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OSTRACODES (CRUSTACEA, OSTRACODA) IN THE ROCKY NEARSHORE WATER AREA OF ZMIINIY ISLAND (BLACK SEA)

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Ostracodes (Crustacea, Ostracoda) in the Rocky Nearshore Water Area of Zmiiniy Island (Black Sea). Uzun, O. — Data about meiobenthic ostracodes species on the different substrates of Zmiiniy Island nearshore water area are presented. The density and biomass means of the ostracodes were higher on the algal substrates (on *Laurencia paniculata* made up 41931 ± 12689 ind.·m^{-2} and 400.56 ± 125.65 mg·m^{-2} respectively). In the current study for the first time 13 ostracodes species were found, most of which are common in all types of substrate. The dominant species were *Loxoconcha pontica* Klie, 1937, *Paradoxostoma intermedium* Müller, 1894, *Xestoleberis cornelii* Caraion, 1963 and *Xestoleberis decipiens* (Müller, 1894). All of them are common species in the north-western Black Sea. Non-metric multidimensional scaling (nMDS) analysis of ostracodes species abundance shown that the samples of sandy-shells bottom differed significantly from algal and mussel substrates. According to the cluster analysis sand-shells bottom samples on almost 80 % differed from hard substrates.
Key words: meiobenthos, meiofauna, seed shrimps, hard substrates, soft substrates, habitat, rocky shores.

Introduction

Nearshore biotopes with specific organisms' communities play a key role in the functioning of aquatic ecosystems, in the hydrobionts' reproduction and are highly sensitive to external influences (Zaitsev et al., 2006). On the rocky shores an essential substrate is formed for the attachment micro- and macrobenthos organisms with their associated species.

Meiofauna in marine benthic ecosystems includes metazoans organisms that are intermediate between macro- and microfauna (body size range: 30–1000 μm) (Giere, 2009). Meiobenthos is a main food source for demersal fish species (Vorobyova et al., 2004; Carpentier et al., 2014; Schückel et al., 2013). Crustaceans from class Ostracoda (also called seed shrimps) are an important ecological group of meiobenthic organisms. Ecological studies dealing with the abundance, biomass and diversity of ostracodes species can be used for monitoring environmental pollutants along coastal water areas (Ruiz et al., 2005; Shornikov et al., 2015). Seed shrimps are sensitive to herbicides, pesticides, oil spills or heavy metals pollution (Parameswari et al., 2020). Their valves are archives of geochemical information related to paleoclimatic and palaeohydrological changes, ecotoxicity monitoring, biostratigraphy indicator (Meyer et al., 2017; Smith, Palmer, 2012).

In the north-western Black Sea, the ecological, taxonomy and structure features of meiobenthos taxa are well studied (Vorobyova et al., 2008, 2017; Vorobyova, Kulakova, 2009). Meiobenthic organisms were registered at the all types of habitats either natural or artificial origin, including plastic marine litter (Vorobyova, 1999; Snigirova et al., 2020; Uzun, Portianko, 2021). A large amount of studies in this part of the sea focusing on the ostracodes species diversity was conducted during 1960–1970 (Caraion, 1960; Marinov, 1962; Schornikov, 1967, 1969). However, there are few papers concerning present state on the ostracod fauna in the north-western Black sea (Marinov, 1990; Opreanu, 2005, 2007).

The recent data on meiobenthos community in Zmiiniy Island coastal waters are relatively poor (Kulakova, Vorobyova, 2019; Portianko, 2017; Vorobyova et al., 2019). In the preliminary studies, concerning quantitative characteristics of the meiobenthic organism at the different type of substrates in Zmiiniy Island water area, the high ostracode density was shown (Vorobyova et al., 2019). The data about ostracod species in this water area to the best of author's knowledge are absent.

Thus, the aim of this study is to determine the diversity of ostracodes and their role in biomass and abundance of the total meiobenthos on different types of substrates in the coastal area of Zmiiniy Island.

Material and methods

Study area

The field work was carried out in near-shore water zone of Zmiiniy Island (45°15'18" N, 30°12'15" E) (fig. 1). Zmiiniy Island is located in the north-western Black Sea shelf (Ukrainian part). Hydrological and hydrochemical regime of the island coastal waters is effected by large rivers (Danube, Dniester, South Bug and Dnipro) that create unique conditions for organisms (Zaitsev et al., 2006). Zmiiniy Island coast represented by rocky shores and partially sandy-shells bottom sediments that form appropriate habitats for benthos (Brayko, 1985; Zaitsev et al., 1999).

