Yuzuncu Yil University Journal of the Institute of Natural & Applied Sciences, Volume 28, Issue 3 (December), 803-817, 2023

Yuzuncu Yil University
Journal of the Institute of Natural & Applied Sciences

https://dergipark.org.tr/en/pub/yyufbed

Research Article

Mollusc Diversity of Hard Substrate Habitats of Gökçeada Island

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Article Info

Received: 07.11.2022
Accepted: 26.04.2023
Online December 2023

DOI:10.53433/yyufbed.1199833

Keywords
Gokceada Island,
Hard substrate,
Infralittoral zone,
Mollusc,
Mucilage

Abstract: In the present study, molluscs diversity between 0-0.5 m depths of the hard substrate habitats of Gökçeada coasts was investigated qualitatively and quantitatively, seasonally, and monthly in 2010 and 2011. In addition, in summer months of 2021, samples were taken to investigate the mucilage impact on the mollusc fauna, which occurred in the Marmara Sea in 2021 and affected Gökçeada coasts due to the currents. A total of 76 mollusc species were identified and 27 of the determined species are new records for Gökçeada. Among the found species, while *Cardita calyculata* (Linnaeus, 1758) was the most dominant species at the Yıldız Koy station sampled monthly, *Musculus costulatus* (Risso, 1826) was the dominant one at all other sampling stations. The Tepeköy station was found to has the highest number of species and individuals. As the main reason for this can be indicate the limited human access to the region and the presence of various habitats. Mollusc species diversity, which was detected in 2010 due to the pouring of sand for tourists by the municipality at Yıldız Koy station, was found to be increased greatly in 2021 after this practice was abandoned. It was also detected that the mollusc species distributed on the coasts of Gökçeada were not acutely affected by the mucilage event occurred in 2021. However, more detailed studies need to be monitoring and report the negative effects that may occur the mucilage event on the species diversity of the region in the coming years.

Gökçeada'nın Sert Substratum Habitatlarının Mollusk Çeşitliliği

Makale Bilgileri

Geliş: 07.11.2022
Kabul: 26.04.2023
Online Aralık 2023

DOI:10.53433/yyufbed.1199833

Anahtar Kelimeler
Gökçeada,
Infralittoral bölge,
Mollusc,
Müsilaj
Sert substrat

Bu çalışmada, Gökçeada kıyılarının sert substratum habitatlarının 0-0.5 m arası derinliklerinde bulunan mollusc tür çeşitliliği nitel ve nicel olarak araştırılmış olup, araştırma 2010 ve 2011 yıllarında mevsimsel ve aylık olarak gerçekleştirilmiştir. Ayrıca, 2021 yılında Marmara Denizi'nde oluşan ve akıntılar nedeniyle Gökçeada'nın da etkisinde kaldığı müsilaj olayının mollusk faunasını nasıl etkilediği 2021 yılının yaz aylarında araştırılmıştır. Toplam 76 mollusk türünün tespit edildiği bu çalışmada 27 tür Gökçeada için yeni kayıttır. Aylık örneklenen Yıldız Koy istasyonunda en baskın tür *Cardita calyculata* (Linnaeus, 1758) iken, diğer tüm örnekleme istasyonlarında en baskın tür *Musculus costulatus* (Risso, 1826)'tur. Tepeköy istasyonu en fazla tür ve birey sayısına sahip istasyon olarak bulunmuştur. Bu durumun nedenleri arasında bölgeye insan ulaşımının sınırlı olması ve farklı habitat tiplerinin yer alması gösterilebilir. Yıldız Koy istasyonuna belediye tarafından turistler için kıyıya kum dökülmesi sonucu, 2010 yılında tespit edilmiş yumuşakça tür çeşitliliğinde, bu uygulamadan vazgeçilmesi ile 2021 yılında büyük bir artışın gerçekleştiği ortaya çıkarılmıştır. Diğer taraftan, Gökçeada kıyılarında yaşayan mollusk türlerinin 2021 yılındaki müsilajdan akut olarak etkilenmediği saptanmıştır. Ancak gelecek yıllarda meydana gelebilecek olumsuz etkileri tespit etmek ve bu bölgedeki tür çeşitliliğini korumak için, bu bölgenin izlenmesi ve raporlanması için daha detaylı çalışmalara ihtiyaç duyulmaktadır.

1. Introduction

The islands, which are important in terms of biological and cultural diversity (Kueffer & Kinney, 2017), can host endemic species and cover 5.3% of the earth (Tershy et al., 2015), are the regions most affected by the changes (Kueffer & Kinney, 2017). Gökçeada which is the largest island in Türkiye, located in the northeast of the Aegean Sea, is found at a distance of 51 km to the nearest mainland (Kocaman, 2020) with a 95 km coastline and a total surface area of 290 km^2 (Aslan et al., 2021a). Gökçeada Island's coast and surrounding area are important in terms of hosting many invertebrates, vertebrates, plants, algae, and planktonic species (Gönülal & Güreşen, 2014; Gönülal & Güreşen, 2017; Aslan et al., 2018; Aslan & İşmen, 2019; Aslan et al., 2021a and 2021b).

