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RESEARCH ARTICLE

Effects of mucilage on the benthic crustacean in the North Aegean Sea

Herdem Aslan*, **Zeynep Tekeli, Özge Bacak**

ORCID IDs: H.A. 0000-0002-0872-2919; Z.T. 0000-0002-3539-6805;
Ö.B. 0000-0002-7453-2291

Department of Biology, Faculty of Arts and Science, Çanakkale Onsekiz Mart University, Çanakkale, TURKEY

***Corresponding author:** asherdem@comu.edu.tr

Abstract

The mucilage (sea-snot) event during autumn 2020 in the Marmara Sea turned into a major disaster, carried by winds and currents passing the Çanakkale Strait (Dardanelles), Turkey, and extending to the North Aegean Sea, threatening tourism and fisheries. This study aims to compare the peracarid crustacean diversity in Gökçeada Island, the North Aegean Sea, in 2010/2012, before the mucilage disaster, and in 2021 after the disaster. Samples were collected using a 20 × 20 cm quadrat as three replicates from hard substrate at 0.5 m and at 5 m depth during the summer season at five stations. All samples were sorted through 0.5 mm sieves. Water quality were assesed in 2012 and 2021 for physico-chemical properties. As a result, the number of species and specimens, richness and diversity values of all stations (except Yıldız Koy) decreased dramatically in 2021. The species composition of Yıldız Koy station, located in the northern shore of the island, with no intense mucilage presence, was evaluated as a reliable indicator of organic matter increase. The study revealed that mucilage adversely affected the peracarid assemblages, important for the marine ecosystem in the southern shore of Gökçeada.

Keywords: Mucilage, sea-snot, North Aegean Sea, infralittoral zone, zoobenthos, Crustacea, biomonitoring

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Introduction

Coastal ecosystems are important as they provide livelihoods for many people, shelter and feeding places for marine organisms, added economic value of tourism, maritime trade and fishing (UNEP 2006). Factors such as the increase in human population, overfishing, settlement of coastal areas, domestic wastes, global warming impact these ecosystems (Gray 1997; UNEP 2006; Tekeli and Aslan 2020). Although the mucilage phenomenon, which is one of these factors, was first recorded in 2007-2008 in Turkish seas, it emerged as a major disaster that started in the Sea of Marmara in the autumn of 2020 and covered the whole sea. In addition, it affected the North Aegean Sea by passing the Çanakkale Strait (Dardanelles) in 2021 with the surface currents (Jarosz *et al.* 2013). Gökçeada, an island located in the North Aegean Sea, with total surface area of 289 km^2 and 95 km long coastline, is the largest island in Turkey. Gökçeada is an important area in terms of fishing and tourism (Aslan and İşmen 2019). Unfortunately, the marine ecosystem of Gökçeada was threated by mucilage from the Çanakkale Strait, starting in spring 2021 (Figure 1).

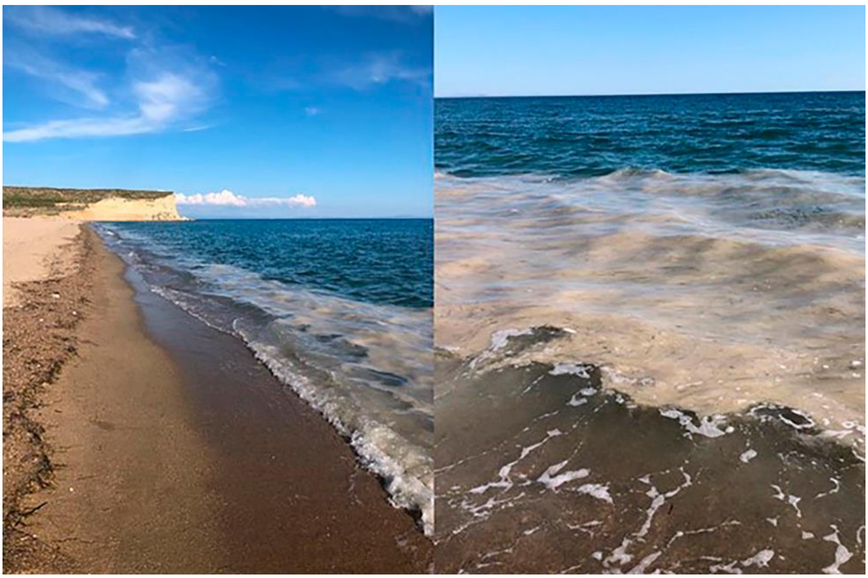

Figure 1. The mucilage formation in the station Kefaloz on 16 June 2021 before sampling period. Left picture is the general view and the second one is focused on the small area (photos: H. Aslan).

Mucilage contains gelatinous organic substances, carbohydrates secreted by phytoplanters, polysaccharide produced by diatoms, bacteria and also contends decayed matter components (Posedel and Faganeli 1991; Alonso-Betanzos *et al.* 1995; Wimpenny *et al.* 2000; Altuğ *et al.* 2021). Mucilage is suspended in the water column, begins to accumulate and spreads in one area, covering the water surface, then decomposes and sinks to the bottom of the sea. The mucilage that sinks to the bottom of the sea covers the habitats of benthic organisms and causes their death by lowering dissolved oxygen level (Aktan Turan *et al.* 2017). Members of the Peracarida superorder which have limited mobility are important organisms for marine ecosystems, as they help oxygenate the sediment, organic matter converter in the biogeochemical cyles, and are an important food source for fish and other invertebrates (Çamur-Elipek and Aslan-Cihangir 2007; Aslan-Cihangir and Pancucci-Papadopoulou 2011; Di Franco *et al.* 2020).