The part of Zmiiniy Island and coastal waters around it were included to the Natural heritage site as zoological reserve of national significance by the Decree No 1341/98 signed by the President of Ukraine in 9.12.1998.

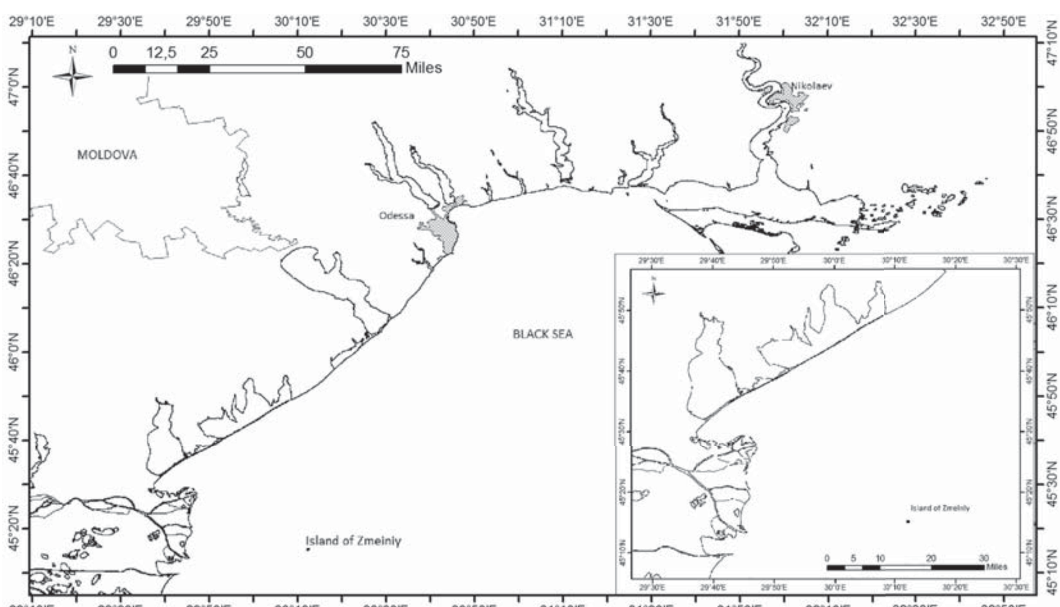

Fig. 1. Location of Zmiiniy Island study area in north-western Black Sea, Ukraine.

Sampling

Meiobenthos was taken in summer seasons during 2013–2015 at depths from 1 to 5 m. Samples were collected from three types of substrate: sandy bottom sediments, mussels (*Mytilus galloprovincialis* (Lamarck, 1819)) and alga growing attached to large rocks. Algae include six species: *Ceramium elegans* (Ducluzeau, 1806), *Cladophora vagabunda* (Hoek, 1963), *Ulva intestinalis* (Linnaeus, 1753), *Polysiphonia denudata* (Greville et Harvey, 1833), *Corallina officinalis* (Linnaeus, 1758), *Laurencia paniculata* (Kützing, 1849).

Samples was collected by the 0.1 m^2 benthos frame by scuba diver into the separate plastic bags and transported to the laboratory of the Institute of marine biology. Then they were washed used fine-meshed net with upper size 1 mm and lower — 70 μm for collecting meiobenthos. The received samples were preserved in 4 % buffered formaldehyde solution and stained with Rose Bengal. The meiobenthos taxa were counted in Bogorov chamber under stereomicroscope MBS-10 (×32 magnification) and recalculated to density of individuals per 1 m^2 (ind.·m^{-2}). The biomass was defined by the use of the shape and body sizes nomograms as mg per 1 m^2 (Chislenko, 1968; Vorobyova, Torgonskaya, 1998).

From the received sample all individuals of ostracodes were collected. Their further study was carried out under the light microscope Konus (×200, ×400 magnification) in glycerol-alcohol solution with the identification key (Dykan, 2006; Schornikov, 1969). All scientific names are given according to the World Ostracoda Database (Brandão, Karanovic, 2022).

Data and statistical analyzes

For estimate the similarity between the samples was used the Bray–Curtis index. Grouping of samples with similar species composition was done by hierarchical agglomerative clustering (CLUSTER analysis) based on the unweighted pair-group average cluster model with the similarity profile test (SIMPROF) for determine significant differences between the clusters.

