublittoral.

**Key words:** macrozoobenthos, spatial distribution, supralittoral, pseudo-littoral, sublittoral, Romanian coast, Black Sea

## INTRODUCTION

Most shorelines of the worlds' oceans and seas experience tides – the periodic and predictable rise and fall of the sea level. One exception is the Black Sea which because of its semi-enclosed character virtually lacks tidal action along it's shore, experiencing only a 13 cm amplitude during spring tides (ARNOLDI, 1948). Nevertheless, the shoreline of the Black Sea does experience fluctuations in water level due to waves and wind action which pushes the water seaward or landward (ARNOLDI, 1948, 1949; MOKYEVSKY, 1969). This action exposes organisms inhabiting the littoral zone to extreme mechanical and chemical disturbance, expressed as desiccation, intense wave battering (GOMOIU, 1968) and fluctuating levels of temperature and salinity (BORCEA, 1931; BACESCU, 1954; BACESCU *et al*., 1971). Shorelines are also the habitats most often subjected to intense anthropogenic disturbances. The Romanian coast of the Black Sea is characterized by calcareous cliffs that at several isolated points, south of Constanţa, are continuously exposed to wave action (BACESCU *et al*., 1971; ANDRIESCU, 1977; PETRAN, 1997).

Despite being the most accessible of the marine habitats, benthic communities along the Romanian shoreline have received little attention (but see BACESCU *et al*., 1971; SURUGIU, 2000; ABAZA, 2002). This is essentially due to difficulties in quantitative sampling of rocky substrates (BACESCU *et al*., 1963). Moreover, quantitative studies on fauna inhabiting the rocky pseudolittoral zone of the Black Sea are scarce (ARNOLDI, 1949; MUSTATA *et al*., 1998) and are almost absent for the rocky supralittoral zone. The quantitative data on superior sublittoral rocky substrate can be derived from works of ARNOLDI (1949), BACESCU *et al*. (1963) and ŢIGANUS (1981).

The purpose of this study was to: (1) to provide information on the abundance and biomass of organisms which inhabit the Romanian rocky shoreline, (2) to characterise the spatial distribution of macrofauna and (3) to highlight the changes in the structure of the pseudolittoral communities as result of the anthropogenic impacts.

## MATERIAL AND METHODS

Sampling for this study was conducted on the 2-5 of August 2003. To characterise spatial community patterns, four transects were set up perpendicular to the shoreline including three at Agigea (A-C) and one at Vama Veche (D), (Fig. 1). At Agigea transects were separated by 20 m intervals, with the northern-most transect (A) located approximately 300 m south of the Cherhanaua Agigea. Mid-shoreline position determined the placement of stations on individual transects at the time of sampling. Transects consisted of three stations: the first was placed in supralittoral zone, the second in the pseudolittoral zone and a third in the adjacent superior sublittoral. Two replicate samples were taken from each station, except at station C1 where four replicates were taken, providing a total of 26 samples.

The vertical zonation of the shoreline used in this study was derived from SURUGIU (1999). The supralittoral or spray zone represents the narrow fringe of the sea-shore situated above the maximum level of the penetration of waves, at a given moment of time, and only receives water originating from wave splash. The pseudo-littoral or splash zone is designated as the zone of intermittent immergence and emergence resulting from the braking of waves. The superior sublittoral zone comprises the part of the sea-bed permanently submerged and whose lower limit is concurrent with lower limit of distribution of sea grasses and photophilic algae (~15-20 m depth in the Black Sea). In the present study only bottoms less than 1 m depth were considered.

Sampling was performed by the removal of isolated boulders, of comparable sizes (144-612 $cm^2$), and by wrapping them (*in situ*) in polyethylene bags. The boulders were transported to the laboratory where they were washed in buckets with sea-water. The sea-water sample was then processed over a 500 μm mesh sieve. The retained organisms were placed in separate jars containing 4% formaldehyde solution for at least 24 hour. Afterwards the samples were rinsed in tap-water and sorted according to major taxonomic groups and preserved in 70% ethanol. The organisms were later identified to species and counted under a stereomicroscope. Wet weights of organisms from each sample were measured with an analytical balance of 0.0001 g sensitivity. For the extrapolation of the results to the square metre the surface of the boulders was measured precisely.

In order to elucidate the qualitative and quantitative structure of the communities from rocky shores, the following ecological indices were used: species richness ($S$), abundance ($A$, ind. $m^{-2}$), biomass ($B$, g wwt $m^{-2}$) and Soyer's frequency index ($F$). Shannon-Wiener's diversity index ($H'$, $\log_2$ base) and Pielou's evenness index ($J'$) were also used to estimate community diversity. To reveal the small-scale variations between the fauna inhabiting different levels of the rocky shore the Bray-Curtis similarity index, based on the fourth root transformed species abundances, was calculated between stations. Hierarchical clustering was performed on the similarity matrix using group average linking.

