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FAUNAL COMMUNITY OF SOFT-BOTTOM MOLLUSC OF THE TURKISH BLACK SEA

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ABSRACT: *In August-September-1988 and January-1989, single quanttative samples of the soft-bottom benthos were collected with a Van Veen grab (0.175 m^2) from 20 localities along the Anatolian coasts of the Black Sea. A total of 37 molluscan taxa was distinguished. The quantitative and quantitative distributions of this community inclined to have a decreasing phenomena towards the deep bottom, especially after 65-75 m., interacting with the dissolved oxygen condition and texture of superficial sediment. The most important molluscan members in numerical distribution were* Mytilus galloprovincialis *in the shallower-waters and* Modiolus phaseolinus *in the deeper zones where the mud fraction was predominant. The sandy bottom near the coastal line was characterized by means of a series of* psammophilic *molluscan fauna such as* Divaricella divaricata, Venus gallina, Gafrarium minima, Donax venustus, Pitar mediterranean.

Circomphalus casinus and Abra prismatica *were newly reported molluscan representatives in the Black Sea.*

Keywords: Black Sea, Benthos, Mollucs, Distribution

KARADENİZ'İN ANADOLU KIYILARINDAKİ YUMUŞAK ÇAMUR YUMUŞAKÇA BİRLİĞİ

ÖZET: *1988 Ağustos, Eylül ve 1989 Ocak aylarında Karadeniz'in Anadolu kıyılarındaki 20 istasyondan, van Veen (0.175 m^2) aleti ile yumuşak çamur örnekleri alındı. Toplam 37 yumuşakça türü bulundu. Bu organizma grubunun kalitatif ve kantitatif dağılımları oksijen ve üst sediment yapısıyla ilgili olarak, özellikle 55-70 m'den sonra, derine doğru azalma eğilimi göstermektedir. Sayıca öneme sahip sığ sularda* Mytilus galloprovincialis, *derinsularda* Modiolus phaseolinus *türleridir. Kumlu tabanlarda* Divaricella divaricata, Venus gallina, Gafrarium minima, Donax venustus, Pitar mediterranean *türleri gözlenmiştir.*

Circhomphalus casinus *and* Abra prismatica *Karadeniz'de yenice görülen türlerdir.*

Anahtar Kelimeler: Karadeniz, Bentoz, yumuşakça, Dağılım

INTRODUCTION

The Black Sea is a unique largest anoxic basin of world's water bodies characterized by a permanent halocline (20). The number of zoobenthic species of this Sea is four or five times less than that of the Mediterranean and also Sea of Marmara due to the lowered salinity (19%.) and due to the presences of intensive anoxic water body and of a narrow habitable upper layer (Wodjanitcky, 1936 cf. 28). The number of recent macrozoobenthonic species in the Black sea amounts to about 1785 whose 174 species belong to the phyla of *Mollusca* (2). The lower limit of colonization of the bottom is controlled by the hydrological factors and accordingly differs from one region to another. There are broad parallels with the extent of the water depth for the living plankton which co-exists with benthos. Being awer that there are only a few regionally limited studies which have been done in the study are (15 and 16) and extended investigation was undertaken to obtain an overall pictuRe of benthic molluscan fauna of the Turkish Black Sea Coast.

The present study concerns with the results of this investigation.

DESCRIPTION OF STUDY AREA

The investigation area lies between the longitudes of 28o 30' E and 40o 32' E and has a coastal length of about 1027 km, with the depth ranging from 20 m (sta.B20) to 112 m (sta. B7) (Fig.1). About 40% of the stations investigated had depths less than 50 m along the study area. In order to be able to eliminate possible effects of regional ecologic distinctness on the molluscan distribution, the study area was geographically subdivided into three sites, namely: western part (I), central part (II) and eastern part (III); (Fig. 1). Western part (I in Fig. 1) is affected by means of water system of the Bosphorus with underwater current of the Mediterranean Sea to the Black Sea and the input system of the river SAKARYA. central part of coast (II in Fig. 1) where no terrestrial influence with the discharge of big river or stream (excepted Kızılırmak river near sta. B15 or brooks and climatic conditions) is present and eastern part (III in Fig. 1) which bears the optimum hydrological aspects of the Black Sea (Fig. 1).

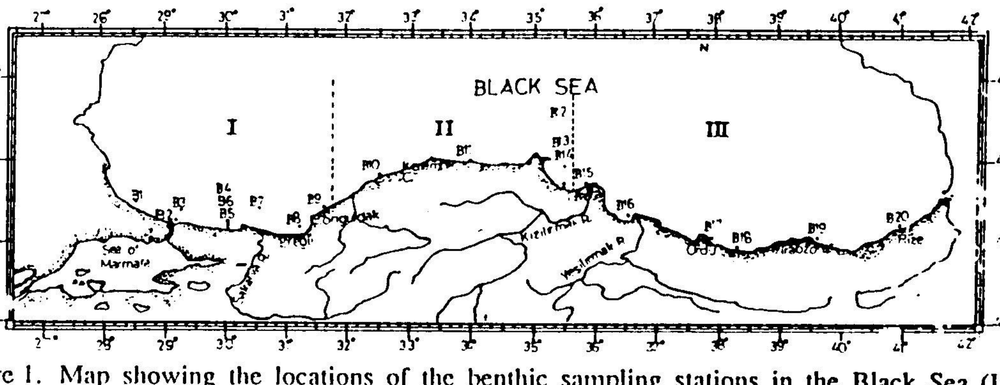

Figure 1. Map showing the locations of the benthic sampling stations in the Black Sea (I: Southwestern; II: Central and III: Southeastern part)

Hydrographical factors of this region have recently been studied by some researchers (6, 21 and 20). Its hydrographical peculiarities are mainly caused by the narrow and shallow connections with the Seas of Marmara and Azov, the strong inflow of fresh water from rivers, and climate, which affects many of the process operating it.

The sediment pattern is governed by surface and longshore bottom currents and wave action in the nearshore zone, and by and isolated cyclonic current system and bottom morphology in the deep basins of the Black Sea (24).