Coastal habitats are important as nesting sites for the shelter of many marine invertebrates (Seitz et al., 2014), as well as creating many productive areas (Andrade-Tubino et al., 2019) and acting as a gateway to connect terrestrial and aquatic environments (Niemelä et al., 2015). Mollusc representatives can live in coastal habitats and both terrestrial and freshwater habitats. These organisms can be used in biological monitoring studies (Oehlmann & Schulte-Oehlmann, 2003), can act as ecosystem engineers (Fortunato, 2015) and can take part in the functions of ecosystems (Carnegie et al., 2016). However, the productive habitats covering these classes are under the influence of man-made factors, such as the opening of coastal areas to settlement (Von Storch et al., 2015), pollution (Bloch & Klingbeil, 2015), climate change (Burden et al., 2020), mucilage (Tüfekçi et al., 2010; Savun-Hekimoğlu & Gazioğlu, 2021; Aslan et al., 2021b). Among these factors, mucilage formation was observed in the Sea of Marmara in 2020 and reached the Çanakkale Strait and also Gökçeada by the effect of currents and winds. Aslan et al. (2021b) determined that in Gökçeada the mucilage formation had negative effects on peracarid crustaceans. Also, human-made waste materials in coastal areas can cause adverse effects on marine organisms and the region where they are located (Weideman et al., 2020). For these reasons, it is of great importance to protect and monitor, especially these coastal areas with hard bottoms.

In the present study were studied the molluscs belonging to the classes Gastropoda, Bivalvia and Polyplacophora. The gastropods regulate the structure of their communities living in the tidal zone (Lumeran, 2019). On the other hand, bivalves organize nutrient circulation, change the density values of metal and oxygen (Coen & Bishop, 2015) and create habitats and avert coastal erosion (Ramón & Galimany, 2022), whereas the polyplacophores are significant grazers that can check the development and dispersion of algae by feeding on algae communities (Mendonça et al., 2014). Regarding these mollusc classes, we detected both live and dead species in our study. Species attributed as dead are single-shelled or hollow molluscs but are taxonomically identifiable organisms that have lived in an area for a short or long period (Kidwell, 2013). The mollusc fauna of Gökçeada was examined in different studies by various authors such as Albayrak (2002), Öztürk et al. (2008), Öztürk (2011), Öztürk et al. (2011 and 2013), Gönülal & Güreşen (2014), Gönülal & Güreşen (2017), Aslan et al. (2018) and Barraud & Öztürk (2022).

The aim of this study; (i) to create mollusc species lists of the coastal areas with the rocky habitats of Gökçeada Island in the years 2010, 2011 and 2021; (ii) to compare the lists according to the years; (iii) to make monthly observations of mollusc species diversity in the studied area for the first time; (iv): to test the effect of mucilage on the benthic mollusc fauna in Gökçeada.

2. Material and Methods

This study was carried out seasonally at 13 stations in the hard bottom areas in the upper infralittoral zone of Gökçeada Island in 2010 and 2011 (Map 1, Table 1). One of the stations located in Yıldız Koy was sampled monthly. In addition, in five stations the samples were taken in the summer only in the year 2021. As sampling gear, a quadrat frame of 20 x 20 cm was used and the area within the quadrat was scraped by the help of a spatula from depths between 0-0.5 m as 3 replicates. The samples were taken into jars containing 4% formaldehyde, labeled, and brought to the laboratory.

Map 1. Sampling stations along Gökçeada Island (Source: Google Earth).

Table 1. Code of the stations, locality, coordinates and sampling dates

Stations		Coordinates		Sampling Date
Code	Locality	Latitude	Longitude	
YZ	Yıldız Koy	40º 14´ 04.57"	25º 54´ 11.16"	05.04.2010,11.05.2010, 08.06.2010, 07.07.2010, 10.08.2010, 10.09.2010, 10.10.2010, 09.11.2010, 09.12.2010, 06.01.2011, 09.02.2011, 11.03.2011, 27.06.2021
TP	Tepeköy	40º 12´ 40.39"	25º 50´ 23.60"	04.04.2010, 07.07.2010, 26.10.2010, 23.12.2010
MS	Marmaros	40º 11´ 41.99"	25º 45´ 17.86"	27.03.2010, 20.06.2010, 12.10.2010, 24.12.2010
GL	Gizli Liman	40º 07´ 26.02"	25º 40´ 25.49"	27.03.2010, 07.07.2010, 12.10.2010, 06.01.2011
GM	Gizli Liman 2	40º 07´ 26.80"	25º 40´ 02.14"	27.03.2010, 07.07.2010, 17.10.2010, 06.01.2011
AK	Adalet Kampı	40º 05´ 45.31"	25º 45´ 23.71"	27.03.2010, 20.06.2010, 12.10.2010, 06.01.2011, 28.06.2021
KR	Karakol	40º 06´ 07.44"	25º 49´ 09.08"	24.03.2010, 16.06.2010, 10.10.2010, 06.01.2011
SL	Şapel	40º 06´ 04.69"	25º 50´ 8.46"	24.03.2010, 16.06.2010, 10.10.2010, 06.01.2011, 28.06.2021
SK	Şen Kamping	40º 07´ 40.79"	25º 56´ 20.28"	24.03.2010, 16.06.2010, 10.10.2010, 06.01.2011, 30.06.2021
TK	Kefaloz	40º 07´ 34.94"	25º 55´ 51.98"	24.03.2010, 20.06.2010, 10.10.2010, 06.01.2011
DK	Aydıncık Koyu	40º 09´ 41.85"	25º 57´ 56.38"	01.04.2010, 20.06.2010, 10.10.2010, 24.12.2010
BD	Bozdere	40º 11´ 56.48"	25º 58´ 27.24"	01.04.2010, 16.06.2010, 10.10.2010, 24.12.2010
KL	Kuzu Limanı	40º 14´ 05.27"	25º 56´ 53.38"	01.04.2010, 17.06.2010, 10.10.2010, 24.12.2010, 26.06.2021