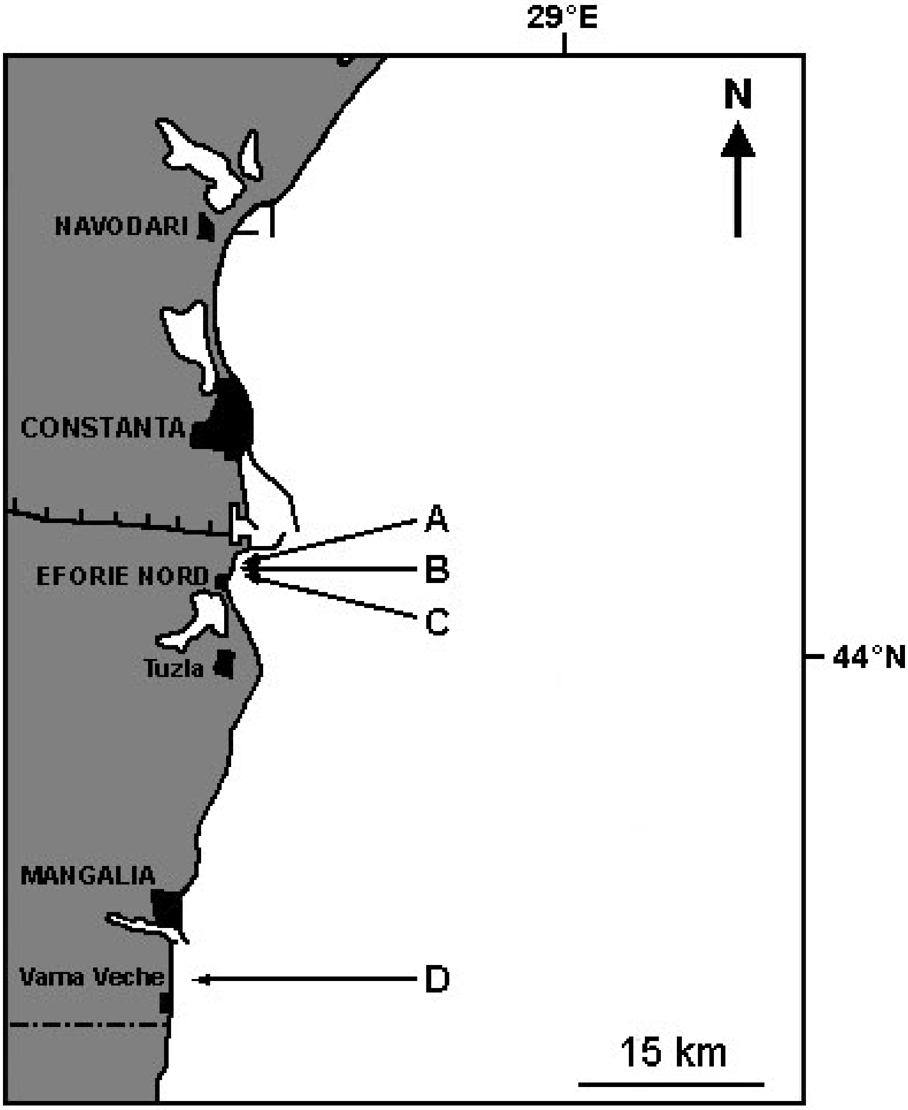


Fig. 1 – Map of the investigated area with the location of sampling sites

## RESULTS AND DISCUSSION

During the sampling period, temperature varied between 24-27°C, salinity was 18-18.5‰ and dissolved oxygen was 4.6-5.5 mg $l^{-1}$ (Table 1). Faunistic analysis of organisms collected on rocky shores at Agigea and Vama Veche revealed 2588 individuals belonging to 23 species (Table 2). Thus, macrobenthic species composition inhabiting the Romanian rocky coast of the Black Sea was relatively poor. This compares very well with BACESCU *et al*. (1971) who reported no less than 32 species for rocky shores. In Constanţa - Agigea area, MUSTATA *et al*. (1998) found 26 macrobenthic species in the rocky pseudolittoral. However, the specific diversity at Romanian shore seems to be higher than in Karkinitsky Bay, where ARNOLDI (1949) found only 17 species.

