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Research Article

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Assessment of The Spatio-Temporal Distribution and Habitat Preferences of Ostracoda (Crustacea) Related to Certain Environmental Factors in Kapıdağ Peninsula (The Sea of Marmara, Turkey)

Kapıdağ Yarımadası'ndaki (Marmara Denizi, Türkiye) Ostrakodların (Crustacea) Çevresel Faktörlere Bağlı Olarak Spatio-Temporal Dağılımı ve Habitat Tercihleri

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ABSTRACT

The Sea of Marmara is exposed to pollutants in excess from the coastal industrial facilities and intensive urbanization, and because of that, the ecosystem is affected negatively. The aim of this study was to determine the environmental factors and ecological parameters on the species distribution and abundance of Ostracoda in Kapıdağ Peninsula coastline. At four seasons (April, July, October 2011 and January 2012), samples were collected from 21 stations (total of 84 samples) and 36 Ostracoda species were identified. The most distributed ostracod species were *Carinocythereis antiquata*, *Aurila convexa*, *Loxoconcha gibberosa, Paradoxostoma fuscum, Cushmanidea elongata,* and *Xestoleberis decipiens*. The highest numbers of individuals observed were *Loxoconcha rhomboidea* and *Xestoleberis aurantia*. During the study, water temperature varied between 7.5 and 30°C, salinity varied between 12.1 and 29.2‰, pH varied between 6.6 and 8.7, and dissolved oxygen varied between 1.2 and 15.3 mgL^{-1} in the stations across the four seasons. Depth, mud percentage and the transparency of the water were the most effective factors on the living ostracod species of Kapıdağ Peninsula coastline according to spearman correlations.

Key Words

Kapıdağ Peninsula, ostracoda, ecology, distribution.

ÖZ

Marmara Denizi, kıyısında yer alan yoğun sanayileşme ve kentleşmeden dolayı kirliliğe maruz kalmakta, bu nedenle de ekosistemi olumsuz yönde etkilenmektedir. Bu çalışmada Kapıdağ Yarımadası kıyısındaki Ostracoda türlerinin dağılımı ve bolluğuna etki eden çevresel faktörlerin ve ekolojik parametrelerin belirlenmesi hedeflenmiştir. Dört mevsim boyunca (Nisan, Temmuz, Ekim 2011 ve Ocak 2012) 21 istasyonda (toplam 84 adet) örnek toplanmış ve 36 Ostracoda türü belirlenmiştir. En geniş dağılım gösteren türlerin *Carinocythereis antiquata*, *Aurila convexa*, *Loxoconcha gibberosa, Paradoxostoma fuscum, Cushmanidea elongata*, ve *Xestoleberis decipiens* olduğu görülmüştür. En fazla birey sayısı *Loxoconcha rhomboidea* ve *Xestoleberis aurantia* türlerinde saptanmıştır.Çalışmada dört mevsim boyunca sıcaklık 7.5-30°C, tuzluluk ‰12.1-29.2, pH 6.6-8.7, ve çözünmüş oksijen 1.2-15.3 mgL^{-1} aralıklarında belirlenmiştir. Spearman korelasyon analizine göre derinlik, çamur yüzdesi ve görünürlüğün Kapıdağ Yarımadası kıyılarında yaşayan ostrakod türleri üzerinde en etkili faktörler olduğu belirlenmiştir.

Anahtar Kelimeler

Kapıdağ Yarımadası, ostrakod, ekoloji, dağılım.

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INTRODUCTION

The small bivalved crustaceans, ostracods, have laterally compressed bodies and two calcified valves. These crustaceans are diverse at very different environmental conditions [1, 2], including estuaries, seas, oceans, lagoons, lakes, ponds, streams, springs, rivers, peatlands, caves [3] and groundwaters from deep seas [4] to coastal and also terrestrial environments [5] Fossils and living ostracods have been used as important indicator organisms for recent paleoecological studies because of their great potential for ecological monitoring [6,7]. The ostracod species, widely distributed in aquatic areas, are important for ecological balance in terms of the separation of detritus and the nutrition of fish. Ostracods are also an important food source for invertebrates [5] and fish [8]. In both polluted and clean aquatic environments, ostracods are indicators of changes in marine habitats [9], which can be more reliable and more economic for environmental monitoring than long-term chemical analyses. Their composition, density, and diversity of assemblages are controlled by environmental parameters (salinity, temperature, pH, oxygen, hydrodynamic conditions with the type of substratum) and also related to anthropogenic pollution (e.g. nutrient and heavy metal content) [2,6,10]. They are sensitive to anthropogenic pollution [11,12] and can be used as indicators in marine, brackish, and freshwater environments [13-17].