MATERIAL AND METHODS

The sampling method corresponds closely to the recommendations given by Stirn (27). Single quantitative samples of the soft-bottom benthos were collected with the help of van Veen Grab having a sampling surface of 0.175-m2 and a clamshell snapper (0.015-m2) from 20 locations chosen approximately at equal intervals (Fig. 1) in August and September-1988 and January-1989. During the sampling, some hydrographical measurements (temperature, salinity, dissolved oxygen, depth) were also obtained with the CTD-probe. A small split of the bulk sediment samples was separated and then stored in the deep-freezer for subsequent grain size analysis based on Folk's method (9). The samples were sifted through a 0.5-mm sieve, and the organsms were handpicked when possible, and stored in 5% neutralized formalin solution.

In the laboratory, the life organisms were sorted under binocular microscope and stored in 70% alcohol. The species composition, abundance and biomass were determined. Identification of species was made level when possible. In order to confirm the identification of some questionable species, they were send to some skilled specialists (10, 5 and 2). The biomass was determined as formalin wet weight after at least one month's preservation to obtain constant figures. To determine the dominancy of each species within the other species and stations, the frequency of occurrence and dominance values were computed according to methods described by Holden and Raitt (14).

Frequency of occurrence:

$$FO_i=\frac{\Sigma F_i}{\Sigma F}$$

Where ΣF_i is total frequency of ith species and ΣF is the sum of the frequencies of all species in a purposed region.

Dominancy:

$$D_i=\frac{\Sigma SF_i}{\Sigma S}$$

Where ΣSF_i is the number of stations where i^{th} species is found and ΣS is total staions number.

The species diversity was calculated according to Shannon's formula (23).

$$H' = -\sum_{i=1}^{S} p_i \ln p_i$$

Where S is the number of species and p_i is the proportion of the abundance of individuals belonging to the i^{th} species ($P_i = n_i/N$).

RESULTS

The quantitative and qualitative compositions of molluscan assemblage and some measurements (Table 1) at the stations along the longshores of the Turkish Black Sea were as follows:

Table 1. Some hydrographical and Sedimentological Measurements at the Stations During the Sampling

Station code (west to East)	Depth (m)	Dis.Oxygen (ml/l)	Temperature (C)	Salinity (%.)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)
B1	76	3.44	7.23	18.46	2.7	12.5	47.8	37.0
B2	68	1.76	14.64	36.64	71.3	28.3	<1	<1
B3	100	3.45	9.08	22.81	.	.	.	.
B4	94	2.59	7.86	20.23	.	.	.	.
B5	58	.	.	.	6.0	66.9	13.4	13.7
B6	44	6.94	7.53	18.24	4.9	17.1	41.8	36.2
B7	112	2.41	7.63	19.78	.	.	.	.
B8	34	.	.	.	<1	3.7	53.5	42.2
B9	70	.	.	.	16.6	9.3	41.4	32.7
B10	80	0.47	8.22	20.61	4.9	4.0	55.0	36.1
B11	90	3.90	7.56	19.59	1.9	6.8	55.4	36.0
B12	101	1.68	8.05	20.01	1.2	7.1	49.2	42.3
B13	80	3.88	7.89	20.01	1.5	1.5	48.0	49.0
B14	28	.	.	.	<1	18.4	58.4	23.2
B15	40	.	.	.	16.9	19.1	35.2	28.9
B16	48	.	.	.	<1	<1	47.6	51.5
B17	63	.	.	.	<1	17.4	55.0	26.9
B18	49	9.78	7.78	18.02	<1	13.2	64.3	22.2
B19	36	7.21	7.69	18.00	<1	18.0	61.5	19.9
B20	20	8.17	7.93	18.05	<1	93.9	5.0	<1

Points; not measured Percent mud could be obtained from [silt+clay]

Total abudance

The mean individual number belonging to the faunal community of the mollusk along the whole coasts was found to be 1022 specimens m-2. The regional individual distribution of three geographic subdivisions from west to east, was approximately 373, 2214 and 758 ind. per square meter, respectively.

The maximum abundances obtained during the present study were recorded to be 3361 ind. /m2 (sta. B9) in the first subregion, 7858 specimens/m2 (sta. B9) in the first subregion, 7858 specimens/m^2 (sta. B15) in the second sub area and finally 2503 ind. /m^2 (sta. B20) in the remaining nearshores in the southeastern sector (III. area). Station B3 which is one (101m) of the deepest stations among the studied localities was devoid of macrobenthic mollusks. In the individual distribution of molluscan fauna, the oxygen content of bottom water is very important. During the physicocchemical surveys of IMS-METU in the Black Sea, the concentration of the dissolved oxygen content showed a profile like a collapsing basin, conversly, the hydrogen sulfide figured out a profile like an arising mountain from the coast to the central part of the Sea. Oğuz et al., (21) demonstrated also the deoth Distribution of the suboxic environment along the Turkish EZ (Economic Zone). In this report whilst suboxic zone was observed at 80-90m in the offshore waters, it was appeared at 100-150 m along the inshore part. The mean abundance of mollusk was found to be 1784 ind. /m^2 in the shallower nearshore waters (less than 70 m) with high oxygen concentration (6.66 ml/l), but 622 specimens m-2 along offshores waters with very low oxygen content (2.53 ml/l) and deeper than 70 m. As it can be easily demonstrated In Fig.2, the abundance and oxygen content inclined to decrease sharply after 50-70 m and such tendency appeared prominently. This appearance resulted from optimal adaptation of some molluscan species such as *Modiolus phaseolinus*, *Abra alba* and *Cordium papillosum* which are characteristic mollusc Representatives of Black Seat at zones extending from 55-60 m down to 112 m (Table 2).