A non-metric multidimensional scaling (nMDS) was carried out to analyze the differences between substrates based on ostracodes density in samples. The ANOSIM test with global R statistic was used for analysis of differences significance. The null hypothesis (i. e. 'no difference between groups') was rejected at a significance level of $p < 0.05$. Multivariate analyses were carried out using the PRIMER version 6 software package (Clarke et al., 2014).

Results

Density and biomass of the ostracodes

In current study the 10 higher taxa of meiobenthos on the different types of substrate were registered: Turbellaria, Nematoda, Harpacticoida (Copepoda), Ostracoda, Halacaridae,

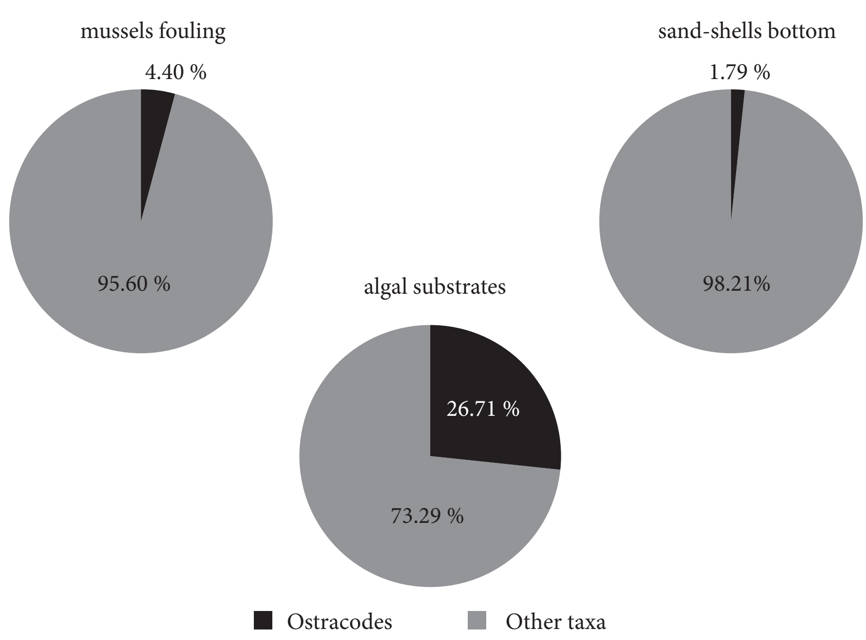

Fig. 2. The percentages of ostracodes in average density of meiobenthos at the different type of substrate from Zmiiniy Island.

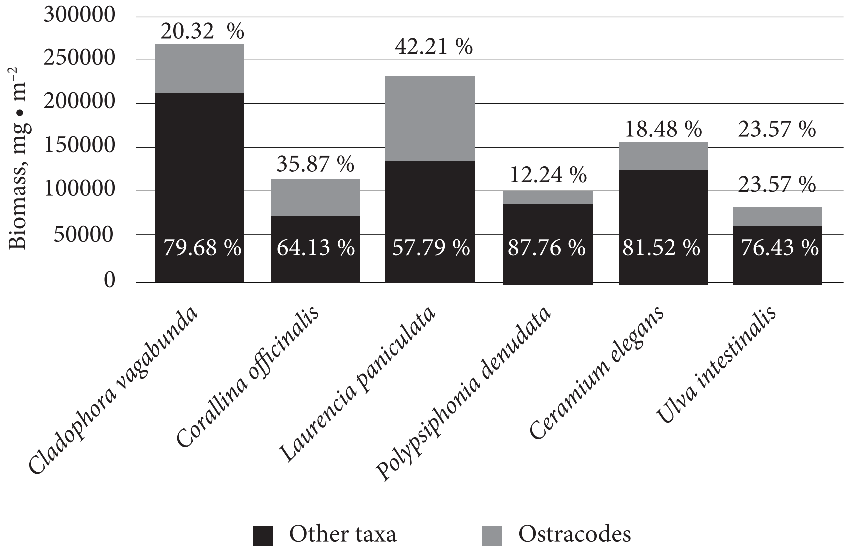

Fig. 3. Percent ratio of the ostracodes with other meiobenthos taxa densities (ind.·m^{-2}) associated with different algal species in Zmiiniy Island.

Oligochaeta, Polychaeta, Bivalvia, Gastropoda, Balanus. The density of ostracodes in the total meiofauna community ranged between 1000 and 167000 individuals per 1 m^{-2}, while biomass made up from 6.5 to 1085.5 mg·m^{-2}.