Afterwards, the sampled material was sieved through a system with mesh size of 2 mm, 1 mm and 0.5 mm in the laboratory. In the sortage and identification of mollusc material was used a stereomicroscope Olympus SZX-16 and then was putted in 40 cc jars containing 70% ethyl alcohol. Parenzan (1970), Parenzan (1974), Poppe & Goto (1993), and numerous specific articles concerning single species have been used for mollusc species identification. All identified mollusc specimens were counted as dead and live. The systematic of the identified species was given according to WoRMS (2022).

Physico-chemical parameters in the infralittoral water column (temperature, salinity, dissolved oxygen, and TDS) were measured with the YSI probe system for YZ, AK, KZ, SL, and SK stations (Figure 1).

Statistical analyzes were carried out to reveal the diversity and abundance of mollusc species. Therefore, frequency values (F>50% continuous, 25% <F> 50% common and F<25% rare) (Soyer, 1970), quantitative dominance, Margalef Richness (Margalef, 1958) (d), Pielou Evenness (Pielou, 1975) (J') and Shannon-Wiener Diversity indices (Shannon & Weaver, 1949) (based on log2) (H') were calculated. For the abundances of the identified species, n-MDS (Non-Metric Multidimensional Scaling) analyzes were calculated using PRIMER (ver. 7). All analyzes were conducted with live mollusc specimens also dead specimens (only shell) were counted and added to the tables.

3. Results

3.1. Biological data

Seasonal data

Totally 7142 individuals m^{-2} belonging to 35 mollusc species were identified seasonally in 2010 and 2011 (Table 2).

Table 2. Average abundance ind/m^2 and standard deviation results (±) of live mollusc species in different stations according to seasons. In parantheses mean dead mollusc individuals.m^{-2}. ***:** New records for the island

	TP	**MS**	**GL**	**GM**	**AK**	**KR**	**SL**	**SK**	**TK**	**DK**	**BD**	**KL**
GASTROPODA												
Gastropoda (sp.)	(2)											
Alvania cimex (Linnaeus, 1758)	(2)											
Alvania geryonia (Nardo, 1847)*	17±33, (2)											
Alvania lactea (Michaud, 1830*)*										2±4		
Alvania punctura (Montagu, 1803)*	(2)											
Alvania sp.	(8)		(6)					(4)	(2)			(2)
Bittium reticulatum (da Costa, 1778)	63±114, (29)	173±346, (4)	(10)		(8)			29±58	(2)			
Bittium latreillii (Payraudeau, 1826)	8±17, (4)											
Bittium sp.			(4)									
Cerithium vulgatum Bruguière, 1792	4±8, (4)	2±4	4±8									
Cerithium sp.	(2)											
Columbella rustica (Linnaeus, 1758)	(4)						4±8					
Conus ventricosus Gmelin, 1791	15±20, (27)		(2)		(4)	4±8		4±8		15±24		
Fossarus ambiguus (Linnaeus, 1758)*	(2)											
Gibbula sp.	(2)											
Haminoea sp. *	19±32	2±4	2±4									
Manzonia crassa (Kanmacher, 1798)			(2)									
Melarhaphe neritoides (Linnaeus, 1758)	(2)											
Odostomella doliolum (Philippi, 1844)*	2±4											
Odostomia sp.		(2)										
Parvioris ibizenca (F. Nordsieck, 1968)*	2±4											
Patella sp.										2±4	2±4	
Patella caerulea Linnaeus, 1758	(2)	2±4		6±13						6±13		
Philine sp. *					2±4							
Philine aperta (Linnaeus, 1767)*						6±13			2±4			
Pisania striata (Gmelin, 1791)	2±4											
Pusia granum (Forbes, 1844)*	(8)											
Pusia tricolor (Gmelin, 1791)*	(2)											
Pusillina radiata (Philippi, 1836)*	(4)							(19)				
Pusillina sp.									(19)			

Table 2. Average abundance ind/m^2 and standard deviation results (±) of live mollusc species in different stations according to seasons. In parantheses mean dead mollusc individuals.m^{-2}**. *:** New records for the island (continued)