Although there are some studies on the effects of mucilage on benthic marine organisms (Occhipinti-Ambrogi *et al.* 2005; Devescovi and Iveša 2007; Cornello *et al.* 2005; Schiaparelli *et al.* 2007; Piazzi *et al.* 2018), presently they are very limited, hence knowledge is scarce. In Turkey, there are no studies about effects of mucilage on the benthic macroinvertebrates except for the observation of mucilage on gorgonians (Özalp 2021).

The aim of this study is to compare the peracarid crustacean species diversity after mucilage settlement on the sea bottom around Gökçeada in 2021 to that of 2010/2012, when mucilage was not reported.

Materials and Methods

This study was carried out at five stations in the infralittoral zone around Gökçeada Island during summer season in 2010, 2012 and 2021 (Table 1, Figure 2). All samples were obtained at the 0.5 m depth as three replicates, in addition at the 5 m depth from the stations of Kokina and Kuzu Limanı in 2012 and 2021 by SCUBA diving. In each sampling, an attention was paid to sampling from the same locations.

Figure 2. Satellite image of Gökçeada Island showing sampling stations. (Source: Google Earth)

The biotic material remaining in the 20 × 20 cm quadrat from the surface of the hard ground structure was scraped using a spatula. All samples were placed in jars containing 4% formaldehyde and brought to the laboratory and samples were washed through a set of 2, 1 and 0.5 mm mesh sieves. The peracarids in the jars were selected under the stereo zoom microscope and placed in 40 cc jars containing 70% ethyl alcohol, and species identifications were made up to the smallest taxon and the number of specimens was counted. The identification was made based on WoRMS (2021).

Table 1. Sampling stations, coordinates and sampling dates.

Stations		Coordinates	Dates
YZ	Yıldız Koy	25° 54' 11.127" 40° 14' 04.481"	07.07.2010, 12.07.2012, 27.06.2021
KZ	Kuzu Limanı	25° 56' 54.389" 40° 14' 12.905"	17.06.2010, 04.08.2012, 02.07.2021
KS	Kefaloz	25° 56' 20.61" 40° 07' 40.69"	16.06.2010, 13.07.2012, 30.06.2021
KO	Kokina	25° 55' 39.056" 40° 07' 30.434"	16.06.2010, 02.07.2012, 30.06.2021
LZ	Laz Koyu	25° 47' 04.485" 40° 05' 55.612"	20.06.2010, 28.07.2012, 28.06.2021

Water physico-chemical parameters, such as temperature, salinity, dissolved oxygen and TDS, were measured at the depth of 0.5 m with the YSI probe in 2010 and 2021. Unfortunately, these variables could not be measured in 2012.

Statistical tests were performed to characterize the relative abundance and diversity of peracarid species. Quantitative dominance degrees of species, frequency index values (F>50% continuous, 25%<F>50% common, and F<25% rare) (Soyer 1970), Margalef richness index (d), Pielou evenness index (J') and Shannon-Weaver diversity index (based on $\log_2$) (H') values of stations were calculated. The abundances of peracarid species were analyzed using n-MDS (Non-Metric Multidimensional Scaling), analysis of variance (ANOSIM) using PRIMER version 7 software.

Results

Abiotic Properties

The measurements of water physico-chemical parameters did not change in 2010 and 2021. Water temperature changed between 26.09°C and 29.01°C in 2010, 26.79°C and 28.31°C in 2021. Salinities ranges as 31.88-33.7‰ during 2010 and 31.77-33.08 ‰ in 2021. Dissolved oxygen changed as 7.61-9.48 mg/L in 2010 and 7.91-10.51 mg/L in 2021 (Table 2).

Table 2. Physico-chemical variables of infralittoral zone water column
T: Temperature, S: Salinity, DO: Dissolved oxygen, TDS: Total Dissolved Solids

2010	T (°C)	S (‰)	DO (mg/L)	TDS (mg/L)
Yıldız Koy	26.1	33.46	7.61	33.16
Kuzu Limanı	26.43	33.05	8.68	32.8
Kefaloz	27.42	33.7	7.9	33.41
Kokina	29.01	31.88	9.48	31.82
Laz Koyu	26.09	32.28	8.65	32.1
2021				
Yıldız Koy	27.8	32.22	8.73	32.11
Kuzu Limanı	27.76	33.08	8.17	32.87
Kefaloz	28.31	32.52	7.91	32.39
Kokina	27.19	32.76	10.51	32.57
Laz Koyu	26.79	31.77	8.75	31.68

Although there was no mucilage formation on the surface water surrounding Gökçeada Island during the sampling period in 2021, intense mucilage was observed on the seabed as expected, especially on the southern coasts of the island (Figure 3).