Table 1

Environmental characteristics of the stations studied

| **Site** | **Agigea** | **Vama Veche** |
|---|---|---|
| Date | 03.08.2003 | 05.08.2003 |
| T ($^0$C) | 27 | 24 |
| S (‰) | 18.0 | 18.5 |
| $O_2$ (mg $l^{-1}$) | 4.60 | 5.49 |

It has been shown that in the last 30 years a number of species inhabiting rocky shores has declined in number or disappeared completely (PETRAN, 1997; ABAZA, 2002). The main cause for this was intensification of pollution, which has severely degraded near-shore habitats. In addition, extremely reduced temperatures occurred in winter 1995/1996, which killed near-shore organisms due to freezing of the water and ice scour. Several species found to be present on the Romanian rocky coast in previous studies were absent from the present study including: the nudibranchiate mollusc *Limapontia capitata*, the limpet *Patella caerulea*, the barnacle *Chthamalus stellatus* and the amphipod *Gammarus aequicauda*. Of the species identified, *Orchestia gammarellus*, *O. montagui* and dipterans occurred only in supralittoral samples, whereas, *Lepidochitona cinerea* and *Echinogammarus foxi* were present exclusively in pseudolittoral zone. *Neanthes succinea*, *Platynereis dumerilii*, *Mytilus galloprovincialis*, *Melita palmata* and *Xantho poressa* were restricted to superior sublittoral zone (Table 2).

Among the major taxa, amphipods ranked first in terms of number of species (10 species, 43% of the total number of species), followed by isopods (3 species, 13%), polychaetes, bivalves and decapods (2 species each). The taxa represented by highest numbers of individuals were isopods (1302 specimens, 50% of the total number of individuals), amphipods (769 specimens, 30%) and bivalves (213 specimens, 8%). The numerically dominant species found on rocky shores were *Sphaeroma pulchellum* (665 individuals, 26% of the total number of specimens), *Idotea balthica* (617 individuals, 24%), Diptera (177 individuals, 7%), *Ochestia montagui* (174 individuals, 7%), *Orchestia gammarellus* (160 individuals, 6%) and *Mytilaster lineatus* (116 individuals, 5%). The calculation of the Soyer's frequency index (*F*) revealed that *Sphaeroma pulchellum* (96%), *Idotea balthica* (92%) and *Mytilaster lineatus* (50%) can be classified as constant species (F≥50) on the rocky shores, *Hyale pontica* (46%), *Actinia equina* (31%), *Echinogammarus olivii* (31%), *Balanus improvisus*, *Amphithoe ramondi*, *Orchestia gammarellus* and *O. montagui* (27% each) as common species (25≤F<50) and the remaining 13 species as rare (F<25).

Table 2

List of species identified on rocky shores
and their abundance (number of individuals)

| **Species** | **Supra-littoral** | **Pseudo-littoral** | **Superior sublittoral** | **Total** |
|---|---|---|---|---|
| *Actinia equina* (Linnaeus, 1758) | | 24 | 14 | 38 |
| *Neanthes succinea* (Frey & Leuckart,1847) | | | 2 | 2 |
| *Platynereis dumerilii* (Audouin & Milne-Edwards, 1833) | | | 1 | 1 |
| *Lepidochitona cinerea* (Linnaeus, 1767) | | 11 | | 11 |
| *Mytilaster lineatus* (Gmelin, 1791) | | 60 | 56 | 116 |
| *Mytilus galloprovincialis* Lamarck, 1819 | | | 97 | 97 |
| *Balanus improvisus* Darwin, 1854 | | 17 | 54 | 71 |
| *Sphaeroma pulchellum* Montagu, 1813 | 160 | 206 | 299 | 665 |
| *Sphaeroma serratum* (Fabricius, 1787) | 3 | 8 | 9 | 20 |
| *Idotea balthica* (Pallas, 1772) | 61 | 243 | 313 | 617 |
| *Amphithoe ramondi* Audouin, 1826 | | 72 | 19 | 91 |
| *Echinogammarus olivii* (Milne-Edwards,1830) | | 77 | 30 | 107 |
| *Echinogammarus foxi* (Schellenberg, 1928) | | 10 | | 10 |
| *Orchestia gammarellus* (Pallas, 1766) | 160 | | | 160 |
| *Orchestia montagui* Audouin, 1826 | 174 | | | 174 |
| *Hyale pontica* Rathke, 1837 | 15 | 46 | 36 | 97 |
| *Jassa ocia* (Bate, 1862) | | 7 | 19 | 26 |
| *Microdeutopus gryllotalpa* Costa, 1853 | | 7 | 42 | 49 |
| *Stenothoe monoculoides* (Montagu, 1815) | | 5 | 20 | 25 |
| *Melita palmata* (Montagu, 1804) | | | 30 | 30 |
| *Pachygrapsus marmoratus* (Fabricius, 1787) | 2 | | 1 | 3 |
| *Xantho poressa* (Olivi, 1792) | | | 1 | 1 |
| Unid. Diptera | 177 | | | 177 |
| Total | 752 | 793 | 1043 | 2588 |