The percentage of the ostracode in the total meiobenthos density ranged between different types of the substrates, the lowest percentages of which were on the sand-shell sediments and on mussels substrate (1.79 and 4.40 % respectively) (fig. 2).

The average mean of ostracodes density was relatively high on algal substrate. On *Laurencia paniculata* the average mean of ostracode density was 41931 ± 12689 ind.·m^{-2} which made up 42.21 % of the total meiobenthos (fig. 3).

In Zmiiniy Island nearshore zone ostracodes play significant role in the total meiobenthos biomass formation (fig. 4). The higher mean of ostracod biomass was registered on *Laurencia paniculata* and made up 400.56 ± 125.65 mg·m^{-2}. On the sand-shells bottom biomass of ostracodes only made up 2.3 ± 0.5 mg·m^{-2} and was lowest.

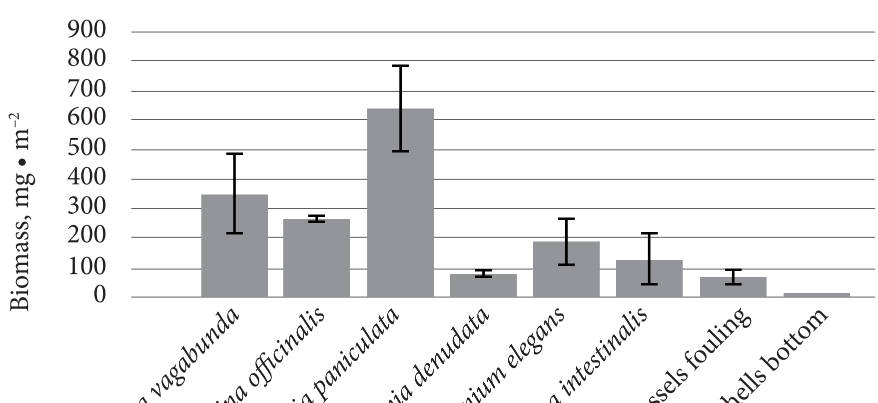

Fig. 4. The average means of the ostracodes biomass on different substrates in Zmiiniy Island.

Table 1. The list of ostracodes species on the different substrate types in Zmiiniy Island nearshore water zone (Black Sea)

Ostracod species	Algal substrate						mussels fouling	sand-shells bottom
	Ceramium elegans	*Cladophora vagabunda*	*Ulva intestinalis*	*Corallina officinalis*	*Laurencia paniculata*	*Polysiphonia denudata*		
Family Loxoconchidae								
Loxocauda sp.	–	–	–	+	+	–	–	–
Loxoconcha aestuarii Marinov, 1963	+	–	+	+	–	–	–	+
Loxoconcha bulgarica Caraion, 1961	+	+	–	+	–	+	+	+
Loxoconcha elliptica Brady, 1868	+	+	+	+	–	–	+	–
Loxoconcha lepida Stepanaitys, 1962	+	+	+	+	–	–	–	–
Loxoconcha pontica Klie, 1937	+	+	+	+	+	+	–	+
Family Paradoxostomatidae								
Paradoxostoma intermedium Müller, 1894	+	+	+	–	+	+	+	+
Paradoxostoma mediterraneum Müller, 1894	–	+	–	–	–	–	–	–
Family Bythocytheridae								
Sclerochilus dubowskyi Marinov, 1962	–	–	–	–	+	–	+	–
Family Xestoleberididae								
Xestoleberis acutipenis Caraion, 1963	+	+	+	+	+	+	+	+
Xestoleberis aurantia (Baird, 1838)	+	+	–	+	–	+	+	–
Xestoleberis cornelii Caraion, 1963	+	+	+	+	+	+	+	+
Xestoleberis decipiens (Müller, 1894)	+	+	+	+	+	+	+	+
Total	10	10	8	10	7	7	8	7