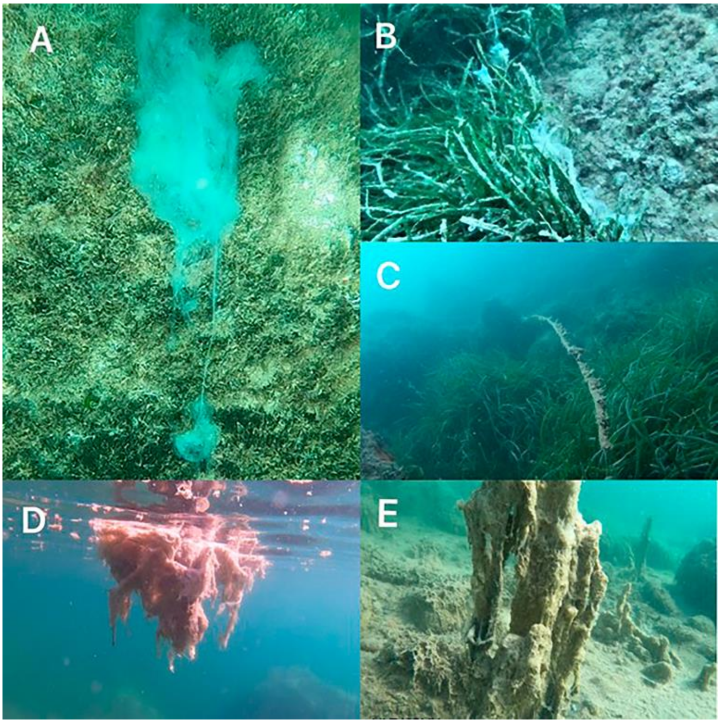

Figure 3. The mucilage formations in the sampling stations of Gökçeada (A: Yıldız Koy, B-C: Kokina, D-E: Laz Koyu, photos: Ahmet S. Becan)

Peracarid crustacean assemblages at the depth of 0.5 m

We found 8,473 ind/m^2 belonging to 38 species in 2010, 12,875 ind/m^2 to 31 species in 2012, and 13,715 ind/m^2 only to 24 species in 2021 (Table 3, Figure 4).

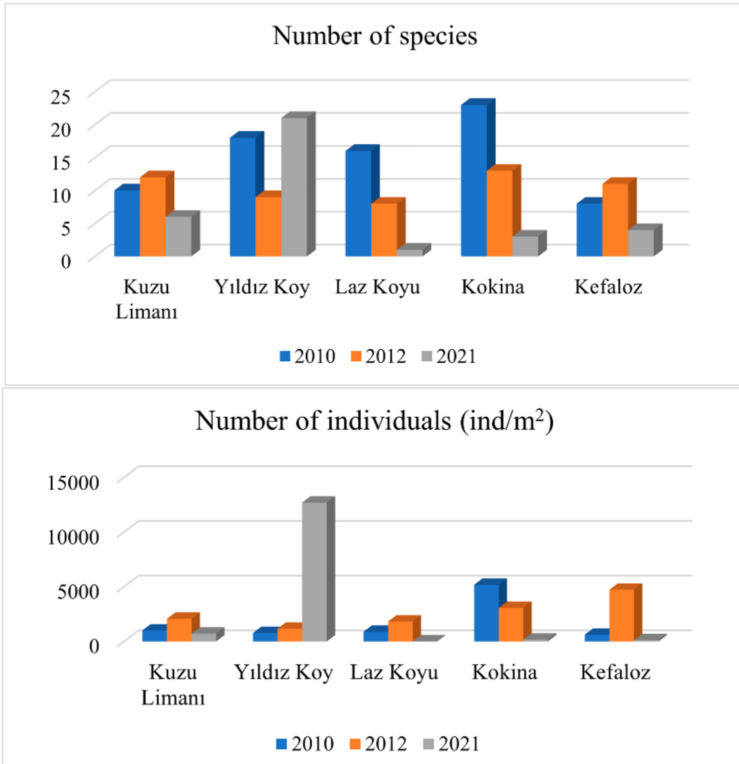

Figure 4. Number of species and individuals (ind/m^2)

Frequency index and quantitative dominance values of peracarids were calculated for 0.5 in 2010, 2012 and 2021. In 2010, *Ampithoe ferox*, *Ampithoe ramondi*, *Chondrochelia savignyi* were the most frequent peracarid species, while *A. ramondi* (15%), *Caprella rapax* (13%), *Protohyale (Protohyale) schmidtii* (12%), *Microdeutopus chelifer* (11%) were the most dominant peracarid species. In 2012, *A. ramondi* was the most frequent peracarid species, while *A. ramondi* (13%), *C. savignyi* (18%), *Elasmopus brasiliensis* (15%), *M. chelifer* (18%), *Protohyale* (*Boreohyale*) *camptonyx* (11%) were the most dominant peracarid species. In 2021, *C. savignyi* was the most frequent peracarid species, while *Apohyale crassipes* (21%) and *C. savignyi* (38%) were the most dominant peracarid species.

Table 3. Number of peracaridian crustaceans collected from depth of 0.5 m in 2010, 2012 and 2021.

	Kuzu Limanı			**Yıldız Koy**			**Laz Koyu**			**Kokina**			**Kefaloz**		
	2010	**2012**	**2021**	**2010**	**2012**	**2021**	**2010**	**2012**	**2021**	**2010**	**2012**	**2021**	**2010**	**2012**	**2021**
Ampithoe ferox (Chevreux, 1901)	242			42			17			142			342		
Ampithoe ramondi (Audouin, 1826)	233	800	25	100	150	700	142	225	8	800	125		17	400	
*Apanthura corsica (*Amar, 1953)				8											
Apherusa mediterranea (Chevreux, 1911)							25			25			92		
Apocorophium acutum (Chevreux, 1908)														25	
Apohyale crassipes (Heller, 1866)			125			2775									
Apseudes sp.											150				
Apseudopsis latreillii (Milne Edwards, 1828)											75				
Atylus sp.		25													
Caprella acanthifera (Leach, 1814)							8				125				
Caprella grandimana (Mayer, 1882)			50							300					
Caprella rapax (Mayer, 1890)				42			83			967					
Caprella sp.							8					8			
Chondrochelia savignyi (Kroyer, 1842)	25		200	8		4850	133	25		33	2200	100	8	75	50
Colomastix pusilla (Grube, 1861)		150													
Cumella (Cumella) limicola (Sars, 1879)						1175						58	8		8
Cymodoce bidentata (Haswell, 1882)						50									
Cymodoce emarginata Leach, 1818								50							
Cymodoce sp.										83					
Cymodoce spinosa (Risso, 1816)		25				100	17			133					
Cymodoce truncata (Leach, 1814)		25			50									225	
Cymodoce tuberculata (Costa in Hope, 1851)										42					

