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Distribution of Ciliates in Relation to Environmental Parameters in Two Gulfs of Kapıdağ Peninsula (The Sea of Marmara)

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Research Article

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Abstract

This study was carried out seasonally in order to determine the environmental variables affecting the ciliate species and their distribution in Gulfs of Erdek and Bandırma by using three stations in each gulf between 2006 and 2008. A total of 14 ciliates taxa were identified, three of them were the genus level. *Epiplocyloides* sp., *Proplectella ovata*, *Laboea strobila* and *Tiarina fusus* species identified are the new records for the Sea of Marmara. The maximum number of species belonged to the Choreotrichida ordo with 11 taxa. The Choreotrichida ordo showed the highest diversity in summer season. The ecological data used in this study were obtained from the previous study concurrently conducted in the same region. According to the Spearman's rank-correlation, it was determined that the salinity, dissolved oxygen (DO), chlorophyll-a (Chl-a) and NO_3+NO_2-N levels affected the distribution of the ciliates and the salinity was increased and species abundance was decreased based on the rise in depth. The highest similarity between the stations was observed in stations 2 and 3 in the Gulf of Bandırma at a depth of 0.5 m (96.5%) and all the depths of the stations were found to be 23.6% similar.

Keywords: Ciliates, tintinnids, Kapıdağ Peninsula, ecological variables, Sea of Marmara

Kapıdağ Yarımadası'nın (Marmara Denizi) İki Körfezinde Siliyatların Çevresel Parametrelere Göre Dağılımı

Özet

Bu çalışma, Erdek ve Bandırma Körfezi'nde siliyat türlerini ve bu türlerin dağılımını etkileyen çevresel değişkenleri belirlemek amacıyla, 2006 ve 2008 yılları arasında her iki körfezde üçer istasyonda mevsimsel olarak gerçekleştirilmiştir. Çalışma sonucunda üç tanesi cins düzeyinde olmak üzere toplam 14 taksa belirlenmiştir. Bulunan türlerden *Epiplocyloides* sp., *Proplectella ovata*, *Laboea strobila* ve *Tiarina fusus* Marmara Denizi için yeni kayıttır. En fazla tür sayısı 11 tür ile Choreotrichida ordosuna aittir. Choreotrichida ordosunun yaz mevsiminde en fazla çeşitliliği sahip olduğu belirlenmiştir. Bu çalışmada kullanılan ekolojik veriler, aynı bölgede eş zamanlı yapılmış önceki çalışmadan alınmıştır. Spearman'ın sıra korelasyonuna göre ekolojik değişkenlerden tuzluluk, çözünmüş oksijen (ÇO) , klorofil-a (Kl-a) ve NO_3 + NO_2-N'in siliyatların dağılımını etkilediği, derinlik artışına bağlı olarak tuzluluğun arttığı ve tür bolluğunun azaldığı belirlenmiştir. İstasyonlar arasında en yüksek benzerlik, Bandırma Körfezi'nde 2 ve 3 nolu istasyonlarda 0,5 m derinlikte (% 96,5) gözlenmiş ve istasyonlara ait tüm derinliklerin ise % 23,6 benzer olduğu ortaya konmuştur.

Anahtar kelimeler: Siliyat, tintinnid, Kapıdağ Yarımadası, ekolojik değişkenler, Marmara Denizi

INTRODUCTION

In terms of the food web in pelagic systems, microzooplankton have an important role in the transfer of matter and energy since they feed on pico- and nanoplankton predominantly in found in the marine environment. They are also food to higher organisms (Godhantaraman and Uye, 2001; Pitta et al., 2001; Gómez, 2007; Wang et al., 2014). The members of the phylum Ciliophora are eukaryotic and unicellular protists. Also, phylum Ciliophora is composed of a group of living organisms which have lengths ranging from 10 to 4500 µm, are free-floating or sessile, have pellicular alveoli and whose bodies are totally or partially covered by cilia in at least period of their lives (Lynn, 2008). Ciliates, which show a cosmopolitan distribution in the seas and oceans, are common in the seas but also live in freshwaters.

Although studies have been carried out on the ecology of marine ciliates in the coastal waters of Turkey, these studies are generally related to tintinnids (Koray and Özel, 1983; Koray et al., 1992; Koray et al., 1999; Türkoğlu and Koray, 2000; Polat et al., 2001; Çolak-Sabancı and Koray, 2001; Balkis, 2004; Durmus and Balkis, 2014). The number of studies in which groups other than tintinnids have been investigated is limited because of the small size, rapid movement capabilities, the fragility of external membranes of ciliates and the difficulty of laboratory culture (Koray et al., 1992; Koray et al., 1994; Zervoudaki et al., 2011; Esensoy, 2014). Previous studies showed that Gulf of Izmir (Aegean Sea) and the Sea of Marmara have been extensively studied (Acara and Nalbantoğlu, 1960; Ergen 1967; Koray and Özel, 1983; Koray et al., 1992; Koray et al., 1999; Türkoğlu and Koray, 2000; Polat et al., 2001; Çolak-Sabancı and Koray, 2001; Balkis, 2004; Balkis and Wasik, 2005; Balkıs and Toklu-Alıçlı, 2009; Toklu- Alıçlı et al., 2010; Balkis and Koray, 2014; Durmus and Balkis, 2014; Yurga, 2018). In the Sea of Marmara several studies including two checklists are available (Sorokin et al., 1995; Balkis, 2004; Göktürk, 2005; Toklu-Alıçlı et al., 2010; Durmus et al., 2011; Balkıs and Koray, 2014; Durmus and Balkis, 2014; Durmus et al., 2016a, 2016b).