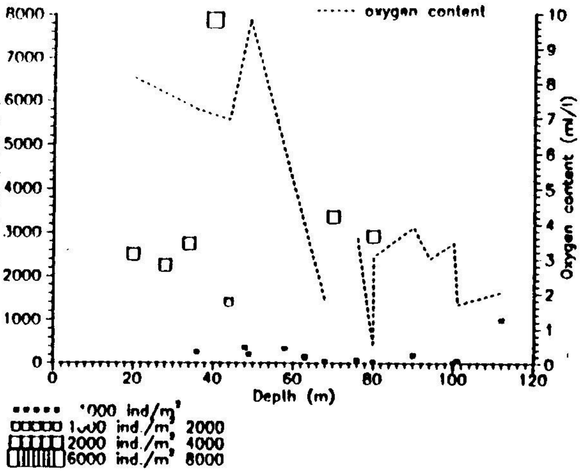

Figure 2. Variations of abundance and dissolved oxygen content in the different depths.

Table 2. Percent Contribution to Total Abundance of the Most Abundant Species in the Southern Part of the Black Sea in August-September 1988 and January-1989.

Taxa	STATIONS																			
	Southwestern sector									Central part						Southeastern sector				
	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14	B15	B16	B17	B18	B19	B20
Calyptrea chinensis	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.
Hydrobia ventrosa.		.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.
Trophonopsis breviatus	.	.	.	.	.	.	0.61		.	2	.	.	.	.	.	.	.	.	.	.
Retusa truncaluta	.	.	.	.	.	.	.	.	.	.	.	.	50	.	.	13	.	.	9	.
Odostomia rissoides	.	.	.	.	42	.	.	.	.	.	.	.	.	.	7	.	.	.	.	.
Abra alba	66	.	.	50	14	10	.	1	1	0.918		19	.	.	.	23	33	18	.	.
Abra prismatica	.	.	.	.	.	.	.	.	.	.	.	.	.	9	.	.	16	.	9	.
Acanthocardia tuberculata	.	.	.	.	.	.	.	.		.	.	.	.	.	.	.	16	.	.	.
Arca lactea	.	100	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cardium exiguum	.	.	.	.	.	.	.	.	0.1	.	.	.	.	.	.	.	.	.	.	.
Cardium papillosum	34	.	.	.	14	8	.	.	.	.	18	.	50	.	.	36	33	.	.	.
Divaricella divaricata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	76
Donax venustus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4
Gafrarium minima.		.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.
Modiolus phaseolinus	.	.	.	50	.	72	99	.	98	96	63	81	.	9	36	.	.	.	.	.
Myella bidendata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	36	.	.
Mytillus galloprovincialis	.	.	.	.	.	.	.	92	.	.	.	.	.	.	47	.	.	.	.	.
Ostrea edulis (juv.)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	24	.	.
Pitar mediterrenea	.	.	.	.	.	.	.	.	.	.	.	.	.	50	.	.	.	.	.	.
Spisula truncatula	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	64	.
Venus gallina	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	14

Such opportunistic species were predominant on the soft substratum of deep bottom. In longshores of the southeastern part (sector III) of the Black Sea, the bottom depths were, in common, shallower or less than 60-70m. These topographic and geological and also hydrological peculiarities caused the opportunistic molluscan species not to settle there. Thus, the individual number was low in spite of the presence of high oxygen content and shallower waters on the continental shelves of the southern subdivisions.

Total biomass

The characteristic biomass amounted to an average value of 116.65 g/m^2 in the longshores of the Turkish Black Sea. The formalin wet-weights of the organisms were found to be uneven among the stations (Fig. 3) and their contributions of biomass within three geographical subregions were as follows: 129.95 g/m^2 in the first area; 185.01 g/m^2 along the nearshores of the central part (second area) and 34.992 g/m^2 on the continental shelves of the southeastern coasts of the Black Sea.