The Sea of Marmara, which divides the Asian and European parts of Turkey, is a transitional waterway between the Black Sea and the Mediterranean Sea in the Turkish Strait System (TSS). This inner sea connects the Black Sea and the Aegean Sea with the Bosporus in the north and the Dardanelles in the south [18]. The Sea of Marmara which covers a surface area of 11,350 km² is under pressure of pollution from large industrial establishments as well as the high population density and its domestic waste [19].

To date, 210 benthic ostracod species have been determined from the Sea of Marmara [20]. Also, 382 ostracod species have been reported in Turkish seas (326 from marine and 56 from coastal brackish waters) [21]. Perçin-Paçal and Balkıs, (2012) [22] reported 112 ostracod species (including most of the ostracod species identified in this study) together with their SEM photographs from Bandırma Bay and Erdek Bay, which compose the east end west side of Kapıdağ Peninsula. Our new data of the ecological parameters and species compositions are compared with the above-mentioned study by Perçin-Paçal and Balkıs, (2012) [22] and other studies [23, 24].

The present study aims to investigate the relationships of the recent ostracod species with different physicochemical parameters, a determination of spatio-temporal distributions, and habitat preferences of the species living between a depth of 0.5 and 30 m on the Kapıdağ Peninsula coastline. The secondary objective of this paper is to analyze the spatial and seasonal change of physicochemical and biological parameters considered to be caused by anthropogenic activities.

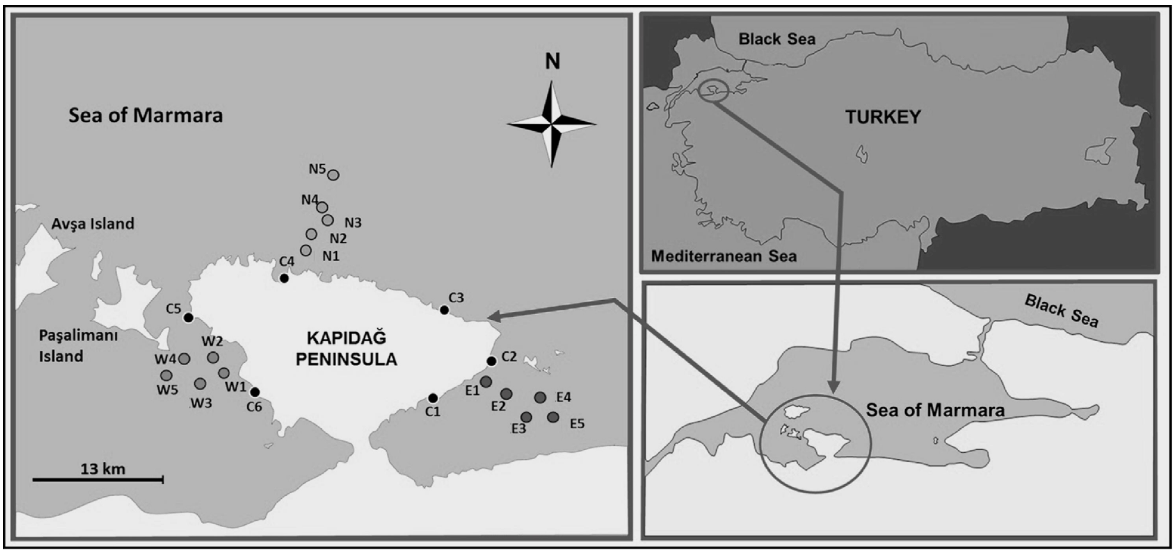

Figure 1. Locations of the sampling stations.