When considering the total number of species within each zone, the highest number of species was found in the superior sublittoral (18 species), the lowest in the supralittoral zone (8 species) and 14 species in the pseudolittoral zone (Table 2). In the supralittoral zone total population densities ranged from 635 to 5710 ind. $m^{-2}$ (Table 3). The dominant species sampled in the supralittoral zone were dipterans (30% of the total mean abundance), *Orchestia montagui* (22%), *Sphaeroma pulchellum* (19%) and *O. gammarellus* (18%). *Idotea balthica* represented only 8% of the total average population density. Similarly, BACESCU *et al*. (1971) showed that rocky supralittoral covered by dense mats of decaying seaweeds can shelter a rich fauna composed by the isopods *Idotea balthica* and *Sphaeroma pulchellum*, by the amphipods of the genus *Hyale* and *Orchestia*, by the gastropods *Tricolia pullus* and *Rissoa splendida* and by larvae of halophilic dipterans. Population densities of several species varied considerably among profiles, indicating a patchy distribution. Thus population density of *Orchestia montagui* varied from 0 to1821 g $m^{-2}$. The values of the total biomass in the supralittoral zone varied from 7.4 g $m^{-2}$ at Vama Veche to 54.9 g $m^{-2}$ at Agigea (Table 4). Species having very high biomass included *Orchestia montagui* (33% of the total mean biomass), *O. gammarellus* (24%) and *Sphaeroma pulchellum* (19%). In addition, relatively rare but large-sized species such as *Pachygrapsus marmoratus* (13%) and *Idotea balthica* (12%) were important contributors to overall biomass.

Table 3

Abundance of species (ind.$m^{-2}$) identified in supralittoral zone

| **Species** | **A1** | **B1** | **C1** | **D1** | **Average** |
|---|---|---|---|---|---|
| *Sphaeroma pulchellum* | 638 | 242 | 956 | 184 | 505 |
| *Sphaeroma serratum* | 25 | | | | 6 |
| *Idotea balthica* | 150 | 153 | 418 | 102 | 206 |
| *Orchestia gammarellus* | 470 | 105 | 981 | 348 | 476 |
| *Orchestia montagui* | 218 | 239 | 1821 | | 569 |
| *Hyale pontica* | 26 | 66 | 72 | | 41 |
| *Pachygrapsus marmoratus* | | | 31 | | 8 |
| Unid. Diptera | | 1723 | 1431 | | 788 |
| Total | 1526 | 2528 | 5710 | 635 | 2600 |

In the pseudolittoral zone the abundance values varied from 2128 ind. $m^{-2}$ to 4573 ind. $m^{-2}$ (Table 5). Much higher values for the total abundance, ranging from 11,560 ind. $m^{-2}$ to 21,024 ind. $m^{-2}$, were found in the pseudolittoral zone of Karkinitsky Bay by ARNOLDI (1949). The most important species in the pseudolittoral zone were *Sphaeroma pulchellum* (28%

of the total mean abundance) and *Idotea balthica* (26%). An important role in pseudolittoral zone was also played by *Echinogammarus olivii* (12% of the total mean abundance), *Mytilaster lineatus* (9%) and *Amphithoe ramondi* (9%), (Figs. 2 and 3). *Sphaeroma pulchellum* and *Idotea balthica* were frequently encountered, occurring in all samples taken in the pseudolittoral zone. Similarly, the study done by MUSTATA *et al*. (1998) indicated that these two isopods were the most abundant and most frequent species in the pseudolittoral zone of Constanţa – Agigea area. However, the values of the population densities in the work of MUSTATA *et al*. (1998) were much higher: 74,525 ind. $m^{-2}$ for *Sphaeroma pulchellum* and 40,325 ind. $m^{-2}$ for *Idotea balthica*. In the Mediterranean Sea characteristic species for the littoral boulder fields are *Echinogammarus olivii*, *Sphaeroma serratum*, *Pachygrapsus marmoratus*, *Allorchestes aquilinus* and *Perinereis cultrifera* (PĖRĒS & PICARD, 1958). The biomass in the pseudolittoral zone ranged from 23.7 g $m^{-2}$ to 174.0 g $m^{-2}$ (Table 6). It was dominated by sessile fauna, represented by *Mytilaster lineatus*, *Balanus improvisus* and *Actinia equina*, which accounted for almost 80% of the total mean biomass of the macrozoobenthos. For the pseudolittoral zone of the Karkinitsky Bay, ARNOLDI (1949) indicated that the total biomass values varied between 127.0 and 555.28 g. $m^{-2}$, of which *Mytilaster lineatus* alone represented 83%. MUSTATA *et al*. (1998), without giving absolute values, showed that on the rocky pseudolittoral zone of Mamaia – Eforie area molluscs represented 68.24% of the total biomass, crustaceans 23.53%, polychaetes 5.88% and other groups 2.34%. In the present study we have found that molluscs represent 52.95% of the total biomass, crustaceans 20.33% and other groups 26.71%. In terms of biomass dominant species in the superior sublittoral were *Mytilaster lineatus* (52% of the total mean biomass), *Actinia equina* (26.7%) and *Idotea balthica* (9%).