Table 3. Continued

	Kuzu Limanı			Yıldız Koy			Laz Koyu			Kokina			Kefaloz		
	2010	**2012**	**2021**	**2010**	**2012**	**2021**	**2010**	**2012**	**2021**	**2010**	**2012**	**2021**	**2010**	**2012**	**2021**
Dexamine spiniventris (Costa, 1853)		25								83					
Dexamine spinosa (Montagu, 1813)										8					
Dynamene bicolor (Rathke, 1836)	8						17			42					
Dynamene bidentata (Adams, 1800)				8									67		
Dynamene edwardsi (Lucas, 1849)							8								
Elasmopus brasiliensis (Dana, 1853)	258	725	300	117		375	267			142	50			1125	
Elasmopus pocillimanus (Spence Bate, 1862)	108	125		75	175	100	8	50						75	
Elasmopus rapax (Costa, 1853)	17	100		17	200										
Ericthonius brasiliensis (Dana, 1853)						25									
Ericthonius punctatus (Spence Bate, 1857)										50	25			25	
Gammarella fucicola (Leach, 1814)						25				17	125			25	
*Gammaropsis crenulata (*Krapp-Schickel & Myers, 1979)	25			25											
Idotea metallica (Bosc, 1802)			25												
Janira maculosa (Leach, 1814)					25						25				
Leucothoe serraticarpa (Della Valle, 1893)						25									
Leucothoe spinicarpa (Abildgaard, 1789)											25				
Lysianassa costae (H. Milne Edwards, 1830)								25							
Maera grossimana (Montagu, 1808)								50							
Melita palmata (Montagu, 1804)						25	8								
Microdeutopus algicola (Della Valle, 1893)													25		
Microdeutopus anomalus (Rathke, 1843)						50		175							
Microdeutopus chelifer (Spence Bate, 1862)				142			133			658				2350	

Table 3. Continued

	Kuzu Limanı			Yıldız Koy			Laz Koyu			Kokina			Kefaloz		
	2010	**2012**	**2021**	**2010**	**2012**	**2010**	**2012**	**2021**	**2010**	**2012**	**2010**	**2012**	**2021**	**2010**	**2012**
Microdeutopus obtusatus (Myers, 1973)				25		600				142			58		33
Microdeutopus sp.				8		475	8								25
Microdeutopus stationis (Della Valle, 1893)											75				
Paranthura costana (Bate & Westwood, 1866)				8		125				25					
Pereionotus testudo (Montagu, 1808)				8	25	175									
Podocerus variagatus (Leach, 1814)							8			8					
Protohyale (Boreohyale) camptonyx (Heller, 1866)								1225		600				150	
Protohyale (Protohyale) schmidtii (Heller, 1866)	67	25		58	175	450				850	25				
Quadrimaera inaequipes (A. Costa in Hope, 1851)		25		75	150										
Stenothoe elachista (Krapp-Schickel, 1975)		25				50				17					
Stenothoe monoculoides (Montagu, 1813)						450				17				250	
Tanais dulongii (Audouin, 1826)	25			8	225	100					50				
Total number of species	**10**	**12**	**6**	**18**	**9**	**21**	**16**	**8**	**1**	**23**	**13**	**3**	**8**	**11**	**4**
Total number of specimens (ind/m^2)	**1008**	**2075**	**725**	**774**	**1175**	**12700**	**890**	**1825**	**8**	**5184**	**3075**	**166**	**617**	**4725**	**116**

According to the results of the indices (Table 4), the lowest richness index value was found in 2021, Laz Koyu had zero richness. In the Pielou Evenness index value, it was determined that there was no great increase or decrease in the stations over the years except Laz Koyu which has zero value again. Shannon-Weaver Diversity index values were also recorded as minimum values from all stations in 2021, except for Yıldız Koy.

Table 4. Results of Margalef Richness (d), Pielou Evenness (J), Shannon-Weaver Diversity (H) Index values according to the years.

	Kuzu Limanı			**Yıldız Koy**			**Laz Koyu**			**Kokina**			**Kefaloz**		
	2010	**2012**	**2021**	**2010**	**2012**	**2021**	**2010**	**2012**	**2021**	**2010**	**2012**	**2021**	**2010**	**2012**	**2021**
d	1.30	1.44	0.76	2.56	2.13	2.12	2.21	0.93	0	2.57	1.49	0.39	1.09	1.18	0.63
J	0.80	0.65	0.80	0.85	0.91	0.66	0.75	0.56	0	0.76	0.49	0.75	0.68	0.64	0.89
H	2.64	2.33	2.08	3.55	2.90	2.92	2.98	1.68	0	3.43	1.80	1.18	2.04	2.20	1.78

When considering the total number of peracarid species for each station, n-MDS analysis based on the $\log_{10}(x+1)$ revealed three main groups (Figure 5). In this analysis, stations of Laz Koyu, Kefaloz and Kokina were separated from the stations in 2021 in other years, except Kefaloz in 2010. According to the results of ANOSIM analysis, this difference was found to be statistically significant ($R = 0.887$, $p = 0.001$).