MATERIALS and METHODS

Study Area

Kapıdağ Peninsula is located between Bandırma Bay (in the southeast) and Erdek Bay (in the southwest) on the southern coast of the Sea of Marmara (Figure 1). The area of the peninsula is approximately 290 km^2. It is generally covered with bushes and, in some areas, forests, too. Tourism and fishing are widespread in the region. Erdek, covered with olive groves, fruit gardens, and vineyards, is a popular tourist center in the region. Bandırma Bay has a higher population density and industrial activities compared with Erdek Bay, meaning it is threatened by pollution from industrial and domestic waste as a result of industrial facilities surrounding it and population growth.

Bandırma is a developing industrial region and a major contributor to the regional economy and population growth with an organized industrial zone, founded in 1997 and located over an area of 150 hectares [25]. With the acceleration of industrialization, an additional area of 200 hectares was set aside to contribute to the development of trade. Bandırma Port is the second largest port in the Sea of Marmara after Istanbul Port [25]. In the future, Bandırma Port will become bigger, which will create negative environmental effects on the Sea of Marmara, which has already received most of Bandırma's pollution. Therefore, there is a strong possibility that the data from this study will contain valuable information for the future of the region.

The oceanographic characteristics of the coastline of Kapıdağ Peninsula are similar to the Sea of Marmara, and the water column has a two-layer structure. The surface water (the brackish Black Sea water) of the Sea of Marmara has a salinity of 17.6‰ and flows through the Bosporus to the Sea of Marmara. The waters of the Mediterranean originate with a salinity of about 38 ‰ and flow through the Dardanelles to the Sea of Marmara in a lower layer. According to the density differences between the two water layers, there is an intermediate (Halocline zone) salinity mass 25 m deep [19].

Sampling Procedure

The sampling was carried out from 21 stations at depths of 0.5, 1, 5, 10, 20, and 30 m out from the southeast, southwest, and north sides of the peninsula in April, July,

Table 1. Results of human serum samples.

Stations	Coordinates	Depth	Sediment type	Sampling equipment
N1	40°30′48.1″N-27°48′14.1″E	1	Sand	Van Veen Grab
N2	40°30′51.7″N-27°48′15.8″E	5		
N3	40°30′55.8″N-27°48′21.4″E	10		
N4	40°30′59.4″N-27°48′21.3″E	20		
N5	40°31′10.9″N-27°48′27.4″E	30		
W1	40°26′08.2″N-27°44′55.0″E	1	Sand and mud	
W2	40°26′08.4″N-27°44′54.2″E	5		
W3	40°26′08.5″N-27°44′53.2″E	10		
W4	40°26′11.4″N-27°44′48.3″E	20	Shell and mud	
W5	40°26′11.0″N-27°44′46.1″E	30		
E1	40°26′38.7″N-28°00′32.2″E	1	Mud	
E2	40°26′39,1″N-28°00′32.5″E	5		
E3	40°26′37.2″N-28°00′33.4″E	10		
E4	40°26′35.5″N-28°00′31.6″E	20		
E5	40°26′32.5″N-28°00′30.8″E	30		
C1	40°25′22.7″N-27°57′17.7″E	0.5	Mytilus galloprovincialis, photophilic algae	hand net (mesh size 50 μm)
C2	40°27′35.9″N-28°01′23.7″E	0.5		
C3	40°29′33.7″N-27°57′52.9″E	0.5		
C4	40°30′24.1″N-27°47′30. 9″E	0.5		
C5	40°29′38.9″N-27°40′59.5″E	0.5		
C6	40°26′04.0″N-27°44′53.3″E	0.5		

October 2011, and January 2012 (Figure 1). The coordinates for each sampling site were determined using a hand-held GPS. Coordinates and other characteristics of each sampling site are given in Table 1.