Table 4

Biomass of species (g.$m^{-2}$) identified in supralittoral zone

| Species | A1 | B1 | C1 | D1 | Average |
|---|---|---|---|---|---|
| *Sphaeroma pulchellum* | 5.747 | 2.180 | 6.160 | 1.660 | 3.937 |
| *Sphaeroma serratum* | 0.221 | | | | 0.055 |
| *Idotea balthica* | 0.798 | 1.111 | 5.759 | 2.084 | 2.438 |
| *Orchestia gammarellus* | 4.932 | 1.103 | 10.304 | 3.658 | 4.999 |
| *Orchestia montagui* | 2.610 | 2.872 | 21.847 | | 6.832 |
| *Hyale pontica* | 0.067 | 0.020 | 0.188 | | 0.069 |
| *Pachygrapsus marmoratus* | | | 10.645 | | 2.661 |
| Unid. Diptera | | 0.015 | 0.011 | | 0.006 |
| Total | 14.375 | 7.302 | 54.913 | 7.402 | 20.998 |

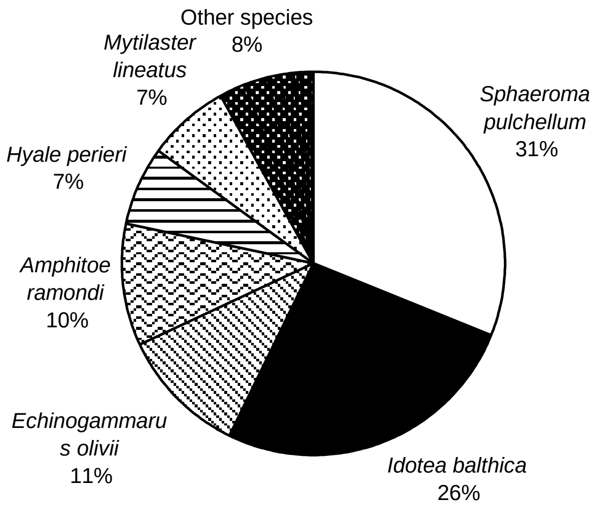


Fig. 2 – Relative dominance of the species in rocky pseudo-littoral at Agigea

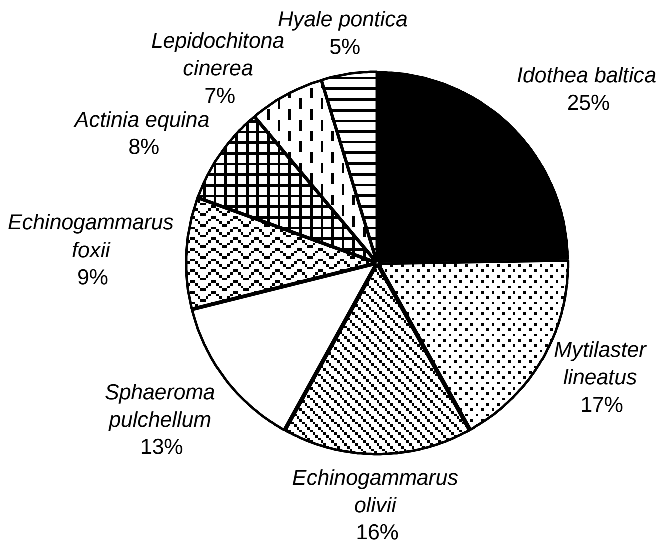


Fig. 3 – Relative dominance of the species in rocky pseudo-littoral at Vama Veche