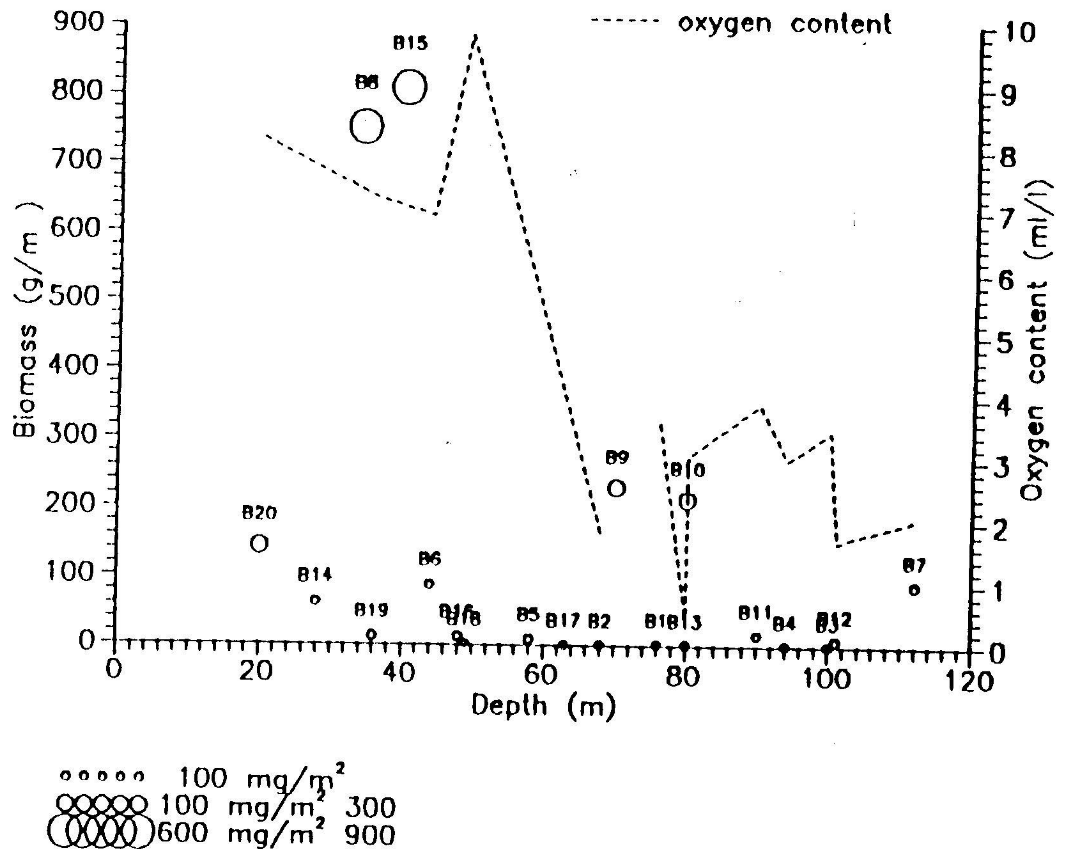

Figure 3. Changes in biomass with the DO and depths

Whilst most of the stations (15 sts. over 20 sts.) yielded little amounts of biomass (less than 100 g per square meter), the highest biomass was gathered at stations B8 off Ereğli and B15 off Bafra with 751.1 and 808.3 g/m^2, respectively (Fig. 4). Figure 4 shows further that the taxonomical distribution of the wet-weight at the level of subclasses of mollusc within the sampling stations. Depending on the depth and of course, on the oxygen content of the bottom water at the stations along the Turkish coasts of the Black Sea, the biomass of these animals contributed much more to that of the sea in shallower waters, than in deeper waters. The mean density of macrobenthic molluscs on the soft-bottom at shallower stations (less than 70 ml) was 176.99 g/m2, while it was calculated to be 41.34 g/m2 at deeper stations. As already mentioned, the oxygen content was more favourable for lots of aerobic organisms to settle and keep their own lives at the depths lower than 70 m. The total biomass varies within the stations or from place to place, not only due to the percent of coarse fraction (coarser than silt) which allowed many molluscan members to dwell, but also to the content of the dissolved oxygen prevailed. The presence of primarily *Mytilus galloprovincialis* and secondly, a few typical bivalve species *(Pitar mediterranean, Gafrarium minima)* have most important contribution to the biomass of the Black Sea, especially at the zones shallower waters than 40 m (Table 3).

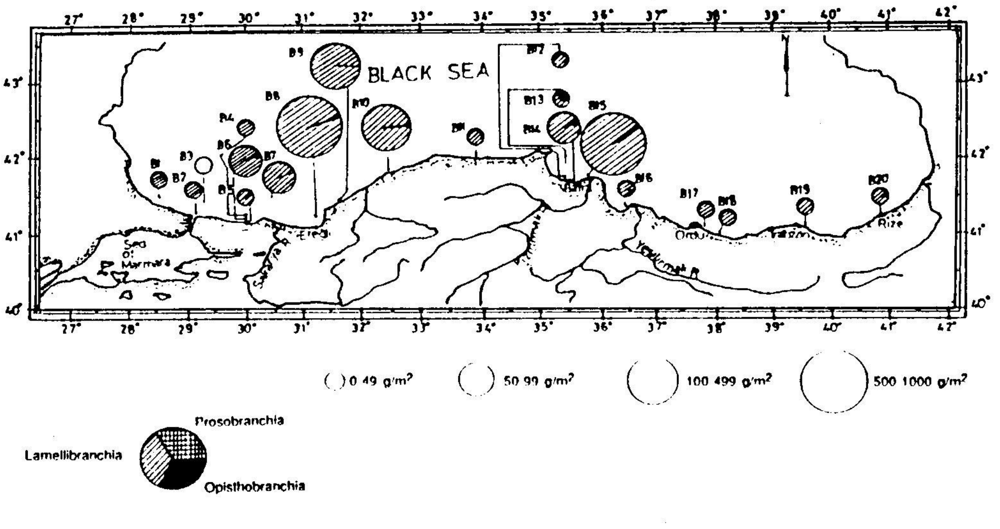

Figure 4. Map showing total biomass contribution of macrobenthic mollusc Subclasses at the sampling stations

Table 3. Percent Contribution to Total Biomass of the Densest Species in the Southern Part of the Black Sea in August-September 1988 and January-1989

Taxa	STATIONS																			
	Southwestern sector									Central part						Southeastern sector				
	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14	B15	B16	B17	B18	B19	B20
Trophonopsis breviatus	.	.	.	.	.	.	0.1	.	.	.	.	.	.	.	.	.	.	.	.	.
Retusa truncatula	.	.	.	.	.	.	.	.	.	.	.	.	38	.	.	.	.	.	.	.
Abra alba	5	.	.	1	.	2	.	.	0.2	.	16	8	.	.	.	10	1	4	.	.
Abra prismatica	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	.	.	.
Acanthocardia pausicostatum	.	.	.	.	37	.	.	.	.	.	.	.	.	4	.	.	.	.	.	.
Arca lactea	.	100	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cardium exiguum	.	.	.	.	.	.	.	.	0.3	.	.	.	.	.	.	29	.	.	.	.
Cardium papillosum	95	.	.	.	17	10	.	0.2	.	.	10	.	60	.	1	54	95	79	.	.
Divaricella divaricata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	77
Gafrarium minima.	.	.	.	.	.	.	.	0.3	.	.	.	.	.	8	.	.	.	.	.	1
Modiolus phaseolinus	.	.	.	99	.	87	99.9	.	99.3	99.5	74	92	.	.	.	.	.	.	.	.
Mysella bidendata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	12	.	.
Mytillus galloprovincialis	.	.	.	.	13	.	.	99.4	.	.	.	.	.	.	91	.	.	.	.	.
Pitar mediterrenca	.	.	.	.	.	.	.	.	.	.	.	.	.	77	1	.	.	.	9	.
Spisula truncatula	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	77	.
Venus gallina	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	19

This common mussel forms large colonies within partial patches on the soft-bottom in the Turkish longshores, especially in the western part of the coast. A large proportion of total biomass on the bottom deeper than 70 m, was corresponding nearly to a bivalve species, *Modiolus phaseolinus* (Table 3).

Taxonomical Aspects and Faunal Composition

Although there are many representative members of several classes of *Mollusca* in the adjacent Seas e.g., Sea of Marmara, Agean Sea and Mediterranean Sea, only some species of a few subclasses; *(Prosobranchia, Opisthobranchia* and *Lamellibranchia)* belonging to classes *Gastropoda and Bivalvia*, respectively were found.