	TP	MS	GL	GM	AK	KR	SL	SK	TK	DK	BD	KL
Retusa sp.*	13±25, (6)				(2)	(4)	(4)					
Retusa variabilis (Milaschewitsch, 1912*)**						2±4						
Rissoa lia (Monterosato, 1884)*						8±17						
Rissoa scurra (Monterosato, 1917)*					(2)							
Rissoa similis Scacchi, 1836	(6)				(10)				(2)	33±67		
Rissoa sp.			(4)	(6)	(4)	(2)	(6)		(71)			
Rissoa splendida Eichwald, 1830*	(2)								(4)	6±13, (6)		
Tritia incrassata (Strøm, 1768)	6±13, (4)		4±8									
Tritia sp.	6±13, (6)											
Trophonopsis muricata (Montagu, 1803)*	(2)	2±4			(2)							
Vexillum sp.	(2)											
BIVALVIA												
Bivalvia (sp.)				(2)								
Cardita calyculata (Linnaeus, 1758)	23±21	2±4			2±4						2±4	15±29
Hiatella arctica (Linnaeus, 1767)			17±33							2±4		
Irus irus (Linnaeus, 1758)	21±42		17±33	4±5	27±33	10±21		25±50	2±4			
Modiolula phaseolina (Philippi, 1844)	6±13		6±8	2±4			2±4		4±5			
Musculus costulatus (Risso, 1826)	225±406	42±49	73±140	38±60	29±43		13±25	4±8	58±56	42±63		4±5
Musculus discors (Linnaeus, 1767)							2±4					
Musculus subpictus (Cantraine, 1835)	2±4											
Mytilaster minimus (Poli, 1795)	4±8	21±25	110±189	190±379	13±25					19±22		2±4
Mytilus galloprovincialis Lamarck, 1819		4±5	79±153	127±147								
Parvicardium scriptum (Bucquoy, Dautzenberg & Dollfus, 1892)					2±4							
Venerupis corrugata (Gmelin, 1791)*					4±8							
POLYPLACOPHORA												
Acanthochitona crinita (Pennant, 1777)*	2±4						2±4					

The highest number of individuals (1558 ind.m^{-2}) and species (16) at the TP station was recorded in July (Figure 1).

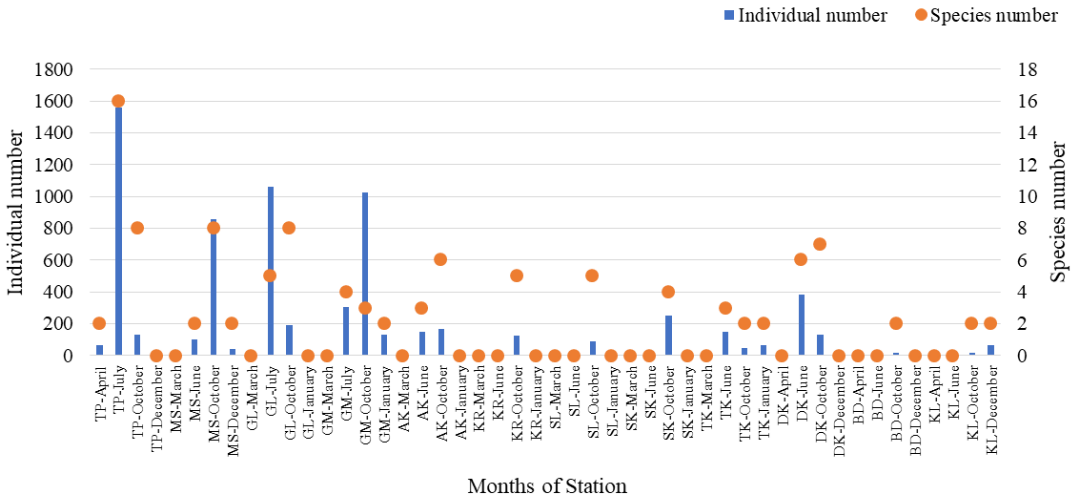

Figure 1. The number of species and individuals in seasonal data (ind/m^2).

In seasonal data, *Musculus costulatus* was the common mollusc species and the other 34 were the rare species while *Musculus costulatus* (30 %), *Mytilaster minimus* (20 %), *Bittium reticulatum* (15 %) and *Mytilus galloprovincialis* (12 %) were the most dominant mollusc species. In fall, TP has the highest Margalef and Shannon-Wiener indices and both BD and KL have the highest Pielou indexes, in winter MS has the highest Margalef, Shannon-Wiener and Pielou indices, in spring TP station has the highest Margalef, Shannon-Wiener and Pielou indices, in summer TP has the highest Margalef and Shannon-Wiener indices and both AK and DK station have the highest Pielou index (Table 3).

Table 3. Margalef Richness (d), Pielou Evenness (J') and Shannon-Wiener Diversity (H') index values obtained in different stations according to seasonal abundance