The Ostracoda samples were collected with a hand net (mesh size 50 µm) from six stations (from shallow waters not exceeding 50 cm in depth) which has 0.1 m2 sampling area. For other stations, a Van Veen Grab sampler was used to perform vertical cross-section sampling at depths of 1, 5, 10, 20, and 30 m which has 0.1 m2 sampling field. Two replicates were collected in each station. The 200 gr of the uppermost sediments was fixed in 70% ethanol in situ. Also 200 gr sediments were gathered and stored for the sediment analysis. For distinguish the ostracod species, the sediment was washed off under pressurized tap water and separated into four grain-size fractions by using standardized sieves (2, 1.5, 0.5, 0.25, and 0.125 mm mesh size). Ostracods were sorted under a stereomicroscope and fixed again in 70% ethanol. Subsequently, the washed specimens were preserved in 70% ethanol, and the retained material transferred to a petri dish to be picked out of the sediment under a stereo zoom microscope, and the soft body parts were dissected in lactophenol solution for taxonomic identification. The number of adult individuals belonging to each identified ostracod species was detected. The ostracods were handpicked and identified using the keys developed by Mordukhai and Boltovskoi (1969) [26], Schornikov (1969) [27], Barbeito-Gonzales (1971) [28], Hartmann and Puri (1974) [29], Bonaduce et al. (1975) [30], Athersuch et al. (1989) [31], Yassini (1979) [32], and Stambolidis (1985) [33]. The current taxonomy and classification of ostracod species were checked using the WoRMS (2018) [34] (http://www.marinespecies.org/aphia.php? p=taxdetails&id=1078).

Analytical Procedure

The sea water was collected by 3L Ruttner water sampler with marked rope at 5m intervals from five different depths (1, 5, 10, 20 and 30m) for the physico-chemical analyses. The sea temperature (°C) at the water sampling depth was measured by means of a thermometer fixed to the Ruttner water sampler. The Winkler method [35] was used to measure dissolved oxygen (DO) (mgL^{-1}) and the Mohr-Knudsen method [36] for the salinity (Sal.) (‰). The Orion multiparameter device was used to measure the pH and ORP value of the seawater in situ. The transparency of the water was determined by using a 25 cm diameter Secchi disc. Mud percentage analyses of the sediments were defined according to Folk (1974) [37] methods and classification, sand fraction is composed by grains whose diameter varies from 63 to 2000 mm, silt fraction consists of grains with diameter ranging between 4 and 63 mm, and clay fraction constitutes very fine material, whose diameter is less than 4 mm. Total organic carbon (TOC) was analyzed using the Walkey-Blake method, which involves titration after a wet combustion of the samples [38,39]. The total calcium carbonate contents of the sediments were determined using the gasometric-volumetric method [39].

Statistical Analyses

Bray-Curtis similarity index was used to detect the species similarity among the 21 sampling stations. The degree of similarities were expressed as dendrograms. Bray-Curtis similarity index were estimated using Biodiversity Pro software package 2.0 [40]. Also this software package was used to examine seasonal distributional differences in ostracod species and to calculate the Shannon–Weaver diversity index (H') Pielou's evenness (J') and Margalef richness (D') for each site across four seasons. [40]. These calculation indexes were based on the 36 ostracod species found at the sites.

The frequency of ostracod species was calculated by using the formula F = Nax100/Nn. F is the frequency of the species, Na is the number of sampling stations containing the species, and Nn is the total number of sampling stations [41, 42].

The two-tailed Spearman rank correlation test [43] was applied to evaluate the levels of correlations between the environmental variables (temperature, salinity, pH, dissolved oxygen, total organic carbon, total calcium carbonate, transparency of the water, oxidation-reduction potential, and depth), and 36 ostracod species.

Canonical correspondence analysis (CCA) was also used to evaluate the species–environment relationships and to identify environmental factors potentially influencing ostracod assemblages [44]. Data were analyzed using the Multi-Variate Statistical Package (MVSP), version 3.22 [45].

Table 2. The names and name abbreviations of identified ostracod species with their abundance at each sampling station from the Kapıdağ Peninsula coastline. The frequency is also given.