The Sea of Marmara is a small basin situated between Asia and European continents with a surface area of 11500 km^2 and a maximum depth of 1390 m (Beşiktepe et al., 1994). While the Black Sea waters with brackish water characteristics (17.6 -‰) flow towards the Sea of Marmara with an upper stream, Mediterranean waters with a salinity of about 38.5 -‰ are also transported to the Sea of Marmara by a lower stream. There is a halocline layer between these two water layers which do not join together due to the difference in density (Ullyott and Pektaş, 1952; Yüce and Türker, 1991; Ünlü et al., 2008). The oxygen entry from the oxygen-rich surface layer to the bottom layer is prevented by the density stratification in halocline and the dissolved oxygen content of the bottom layer water decreases because biogenic-origin particles at the bottom increase the oxygen consumption (Yüce and Türker, 1991; Beşiktepe et al., 2000). The Sea of Marmara, which has two different water layers, differs in terms of biodiversity for this reason..

The oceanographic properties of the Gulfs of Erdek and Bandırma situated on both sides of the Kapıdağ Peninsula are similar to the oceanographic properties of the Sea of Marmara and the water column has a two-layer structure. Gulf of Erdek is a relatively peaceful area both in terms of population density and industrial activities compared to the Gulf of Bandırma. The source of high mercury, chromium, copper and lead contents in the Gulf of Erdek is the transport from the mines that lie behind the region through rivers. Gulf of Bandırma is a gulf where industrial pollution is higher and domestic settlement is denser (Balkıs and Çağatay, 2001). It has been revealed by the past studies that the surface waters of the region, which is located in the northeast Kapıdağ Peninsula and Gulf of Bandırma contain more phosphate than the other parts of the Sea of Marmara (Balkis et al., 2012). The presence of a fertilizer factory in this gulf in addition to domestic wastes triggers this increase (Koç, 2002; Balci et al., 2014).

As can be seen from the studies mentioned above, there is no comprehensive and published study, which identified the ecological variables affecting ciliates and their distribution in Kapıdağ Peninsula. The aim of this study is to represent the ciliate species seasonally in the Gulfs of Erdek and Bandırma located on both sides of the peninsula with the ecological variables and to reveal their abundance.

MATERIALS and METHODS

This study was carried out to determine the environmental variables affecting the species and the distribution of microzooplankton living in the neritic waters of the Gulfs of Erdek and Bandırma located on both sides of the Kapıdağ Peninsula, which is located to the south of the Sea of Marmara. The samples were collected from the three stations illustrated in Figure 1 on both gulfs during November 2006-August 2008 period with a fishing boat seasonally (November, February, May and August) for two years.

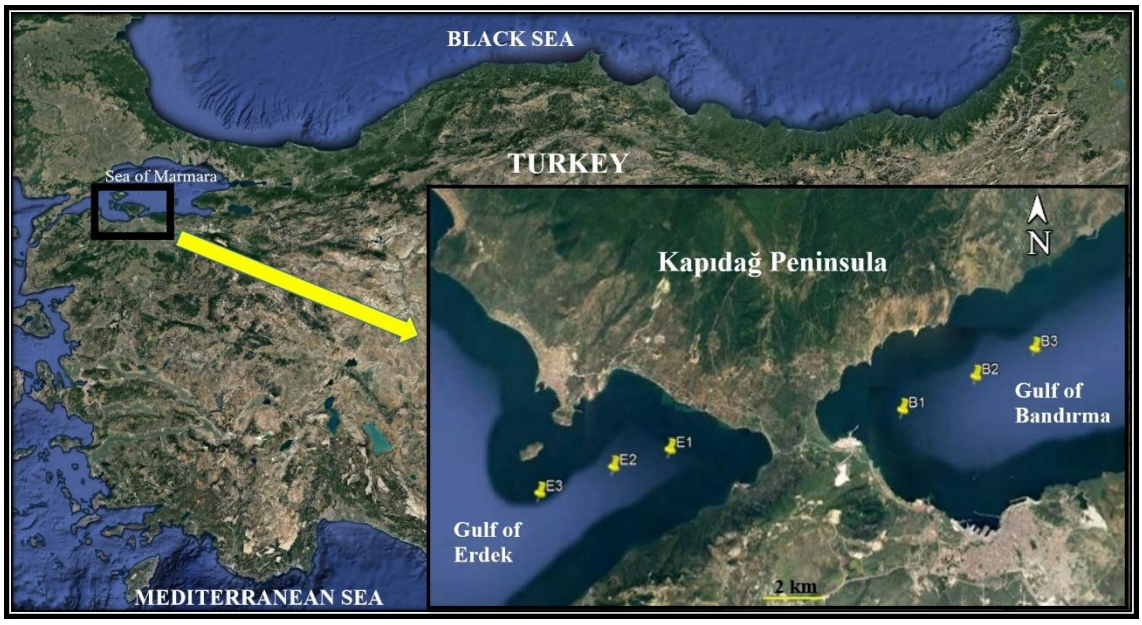

Figure 1. Stations in the Gulfs (courtesy of Google Earth).