	Seasons of Stations											
Indices	**TP**				**MS**				**GL**			
	Spring	**Summer**	**Fall**	**Winter**	**Spring**	**Summer**	**Fall**	**Winter**	**Spring**	**Summer**	**Fall**	**Winter**
d	0.24	2.04	1.43	*	*	0.22	1.04	0.27	*	0.57	1.33	*
J'	0.95	0.63	0.97	*	*	0.41	0.37	0.72	*	0.80	0.85	*
H'	0.95	2.51	2.91	0	0	0.41	1.12	0.72	0	1.86	2.55	0.00
Indices	**GM**				**AK**				**KR**			
	Spring	**Summer**	**Fall**	**Winter**	**Spring**	**Summer**	**Fall**	**Winter**	**Spring**	**Summer**	**Fall**	**Winter**
d	*	0.52	0.29	0.20	*	0.40	0.98	*	*	*	0.83	*
J'	*	0.38	0.60	0.34	*	0.82	0.82	*	*	*	0.93	*
H'	0	0.76	0.94	0.34	0	1.30	2.11	0	0	0	2.15	0
Indices	**SL**				**SK**				**TK**			
	Spring	**Summer**	**Fall**	**Winter**	**Spring**	**Summer**	**Fall**	**Winter**	**Spring**	**Summer**	**Fall**	**Winter**
d	*	*	0.89	*	*	*	0.54	*	*	0.40	0.026	0.24
J'	*	*	0.80	*	*	*	0.78	*	*	0.39	0.65	0.54
H'	0	0	1.87	0	0	0	1.56	0	0	0.61	0.65	0.54
Indices	**DK**				**BD**				**KL**			
	Spring	**Summer**	**Fall**	**Winter**	**Spring**	**Summer**	**Fall**	**Winter**	**Spring**	**Summer**	**Fall**	**Winter**
d	*	0.84	1.23	*	*	*	0.36	*	*	*	0,36	0.24
J'	*	0.82	0.88	*	*	*	1	*	*	*	1	0.54
H'	0	2.13	2.48	0	0	0	1	0	0	0	1	0.54

Monthly data

In total 2292 individuals.m^{-2} belonging to 25 mollusc species were identified monthly at the station of YZ in the years 2010 and 2011 (Table 4).

Table 4. Average abundance and standard deviation (±) results of live mollusc species in the stations according to seasons and average abundance results of dead molluscs (ind/m^2) in the YZ station. *: New records for the island

	April	May	June	July	August	September	October	November	December	January	February	March
GASTROPODA												
Gastropoda (sp.)					(8)	(8)						
Alvania cimex (Linnaeus, 1758)					(8)	(8)						
Alvania sp.							(8)					
Aplus scacchianus (Philippi, 1844)							17±29					
Bittium latreillii (Payraudeau, 1826)						25±43	(8)					
Bittium reticulatum (da Costa, 1778)				(33)	(17)			17±29, (8)				
Cerithium vulgatum Bruguière, 1792											17±29, (17)	
Chrysallida sp.								(8)				
Columbella rustica (Linnaeus, 1758)				(33)			(17)	(8)				(8)
Conus ventricosus Gmelin, 1791				(25)	(25)	17±29, (8)	(33)	8±14			17±29	
Diodora graeca (Linnaeus, 1758)*						25±25	8±14					
Manzonia crassa (Kanmacher, 1798)								(17)				
Melarhaphe neritoides (Linnaeus, 1758)								(8)				
Pisania striata (Gmelin, 1791)							(8)				(8)	
Pusia granum (Forbes, 1844)*								(8)			8±14	
Pusillina radiata (Philippi, 1836)*											42±72	
Raphitoma sp.						(8)						
Retusa sp.*						(8)						
Rissoa splendida Eichwald, 1830*				(8)	8±14		(8)					
Tritia incrassata (Strøm, 1768)						25±43	(17)	8±14			8±14	
Tritia sp.							(17)			(8)		
Tritia varicosa (W. Turton, 1825)*								8±14				
Trophonopsis muricata (Montagu, 1803)*		19±29					25±43	(8)				
Trophon sp.*				(8)		(8)						
BIVALVIA												
Cardita calyculata (Linnaeus, 1758)		58±80	8±14	8±14		25±43	250±130	325±563	75±75	125±139	108±188	33±29
Ctena decussata (O. G. Costa, 1829)								8±14			92±159	
Hiatella arctica (Linnaeus, 1767)								8±14				
Irus irus (Linnaeus, 1758)								50±87				
Limaria tuberculata (Olivi, 1792)											8±14	8±14
Modiolula phaseolina (Philippi, 1844)			8±14							8±14		
Musculus costulatus (Risso, 1826)		333±290	17±29	17±29			83±38	42±72		17±29	8±14	25±25
Mytilaster minimus (Poli, 1795)		33±29		8±14	25±43	8±14	8±14	25±43	25±25	50±66		
Mytilus galloprovincialis Lamarck, 1819												8±14
Parvicardium scriptum (Bucquoy, Dautzenberg & Dollfus, 1892)								8±14				
Venerupis corrugata (Gmelin, 1791) *											17±29	
POLYLACOPHORA												
Acanthochitona crinita (Pennant, 1777)*							8±14				8±14	
Rhyssoplax olivacea (Spengler, 1797)							8±14					

YZ station has the highest individual number (508 ind.m^{-2}) in November and species numbers (11) in November and February (Figure 2).