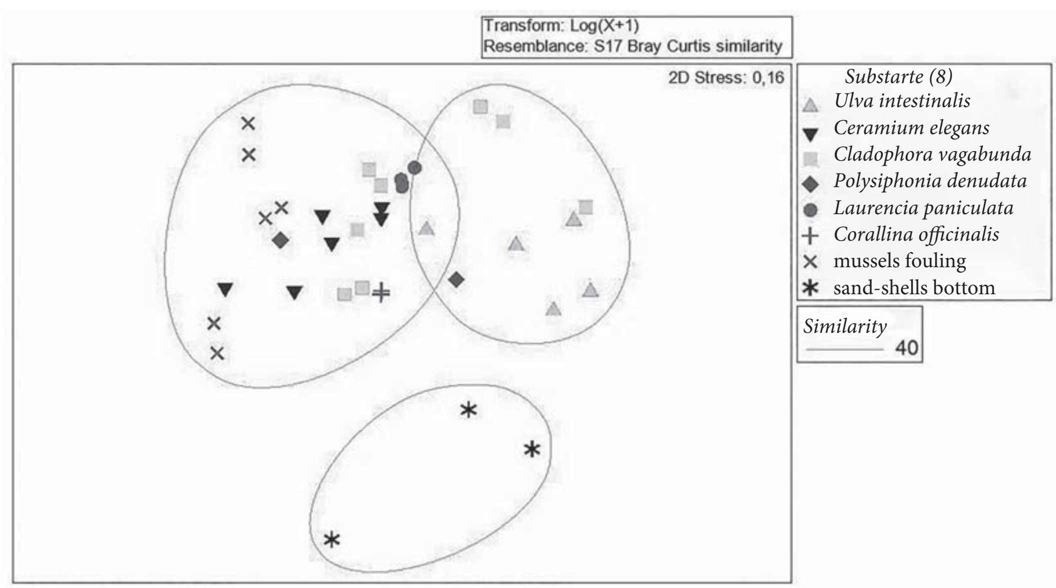

Fig. 5. The non-metric multidimensional scaling (nMDS) analysis of ostracodes species abundance in the sample from different substrates in Zmiiniy Island.

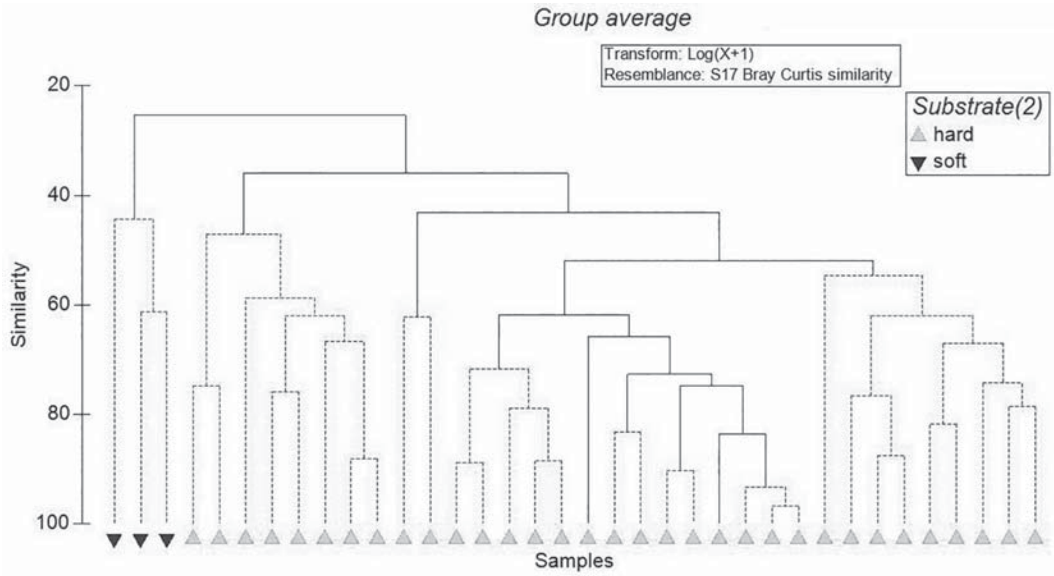

Fig. 6. The results of CLUSTER analysis with the SIMPROF test based on the biomass on different substrates in Zmiiniy Island.

The biggest ostracodes contribution in the total meiobenthos biomass in nearshore Zmiiniy Island waters reached 18.01 %.

The taxonomy structure of ostracodes assemblages

A total of 13 ostracod species belonging to 4 families were identified: Loxoconchidae, Paradoxostomatidae, Bythocytheridae, Xestoleberididae (table 1). All of them are belonging to subclass Podocopa. On the algal substrates were registered from 7 to 10 species. On sand-shell bottom were registered 7 species. Ostracodes species *Xestoleberis acutipenis*, *X. cornelii* and *X. decipiens* were widespread on the all substrate types.