Taxon	N1	N2	N3	N4	N5	W1	W2	W3	W4	W5	E1	E2	E3	E4	E5	C1	C2	C3	C4	C5	C6	Abbrev.	Number of individual	Frequency F (%)
TRACHYLEBERIDIDAE																								
Acanthocythereis hystrix (Reuss, 1850) Sissingh, 1972	15		6			9	18	9	6	3				3		15		18		18	9	Achx	129	30.0
Basslerites berchoni (Brady, 1870)	12					12	15	15	21	18	21	3	3									Bber	120	34.5
Carinocythereis antiquata (Baird, 1850)	6	9	9	3	15	27	12	15	9	3	15	12	9	3	9	9	15	9	15	12	9	Cant	225	66.7
Carinocythereis carinata (Roemer, 1838)	6	18	3	6	15	3	12	9	6		12	3	3		6	6					9	Ccar	117	32.1
Celtia quadridentata quadridentata (Baird, 1850)						9		9									12	3			6	Cqua	39	10.7
Bosquetina dentata (Mueller, 1894)							3	6														Bden	9	3.6
Buntonia subulata Ruggieri, 1954	9	3		15				6		15				24								Bsub	72	16.7
Costa batei (Brady, 1866) Ruggieri, 1959	6	9			9	3		9						9	3							Cbat	48	13.1
Costa edwardsii (Roemer, 1838)	6	6		9				9						6	3	3						Cedw	42	11.9
Pterygocythereis jonesii (Baird, 1850)			9																			Pjon	9	3.6
Pterygocythereis ceratoptera (Bosquet, 1852)			9												3							Pcer	12	4.8
BAIRDIIDAE																								
Neonesidea mediterranea (Mueller, 1894)	3	3		15		15	15				12	21	9			12				15	9	Nmed	129	36.9
CYTHEROMATIDAE																								
Cytheroma variabilis Mueller, 1894			12					15	9													Cvar	36	11.9
HEMICYTHERIDAE																								
Aurila convexa (Baird, 1850)	12	15	12	15	18	6	15	9	21	15	6	9	12	9	6	24	12	18	18	18	21	Acon	291	77.4
Aurila prasina Barbeito-Gonzalez, 1971	12	15	12	24	18	9	15	15	18	15	9	9		9	9	27	15	30	15	18	18	Apra	312	70.2
Urocythereis margaritifera (Mueller, 1894)							12			15												Umar	27	7.1
Heterocythereis albomaculata (Baird, 1838)						6					6								12			Halb	24	9.5
LEPTOCYTHERIDAE																								
Callistocythere diffusa Mueller, 1894								9							3	15					9	Cdif	36	11.9
Leptocythere lacertosa (Hirschmann, 1912)							9	9	9	9	6	12	15	9	9	9		3			6	Llac	105	36.9
CUSHMANIDEIDAE																								
Cushmanidea elongata (Brady, 1868) Oertli,1956	9	9	15	9	9	18	9	18	6	15	9	3	6	9	12	18	6	3	6	6	12	Celo	207	65.5
CYTHERURIDAE																								
Semicytherura acuticostata Sars, 1866					3	6	9															Sacu	18	7.1

Table 2. The names and name abbreviations of identified ostracod species with their abundance at each sampling station from the Kapıdağ Peninsula coastline. The frequency is also given. Continued.