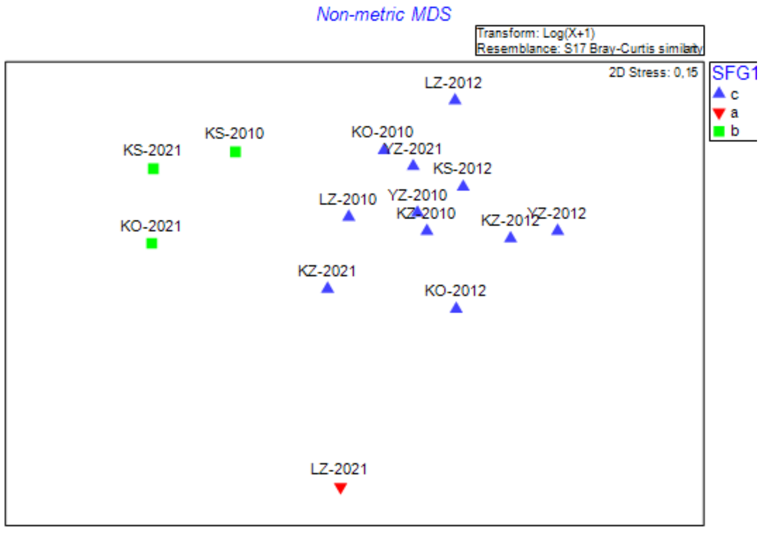

Figure 5. The result of n-MDS analysis applied to total abundance of peracarids for all stations in 2010, 2012 and 2021

Peracarid crustacean assemblages at the depth of 5 m

After the analysing of peracaridian specimens obtained from 5 m depth, 7100 specimens (ind/m^2) belonging to 21 species in 2012 and 5625 (ind/m^2) specimens are belonging only to 16 species in 2021 were obtained (Table 5).

Table 5. Peracaridian crustaceans collected from depth of 5 m in 2012 and 2021

	Kuzu Limanı		**Kokina**	
Species/Stations-Years	**2012**	**2021**	**2012**	**2021**
Ampithoe ferox (Chevreux, 1901)		50		
Ampithoe ramondi (Audouin, 1826)	600	225	75	
Apocorophium acutum (Chevreux, 1908)			100	25
Apohyale crassipes (Heller, 1866)		150		125
Atylus swammerdamei (H. Milne Edwards, 1830)		25		
Caprella acanthifera (Leach, 1814)	25	75	1600	
Caprella lilliput (Krapp-Schickel & Ruffo, 1987)		300		
Chondrochelia savignyi (Kroyer, 1842)		2600		1225
Cymodoce emarginata Leach, 1818			25	
Cymodoce truncata (Leach, 1814)				50
Dexamine spinosa (Montagu, 1813)			675	
Dynamene bicolor (Rathke, 1836)		25		
Elasmopus brasiliensis (Dana, 1853)	50			
Elasmopus pocillimanus (Spence Bate, 1862)			125	
Ericthonius punctatus (Spence Bate, 1857)			150	
Janira maculosa (Leach, 1814)			100	
Leucothoe spinicarpa (Abildgaard, 1789)	25			
Liljeborgia dellavallei (Stebbing, 1906)	25			
Liljeborgia psaltrica (Krapp-Schickel, 1975)			25	
Lysianassa caesarea (Ruffo, 1987)	75			
Lysianassa costae (H. Milne Edwards, 1830)			150	
Microdeutopus anomalus (Rathke, 1843)		250		
Microdeutopus sp.	150			
Microdeutopus versiculatus (Spence Bate, 1857)		75		
Nototropis swammerdamei (H. Milne Edwards, 1830)	25			
Paranthura costana (Bate & Westwood, 1866)	25	25		
Pereionotus testudo (Montagu, 1808)	25		75	
Protohyale (Boreohyale) camptonyx (Heller, 1866)			1775	
Protohyale (Protohyale) schmidtii (Heller, 1866)	25			50
Stenothoe monoculoides (Montagu, 1813)		125	1175	100
Tanais dulongii (Audouin, 1826)				125
Total number of species	**11**	**12**	**13**	**7**
Total number of specimens (ind/m^2)	**1050**	**3925**	**6050**	**1700**

According to the results of the index analyses, the Margalef Richness and Shannon-Weaver Diversity values slightly decreased in Kokina and Kuzu Limanı stations from 2012 to 2021 (Figures 6 and 7).

