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Benthic mollusk composition of some facies in the upper-infralittoral zone of the southern Black Sea, Turkey

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Abstract: The aim of the present study was to describe the mollusk syntaxon associated with *Cystoseira barbata* and *Mytilus galloprovincialis* facies, which are widely distributed along the coasts of the Sinop Peninsula, Turkey. Four stations were chosen for each facies at depths of 0.5-5 m, and a total of 32 seasonal samplings were performed with 4 replicate groups between February 2006 and November 2006. As a result of the qualitative and quantitative analyses, the *C. barbata* facies was shown to be represented by 14 species and 5807 specimens, whereas that of *M. galloprovincialis* was represented by 11 species and 18,407 specimens. Dominant species of the *C. barbata* facies were *Mytilaster lineatus* (56%), *Tricolia pullus* (18%), *Rissoa splendida* (12%), and *Gibbula adansonii* (7%). Dominant species of the *M. galloprovincialis* facies were, however, *Mytilaster lineatus* (63%) and *Mytilus galloprovincialis* (36%). Seasonal water parameters were also measured at the stations. Seasonal and spatial variations in the mollusk fauna were observed and showed the highest values in station 3 and during the summer period.

Key words: Facies, mollusk assemblages, seasonality, Black Sea

Güney Karadeniz sahillerinin üst-infralittoral zonunda yer alan bazı fasiyeslere ait bentik mollusk kompozisyonu

Özet: Bu çalışmanın amacı, Sinop Yarımada'sı kıyılarında geniş dağılım gösteren bazı fasiyesleri (*Cystoseira barbata, Mytilus galloprovincialis*) incelemektedir. Her fasiyes için 4 istasyon seçilmiş ve bu istasyonlardan mevsimsel olarak, 4 örnekleme olmak üzere toplam 32 örnekleme yapılmıştır. Örnekler, Şubat 2006 ve Kasım 2006 ayları arasında seçilen 4 istasyonun 0,5-5 m derinliklerindeki biyotoplardan gerçekleştirilmiştir. Fasiyeslerin kalitatif ve kantitatif analizleri sonucunda, *C. barbata* fasiyesi 14 tür ve 5,807 bireyle ve *M. galloprovincialis* fasiyesi 11 tür ve 18,407 bireyle temsil edilmiştir. *C. barbata* fasiyesi sırasıyla, *M. lineatus* (% 56), *T. pullus* (% 18), *R. splendida* (% 12) ve *G. adansonii* (% 7) oranlarında baskın bulunmuştur. Yine, *M. galloprovincialis* fasiyesi ise, % 63 ile *M. lineatus* ilk sırayı alırken, % 36 baskınlık ile *M. galloprovincialis* ikinci sırayı almaktadır. Mollusk fauna'sında mevsimsel ve istasyon bazında su değerleri ölçülmüştür. Bu değişimlerdeki en yüksek değerler istasyon 3'te ve yaz periyodunda gözlenmiştir.

Anahtar sözcükler: Fasiyes, mollusk topluluğu, mevsimsel, Karadeniz

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Introduction

Investigations of Bivalvia and Gastropoda species along the Black Sea coasts of Turkey are uncommon. Depending on the depth, most other studies of the Black Sea coasts are also scarce, except for studies on the Russian and Romanian coasts (Mutlu et al., 1993; Anistratenko and Anistratenko, 2001). Identification of mollusk fauna of the Black Sea coasts is far from being complete. The aim of the present study was, therefore, to contribute to our knowledge of molluscan biodiversity of Black Sea coasts.

Although the Black Sea is a deep basin, it has limitations for deep sea organisms due to the hydrogen sulfide (H_2S) that emerges below depths of 150-200 m (Zenkevitch, 1963; Bakan and Büyükgüngör, 2000). Therefore, biodiversity, particularly of benthic species, is low in this peculiar marine environment. However, the phylum Mollusca represents the second largest group among all of the faunal taxa after Arthropoda, and it is the largest among marine organisms with respect to species richness (Çulha, 2004).

Since the littoral zone along the Black Sea is narrow, benthic areas are limited. The number of species in the Black Sea is one-fifth that of the Mediterranean Sea, although the Black Sea is first in terms of productivity, accounting for 70% of Turkey's fishery production (Cbd, 2007:[Ministry of Environment and Forestry]).

Approximately 2700 invertebrate species are known within the Turkish seas, 57 of which have some economic value. The largest number of commercial species, 48, is recorded from the Mediterranean and Aegean coasts of Turkey. The effects on the distribution of native species (e.g. competition or substitution) by some alien invertebrates recently established in the area have also been reported (Doğan et al., 2007).