Microzooplankton samples were obtained from horizontally (0.5 m) and vertically (30 m) with a plankton net at 40 µm length of mesh, and fixed with borax buffered formaldehyde in a way to achieve a final concentration of 2-4%. Kofoid and Campbell (1929), Tregouboff and Rose (1957), Balech (1959), Marshall (1969) and Abbooud-Abi Saab (2008) studies were used for the determination of microzooplankton species. In order to determine the quantitative distributions of microzooplankton species, samples were taken at the stations from the surface (0.5 m) and from the depths of 15 and 30 m via water samplers and fixed with Lugol. The abundance of ciliates in the precipitated samples was determined using the Sedgewick Rafter counting chamber with a capacity of 1 ml. Kocataş (1996) was taken into consideration in determining the frequency of the species identified. In addition, the ecological data used in this study were taken from the concurrently run study (Balkis et al., 2012).

Spearman's Rank-Correlation was used to determine the relationships between biotic and abiotic variables (Siegel, 1956), and Shannon-Wiener Diversity Index was used to calculate the diversity of species (Shannon and Weaver, 1964) and Bray-Curtis Similarity Index was used to determine the similarity based on the species number and abundance of the stations (Clarke and Warwick, 2001).

RESULTS

The ecological data of the Gulfs of Erdek and Bandırma were gotten from Balkis et al. (2012). The seawater temperature in the Gulf of Erdek was between 6.5 - 25.5 °C, salinity was 22.4 - 38.6 -‰, DO was between 3.78 - 14.96 mg L-1, Chl-a values were between 0.10 - 2.83 µg L-1, secchi depth was between 6.0 - 15.0 m, NO3+NO2-N values were between 0.07 - 5.41 µg-at N L-1, PO4-P values were between 0.09 - 2.11 µg-at P L-1 and SiO4-Si values were between 0.29 - 21.62 µg-at Si L-1. In the Gulf of Bandırma, it was determined that the sea water temperature was between 6.5 - 26.0 °C, the salinity is between 21.4 - 38.5 -‰, the DO was between 3.50 - 15.62 mg L-1, the Chl-a values were between 0.21 - 14.79 µg L-1, the secchi depth was between 4.0 - 16.3 m, NO3+NO2-N values were between 0.08 - 6.25 µg-at N L-1, PO4-P values were between 0.18 - 8.60 µg-at P L-1 and SiO4-Si values were between 0.05 - 20.37 µg-at Si L-1.

As seen in Table 1, a total of 14 ciliate taxa, three of which were at the genus level, were found in the study. Found species Epiplocyloides sp., Proplectella ovata Jörgensen, 1924, Laboea strobila Lohmann, 1908 and Tiarina fusus Bergh, 1881 are the new record taxa for the Sea of Marmara. The highest number of species belonged to the Choreotrichida ordo (Tintinnid) with 11 taxa (79%), Oligotrichida ordo was represented by two taxa (14%), while the Prorodontida ordo was represented by one species only (7%). It was determined that intendeds were represented with the highest number of species in the summer period (9 species) and the species belonging to the Oligotrichida ordo were observed in every period except summer 2008, while only one species of Prorodontida was observed in

all seasons except winter 2007 and spring 2008. Two of the species (Favella ehrenbergii and Helicostomella subulata) obtained in the study were observed only in the Gulf of Erdek, five species were observed only in the Gulf of Bandırma (Amphorellopsis tetragona, Eutintinnus lusus-undae, Metacylis jörgensenii, Salpingella decurtata and Xystonella treforti) and seven species were recorded in both gulfs.

Table 1. Seasonal distrubution and frequency (f) of Ciliophora species in the Gulf of Erdek and Bandırma.