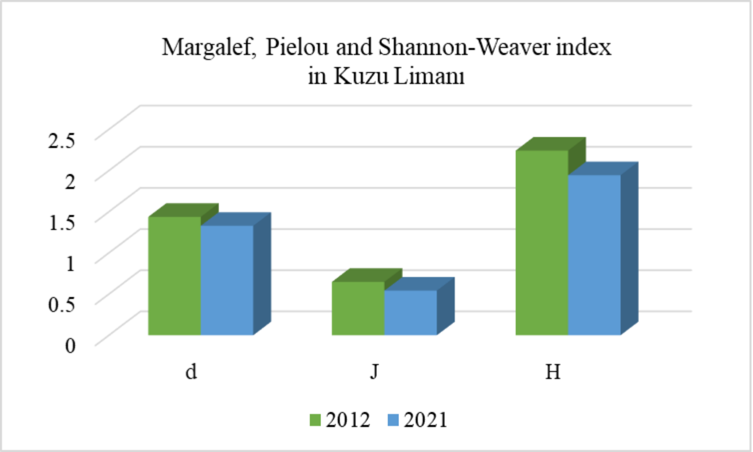

Figure 6. Results of Margalef Richness (d), Pielou Evenness (J), Shannon-Weaver Diversity Index (H) values at 5 m depth in Kuzu Limanı station in 2012 and 2021

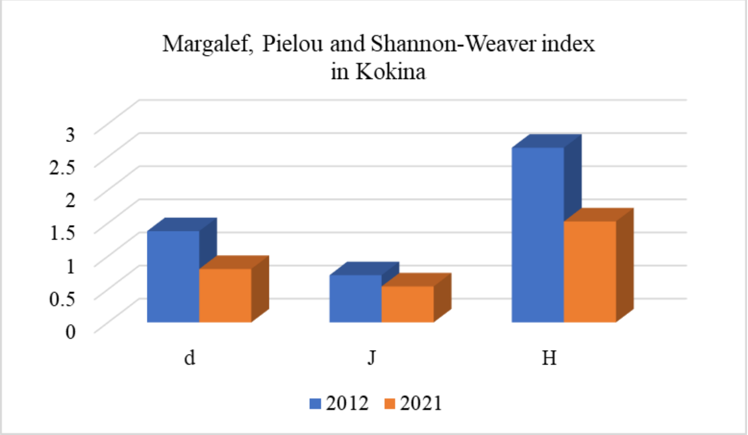

Figure 7. Results of Margalef Richness (d), Pielou Evenness (J), Shannon-Weaver Diversity Index (H) values at 5 m depth in Kokina station in 2012 and 2021

Discussion

Mucilage, which was observed in the Adriatic Sea for the first time in the world in the 17th century (Umani *et al.* 2007), was also detected in the Tyrrhenian Sea in 1991, and later on the coasts of France and Italy (Schiaparelli *et al.* 2007; Aktan Turan *et al.* 2017). It was first seen in Turkey in 2007 (Aktan *et al.* 2008; Tüfekçi *et al.* 2010; Polat Beken *et al.* 2011; Taş *et al.* 2020) and formed inconspicuously in the following years (Aktan Turan *et al.* 2017). However, mucilage formation was very dense in 2020 autumn in the Marmara Sea. We have limited knowledge about the effects of mucilage on the marine ecosystem, which can be transported much farther from its place of origin due to air and water movements and cover not only the water column, but also the benthic habitat depending on time (Savun-Hekimoğlu and Gazioğlu 2021).

There are some studies on the effect of mucilage on benthic marine organisms except on peracarida in the Mediterranean Sea. Occhipinti-Ambrogi *et al.* (2005) showed that the mucilage was not dense enough to affect benthic organisms. Giuliani *et al.* (2005) investigated the effects of mucilage on gorgonian colonies and found that the gorgonian's exposure to mucilage affects its ability to regenerate itself. Devescovi and Iveša (2007) found that *Aplysina aerophoba* sponge colonies were suffocated by mucilage and there was a significant number of deaths in bivalve *Arca noae*. In addition, they determined that the absence of mass mortality in organisms during this period may be due to the intense and short duration of mucilage formation. Cornello *et al.* (2005) determined that mucus aggregates affect the growth of *Mytilus galloprovincialis*, large mucoid layers adhering to mussels have an effect on reducing the filtration rate and uptake of food particles. Schiaparelli *et al.* (2007) reported that *Cladocora caespitosa* bleaching occurs due to mucilage growth, which is stimulatory at prolonged temperature increases. Piazzi *et al.* (2018) reported that the organisms most damaged by mucilage aggregates are gorgonians, but gorgonians have regeneration capability.

Faunistic analyses of peracarid crustacea community of the hard substrate of the coast of Gökçeada Island during summer in 2010 and 2012 before the mucilage phenomenon and in 2021 after exposure to mucilage originated in the Sea of Marmara revealed that the total number of species decreased from 38 (in the years of 2010 and 2012) to 24 (in 2021). On the other hand, total abundance of peracarids increased from 2010 (8,473 ind.m^{-2}) to 2012 (12,875 ind.m^{-2}) and the highest values were recorded in 2021 (13,715 ind.m^{-2}). However, Yıldız Koy station, located in the northernmost part of the island, has 12,700 individuals, is responsible for this increase in the number of individuals in 2021. The species diversity was low in 2010 and 2012 due to the sand dumping by the municipality in order to cover the natural pebble beach of Yıldız Koy, which is under significant constrain. It can be thought that species diversity increased when this implementation was abandoned later on. Besides, tanaid species *Chondrochelia savignyi* and cumacea species *Cumella* (*Cumella*) *limicola*, which are indicators of organic matter richness (Bellan-Santini 1969; Chintiroglou *et al.* 2004; Corbera and Garcia-Rubies 1998; Aslan-Cihangir and Pancucci-Papadopoulou 2011) were found in very high abundance (4,850ind.m^{-2} and 1,175 ind.m^{-2}, respectively) at this station in 2021.