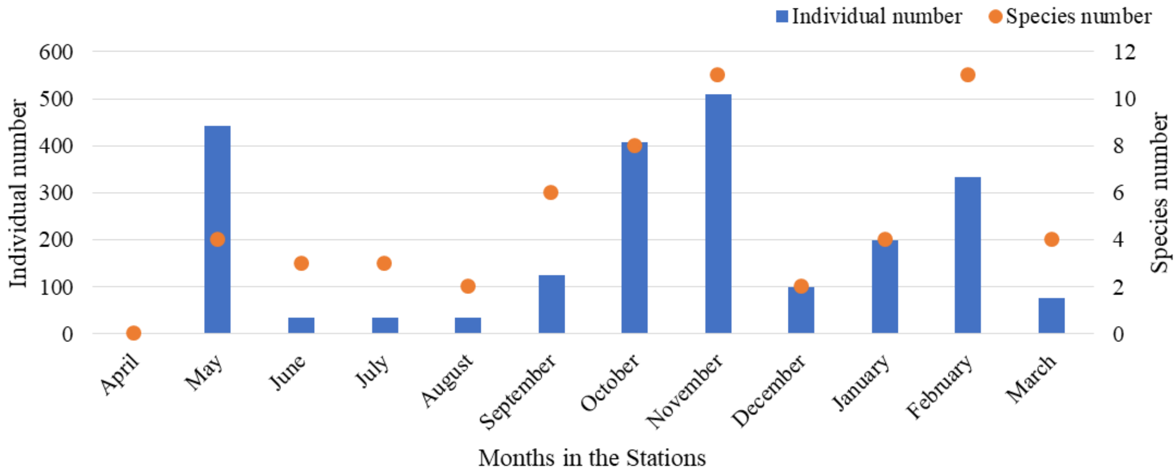

Figure 2. The number of species and individuals/m^2 in YZ station according to months.

According to the monthly obtained data, *Cardita calyculata*, *Musculus costulatus* and *Mytilaster minimus* were the species with continuous distribution, *Conus ventricosus*, *Tritia incrassata* were withcommon distribution and the other 20 ones were rarely distributed. *Cardita calyculata* (44 %) and *Musculus costulatus* (24 %) were the most dominant species. In the February was calculated the highest Margalef and Shannon-Wiener index and in the September the highest Pielou index value (Table 5).

Table 5. Margalef Richness (d), Pielou Evenness (J’) and Shannon-Wiener Diversity (H’) index values according to monthly data in YZ Station

Indices	April	May	June	July	August	September	October	November	December	January	February	March
d	*	0.49	0.57	0.57	0.29	1.04	1.16	1.61	0.22	0.57	1.72	0.69
J'	*	0.58	0.95	0.95	0.81	0.97	0.60	0.58	0.81	0.71	0.79	0.88
H'	0	1.15	1.50	1.50	0.81	2.51	1.80	2.00	0.81	1.41	2.73	1.75

Comparison between the summers of the years 2010 and 2021

In Gökçeada Island, five mollusc species including 183 individuals.m^{-2} in the summer of 2010 and 26 mollusc species with 4183 individuals.m^{-2} in the summer of 2021 were identified (Table 6). YZ was the highest individual (3267 ind.m^{-2}) and species numbers (23) in 2021 (Figure 3).

Table 6. The mean, standard deviation results (±) of live mollusc species in different stations according to seasons and the mean results of dead molluscs in the summers of 2010 and 2021 (ind.m^{-2}) in the brackets. *: New records for the island

	YZ		**AK**		**KL**		**SL**		**SK**	
	2010	**2021**	**2010**	**2021**	**2010**	**2021**	**2010**	**2021**	**2010**	**2021**
GASTROPODA										
Alvania cimex (Linnaeus, 1758)		(67)								
Alvania sp.		8±14								
Bittium reticulatum (da Costa, 1778)	(33)	725±458, (358)		192±176, (42)		167±95				(17)
Caecum trachea (Montagu, 1803)								25±43		
Caecum sp.						(8)				
Caecum subannulatum de Folin, 1870*								8±14		
Cerithium vulgatum Bruguière, 1792		717±413								(8)
Columbella rustica (Linnaeus, 1758)	(33)									
Conus ventricosus Gmelin, 1791	(25)	75±66, (33)								(8)
Mangelia vauquelini (Payraudeau, 1826)*		17±29								
Mangelia sp.		(8)								
Odostomia sp.		8±14								
Phorcus turbinatus (Born, 1778)										(8)
Pusia granum (Forbes, 1844)*		8±14, (17)								
Pusillina radiata (Philippi, 1836)*		(17)								
Retusa sp.*		(17)	(8)							
Rissoa sp.		25±43, (33)	(8)	(8)						
Rissoa similis Scacchi, 1836		8±14								
Rissoa splendida Eichwald, 1830*	(8)									
Tritia sp.		67±58, (17)		8±14						
Tritia varicosa (W. Turton, 1825)*		25±25								
Trophonopsis muricata (Montagu, 1803)*		(17)								
Trophon sp.*	(8)									
Spiralinella incerta (Milaschewitsch, 1916)*						(8)				
Steromphala varia (Linnaeus, 1758)		17±14								
BIVALVIA										
Bivalvia (sp1.)		42±72								
Bivalvia (sp2.)		25±43								
Bivalvia (sp3.)		8±14								
Cardita calyculata (Linnaeus, 1758)	8±14	125±175								
Hiatella arctica (Linnaeus, 1767)		17±14								
Irus irus (Linnaeus, 1758)		17±14	42±72	25±25						
Modiolula phaseolina (Philippi, 1844)		8±14		8±14						
Modiolus barbatus (Linnaeus, 1758)		75±66								42±38
Mytilus galloprovincialis Lamarck, 1819		42±52		108±166						150±238
Mytilaster minimus (Poli, 1795)	8±14									
Musculus costulatus (Risso, 1826)	17±29	1142±600	92±159	25±25				17±14		133±38
Parvicardium scriptum (Bucquoy, Dautzenberg & Dollfus, 1892)		67±115								
Sphenia binghami W. Turton, 1822				8±14						
Venerupis corrugata (Gmelin, 1791)*			17±29							