Besides the phylum's species richness, there are also many commercially important mollusks (Da Ros et al., 2003; Karayücel et al., 2003; Sequeira et al., 2008). Representatives of the phylum Mollusca thus deserve to be investigated in greater detail. The aims of the present study were, therefore, to contribute to the knowledge of mollusk biodiversity of the area and to assess the qualitative and quantitative composition of mollusk assemblages that were associated with the *Cystoseira barbata* and *Mytilus galloprovincialis* facies in the upper-infralittoral zone of the southern Black Sea.

Materials and methods

Samples were obtained by sampling between February 2006 and November 2006 at 4 stations on the Sinop Peninsula (southern Black Sea). The first 2 stations were located in the inner bay and the second 2 stations were located in the outer bay, all at depths of 0-0.5 m (Figure 1).

Sampling at the 4 stations was conducted seasonally within the *Cystoseira barbata* and *Mytilus galloprovincialis* facies at depths of 0.5-5 m. A spatula or shovel was used to collect specimens from a 20 × 20 cm area using a quadrat sampling methodology, suggested as being representative of community structure (Kocataş, 1978). Sampling was carried out by diving. Additionally, the physicochemical parameters of the sampling stations were measured seasonally from the surface to a depth of approximately 2 m, using a Horiba U-10 water quality meter. The collected material was fixed in 4% formalin solution and examined in the laboratory. Material was washed through a sieve with 0.5 mm and 1 mm mesh sizes, with the help of pressurized water, and was then stored in 70% alcohol. Specimens were classified into groups using a stereomicroscope, and species were identified. Identification was performed according to shell characteristics and several reference sources, including Nordsieck (1968), Graham (1971), Barash and Danin (1992), Cachia et al. (1996, 2001), Butakov et al. (1997), Çulha (2004), and Doğan (2005), were used. The methods of Sabelli et al. (1990, 1992) and the Check List of European Marine Molluscs (CLEMAM, 2007) were followed for the systematic status of the species.

Some information regarding the study stations is presented in Table 1.

Figure 1. Map showing the sampling sites of stations 1 (Akliman), 2 (Pazar Yeri), 3 (Karakum), and 4 (Orman Kampı) in the study area.

Table 1. Information related to the study stations (R: rocky; S: stony).

Station No.	Dates	Depth	Biotope (m)	Sampling Device	Latitude and Longitude
1 (Akliman)	February 2006, May 2006, July 2006, November 2006 0-0.5,	5	R, S	Quadrat, Spatula	35°02′03″E 42°03′06″N 35°02′05″E 42°03′04″N
2 (Pazar Yeri)	February 2006, May 2006, July 2006, November 2006	0-0.5,5	R, S	Quadrat, Spatula	35°08′18″E 42°01′03″N 35°08′17″E 42°01′04″N
3 (Karakum)	February 2006, May 2006, July 2006, November 2006	0-0.5,5	R, S	Quadrat, Spatula	35°11′23″E 42°01′02″N 35°11′23″E 42°01′00″N
4 (Orman Kampı)	February 2006, May 2006, July 2006, November 2006	0-0.5,5	R, S	Quadrat, Spatula	35°06′14″E 42°00′01″N 35°06′15″E 42°00′01″N

Results

This study was conducted in order to determine the mollusk species in 2 infralittoral facies at Sinop and its vicinity. The identified species and their systematic statuses are identified in Table 2.

All of the collected species and their taxonomic positions are listed in Table 2. A total of 14 species and 5807 individuals were found in the *C. barbata* facies, whereas 11 species and 18,407 individuals were identified in the *M. galloprovincialis* facies.

As a result of the qualitative investigations on the species identified, station 3, with the greatest individual abundance, was found to be represented by 14 species in the *C. barbata* facies and 10 species in the *M. galloprovincialis* facies, whereas the second most abundant station was identified as station 1, with 9 and 7 species for the *C. barbata* and *M. galloprovincialis* facies, respectively (Figure 2).

In terms of species abundance, the highest number of individual specimens (11,746) was collected from

Table 2. List of the mollusk species collected in both facies and their taxonomic positions.