Kingdom: Chromista **Phylum: Ciliophora**	**Aut' 06**		**Win' 07**		**Spr' 07**		**Sum' 07**		**Aut' 07**		**Win' 08**		**Spr' 08**		**Sum' 08**		f	f
Order: Choreotrichida	E	B	E	B	E	B	E	B	E	B	E	B	E	B	E	B	E	B
Amphorellopsis tetragona (Jörgensen) Kofoid & Campbell, 1929								+									X	X
Codonellopsis schabi (Brandt) Kofoid & Campbell, 1929							+	+									X	X
**Epiplocyloides* sp.							+	+									X	X
Eutintinnus lusus-undae (Entz, 1885)										+						+	-	R
Favella ehrenbergii (Claparede and Lachmann) Jörgensen, 1924															+		X	-
Helicostomella subulata (Ehrenberg) Jörgensen, 1924									+								X	-
Metacylis jörgensenii (Cleve) Kofoid & Campbell, 1929						+		+									-	R
**Proplectella ovata* Jörgensen, 1924							+	+									X	X
Salpingella decurtata Jörgensen, 1924		+															-	X
Tintinnopsis sp.													+			+	X	X
Xystonella treforti (Daday, 1887)																+	-	X
Order:Oligotrichida																		
**Laboea strobila* Lohmann, 1908	+	+	+	+	+	+				+				+			R	A
Strombidium sp.	+	+	+	+	+	+	+	+	+	+	+	+		+			A	V
Order:Prorodontida																		
**Tiarina fusus* Bergh, 1881	+	+			+	+	+			+	+	+				+	C	A
Total number of species in the gulfs	3	4	2	2	3	4	5	6	2	4	2	2	1	2	1	4		
Total number of species in seasons	4		2		4		7		5		2		3		5			

*: New record species in the Sea of Marmara. V: Very abundant, 81-100%; A: Abundant 61-80%; C: Common, 41-60%; R: Rare, 21-40%; X: Present sporadically,1-20%.

When both gulfs are evaluated in terms of species diversity, it was determined that the overall number of species is higher in the Gulf of Bandırma. While only one species was found in the Gulf of Erdek during the spring of 2008 and summer of 2008 periods (E-2 station), no species was found in the Gulf of Bandırma at B-2 station in the same period and two species were found in each of the B-1 and B-3 stations. It was determined that the minimum number of species was found in winter and spring of 2008 period in both gulfs. It was observed that the number of species in the first year of seasonal sampling was higher than the second year.

Considering the frequencies of ciliate species found in the Gulf of Erdek, it was found that *Strombidium* sp. was abundant (75%), *Tiarina fusus* was common (50%) and *Laboea strobila* was rare (38%) and the other species seen in the gulf were identified as present sporadically (13%). For the Gulf of Bandırma, it was found that *Strombidium* sp. was very abundant (88%), *L. strobila* and *T. fusus* were abundant (63%), *Eutintinnus lusus-undae* and *Metacylis jörgensenii* were rare (25%) and other species seen in the gulf were identified as present sporadically (13%).

When the gulfs are evaluated in terms of species abundance, it was determined that the Gulf of Erdek is more dominant than the Gulf of Bandırma and the maximum abundance in the Gulf of Erdek was obtained at the depth of 0.5 m at E-1 station in autumn of 2007 (9960 ind. L^{-1}). *Strombidium* sp. played an important role in this increase. A similar increase was observed in the same type of E-2 station (6120 ind. L^{-1}). The highest abundance in the Gulf of Bandırma was observed at a depth of 0.5 m (2660 ind. L^{-1}) at the station B-1 in autumn 2006 and the *Strombidium* sp. was the most dominant species (2100 ind. L^{-1}).

The results of Shannon-Wiener Diversity Index are presented in Figure 2 separately for both gulfs. In terms of Gulf of Erdek stations, the diversity varies between 0.00 and 1.56 at E-1 station and the diversity value can be calculated only in autumn of 2006 and summer of 2007 periods. It is also seen that the diversity changed between 0.00 and 1.00 at E-2 station and the diversity was observed in the first three sampling seasons of 2007. Additionally, it was observed that the diversity varied between 0.00 and 1.75 at E-3 station and the highest diversity was achieved at this station (summer of 2007, E-3, 30 m).

According to the results of the Shannon-Wiener Diversity Index in Gulf of Bandırma, the index in B-1 station varies between 0.00 and 1.50, diversity was observed at some depths in autumn of 2006, summer of 2007, spring and summer of 2008, the index at B-2 station varies between 0.00 - 1.36 and diversity was observed in spring, summer and autumn of 2007 periods, and the index at B-3 station varied between 0.00 and 0.81 and diversity was observed in autumn of 2006, spring and autumn of 2007 periods.

As shown in Table 2, according to Spearman's rank-correlation matrix, some relationships between ciliates and ecological variables were determined. In the matrix, it was found that ciliates had positive correlations between DO and Chl-a, and also negative with NO_3+NO_2-N ($p < 0.05$). Additionally, a negative correlation was observed between ciliate abundance and salinity ($p < 0.05$).

According to the Bray-Curtis Similarity dendrogram illustrated in Figure 3, the highest similarity was determined between surface waters of B-2 and surface waters of B-3 (96.5%), and all depths belonging to the stations were found to be 23.6% similar. It was revealed that four groups and two different depths were formed by a line drawn at 59% similarity level. 30 m depths of the B-2 and B-3 stations were separated from the other groups. While the 15 m depths of the stations located in Gulf of Erdek and 30 m depth of the E-1 station constituted the first group, the surface waters of the stations in the same gulf constituted the second group. While the 15 m of B-2 and B-3 stations and 30 m of the B-1 station constituted the third group with the surface waters located in Bandırma, 30 m of the E-2, E-3 stations, and 15 m of the B-1 station formed the fourth and the last group.