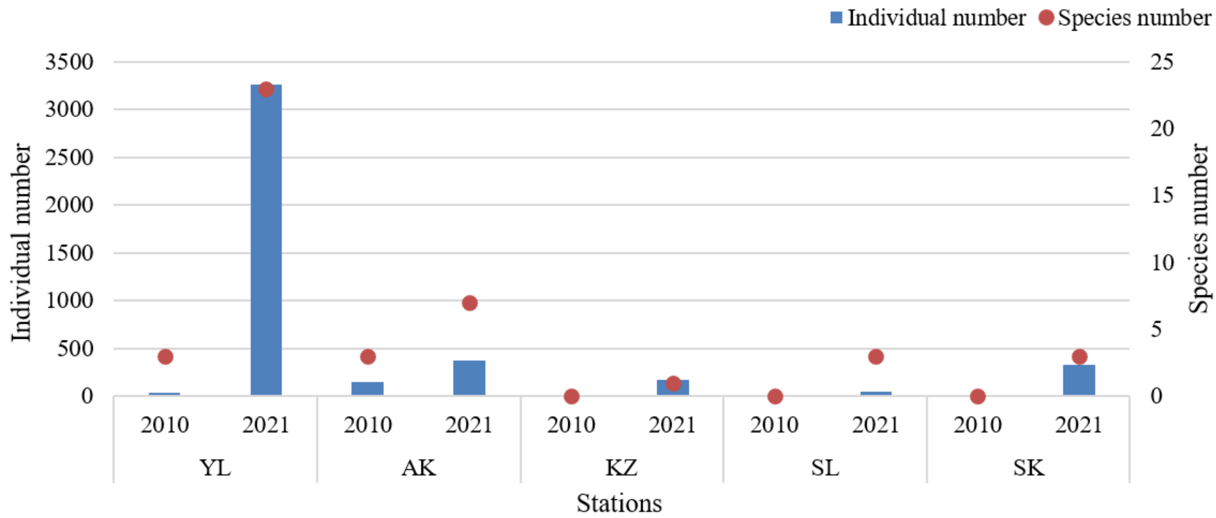

Figure 3. Comparison of individual and species numbers according to stations in the summer seasons of 2010 and 2021 (ind/m^2).

In 2010, *Musculus costulatus* was the species with common distribution, the other four species were rarely distributed and *M. costulatus* (59 %), and *Irus irus* (23 %) were the dominant species. In 2021, *M. costulatus, Bittium reticulatum* and *Mytilus galloprovincialis* were the species with continuous distribution, *Irus irus*, *Modiolula phaseolina*, *Modiolus barbatus, Tritia* sp. were with common distribution, and the other 20 species were rarely distributed. *Musculus costulatus* (31 %), *Bittium reticulatum* (26 %) and *Cerithium vulgatum* (17 %) were the dominant species. YZ and AK stations' Pielou index values decreased in 2021 compared to 2010. The result calculated for KL station in summer 2021 was not statistically significant and no indices values were calculated for the stations KL, SL and SK stations in 2010 since any species was detected (Table 7).

Table 7. Margalef Richness (d), Pielou Evenness (J') and Shannon-Wiener Diversity (H') index values according to stations in the summer periods of 2010 and 2021

	YZ		AK		KL		SL		SK	
Indices	**2010**	**2021**	**2010**	**2021**	**2010**	**2021**	**2010**	**2021**	**2010**	**2021**
d	0.57	2.72	0.40	1.01	*	0	*	0.51	*	0.35
J'	0.95	0.61	0.82	0.68	*	*	*	0.92	*	0.90
H'	1.50	2.76	1.30	1.90	0	0	0	1.46	0	1.42

3.2. Environmental data

In 2010, the physicochemical parameters measured at YZ, AK, KL, SL, and SK stations were as follow: temperature between 26.09 °C and 29.01 °C, salinity between 31.88 ‰ and 33.7 ‰, dissolved oxygen between 7.61 mg L^{-1} and 9.48 mg L^{-1}, and TDS between 31.82 mg L^{-1} and 33.41 mg L^{-1}. Similarly, for these five stations in 2021, the temperature was between 26.79 °C and 28.31 °C, the salinity was between 31.77 ‰ and 33.08 ‰, the dissolved oxygen between 7.91 mg L^{-1} and 10.51 mg L^{-1} and the TDS was between 31.68 mg L^{-1} and 32.87 mg L^{-1} (Figure 4).