A total of 37 taxa was accounted along the Turkish nearshores of the Black Sea. The partition of molluscan species among three sampling regions was as follows: 21 in the southwestern sector, 28 along the coast line of the middle part and 25 species on the continental shelve of the southeastern part. All molluscan species accounted and their distributional pattern were represented in Table 4 and Fig. 5.

The species diversity calculated for the soft-bottom macro molluscan fauna along the longshores of the Turkish Black Sea in 1988 is shown in Fig. 6 and 7. The proportional distributions of individuals among the species as diversity values which were characterized by Shannon's formula were similar to those of the individual and species distributions with the depth and the oxygen conditions within the localities. Under 70 m, a few molluscan species such as *Modiolus phaseolinus*, *Cardium papillosum* etc. were predominant in abundance. This caused the diversity measurements to decline. The diversity of the molluscan species living at deep bottoms created unevenness among the stations (Fig 6). In case of the shallower ones, similarly there were a few abundant molluscan species which play important role in the individual equitableness For each species. Some areas were more patchily and abundantly occupied by mytilid mussels *(mytilus galloprovincialis*, some psammophilic molluscs) at the waters shallower than 70 m, at which the reduction of diversity values was observed. Changing the bottom depth, higher resolution of diversity measurements was found eastward the Sea, where less fluctuation in salinity of the water close to bottom occurred throughout a year (Figure. 7).

The distribution of the most frequent species of three subclasses, is represented in Table 5. This Table shows the frequency of occurrence and dominance values of species.

The existence of frequent and abundant species was found to be related not only to high content of the dissolved oxygen, of course to the shallowness of the bottom depth but also to the percentage of mud fraction of superficial sediment . (Fig 5 demonstrates most sharply that the species number of macro molluscan fauna inclined to have a decreasing tendency with the depth. Particularly the locations deeper than 70 m were inhabited by less species than those of shallower water. In the Black Sea, especially in areas, where the oxygen conditions are unfavourable- still develops a macrofauna community. Of these species. *Abra alba, Cardium papillosum* and *Modiolus phaseolinus* were identified. The average value of the species number was found to be approximately 10 in shallower waters (less than 70 m), but rather low (about 2) in deeper parts. Also a second important factor affecting the species number of macrofauna community of mollusc is the percentage of mud [Silt+Clay] fraction of the surface sediment along the nearshores of the Southern Black Sea (Table 6).

Table 4. Faunal Composition of Benthic Mollusc Community Collected From the Sampling Stations

Taxa	STATIONS																			
	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14	B15	B16	B17	B18	B19	B20
MOLLUSCA																				
Gastropoda	0	0	0	0	2	5	1	4	2	3	0	0	1	6	6	1	0	2	1	3
Prosobranchia																				
Bittium reticulatum (Costa, 1778)	.	.			.	+	.	+	+	.	.	.	.	+	+	.	.	+	.	+
Calyptraea chinensis (Linnaeus, 1758)	.	.	.	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Hydrobia ventrosa (Montagu, 1866)	.	.	.	.	.	+	.	+	+	+	.	.	.	+	.	.	.	.	.	+
Nassa neritea (Linneaus, 1758)	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.
Rissoa euxinica (Milaschewich, 1916)	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.
Trophonopsis breviatus (Jeffreys, 1882)	.	.	.	.	.	+	+	+	.	+	.	.	.	.	+	.	.	.	.	.
Turricaspia dybowski (Milachevitch, 1909)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.
Opisthobranchia																				
Crysallida intersitincata (Milaschewich)	.	.	.	.	.	+	.	.	.	.	.	.	.	+	.	.	.	.	.	+
Odostomia rissoides (Hanley, 1844)	.	.	.	.	+	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.
Retusa truncatula (Bruguiere, 1792)	.	.	.	.	.	+	.	.	.	+	.	.	+	.	+	+	.	+	+	.
Retusa variabilis (Milaschewich, 1916)	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.
Bivalvia	2	1	0	2	8	5	1	8	3	4	3	2	1	14	13	8	4	4	6	8
Lamellibranchia																				
Abra alba (Wood, 1802)	+	.	.	+	+	+	.	+	+	+	+	+	.	+	+	+	+	+	.	.
Abra prismatica (Montagu, 1808)	.	.	.	.	.	+	.	.	.	.	.	.	.	+	+	+	+	.	+	.
Acanthocardia pausicostatum (Sowerby, 1839)	.	.	.	.	+	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.
Acanthocardium tuberculata (Linnaeus, 1758)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.
Acanthocardium sp. (juvenile) (Gray, 1851)	.	.	.	.	.	.	+	.	.	.	+	.	.	.	+	.	.	.	.	.
Arca lactea (Linnaeus, 1758)	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cardium exiguum (Gmelin, 1791)	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+	+	.	.	.	.
Cardium papillosum (Poli, 1791)	+	.	.	.	+	+	.	+	.	.	+	.	+	+	+	+	+	+	.	.
Circomphalus casinus (Linnaeus, 1758)	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.
Divaricella divaricata (Linnaeuss, 1758)	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	+	+
Donax venustus (Poli, 1795)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Gafrarium minima (Montagu, 1803)	.	.	.	.	+	.	.	+	.	.	.	.	.	+	+	.	.	.	.	.
Hypanis plicatus (Eichwald, 1829)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.
Kellya suborbicularis.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.
Modiolus adriaticus (Lamarck, 1819)	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.
Modiolus phaseolinus (Phillippi, 1844)	.	.	.	+	+	+	+	+	+	+	+	+	.	+	+	+	.	.	.	.
Mysella bidentata (Montagu, 1803)	.	.	.	.	+	.	.	.	.	.	.	.	.	+	+	+	.	+	.	.
Mytilaster lineatus (Gmelin, 1790)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Mytilus galloprovincialis (Lamarke, 1819)	.	.	.	.	+	.	.	+	.	.	.	.	.	+	+	.	.	.	.	+
Ostrea edulis (juvenile)	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	+	.	.
Pitar mediterranea (Tiberi, 1855)	.	.	.	.	+	.	.	+	.	.	.	.	.	+	+	.	.	.	+	+
Polititapes rostrata (Loc., 1886)	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	+	.
Spisula triangula (Costa, 1778)	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	+	.
Tellina tenis (Costa, 1778)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.
Venerupis aurea (Gmelin, 1791)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.
Venus gallina (Linnaeus, 1758)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+
Species number	2	1	0	2	10	10	2	12	5	6	3	2	2	20	19	9	4	6	7	11