Table 2. Spearman's rank-correlation matrix to correlate ciliate assemblages and environmental variables in the study areas.

	Temp	Sal	DO	Chl-a	SD	NO_3+ NO_2 - N	PO_4-P	SiO_4-Si	S
Sal	-.314**								
DO	-.138	-.326**							
Chl-a	-.241	-.421**	.166						
SD	.016	.241	.393**	-.361**					
NO_3+NO_2-N	-.054	.626**	-.476**	-.428**	-.055				
PO_4-P	.042	.132	-.111	.160	-.025	.357**			
SiO_4-Si	-.181	.736**	-.262	-.443**	.219	.623**	.228		
S	-.014	-.124	.281*	.146*	.116	-.235*	-.069	.008	
N	-.060	-.199*	.286*	.192*	.091	-.296*	-.057	-.071	.919**

* $p < 0.05$, ** $p < 0.01$ (Temp: Temperature, Sal: Salinity, DO: Dissolved oxygen, Chl-a: Chlorophyll-a, SD: Secchi Disk, S: Number of species, N: Number of individuals).

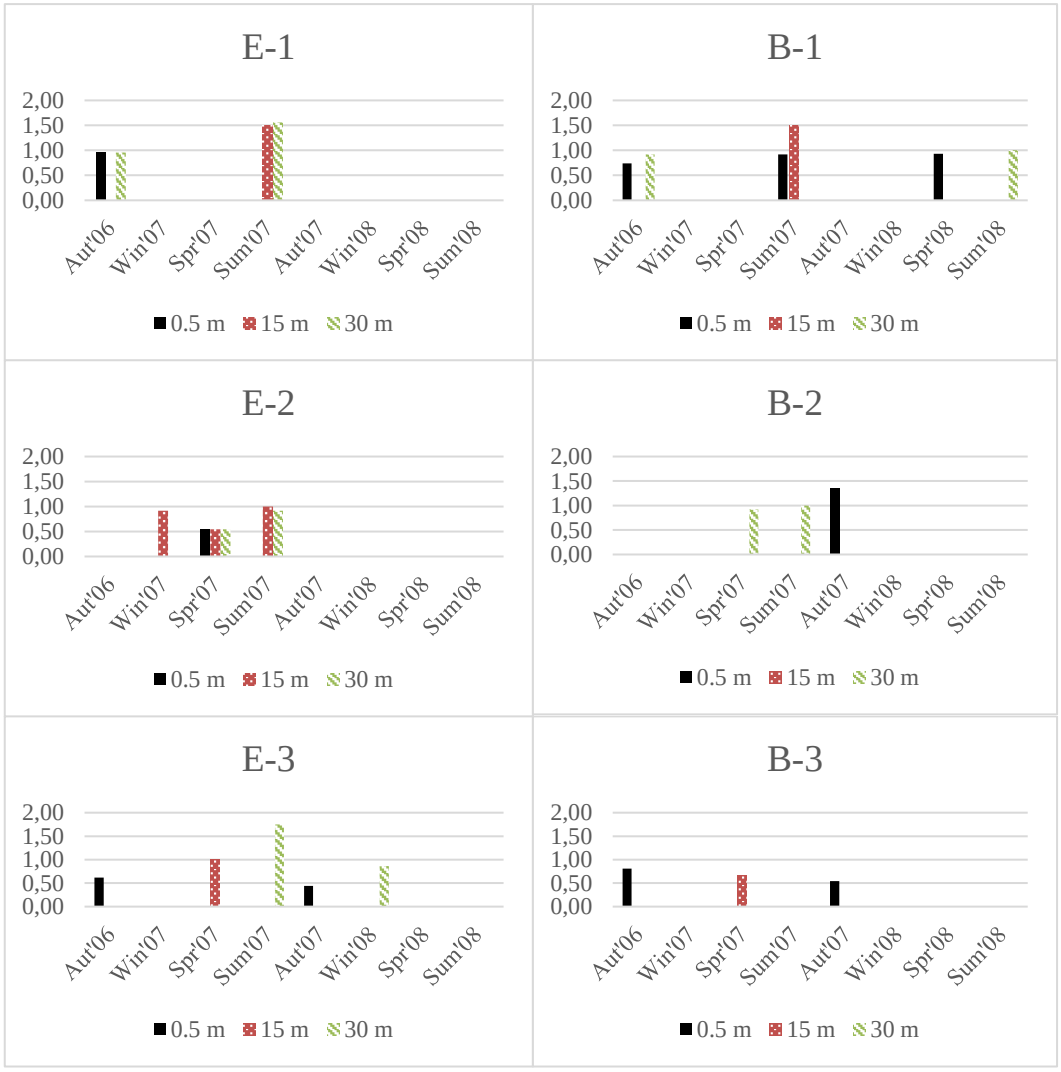

Figure 2. Shannon-Wiener Diversity Index for each stations.