The number of species, the number of specimens, species richness and Shannon-Weaver Diversity Index values decreased dramatically in all the stations, except for Yıldız Koy in 2021. Laz Koyu, which has the lowest number of species (1), individuals (8) and zero richness and diversity in this study, was the region where mucilage was most intense according to the personal observations of the authors and local media outlets. According to the n-MDS figure, the benthic peracarid crustacean fauna was most intensly effected by the sinking mucilage in the stations Kefaloz (KS), Kokina (KO), Laz Koyu (LZ), located in Southern part of Gökçeada Island. Also the result of the analysing abundance of peracarid species obtained from 5 m depth supported the idea that stations located in the South of the island are more severely affected by mucilage. However, the physico-chemical properties of the seawater did change between the years. More detailed monitoring studies are needed to be able to say that mucilage is the cause of the decline in species diversity in the southern part of the island.

The mucilage formed due to human-induced pollution in the Sea of Marmara (Aktan *et al.* 2008; Tüfekçi *et al.* 2010; Polat Beken *et al.* 2011; Savun-Hekimoğlu and Gazioğlu 2021; Altuğ *et al.* 2021) passed the Çanakkale Strait with surface currents and reached Gökçeada, threatening the ecosystem of an island with high biodiversity. It is of great importance to investigate the extent to which the mucilage impacts life on the seabed after its sinking in the Marmara Sea, the Çanakkale Strait and the North Aegean Sea, and to carry out monitoring studies in case it reoccurs in the future.

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Deniz salyasının Kuzey Ege Denizi'nde bentik crustacea üzerine etkileri

Öz

2020 yılının sonbaharında Marmara Denizi'nde oluşmaya başlayan ve büyük bir felakete dönüşen deniz salyası (müsilaj) olayı, rüzgar ve akıntılar yoluyla Çanakkale Boğazı'nı geçerek Kuzey Ege Denizi'ne yönelmiş ve bu bölgedeki turizm ile balıkçılık faaliyetlerini tehdit etmeye başlamıştır. Bu çalışmada, müsilajın görülmediği 2010 ve 2012 yılları ile müsilajın görüldüğü 2021 yılında Gökçeada'da yaşayan perakarid crustase tür çeşitliliğinin karşılaştırılması amaçlanmıştır. Örnekler, toplam 5 istasyonun aynı koordinatlarında yazın 20 x 20 cm'lik bir kuadrat kullanılarak üç tekrarlı şekilde 0.5 ve 5 m derinlikte bulunan sert zeminlerden elde edilmiştir. Tüm örnekler 0.5 mm'lik elekten geçirilmiştir. Ayrıca bazı fiziko-kimyasal özellikler 2012 ve 2021 yıllarında ölçülmüştür. Elde edilen sonuçlara göre, 2021 yılında tüm istasyonların (Yıldız Koy hariç) tür sayısı, birey sayısı, zenginlik ve çeşitlilik indeks değerleri önemli ölçüde azalmıştır. Adanın kuzeyinde yer alan ve yoğun müsilajın olmadığı Yıldız Koy istasyonunun tür kompozisyonunun, organik madde artışının bir göstergesi olduğu belirlenmiştir. Bu çalışma ile deniz ekosisteminde önemli bir yeri olan perakarid topluluklarının Gökçeada'nın güneyinde müsilajdan olumsuz yönde etkilendiği ortaya konulmuştur.

Anahtar kelimeler: Müsilaj, deniz salyası, Kuzey Ege Denizi, infralittoral bölge, zoobentos, Crustase, biyolojik izleme

References

Aktan, Y., Dede, A., Çiftçi Türetken, P.S. (2008) Mucilage event associated with diatoms and dinoflagellates in Sea of Marmara, Turkey. *Harmful Algae News* 36: 1-3.

Aktan Turan, Y., Keskin, Ç., Ersoy, S. (2017) Algae overgrowth in a changing Mediterranean ecosystem: Mucilage formation and its effect on Posidonia beds. TÜBİTAK Project 115Y486 (in Turkish).

Alonso-Betanzos, A., Cabrero-Canosa, M., Moret-Bonillo, V. (1995) Automated analog-to-digital conversion of graphical cardiotocographic records. *Journal of Clinical Engineering* 20: 57- 65.

Altuğ, G., Çiftçi Türetken, P.S., Çardak, M., Öztaş, M. (2021) Bacterial levels in mucilage; sample case of preliminary study in Istanbul Province, the Sea of Marmara. In: Ecology of the Marmara Sea: Formation and Interactions of Marine Mucilage, and Recommendations for Solutions, (eds., Öztürk, İ., Şeker, M.), Turkish Academy of Sciences, Ankara, pp. 137-154.

Aslan, H., İşmen, P. (2019) Peracarid Crusteceans species from upper infralittoral rocky shores of Gokceada Island (Aegean Sea). *Çanakkale Onsekiz Mart University Journal of Marine Sciences and Fisheries* 2: 109-119.

Aslan-Cihangir, H., Pancucci-Papadopoulou, M.A. (2011) Spatial and temporal variation of soft-bottom peracarid (Crustacea: Peracarida) infauna in the Çanakkale Strait (Turkey). *Mediterranean Marine Science* 12: 153-182.

Bellan-Santini, D. (1969) Etude floristuque et faunistuque de quelques peuplements infralittoraux de substratrocheus. *Rec Travaux de la Station Marine d'Endoume* 26: 237-298.

Chintiroglou, C., Antoniadou, C., Baxevanis, A., Damianidis, P., Karalis, P., Vafidis, D. (2004) Peracarida populations of hard substrate assemblages in ports of the NW Aegean Sea (eastern Mediterranean). *Helgoland Marine Research* 58: 54-61.