The results of statistical analysis

Non-metric multidimensional scaling (nMDS) analysis of ostracodes species abundance shown strong differences between the samples of different substrate types (fig. 5). Comparison abundance of ostracode species in the samples on sandy-shells bottom sediments differed significantly from other substrates. The species diversity of the ostracodes from *Ulva intestinalis* and some *Cladophora vagabunda* differed from another samples of alga and mussel's substrates. The stress count 0.16, that indicates of satisfactory level of nMDS.

CLUSTER analysis and SIMPROF test recognized two groups with similar ostracodes taxonomic composition: sand-shells bottom samples on almost 80 % differed from hard substrates, covered by algae and mussels (fig. 6).

According to the ANOSIM test results the null hypothesis (i. e. 'no difference between groups') was rejected. There was a significant difference in ostracod abundance between hard and soft sediments substrates tested by ANOSIM (global R = 0.798, p = 0.02).

Discussion

In the nearshore water area of Zmiiniy Island 10 meiobenthic taxa were registered at the different types of substrate. The percentage of ostracodes range between 1.79 % and 26.71 % depending on the substrate type. The average means of the density and biomass of ostracodes were large on the algal substrates and were biggest on *Laurencia paniculata* (means 41931 ± 12689 ind.·m^{-2} and 400.56 ± 125.65 mg·m^{-2} respectively). The high abundance of ostracodes on the algal substrates was typical and confirmed by other researchers (Rutledge, Fleeger, 1993; Walters, Bell, 1984).

It should be noted that these means are bigger than in other nearshore regions of the north-western Black sea region. For example, the density of ostracodes from the algal substrate in the Odessa marine region is almost three times lower (Vorobyova et al., 2017). The abundance of ostracodes in Zmiiniy Island nearshore water area is higher than that on fouling artificial hydrotechnical constructions and on the plastic litter (Vorobyova et al., 2016; Uzun, Portianko, 2021). Such differences might be explained by the high sensitives of ostracodes on the impact of anthropogenic factor. The benthic fauna of Zmiiniy Island water area is healthier than in other regions of the NWBS (Kovalova et al., 2017).

The identification of ostracode species in the coastal area of Zmiiniy Island was made for the first time. It was observed that the biodiversity of ostracodes was represented by typical species registered both on the natural and artificial origin hard substrates in other north-western regions of the Black sea. The most widespread species were *Loxoconcha pontica*, *Paradoxostoma intermedium*, *Xestoleberis cornelii* and *X. decipiens*, that are common at the shallow zone along the entire coastline of the Black Sea (Shornikov, 1969). They may inhabit both in open waters and in sea beds and other aquatic vegetation (Shornikov, 1967).

According to the non-metric MDS analysis ostracod assemblages show marked changes in species composition and density with type of algal substrate. The ostracodes assemblages on the *Ulva* and some *Cladophora* differed from another samples of the algal substrates. There are complex relationships between ostracodes and algae. Algal fronds appear to provide protection from wave action and increased habitable living space for many organisms of meiofauna, including ostracodes (Hull, 1997). The high algal complexity with numerous fronds can accompanied by an increasing diversity of food availability for both ostracodes and meiofauna.

Ostracode assemblages associated with algae and macrobenthic communities on rocks differ from surrounding bottom assemblages. Hard surfaces forms substrates for attaching sessile, that may increase living space for associated with them meiobenthic organisms (Hicks, 1980, 1986). The species composition of marine invertebrates on hard surface with fouling is regulated by a combination of factors that include substrate type, orientation and immersion season (Siddik et al., 2018). Algae and macrobenthic communities serves as habitat for meiobenthos organisms increasing species diversity and abundance (Bell, 1980; Hicks, 1986). In meiobenthos assemblages associated with hard surfaces fouling the dominant groups are mainly crustaceans (harpacticoids, isopods, amphipods etc.) and mollusks (Beckley, 1982; Coull et al., 1983).

Thus, the high means of the percentage, density and biomass have showed favorable ecological conditions for the ostracodes in the nearshore water area, which might indicate low levels of anthropogenic impacts in the waters. Despite, the island waters are under the strong influence of the riverine flows which considered as the main resource of nutrients and pollutants in the western Black Sea coastal area (Gasparotti, 2014, 2015) and might effects on the benthos structure. The growth of pressure from fishery, hydrotechnical construction and shore-protection activities in the area of the island probably caused negative changes on fauna, i.g. on meiobenthos.

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