Mytilus galloprovincialis		
Facies Class	**Family**	**Species**
Polyplacophora	Ischnochitonidae	*Lepidochitona corrugata* (Reeve, 1848)
Polyplacophora	Acanthochitonidae	*Acanthochitona fascicularis* (Linnaeus, 1767)
Gastropoda	Trochidae	*Gibbula adansonii* (Payraudeau, 1826)
Gastropoda	Tricoliidae	*Tricolia pullus* (Linnaeus, 1758)
Gastropoda	Cerithiidae	*Cerithidium submamillatum* (De Rayneval & Ponzi, 1854)
Gastropoda	Rissoidae	*Rissoa splendida* Eichwald, 1830
Gastropoda	Cerithiopsidae	*Cerithiopsis minima* (Brusina, 1865)
Gastropoda	Cerithiopsidae	*Cerithiopsis tubercularis* (Montagu, 1803)
Gastropoda	Omalogyridae	*Ammonicera fischeriana* (Monterosato, 1869) [*Homalogyra*]
Bivalvia	Mytilidae	*Mytilus galloprovincialis* Lamarck, 1819
Bivalvia	Mytilidae	*Mytilaster lineatus* (Gmelin, 1791)
***Cystoseira barbata* Facies**		
Class	**Family**	**Species**
Polyplacophora	Ischnochitonidae	*Lepidochitona corrugata* (Reeve, 1848)
Gastropoda	Trochidae	*Gibbula adansonii* (Payraudeau, 1826)
Gastropoda	Tricoliidae	*Tricolia pullus* (Linnaeus, 1758)
Gastropoda	Cerithiidae	*Bittium reticulatum* (Da Costa, 1778)
Gastropoda	Cerithiidae	*Cerithidium submamillatum* (De Rayneval & Ponzi, 1854)
Gastropoda	Rissoidae	*Rissoa splendida* Eichwald, 1830
Gastropoda	Rissoidae	*Pusillina lineolata* (Michaud, 1832)
Gastropoda	Rissoidae	*Setia pulcherrima* (Jeffreys, 1848)
Gastropoda	Cerithiopsidae	*Cerithiopsis minima* (Brusina, 1865)
Gastropoda	Cerithiopsidae	*Cerithiopsis tubercularis* (Montagu, 1803)
Gastropoda	Muricidae	*Cyclope neritea* (Linnaeus, 1758)
Gastropoda	Omalogyridae	*Ammonicera fischeriana* (Monterosato, 1869) [*Homalogyra*]
Bivalvia	Mytilidae	*Mytilus galloprovincialis* Lamarck, 1819
Bivalvia	Mytilidae	*Mytilaster lineatus* (Gmelin, 1791)

Table 3. The seasonal physicochemical water parameters measured at the stations.

Station 1 (Akliman)	**February 2006**	**May 2006**	**July 2006**	**November 2006**
Temperature (°C)	6.20	14.00	25.00	21.00
Salinity (‰)	18.50	16.70	17.40	17.50
pH	8.10	8.15	8.90	7.55
Conductivity (mS/cm)	28.70	27.70	27.20	28.50
Turbidity (NTU)	15.00	15.00	10.00	10.00
Station 2 (Pazar Yeri)	**February 2006**	**May 2006**	**July 2006**	**November 2006**
Temperature (°C)	7.70	13.70	23.50	16.90
Salinity (‰)	18.80	16.50	17.05	17.90
pH	8.10	8.18	8.14	8.90
Conductivity (mS/cm)	30.60	26.90	27.25	29.10
Turbidity (NTU)	20.00	10.00	10.00	15.00
Station 3 (Karakum)	**February 2006**	**May 2006**	**July 2006**	**November 2006**
Temperature (°C)	6.70	12.70	24.50	18.00
Salinity (‰)	19.40	17.40	16.80	19.30
pH	8.14	8.30	8.25	8.24
Conductivity (mS/cm)	32.20	28.40	27.00	30.90
Turbidity (NTU)	15.00	10.00	10.00	10.00
Station 4 (Orman Kampı)	**February 2006**	**May 2006**	**July 2006**	**November 2006**
Temperature (°C)	6.60	13.10	24.20	18.20
Salinity (‰)	19.30	17.40	16.80	19.00
pH	8.18	8.30	7.91	8.22
Conductivity (mS/cm)	32.10	28.40	27.00	29.80
Turbidity (NTU)	75.00	50.00	20.00	35.00