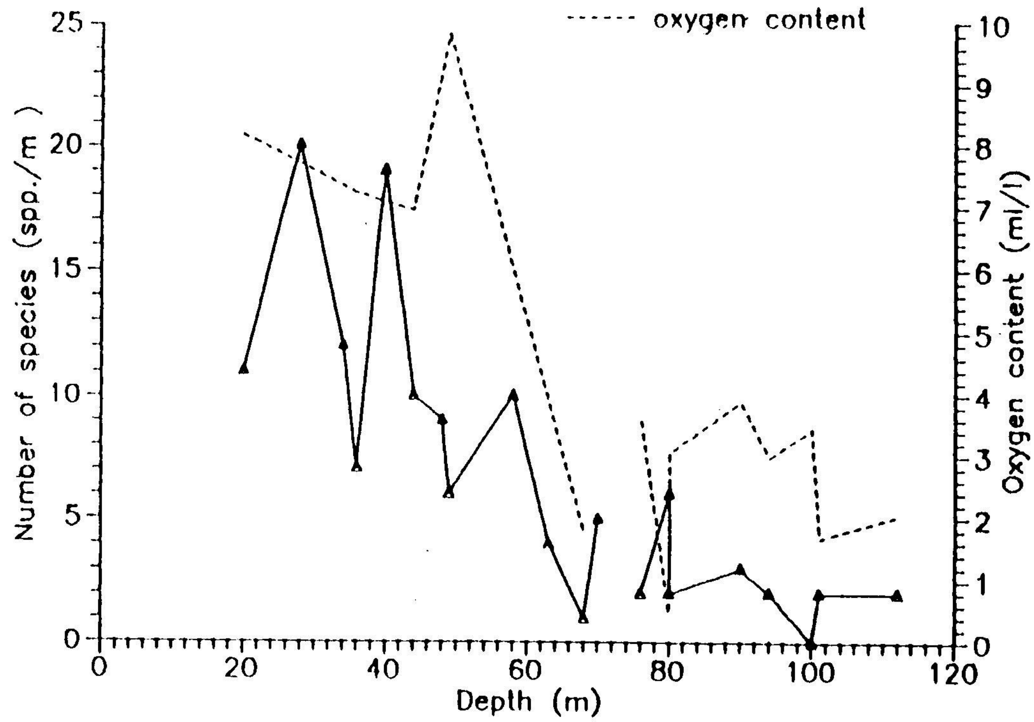

Figure 5. Qualitative fluctuations of mollusc species with depths and DO

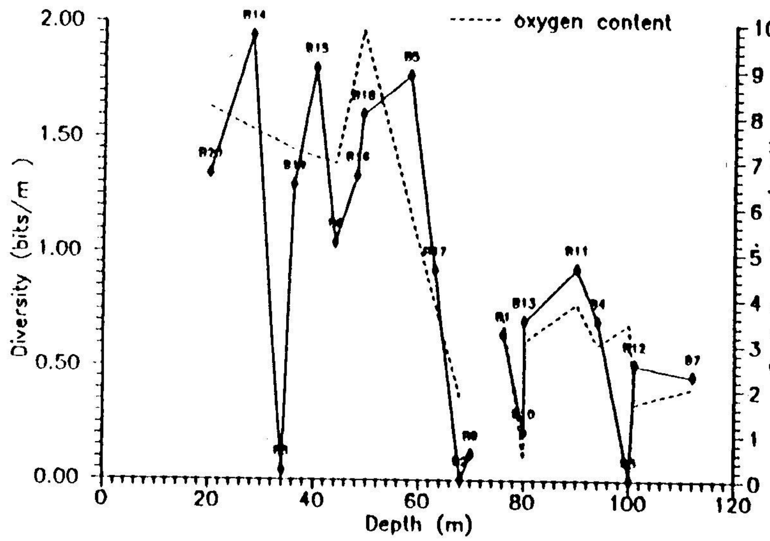

Figure 6. Individual equatability of all molluscan species at the sampling stations

Table 5. Frequency of Occurrence and Dominancy of the Most Important Species of Three Molluscan Subclasses

Taxa	Frequency of occurrence (%)	Dominancy (%)
Gastropoda		
Prosobranchia		
Bittium reticulatum	5.20	35
Hydrobia ventrosa	4.51	30
Trophonopsis breviatus	3.76	25
Opisthobranchia		
Retusa truncatula	5.26	35
Crysallida interstincata	2.25	15
Bivalvia		
Lamellibranchia		
Abra alba	10.53	70
Modiolus phaseolinus	9.02	60
Cardium papillosum	8.27	55

Table 6. Mean Species Number of Molluscan Phyla With the Mean Percent Mud of the Surface Sediments in Three Subregions Along the Southern Coasts of the Black Sea

Sectors	Species number	Percent Mud
Southeastern region	4	58
Middle southern part	9	86
Southeastern sector	7	70

In respect to the species number within the sampling stations, maximum value (20 spp. / m2) was found at station B14 and this was followed by 19 spp. at station B15. These stations located off Bafra at the depths of 28 and 36 m respecticly, around the mouth of Kızılırmak river in the middle part. In the southwestern region, stations B5 and B6 contained same number of species (10 species/m2), and B8 contained somewhat higher (12 spp. /m2) whilst no species was found at station B3.