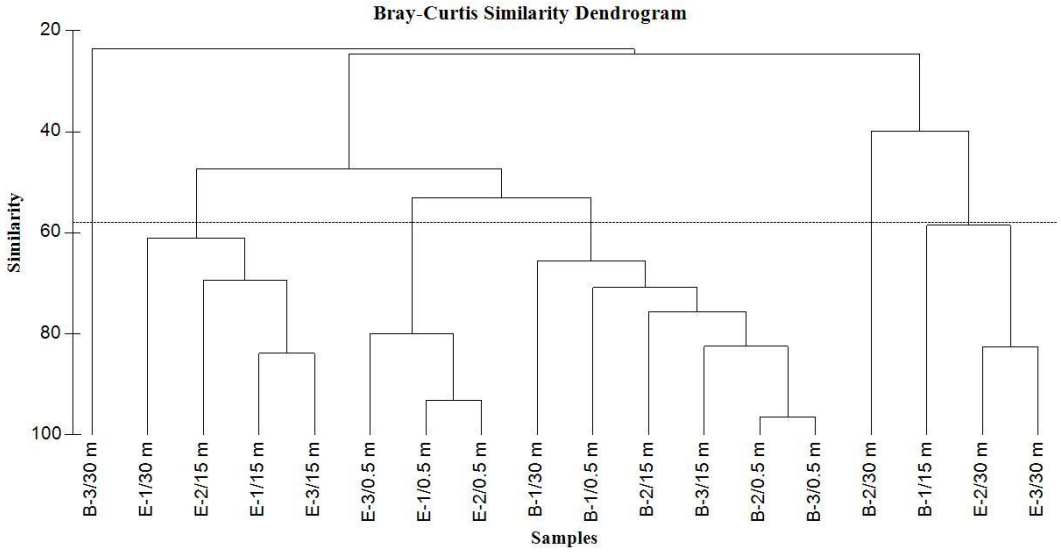

Figure 3. Bray-Curtis similarity dendrogram according to stations and depths.

DISCUSSION

From the identified species, *Epiplocyloides* sp. as genus, *Proplectella ovata*, *Laboea strobila* and *Tiarina fusus* are new records of taxa for the Sea of Marmara. 11 species (79%) belonging to the Choreotrichida ordo (Tintinnid), two species belonging to the Oligotrichida ordo (14%) and one species belonging to the Prorodontida ordo (7%) were obtained. In the tintinnid checklist study by Balkis and Koray (2014) covering the Turkish seas, they reported 109 tintinnid taxa for all Turkish coastal waters while including 15 species for the Sea of Marmara. In their study, Durmus and Balkis (2014) reported 18 new species for the Sea of Marmara, four of which (*Eutintinnus medius*, *Metacylis mediterranea, Tintinnopsis urnula* and *T. acuminata*) are new record tintinnid species for Turkish coastal waters, and with the addition of these species in the list, the total number of species rose to 113 for Turkey and to 33 for the Sea of Marmara (Durmus et al., 2016a). The total number of tintinnid species for the Sea of Marmara was revealed to be 35 with the addition of 2 new recorded tintinnid species obtained in this study carried out in the Kapıdağ Peninsula. Eleven Tintinnid species in the study, accounted for ~ 10% of all taxa reported for the coastal waters of Turkey, and ~ 31% of the taxa reported for the Sea of Marmara.

When studies which have obtained 35 tintinnid species so far in the Sea of Marmara including the present study are examined, it is seen that the study carried out in the north of the Sea of Marmara by Balkis (2004) reported 14 species, Göktürk (2005) reported 7 species in the ballast water of some ships in Istanbul ports, Toklu-Alıçlı et al. (2010) and Durmus et al. (2011) reported one species each. Also, the study carried out by Durmus and Balkis (2014) in the in southeastern part of the Sea of Marmara reported 28 species, and Durmus et al. (2016b) reported 7 species in the study they conducted in Kapıdağ Peninsula. In a different study with a sampling date covering 2011-2012 carried out in Kapıdağ Peninsula (Durmus et al., 2016b) fewer stations were investigated and *A. tetragona, E. lusus-undae, F. ehrenbergii, H. subulata* and *S. decurtata* species were identified as common species with their study. However, different than the findings of Durmus et al. (2016b), *C. schabi*, *Epiplocyloides* sp., *M. jörgensenii, P. ovata* and *X. treforti* species were only observed in this study. Thus, the total number of tintinnid species known from Kapıdağ Peninsula was determined as 12.

Epiplocyloides reticulata belonging to the genus *Epiplocyloides*, which was reported as a new record for the Sea of Marmara in this study, was reported by Polat et al. (2001) from the Eastern Mediterranean. *Proplectella ovata*, which is the first known record from Turkey territorial waters, was reported from the Aegean Sea by Koray and Kesici (1994) and also Polat et al. (2001, 2002) reported it from the eastern Mediterranean. *Laboea strobila* and *Tiarina fusus* were reported by Esensoy (2014) from Eastern Black Sea. Among these species, *L. strobila* was recorded from Aegean Sea and Mediterranean Sea out side Turkish territorial waters (Pitta and Giannakourou, 2000; Agatha et al. 2004). *Tiarina fusus* was also reported from the Eastern Mediterranean (Hannachi et al., 2008).