Table 5

Abundance of species (ind.m$^{-2}$) identified in pseudo-littoral zone

| Species | A2 | B2 | C2 | D2 | Average |
|---|---|---|---|---|---|
| *Actinia equina* | | 120 | 109 | 181 | 102 |
| *Lepidochitona cinerea* | | 62 | | 143 | 51 |
| *Mytilaster lineatus* | 45 | 354 | 286 | 378 | 266 |
| *Balanus improvisus* | 53 | 44 | 127 | | 56 |
| *Sphaeroma pulchellum* | 279 | 1201 | 1715 | 286 | 870 |
| *Sphaeroma serratum* | 34 | 74 | | | 27 |
| *Idotea balthica* | 1352 | 534 | 767 | 539 | 798 |
| *Amphithoe ramondi* | 181 | 355 | 527 | | 266 |
| *Echinogammarus olivii* | | 443 | 676 | 351 | 368 |
| *Echinogammarus foxi* | | | | 205 | 51 |
| *Hyale pontica* | 79 | 244 | 365 | 102 | 197 |
| *Jassa ocia* | 68 | | | | 17 |
| *Microdeutopus gryllotalpa* | | 109 | | | 27 |
| *Stenothoe monoculoides* | 38 | | | | 9 |
| Total | 2128 | 3541 | 4573 | 2185 | 3107 |

Table 6

Biomass of species (g.m$^{-2}$) identified in pseudo-littoral zone

| Species | A2 | B2 | C2 | D2 | Average |
|---|---|---|---|---|---|
| *Actinia equina* | | 46.754 | 38.236 | 23.245 | 27.059 |
| *Lepidochitona cinerea* | | 0.919 | | 2.111 | 0.757 |
| *Mytilaster lineatus* | 4.499 | 47.971 | 24.713 | 134.368 | 52.888 |
| *Balanus improvisus* | 0.319 | 0.750 | 2.151 | | 0.805 |
| *Sphaeroma pulchellum* | 2.511 | 5.634 | 10.167 | 0.921 | 4.808 |
| *Sphaeroma serratum* | 0.303 | 0.666 | | | 0.242 |
| *Idotea balthica* | 15.277 | 4.128 | 13.325 | 5.071 | 9.450 |
| *Amphithoe ramondi* | 0.488 | 0.320 | 0.475 | | 0.321 |
| *Echinogammarus olivii* | | 4.561 | 6.593 | 6.270 | 4.356 |
| *Echinogammarus foxi* | | | | 1.998 | 0.499 |
| *Hyale pontica* | 0.204 | 0.063 | 0.095 | 0.027 | 0.097 |
| *Jassa ocia* | 0.024 | | | | 0.006 |
| *Microdeutopus gryllotalpa* | | 0.025 | | | 0.006 |
| *Stenothoe monoculoides* | 0.030 | | | | 0.007 |
| Total | 23.655 | 111.791 | 95.755 | 174.011 | 101.303 |

In the superior sublittoral the highest density was of 5114 ind. m$^{-2}$, while the lowest was of 1711 ind. m$^{-2}$ (Table 7). In terms of numerical abundance the dominant components in superior sublittoral were *Idotea* *balthica* (30%) and *Sphaeroma pulchellum* (26%). BACESCU *et al*. (1971) also found *Idotea balthica* to be the most abundant vagile component of the macrozoobenthos in the superior sublittoral. Relatively high densities were also shown for the bivalves *Mytilus galloprovincialis* (7% of the total abundance) and *Mytilaster lineatus* (7%) and in terms of biomass these two species dominated this zone making up 70% of the total biomass. BACESCU *et al*. (1971) showed that *Mytilus galloprovincialis* became a dominant species at depth greater than 1 m. Similarly, ŢIGANUS (1981) indicates that in the superior sublittoral the mussels represent more than 90% of the total biomass, while the amphipods represent 50% of the total abundance. An important contribution to the total biomass had also the smaller but very numerous individuals of *Idotea balthica* (11% of the total mean biomass). The total biomass values in the superior sublittoral ranged from 11.65 g $m^{-2}$ to 311.1 g $m^{-2}$ (Table 8). The values obtained in the present study are in good agreement with the results of BACESCU *et al*. (1963), who have found at Agigea at 1.2 m depth biomass values comprised between 142.48 and 189.94 g $m^{-2}$.