Corbera, J., Garcia-Rubies, A. (1998) Cumaceans (Crustacea) of the Medes Islands (Catalonia, Spain) with special attention to the genera Bodotria and Iphinoe. *Scientia Marina* 62: 101-112.

Cornello, M., Boscolo, R., Giovanardi, O. (2005) Do mucous aggregates affect macro-zoobenthic community and mussel culture? A study in a coastal area of the Northwestern Adriatic Sea. *Science of the Total Environment* 353: 329-339.

Çamur-Elipek, B., Aslan-Cihangir, H., (2007) First observations of two talitrid crustaceans (Amphipoda: Talitridae) from Gokceada Island (NE Aegean Sea). *Mediterranean Marine Science* 8(2): 83-86.

Devescovi, M., Iveša, L. (2007) Short term impact of planktonic mucilage aggregates on macrobenthos along the Istrian rocky coast (Northern Adriatic, Croatia). *Marine Pollution Bulletin* 54: 887-893.

Di Franco, D., Linse, K., Griffiths, H.J., Haas, C., Saeedi, H., Brandt A. (2020) Abundance and distributional patterns of benthic peracarid crustaceans from the atlantic sector of the Southern Ocean and Weddell Sea. *Frontiers in Marine Science* 7: 554663.

Giuliani, S., Virno Lamberti, C., Sonni C., Pellegrini, D. (2005) Mucilage impact on gorgonians in the Tyrrhenian Sea. *Science of the Total Environment* 353: 340-349.

Gray, J.S. (1997) Marine biodiversity: patterns, threats and conservation needs. *Biodiversity and Conservation* 6: 153-175.

Jarosz, E., Teague, W.J., Book, J.W., Beşiktepe, Ş.T. (2013) Observed volume fluxes and mixing in the Dardanelles Strait. *Journal of Geophysical Research: Oceans* 118: 5007-5021.

Occhipinti-Ambrogi, A., Savini, D., Forni, G. (2005) Macrobenthos community structural changes off Cesenatico coast (Emilia Romagna, Northern Adriatic) a six-year monitoring programme. *Science of the Total Environment* 353: 317-328.

Özalp, H.B. (2021) First massive mucilage event observed in deep waters of Çanakkale Strait (Dardanelles), Turkey. *J Black Sea/Medit Environ* 1: 49-66.

Piazzi, L., Atzori, F., Cadoni, N., Cinti, M.F., Frau, F., Ceccherelli, G. (2018) Benthic mucilage blooms threaten coralligenous reefs. *Marine Environmental Research* 140: 145-151.

Polat Beken, S.Ç., Tüfekçi, A.V., Sözer, B., Yıldız, E., Mantıkçı, M., Atabay, H., Telli-Karakoç, F., Hocaoğlu, S., Ediger, D., Tolun, L., Olgun, A. (2011)

Investigation of factors controlling mucilage/mucus formation in marine environment under laboratory conditions. TÜBİTAK Project 108Y083 (in Turkish).

Posedel, N., Faganeli, J. (1991) Nature and sedimentation of suspended particulate matter during density stratification in shallow coastal waters (Gulf of Trieste, northern Adriatic). *Marine Ecology Progress Series* 77: 135-145.

Savun-Hekimoğlu, B., Gazioğlu, C. (2021). Mucilage problem in the semi-enclosed seas: Recent outburst in the Sea of Marmara. *International Journal of Environment and Geoinformatics* 8: 402-413.

Schiaparelli, S., Castellano, M., Povero, P., Sartoni, G., Cattaneo-Vietti, R. (2007) A benthic mucilage event in North-Western Mediterranean Sea and its possible relationships with the summer 2003 European heatwave: Short term effects on littoral rocky assemblages. *Marine Ecology* 28: 341-353.

Soyer, J. (1970) Bionomie benthique du plateau continental de la cote catalan Française. III. Les Peuplements de Copepodes Harpacticoides (Crustacea). *Vie Milieu* 21: 377-511.

Taş, S., Kus, D., Yılmaz, I.N. (2020) Temporal variations in phytoplankton composition in the north-eastern Sea of Marmara: potentially toxic species and mucilage event. *Mediterranean Marine Science* 21: 668-683.

Tekeli, Z., Aslan, H. (2020) Bivalvia (Mollusca) fauna of the Çanakkale Strait (Dardanelles) Coast. *Acta Biologica Turcica* 33: 244-251.

Tüfekçi, V., Balkıs, N., Polat Beken, Ç., Ediger, D., Mantıkçı, M. (2010) Phytoplankton composition and environmental conditions of a mucilage event in the Sea of Marmara. *Turkish Journal of Biology* 34: 199-210.

Umani, S.F., Del Negro, P., Larato, C., De Vittor, C., Cabrini, M., Celio, M., Falconi, C., Tamberlich F., Azam, F. (2007) Major inter-annual variations in microbial dynamics in the Gulf of Trieste (northern Adriatic Sea) and their ecosystem implications. *Aquatic Microbial Ecology* 46: 163-175.

UNEP (2006) World Conservation Monitoring Centre, UNEP. Division of early warning and assessment marine and coastal ecosystems and human well-being. UNEP, Nairobi, Kenya.

Wimpenny, J., Manz, W., Szewzyk, U. (2000) Heterogeneity in biofilms. *FEMS Microbiology Reviews* 24: 661-671.

WoRMS (2021) WoRMS Taxon Details: Peracarida. Available at: http://www.marinespecies.org/aphia.php?p=taxdetails&id=1090 (accessed 12 Aug 2021).