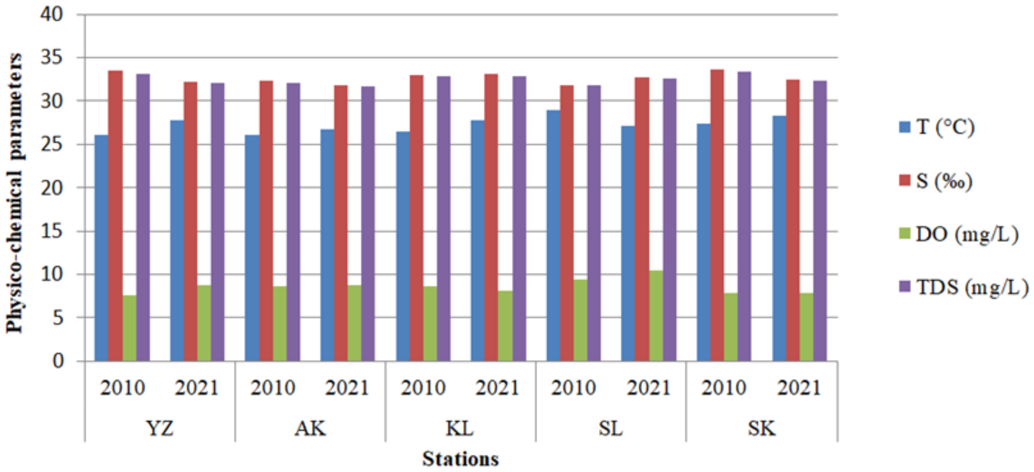

Figure 4. Physicochemical parameters measured at the stations YZ, AK, KL, SL, SK stations in 2010 and 2021 (T: Temperature, S: Salinity, DO: Dissolved oxygen, TDS: Total Dissolved Solids).

4. Discussion and Conclusion

After the check-list by Gönülal & Güreşen (2014), in which a total of 113 bivalves, 84 gastropods and 8 chitons of Gökçeada mollusc fauna were reported, Aslan et al., (2018) listed 62 species and later Barraud & Öztürk (2022) reported 13 species from the same area. In this study, totally 76 mollusc species were identified from which 27 species are new records from the Gökçeada Island.

Among the seasonal samplings, TP Station was with the highest number of individuals and species, probably due to the limited human access and existence of freshwater inflow in the region. Sorgente et al., (2020) mentioned that the freshwater input may change the nutrient amount in an area and make more efficient for organisms' development, which fact supports our findings. In our study, both in seasonal and summer samplings of 2010 and 2021, *Musculus costulatus* was the most dominant species. This species was also reported from Bozcaada Island by Aslan Cihangir & Mutlu (2006), and from the Çanakkale Strait by Aslan-Cihangir & Ovalis (2013) and Tekeli and Aslan (2020). Among the monthly samplings, YZ Station was with the highest number of individuals in November and the highest species number in November and February. In the winter period, YZ station was with higher individual and species numbers compared to other periods. A similar result was obtained by Aslan-Cihangir & Ovalis (2013) in a study carried out in Çanakkale Strait, in which study was found a decrease in the abundance of mollusc species from summer to autumn, and the abundance rate was on its maximum in the winter period. Rueda & Salas (2008) found that the abundance of molluscs was higher in autumn and summer. Urra et al., (2013) stated that the richness and abundance indices for molluscs are higher in the summer period, while the evenness and diversity indices are higher in the spring period.

In our study which is based on monthly data, *Cardita calyculata* is the most dominant species in terms of the number of individuals. This species is known from Lesvos (Bogdanos et al., 2002) and Bozcaada (Aslan Cihangir & Mutlu, 2006), localities close to Gökçeada. On the other hand, when the summer months of 2010 and 2021 are compared, the number of species and individuals in the summer of 2021 was found higher than in 2010. In the summer of 2010, to attract tourists to the region, sand was dumped on the Yıldız Koy shore having a hard bottom structure and this activity resulted with the extinction of some organisms from the environment. Peterson & Bishop (2005) also stated that this situation may disrupt the habitat structures in a region and adversely affect the invertebrate organisms settled in the area.

The mucilage effects on mollusc species were firstly studied in Adriatic Sea in 1729 (Savun-Hekimoğlu & Gazioğlu, 2021). Later, its effects were investigated in different regions of the Mediterranean and as well as in Türkiye. Mucilage formation was found to have negative effects on macrozoobenthic organisms (Schiaparelli et al., 2007; Piazzi et al., 2018; Aslan et al., 2021b; Karadurmuş & Sarı, 2022). Devescovi & Iveša (2007) detected that a significant amount of *Arca noae* died due to the mucilage event and stated that the species is sensitive. In the study conducted by Aslan et al. (2021b), in Gökçeada, comparing the summer months of 2010 and 2021, it was determined that there was a decrease in the number of peracarid crustacean species and individuals in 2021 at all stations, except for the YZ Station and the authors stated that the decrease in those stations was caused by the formation of mucilage in the studied localities. However, mucilage was also detected in AK, SL and SK stations, but was found that it had not a negative effect on mollusc species distribution or survival rates.

Gökçeada, rich in biological diversity and important due to its location in the Aegean Sea, is adversely affected by the human activities nowadays and, as it seems, will continue to be affected in the coming years. To prevent the area becoming irreversible due to many different activities such as mucilage formation, long-term monitoring studies are needed to evaluate the faunistic and floristic features of marine habitats along Gökçeada coasts.

Acknowledgements

We would like to thank Pınar İşmen, Ayşe Karpuzoğlu, Özge Bacak, İrem Yılmaz and Ahmet Becan for sorting mollusc materials. We also thanks to Ergun Baylan for the English corrections. The present study was funded by Çanakkale Onsekiz Mart University, ÇOMÜ-BAP projects (FHD-2010-84; FHD-2011-64). The authors declare that there is no conflict of interest.

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