In this study, it was observed that tintinnids, which are represented by nine species, usually emerge during the summer periods. From the studies carried out in the Sea of Marmara, Balkis (2004) and Durmus and Balkis (2014) reported similar results while Durmus et al. (2016b) stated that the highest number of tintinnid species was seen in autumn. In this study, when both gulfs are evaluated together, the increase in *Strombidium* sp., belonging to ciliates, is of particular importance. Similarly, *L. strobila* species was found in autumn of 2006 and 2007, but the highest abundance was achieved in the spring period (840 ind. L^{-1}, 15 m depth of E-2 station in spring of 2007). In the study carried out in three seasons by Esensoy (2014) in the Eastern Black Sea, *L. strobila* was encountered in all seasons and similar to this study, it was reported that it was the most abundant spring period. Sorokin et al. (1995) and Zervoudaki et al. (2011) mentioned the existence of species belonging to the genus *Strombidium* in the Sea of Marmara. In this study, *Strombidium* sp. was reported from both gulfs. This species was encountered most abundantly in the Gulf of Erdek at surface waters of E-1 station (9960 ind. L^{-1}). In the study conducted by Esensoy (2014), it was stated that during the February period *Strombidium acutum* (196000 ind. L^{-1}) was abundant in surface waters. *Tiarina fusus* was found in both gulfs on the Kapıdağ Peninsula in all seasons except for winter of 2007 and spring of 2008 and it was determined that the highest abundance was achieved in the Gulf of Erdek in winter of 2008 and in the Gulf of Bandırma in autumn 2006. In a study they carried out in the Black Sea, Feyzioglu and Güneroglu (2011) reported that *T. fusus* was the most abundant species of ciliates. Esensoy (2014) encountered *T. fusus* in the study conducted in the Black Sea during the whole study and reported that the number of individuals reached a peak during the spring period. Bodeanu et al. (1998) reported that large organisms (> 50 μm) could be harmful when they reach 10^5 individuals per liter; however, Dale and Dahl (1987) reported that *T. fusus* species could cause red tide by excessive proliferation (3.4×10^4 ind. L^{-1}). In this study, the maximum number of individuals belonging to the *T. fusus* species was determined as 560 ind. L^{-1} (Gulf of Bandırma, surface waters of B-1 st.).

During the study, the highest number of tintinnid individuals were found at a depth of 15 m and the lowest number of individuals was obtained in the surface waters (0.5 m). This is attributed to the fact that the amount of Chl-a is usually high at the depths of 15 m and 30 m in the periods when intendeds are present, and therefore the food requirement can be met at these depths. According to the Spearman's rank-correlation matrix, the positive relationship between ciliate species and the number of individuals and Chl-a ($p < 0.05$) supports this situation. *C. schabi* is the species which reached the highest number of individuals among tintinnid taxa in the Gulf of Erdek in summer of 2007 (480 ind. L^{-1}, 15 m depth of E-1 st.). The tintinnid species, which reached the highest number of individuals in the Gulf of Bandırma, was *A. tetragona* in summer of 2007 (360 ind. L^{-1}, surface waters of B-1 st.). Evaluating the studies conducted in the Sea of Marmara, Balkis (2004) identified the most abundant species as *Eutintinnus fraknoi* (0.4×10^3 ind. L^{-1}). Durmus and Balkis (2014) found in their study that the species of *Tintinnopsis corniger* (=*Rhizodomus tagatzi*) was abundant in October (9×10^3 ind. L^{-1}) and Durmus et al. (2016b) reported in their study that the highest number of individuals (1.9×10^3 ind. L^{-1}) was from the genus *Tintinnopsis* in October.

Favella sp. and *H. subulata*, which are the species observed in the study, were recorded only in The Gulf of Erdek, *A. tetragona, E, lusus-undae, M. jörgensenii, S. decurtata* and *X. treforti* species were recorded only in the Gulf of Bandırma and seven species were recorded from both gulfs. It is reported that *E. lusus-undae* and *S. decurtata* species found in the Gulf of Bandırma are invasive species for Black Sea (Selifonova and Makarevich, 2018). It is known that the waters of the Black Sea with low salinity are effective in the upper layer of the Sea of Marmara (Yüce and Türker, 1991).