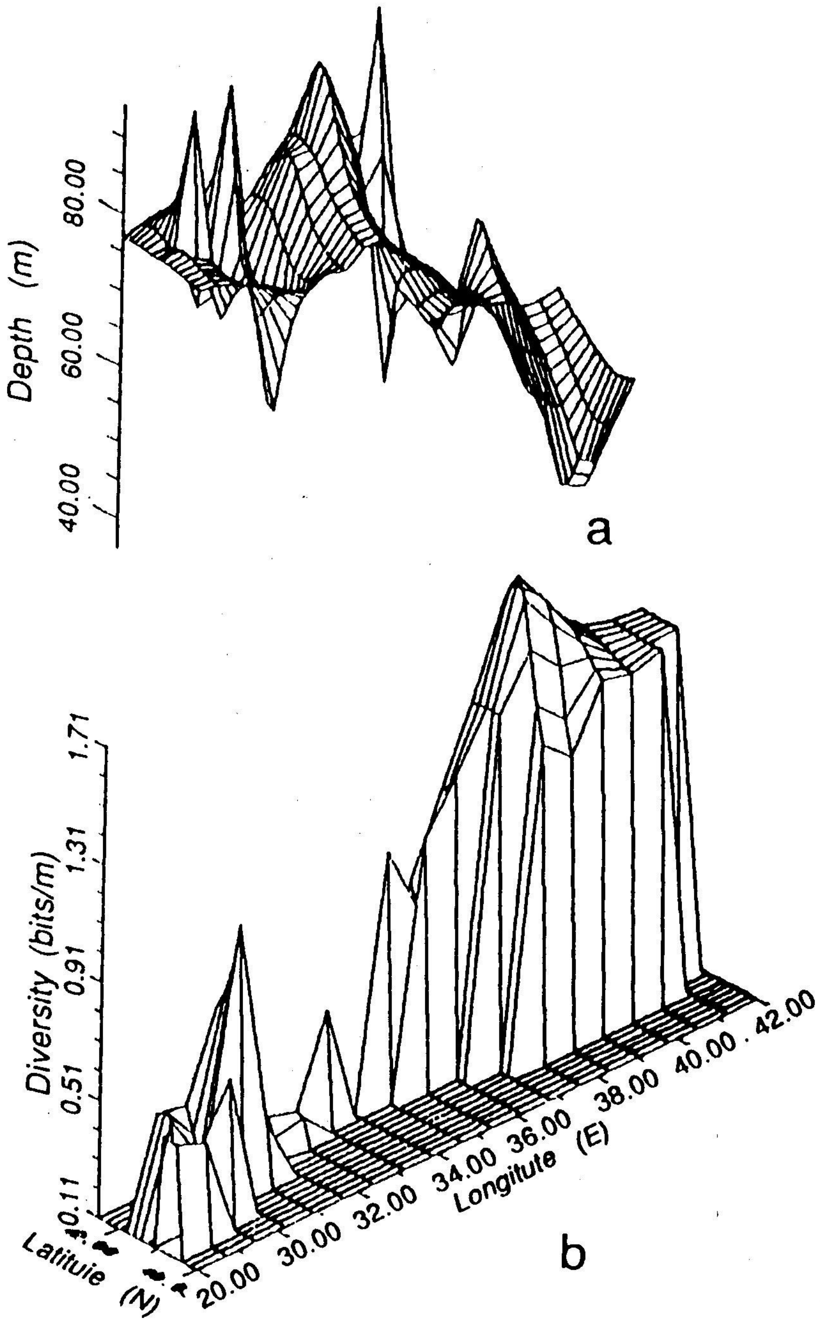

Figure 7. Diversity dependence of molluscan community on depth (a) and localities (b) of sampling area.

Apart from the species distribution explained above, a pre-bosphoric station (B2), with the water body bearing 36% salinity, has only one macro mollusc species, *Arca lactea*. The superficial sediment of station B20 is composed of about 94% fine-sand and was well dwelled by many psammophilic macro molluscan species such as *Venus gallina, Divaricella divaricata, Donax venustus, Gafrarium minima, Venerupis aurea* etc.

Abra prismatica and *Circomphalus casinus* species were the newly coincided species in the Black Sea.

DISCUSSION

Mainly owing to absence of any accurate study on such benthos in the Turkish Black Sea, it is too difficult to compare the recent data with the olders, especially with the quantitative distribution. However, the comparison was achieved by using the previous values belonging to the other countries and also some seas which contain nearly same hydrological and sedimentological peculiarities, such as Baltic Sea etc.

In this study, only 11 gastropod and 26 bivalve species could be identified although 96 and 49 species for each of these groups were previously distinguished by Caspers, (4) and Zenkevicth, (28). This is definitely the fact that this study was performed in the soft bottoms of the infra and also circa-littoral zones.

In general, most of the molluscan species occurred in the coastal waters less than 60-70 m depth. This distribution was observed interacting with the presence of the favourable oxygen content and the texture of the superficial sediment. In the shallower waters, all of the molluscan species (excepted *Modiolus phaseolinus, Abra alba and Cardium papillosum)* were found. Much more species were sampled around the mounths of Sakarya and Kızılırmak rivers at stations B8 and B15, respectively which might contain enough terrigenous nutrient for the phytoplankton, especially for diatoms. In general, the most filter-feeders of macrozoobenthos in the Black Sea co-exist with the phytoplankton (4). *Hydrobia ventrosa* and *Bittium reticulatum* were very dense at depths of 40-48 m. In Bulgarian coasts, *Bittium reticulatum* was frequently observed on the bottom at depths of 30-40 m where it was accompained with *Hydrobia ventrosa* (25). On the shelf bottom, *Mytilus galloprovincialis* was gathered within the colonial aspects at depths less than 40 m. Bacescu *et al.*, (2) figured out that this common mytilid mussel appears frequently and abundantly along the nearshores at depths less than 50-55 m in Romania. Apart from the shallower resresentatives of the sea, *Divaricella divaricata, Venus gallina, Venerupis aurea, Donax venustus, Pitar mediterrenea, Gafrarium minima and Mytilaster lineatus* were the most important members of psammophilic molluscan assemblage as they could be identified at station B20 whose surface sediment was composed mainly of 93% sand fraction. Such animals were classified as the characteristic organisms of the sandy bottoms of the Black Sea by Zenkevicth (28). A Mediterranean species, *Arca lactea* was found in the pre-bosphorus region where the salinity of the bottom waters excessed the average value of the Black Sea (36% at station B2). This species was dredded in the Sea of Marmara by Demir (7).