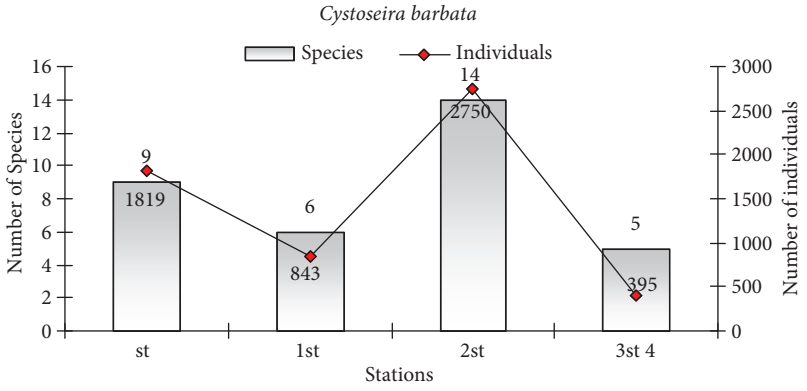

Figure 2. Number of species and abundance of mollusk assemblages in the *C. barbata* facies among the stations.

station 2, followed by station 3 (6139 individuals), station 1 (377 individuals), and station 4 (145 individuals) (Figure 3).

In terms of species dominance, *M. lineatus* (56%) prevailed in the *C. barbata* facies, followed by *T. pullus* (18%), *R. splendida* (12%), and *G. adansonii* (7%) (Figure 4).

For the *M. galloprovincialis* facies, *M. lineatus* was the dominant species, at 63%. *M. galloprovincialis* was the next most prevalent species with a percentage dominance of 36%, which may be due to the high number of specimens belonging to the dominant species encountered in mussel facies. This is due to the surface ratio, and therefore a proportionally higher probability of being sampled (Figure 5).

The frequency index values yielded 7 common, 5 constant, and 3 infrequent species found in the *C. barbata* facies, whereas 4 common, 3 constant, and 4 infrequent species were found in the *M. galloprovincialis* facies. For the *C. barbata* facies, the common species *Tricolia pullus pullus, Bittium reticulatum*, and *Pusillina lineolata* showed 100% frequency (Figure 6).

For the *M. galloprovincialis* facies, *M. lineatus* and *M. galloprovincialis* both had 100% frequency.

With regard to the seasonal occurrence of the species collected from the 2 facies, summer was the leading season, with 14 species for the *C. barbata* facies, followed by autumn (12 species), spring (10 species), and winter (7 species) (Figure 6).

For the *M. galloprovincialis* facies, summer showed the highest number of species, 11, followed by spring (8 species), autumn (6 species), and winter (3 species) (Figure 7).

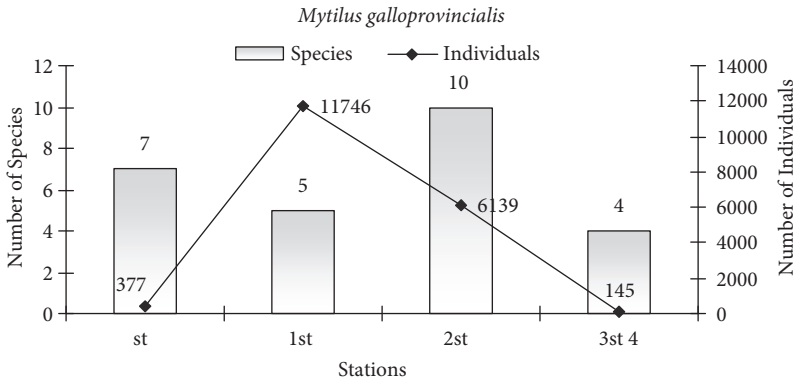

Figure 3. Number of species and abundance of mollusk assemblages in the *M. galloprovincialis* facies among the stations.

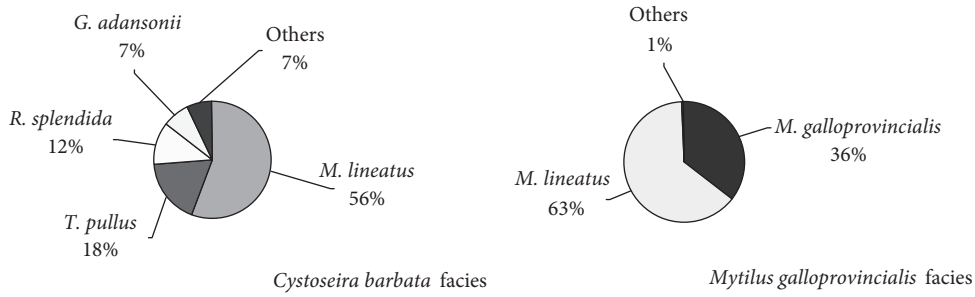

Figure 4. Percentages of dominant species found in the *Cystoseira barbata* and *Mytilus galloprovincialis* facies.