1. When the frequency of the species identified in the study was evaluated, it was found for the Gulf of Erdek that Strombidium sp. was abundant (75%), T. fusus was common (50%) and L. strobila was rare (38%) and other species in this gulf were determined sporadically (13%). In the Gulf of Bandırma, Strombidium sp. was very abundant (88%), L. strobila and T. fusus were abundant (63%), E. lusus-undae and M. jörgensenii were found rare (25%), while other species in this gulf were determined as sporadically (13%). In the study conducted by Balkis (2004) in the northern Sea of Marmara, it was reported that E. lusus-undae, Favella ehrenbergii - were common, M. jörgenseni - was rare, C. schabi and H. subulata - were present sporadically. In the study conducted by Durmus and Balkis (2014) in the southeast of the Sea of Marmara, they found F. ehrenbergii - was very abundant, H. subulata - was abundant, A. tetragona, E. lusus-undae and S. decurtata - were common, M. jörgensenii - was rare, C. schabi and X. treforti - were sporadically. In a study carried out in Kapıdağ Peninsula, which was

sampled later than the present study with fewer number of stations and was seasonally run in one year, seven species (A. tetragona, E. lusus-undae, H. subulata, F. ehrenbergii, Rhizodomus tagatzi (=Tintinnopsis corniger), S. decurtata and Tintinnopsis radix) were identified and it was stated that five of these species were rare, one species was common and one species was abundant. However, there was no information regarding which species these are (Durmus et al., 2016b).

2. The Shannon-Wiener Diversity Index was evaluated separately for both gulfs. In the Gulf of Erdek, nine species were observed during the study and six of these species were tintinnids. Tintinnid individuals in this gulf were never detected in autumn of 2006, winter and spring of 2007 and winter of 2008, while they were detected only at one of the depths of a station in autumn of 2007, spring and summer of 2008. Also Strombidium sp. - and T. fusus -, which are among the other species found in this gulf, are observed throughout the sampling periods and since no other species are observed and they do not have individual, Shannon-Wiener Diversity Index was generally found to be low (H′= 0.00 - 1.75). In the Gulf of Bandırma, 12 taxa were determined during the study. 11 of these taxa are intendeds, which are members of the Choreotrichida ordo. Tintinnids were not observed during both winter and spring of 2008 throughout the study, while they were found at only one depth of a station in autumn of 2006, spring and autumn of 2007. Similar to the other gulfs, Strombidium sp., L. strobila and T. fusus were seen commonly, and were found to range between H′= 0.00 and H′= 1.50 in terms of Shannon-Wiener Diversity Index.

3. The majority of the taxa determined in our study in Kapıdağ Peninsula belong to Choreotrichida ordo. There are many studies carried out in different geographic regions on tintinnids, which are members of these order and it was reported that the species and individual number of tintinnids show variation (Kamiyama and Tsujino, 1996; Dolan et al., 1999; Dolan and Gallegos, 2001; Polat et al., 2001, 2002; Balkis, 2004; Durmus and Balkis 2014). Considering these studies, it is understood that these organisms are sensitive to environmental variables. According to Spearman's rank-correlation matrix administered to determine the effects of environmental variables on ciliate species and individual numbers, the number of species and individuals showed a strongly positive ($p < 0.01$) relationship among each other, while these parameters showed a positive with relationship with DO and Chl-a ($p < 0.05$) and a negative relationship with NO3+NO2-N. In addition, a negative correlation between the number of individuals and salinity was determined ($p < 0.05$). Other studies have reported that tintinnid species and number of individuals have a negative correlation with salinity (Capriulo and Carpenter, 1983; Kamiyama and Tsujino, 1996; Hoffmeyer and Cao, 2007; Lee and Kim, 2010). Durmus and Balkis (2014) found similar results in their study carried out in the southeast of the Sea of Marmara, and also stated that DO is positively correlated with the number of species and individuals. As the depth increases in the Sea of Marmara, salinity and nutrient amounts increase and DO decreases. The fact that the abundance of species decreases with the increase of depth is supported by that abundance of species obtained in this study has a positive correlation with DO, whereas a negative correlation with salinity and NO3+NO2-N amounts.

4. When the Bray-Curtis Similarity dendrogram is evaluated, it is seen that the 30 m depths of the other stations except for the 30 m depth of the E-1 station are separated from the surface and the waters close to the surface (15 m). The reason of this situation is the need for these organisms to be in the waters near the surface to meet the food, light and DO needs. In addition, a halocline layer is formed at a depth of 20 m between the waters of the Black Sea origin and the water body of the Mediterranean origin in the Sea of Marmara (Uysal and Ünsal, 1996), and this layer is thought to restrict the transition of the species into the deeper layers. In general, it was determined that the stations located in the Gulf of Erdek are separated from the depths of the stations located in the Gulf of Bandırma at 53% level.

5. The distribution of some ciliates (tintinnid) in the seas and oceans was investigated by Pierce and Turner (1993) and Dolan and Pierce (2014). Accordingly, from among the tintinnids found in this study, it was determined that Amphorellopsis, Codonellopsis, Eutintinnus, Proplectella and Salpingella were cosmopolitan, Epiplocyloides and Xystonella were warm water, Helicostomella, Metacylis, Favella and Tintinnopsis were neritic genera. Laboea, Strombidium and Tiarina genera, which belong to other order, were reported as cosmopolitan (Hada, 1961; Agatha, 2011).

It was determined that the salinity, DO, Chl-a and NO3+NO2-N from ecological variables affected the distribution of ciliates. In order to determine the distribution of ciliates and the factors affecting this distribution in the Sea of Marmara, which covers the study area, carrying out sampling at more frequent

intervals in more sampling stations will contribute to the determination of the ciliate species diversity of the region.

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