In the deeper part (below 70 m) of the southern Black Sea, particularly on the continental shelves of the southwestern part, *Modiolus phaseolinus* was very important bivalve in abundance and biomass distributions. Besides the accompanist molluscan species to such one were *Abra alba, Cardium papillosum and Trophonopsis breviatus*. Such species begin to inhabit the mussel mud lying between 40 and the phaseolid ooze extending from 55 to 180 m in the coast of the Soviet Union of the Black Sea (Yakobova, 1935 cf. 28). *M. phaseolinus* begins to re-appear below 50 m and extends to 150-160 m along the Rumanian coasts (2). After 70 and 75 m along the Bulgarian continental shelves, *M. phaseolinus, Cardium papillosum and Trophonopsis breviatus* were the most stenohaline species for the present condition in the Black sea (17). An interesting point being able to be noted is about the resistance and adaptation of some molluscan species to the oxygen deficiency near the suboxic zone in the Black Sea. Thus, *M. phaseolinus, Abra alba and Cardium papillosum* could survive in the low oxygen content between 1 and 3 ml/l. In a study carried out by Dries (8), it was pronounced that *A. alba* could ativate the ability of metabolic function under the oxygen deficiency. It was pointed up that the utilization of the food reserves during the exposure to anaerobic water and recovery of respiration after oxygen deficiency were determined for the *A. alba*.

In the different regions of deeper zones in the Baltic Sea, Andersin et al., (1977) claimed that at the depths below 60 m the greater part of the Central Basin, including the Gulf of Finland, was characterized by very low density values, or, over vast areas, by a total absence of macrofauna basically due to the negative effects of hydrogen sulfide on the macro organisms like a phenomenon in the Black Sea Basin.

Depending upon the favourability of the dissolved oxygen condition of the bottom waters, the quantitative contributions of macro molluscan community tend to decrease as depth increases. Whilst *M. phaseolinus* was very effective in quntitative distribution in the deep bottom, *M. galloprovincialis* played very important role in the shallower water. This distributional pattern was derived from the high concentrations of both species in their own habitats. For a second taxa changing the quantitative fate of molluscan assemblage on the *phaseolinus ooze* of the Southern Black Sea, *abra alba and Cardium papillosum* were aceptable. As an addition to these, some species such as psammophilic ones, e.g. *Divaricella divaricata, Venus gallina, Pitar mediterranean* highly contribute to those of the Turkish Black Sea Coasts.

In regard to a comparison with the older data of some countries surrounding the Black Sea, the maximum biomass was 228.5 g/m^2 at station B9 at 3297 ind. /m^2 for *M. phaseolinus* and 748.5 g/m^2 at station B8 at 2526 specimens/m^2 for Mytilus galloprovincialis. The mean biomass of M. phaseolinus was 51.61 g/m2 at 948 ind. /m^2 and M. galloprovincilas ' s was 297 g/m2 at 1255 ind./m^2 at the stations at which these species were found. According to Arnoldy's data (cf. 28) the mean biomass of *M. phaseolinus* was 779 g/m^2 at 10700 ind. /m2 and that of *Mytilus galloprovincialis* was 464 g/m^2 at 185 specimens/m2 n the small area of the southern coasts of the Crimea (from Fiolent to Alupka) In the phaseolina mud (60-180 m) the population density of *M. phaseolinus* was several hundreds per square meter in the Black Sea (26, 1988). Marinov and Golemansky (19) reported that the average biomass of *M. phaseolinus* was 710 g/m^2 and the abundance 1100 ind. /m^2 or more on the bottom deeper than 60 m along the Bulgarian littoral zone. The average specimens of *M.*

phaseolinus was recorded to be 10000 ind. /m^2 on the Romanian continental shelves of the Black Sea (Karandieva, 1959 cf. 1). But the mytilid common mussel *(Mytilus galloprovincialis)* decreases since the carnivore and predator mollusc species *(Rapana thomasiana thomasiana and Mya arenaria)* exist and predate this shell along the Bulgarian continental shelf (18). The maximum number of species reached 1500 ind./m^2 at 60-75 m and the greatest biomass 2000 g/m^2 at 35 to 50 m in the Anatolian Coasts (Nikitin, 1938, cf. 28).

Under the illumination of the older data from several countries, the present numerical values of such important species were too low. This might be a consequence of the wide-spreading and arising of hydrogen sulfide gas and increasingly presence of some Predatory molluscan animals apart from another environmental changes. On the sandy bottom, the predominant species were; *Divaricella divaricata* of 1891 ind./m^2 at the biomass of 110.2 g/m2, *Venus gallina* of 354 ind./m^2 at the biomass of 26.9 g/m^2 (20 m, station B20) and *Pitar mediterranean* of 1131 ind./m^2 at the biomass of 48.3 g/m^2 (28 m, station B14) in this study. On sandy and silty substratum of Caucasian coasts, *D. divaricata* was found to have a mean value of 858 ind./m2 and 5.8 g/m^2 at depths of 15-30 m (Zenkevicth, 1963. The mean species number and biomass for the *Venus gallina* was 248 ind. /m^2 and 5.8 g/m^2 on the silty sand bottom. In the present study *Donax venustus* was observed with a biomass of 8.6 g/m2 and 86 specimens/m^2 only at station B20 at which the bottom contained 93% sand off Rize in the Turkish coasts. Zenkevicth (28) calculated from the Arnoldy's results that the average number of specimens and their biomass of this specimens were 21 ind./m^2 and 6.7 g/m^2 in the coastal pure sand off Caucasian in the Black Sea neighboring to station B20.

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