Table 7

Abundance of species (ind.$m^{-2}$) identified in superior sublittoral

| Species | A3 | B3 | C3 | D3 | Average |
|---|---|---|---|---|---|
| *Actinia equina* | | 63 | 82 | 13 | 40 |
| *Neanthes succinea* | | | 18 | | 5 |
| *Platynereis dumerilii* | | 16 | | | 4 |
| *Mytilaster lineatus* | 430 | 347 | 180 | | 239 |
| *Mytilus galloprovincialis* | | 143 | 823 | | 241 |
| *Balanus improvisus* | 186 | 111 | 373 | | 168 |
| *Sphaeroma pulchellum* | 726 | 905 | 1729 | 478 | 960 |
| *Sphaeroma serratum* | | | 82 | | 21 |
| *Idotea balthica* | 1298 | 1358 | 1637 | 147 | 1110 |
| *Amphithoe ramondi* | | 221 | 73 | | 74 |
| *Echinogammarus olivii* | 680 | | | | 170 |
| *Hyale pontica* | 349 | | | 304 | 163 |
| *Jassa ocia* | 431 | | | | 108 |
| *Microdeutopus gryllotalpa* | | | | 597 | 149 |
| *Stenothoe monoculoides* | 342 | 79 | | | 105 |
| *Melita palmata* | | 111 | 106 | 173 | 98 |
| *Pachygrapsus marmoratus* | | | 9 | | 2 |
| *Xantho poressa* | | 21 | | | 5 |
| Total | 4441 | 3376 | 5114 | 1711 | 3661 |

Table 8

Biomass of species ($g.m^{-2}$) identified in superior sublittoral

| Species | A3 | B3 | C3 | D3 | Average |
|---|---|---|---|---|---|
| *Actinia equina* | | 16.778 | 30.714 | 5.404 | 13.224 |
| *Neanthes succinea* | | | 0.293 | | 0.073 |
| *Platynereis dumerilii* | | 0.010 | | | 0.002 |
| *Mytilaster lineatus* | 23.220 | 77.306 | 7.288 | | 26.953 |
| *Mytilus galloprovincialis* | | 175.873 | 180.477 | | 89.087 |
| *Balanus improvisus* | 3.563 | 4.400 | 5.442 | | 3.351 |
| *Sphaeroma pulchellum* | 6.538 | 8.147 | 13.913 | 4.303 | 8.225 |
| *Sphaeroma serratum* | | | 0.751 | | 0.188 |
| *Idotea balthica* | 38.926 | 17.418 | 12.731 | 1.658 | 17.683 |
| *Amphithoe ramondi* | | 0.199 | 0.066 | | 0.066 |
| *Echinogammarus olivii* | 6.628 | | | | 1.657 |
| *Hyale pontica* | 0.091 | | | 0.088 | 0.045 |
| *Jassa ocia* | 0.155 | | | | 0.039 |
| *Microdeutopus gryllotalpa* | | | | 0.137 | 0.034 |
| *Stenothoe monoculoides* | 0.205 | 0.048 | | | 0.063 |
| *Melita palmata* | | 0.100 | 0.096 | 0.059 | 0.064 |
| *Pachygrapsus marmoratus* | | | 2.161 | | 0.540 |
| *Xantho poressa* | | 10.861 | | | 2.715 |
| Total | 79.326 | 311.139 | 253.931 | 11.650 | 164.011 |

The comparison between averages of the total number of species, abundance, biomass, diversity and evenness indices together with their standard deviations from different zones are presented in Table 9. Mean species richness ranged between 4 species per square metre in the supralittoral zone and 7 species in the pseudolittoral zone and superior sublittoral. The highest total abundance occurred in the superior sublittoral zone (3661 $ind.m^{-2}$), the lowest in the supralittoral zone (2600 $ind.m^{-2}$) and intermediate values in the pseudolittoral zone (3107 ind. $M^{-2}$). The mean biomass values also increased from supralittoral zone (21.0 g $m^{-2}$) to the superior sublittoral (164.01 g $m^{-2}$). Shannon-Weiner diversity ranged from 1.60 in the supralittoral zone to 2.34 in the superior sublittoral (Table 9). Evenness varied from 0.76 in the supralittoral zone to 0.85 in the superior sublittoral. In the work of MUSTATA *et al*. (1998) Shannon diversity was higher (2.01-3.12) comparative to the present study, but the evenness was lower (0.47-0.64). This can be explained by the strong dominance of *Sphaeroma pulchellum* and *Idotea balthica* in MUSTATA *et al*. (1998) whereas in the present study there was a more even distribution of individuals among species which is often indicative for the gradual recovery of this community from the anthropogenic stress. The Bray-Curtis cluster analysis revealed the presence of two main groups of stations at similarity level of approximately 40% (Fig. 4). The first group includes stations A1, B1, C1 and D1, which corresponds to supralittoral zone. The second group comprises stations from pseudolittoral and from superior supralittoral zone. The stations D1, D2 and D3 shows lower similarity with the rest of the group due to the differences in microhabitat conditions at Vama Veche (profile D). It should be noted that at station A2 a lower similarity compared to other groups was due to the absence of some characteristic pseudolittoral species such as *Lepidochitona cinerea* and *Echinogammarus olivii*. Instead it joined with station A3 at a similarity level of 70%, suggesting very small differences in the faunal assemblages from pseudo- and superior sublittoral zone.