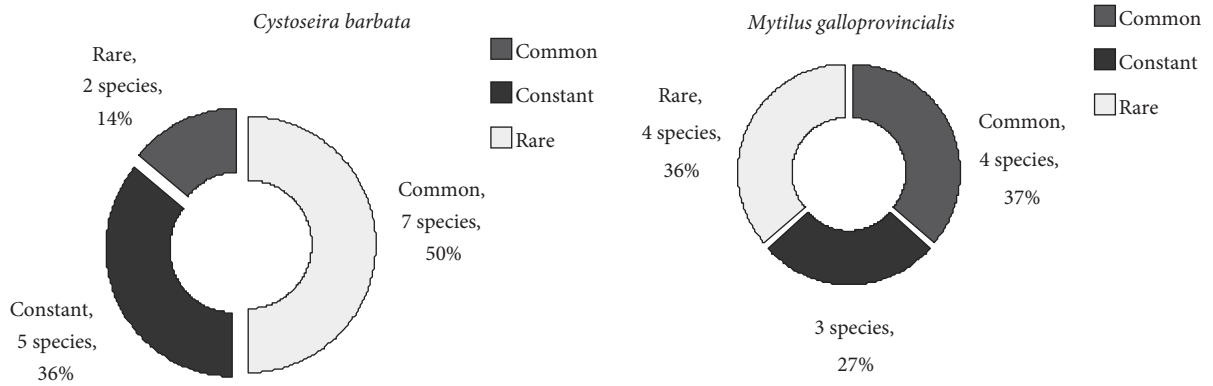

Figure 5. The distribution of the species associated with the *C. barbata* and *M. galloprovincialis* facies, into 3 frequency categories.

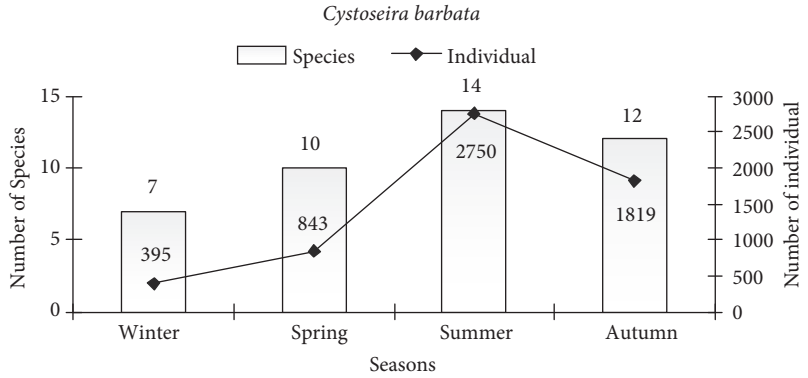

Figure 6. Seasonal pattern of richness and abundance observed in the *C. barbata* facies.

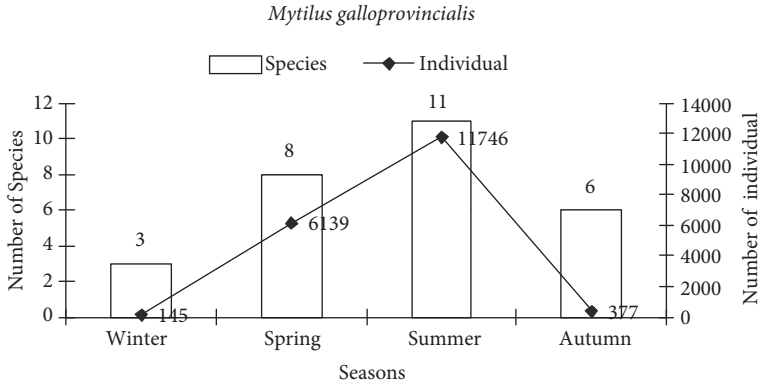

Figure 7. Seasonal pattern of richness and abundance observed in the *M. galloprovincialis* facies.

Discussion and conclusion

The phylum Mollusca contains many economically important species, necessitating the investigation of this group from all perspectives (İlhan and Gülyavuz, 2004). This study was conducted to fulfill that goal, and mollusk species belonging to two facies located along the coast of the Sinop Peninsula were examined.