Table 9

Averages of species richness (S), abundance (A), biomass (B), Shannon diversity index (H') and evenness index (J') estimated in each habitat

| **Zone** | **S** | **A (ind.m$^{-2}$)** | **B (g.m$^{-2}$)** | **H'** | **J'** | **Dominant species** |
|---|---|---|---|---|---|---|
| Supra-littoral | 4.3 ± 0.71 | 2600 ± 2213.8 | 21.00 ± 22.136 | 1.60 ± 0.328 | 0.76 ± 0.120 | Diptera (24%) |
| Pseudo-littoral | 7.0 ± 1.31 | 3107 ± 1175.6 | 101.30 ± 61.796 | 2.32 ± 0.399 | 0.83 ± 0.121 | *Idotea balthica* (31%) |
| Superior sublittoral | 7.0 ± 2.07 | 3661 ± 1483.4 | 164.01 ± 141.560 | 2.34 ± 0.363 | 0.85 ± 0.103 | *Idotea balthica* (30%) |

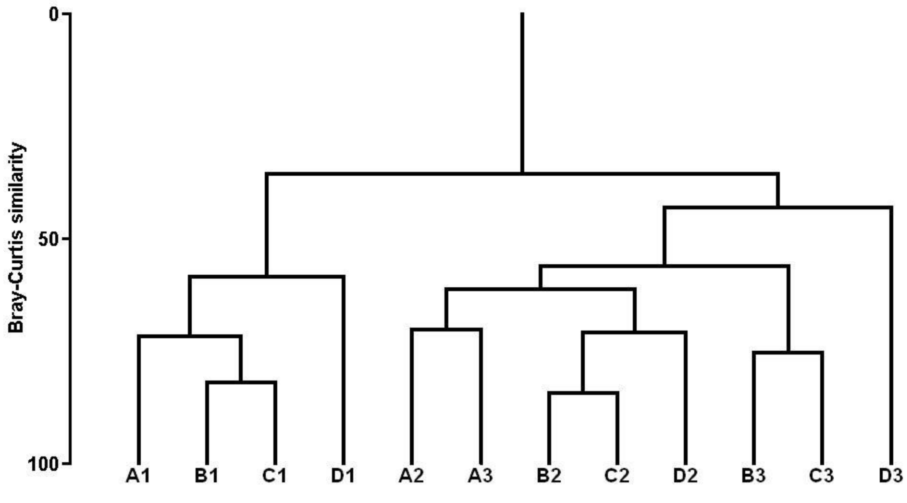


Fig. 4 – Similarity dendrogram of sampled stations

## CONCLUSIONS

The study of the rocky shores from Agigea and Vama Veche revealed the occurrence of 23 macrozoobenthic species. In the supralittoral zone the dominant species in terms of densities, as well as biomass, were the amphipods *Orchestia montagui* (with mean abundance of 569 ind. $m^{-2}$ and mean biomass of 6.8 g $m^{-2}$) and *O. gammarellus* (476 ind. $m^{-2}$ and 5.0 g $m^{-2}$), the isopod *Sphaeroma pulchellum* (505 ind. $m^{-2}$ and 3.9 g $m^{-2}$) and larvae of dipterans. The most frequently encountered and abundant species in the pseudolittoral zone were the isopods *Sphaeroma pulchellum* and *Idotea balthica*. These two species had mean densities of 870 and 798 ind. $m^{-2}$, respectively. Nevertheless, the highest biomass is given by the sessile species such as the bivalve *Mytilaster lineatus* (in average 52.9 g $m^{-2}$) and the anemone *Actinia equina* (27.1 g $m^{-2}$). In the superior sublittoral dominant species in terms of abundance were *Idotea balthica* (1110 ind. $m^{-2}$) and *Sphaeroma pulchellum* (960 ind. $m^{-2}$), while in terms of biomass dominant species included *Mytilus galloprovincialis* (89.1 g $m^{-2}$) and *Mytilaster lineatus* (30.0 g $m^{-2}$). Species richness increased from 4 species per square metre in the supralittoral zone to 7 species per $m^2$ in the superior sublittoral. The total density also increased from 2600 ind. $m^{-2}$ in supralittoral zone to 3661 ind. $m^{-2}$ in superior sublittoral. The same increase from supralittoral to superior sublittoral was observed for the total biomass (from 21.0 g $m^{-2}$ to 164.0 g $m^{-2}$). Shannon diversity *H'* ranged from 1.60 to 2.34 and species evenness was high ranging from 0.76 to 0.85. The present study enhances our knowledge about the small-scale distribution of the macrofauna inhabiting rocky shores of the Romanian coast.

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