As a result of the qualitative and quantitative analysis, the *C. barbata* facies was shown to contain 14 species and 5807 specimens, whereas the *M. galloprovincialis* facies had 11 species and 18,407 specimens. Dominance within the *C. barbata* facies belonged to *M. lineatus* (56%), *T. pullus* (18%), *R. splendida* (12%), and *G. adansonii* (7%). For the *M. galloprovincialis* facies, *M. lineatus* was the dominant species (63%), followed by *M. galloprovincialis* (36%).

Among the 4 stations, pollution stress was highest at station 2, "Pazar Yeri" (Figure 1, Table 1). In particular, the sewage discharged into this area throughout the year has a negative impact on the coastal ecosystem. In addition to the influence of small enterprises located in the city, domestic waste limits some of the aquatic organisms in terms of biological diversity, and, on the other hand, results in dominance by some other organisms such as *Ulva lactuca*, *Enteromorpha linza*, and *Mytilus galloprovincialis* (Bat et al., 2001). At station 1 ("Akliman"), station 3 ("Karakum"), and station 4 ("Orman Kampı"), no pollutants were assessed, except for small fishing ports and some related wastes or remnants. However, wastes produced by vacationers and campers may constitute an additional source of environmental pollution (Çulha et al., 2007).

The faunistic features that were observed in the 2 facies were analyzed both taxonomically and ecologically. Of these ecological findings, several descriptive statistical assessments were made, such as the distribution of species among the stations, the individual dominance index values, the frequency index values, and the seasonal distributions.

As a result of the qualitative examinations of the determined species, station 3 was found to have 14 and 10 species for the *C. barbata* and *M. galloprovincialis* facies, respectively, followed by station 1, with 9 and 7 species. If the stations were assessed in terms of the number of individuals, station 2 had the most abundant population (11,746 individuals), followed by station 3 (6139 individuals), station 1 (377 individuals), and station 4 (145 individuals).

When comparing individual dominance within the facies, *C. barbata* was foremost and was dominated by *M. lineatus* (56%), followed by *T. pullus* (18%), *R. splendida* (12%), and, finally, *G. adansonii* (7%). *M. lineatus* dominated (63%) the *M. galloprovincialis* facies and *M. galloprovincialis* was the second most dominant species (36%), due to the fact that the number of individuals belonging to the dominant species in the mussel facies was high.

Species frequency index values within the facies were estimated according to the method of Soyer (1970). It was found that 7 species were common, 5 species were constant, and 2 species were rare in the *C. barbata* facies, whereas within the *M. galloprovincialis* facies, 4 species were common, 3 species were constant, and 4 species had a rare distribution pattern. For *C. barbata*, the common species were *Tricolia pullus pullus, Bittium reticulatum*, and *Pusillina lineolata*, at a frequency rate of 100%. In the *M. galloprovincialis* facies, the prevalent species were *M. lineatus* and *M. galloprovincialis*, also with a 100% frequency rate.

When the numbers of species and individuals were examined based on their seasonal distributions, the highest number of species in the *M. galloprovincialis* facies was encountered in summer (11 species), followed by spring (8 species), autumn (6), and winter (3 species). The *C. barbata* community had the highest number in summer (14 species), followed by autumn (12 species), spring (10 species), and winter (7 species).

In the present seasonal study, the highest number of species and specimens were observed in summer, when warm water and optimum environmental parameters prevailed (Figures 8 and 9, Table 3). The lowest number of species and specimens were recorded in winter. When the stations were evaluated from the perspective of the number of species and specimens, station 3 had the highest species and specimen numbers. This could be explained by the rocky and stony nature of this station, providing a

more diverse habitat than the other sampling stations, and by its location, sheltered against external environmental effects such as currents and winds. In addition, the fact that neither domestic nor industrial discharges are present in the region (Bat, 1992; Öztürk and Öztürk, 1994; Bat et al., 2001; Çulha et al., 2007; also see Table 3) contributes to this abundance. Additionally, as seen in Figure 3, despite the lower number of species (5 species) at station 2, the number of specimens was considerably increased (11,746 specimens). The consumption of domestic wastes discharged to the station throughout the year by filter-feeding organisms such as *Mytilus* and *Mytilaster* accounts for the increase in these organisms (Öztürk et al., 2004).

Present knowledge on the marine mollusks of Turkey is limited by insufficient specialist researchers and by a low number of taxonomic studies. Further relevant studies about marine biodiversity, especially along the Black Sea coasts of Turkey, must be conducted from all perspectives in the future. There is a need for more detailed research to investigate different Mollusca locations, habitats, and depths.

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