Taxon	N1	N2	N3	N4	N5	W1	W2	W3	W4	W5	E1	E2	E3	E4	E5	C1	C2	C3	C4	C5	C6	Abbrev.	Number of individual	Frequency F (%)
LOXOCONCHIDAE																								
Loxoconcha gibberosa Terquem, 1878	9	6	9	21	3	24	18	42	24	21	6	12	12	9	21	6	12	9	24	12	18	Lgib	318	78.6
Loxoconcha minima Mueller, 1894	21	9	3			18	12	12	54	42	30	18	18	15	9	12	9	9	12	9	3	Lmin	315	70.2
Loxoconcha rhomboidea (Fischer, 1855)	9	15			12	24	33	30	30	24	12	12	6	18	24	27	21	21	12	21	18	Lrom	369	75.0
Loxoconcha stellifera Mueller, 1894	24	21				18	24	27	21	27	15	12	21	12	9	12	18	9	15	9	18	Lste	312	75.0
Loxoconcha tumida Brady, 1868	9	18				24	36	30	45	21	12	12	6	18	15	9	12	6	9	6	12	Ltum	300	66.7
PARACYTHERIDEIDAE																								
Paracytheridea parallia Barbeito-Gonzales, 1971	9	9	9	9	9	12	9			9	9	6	3	12	6	9	12	9	9	12	9	Ppar	171	67.9
PARADOXOSTOMATIDAE																								
Paradoxostoma fuscum Mueller, 1894	12	9	9	9	9	12	9	15	6	12	9	12	9	9	6	6	6	3	6	6	6	Pfus	180	64.3
Paradoxostoma intermedium Mueller,1894	12	9	12	9	15	24	9	9	6	9	9	3	6	12		6	15	9	12	15	15	Pint	216	66.7
Paradoxostoma maculatum Mueller,1894	12	9	12	15	9	15	15	9	9	9	15	3	6	9	6	12	18	12	15	12	15	Pmac	237	71.4
Paradoxostoma simile Mueller,1894	12	9	9	15	9	12	9	9	6	9	12	3	6	12		9	12	15	12	12	9	Psim	201	72.6
XESTOLEBERIIDAE																								
Xestoleberis aurantia (Baird,1838)	15	6				48	45	42	42	30	6	12	9	9	6	6	9	15	24	12	15	Xaur	351	66.7
Xestoleberis communis Mueller, 1894	21	21				57	36	27	24	15	9	12	9	15	9	12	9	9	12	9	9	Xcom	315	73.8
Xestoleberis dispar Mueller, 1894	9	18				24	33	30	33	21	12	12	6	18	9	9	18	6	9	12	6	Xdis	285	65.5
Xestoleberis decipiens Mueller, 1894	9	9	9	9	9	9	9	9	9	9	9	12	6	9	9	18	15	15	15	18	18	Xdec	234	78.6
CYTHERIDEIDAE																								
Cyprideis torosa Jones, 1856																		9	3		18	Ctor	30	8.3

RESULTS

Species Assemblages

In this study, 36 ostracod species belonging to 12 families were determined from the 21 stations sampled over the four seasons (Table 2). A total of 5841 individuals were counted. The highest number of individuals observed were: *L. rhomboidea* (Fischer, 1855) (369 individuals) and *X. aurantia* (Baird, 1838) (351 individuals) species. The greatest numbers of species and individuals were observed from the genera of *Loxoconcha* (5 species and 1614 individuals), *Xestoleberis* (4 species and 1185 individuals), and *Paradoxostoma* (4 species and 834 individuals).

Carinocythereis antiquata, A. convexa, L. gibberosa, P. fuscum, P. maculatum, C. elongata, and *X. decipiens* were the most distributed species on the Kapıdağ Peninsula coastline (see Table 2). The most frequent species were *L. gibbereosa* (78.6%), *X. decipiens* (78.6%), and *A. convexa* (77.4 %); the least frequent species were *B. dentata* (3.6%), *P. jonesii* (3.6%), and *P. ceratoptera* (4.8%) (see Table 2).

Water Quality

During the study, water temperature varied between 7.5°C and 30°C, salinity varied between 12.5 and 29.2 ‰, pH varied between 6.6 and 8.7, ORP varied between -104.1 and 672.3 and DO varied between 1.2 and 15.3 mg L^{-1}. Total organic carbon content of the sediment varied between 0.02% and 3.5%, total calcium carbonate varied between 0.3% and 85.9%, and mud percentages were highest in the deeper stations compared with the coastal sampling stations (Table 3).

Species Tolerance and Environment Correlation

Species such as *L. rhomboidea, L. stellifera, L. tumida, L. minima, X. aurantia, X. communis*, and *A. prasina* are dominant species because these species are highly tolerant to various ecological variables (see Table 3). Some habitat variables and ostracod species observed on the coastline of Kapıdağ Peninsula are shown in Table 3.

According to the Shannon–Weaver diversity index values, the highest species diversity was determined at sampling stations W-2 and W-3 in spring and the lowest in fall at the sampling station N-4. Pielou's evenness (J') results were highest at sampling stations N-3, N-4, and E-4 in fall, E-3, E-4, E-5, and C-5 in winter, and were the lowest at the sampling station E-3 in spring. According to Margalef richness (D') results, the highest value was determined at sampling station N-4 in fall, while the lowest value was at station W-3 in summer (Table 4).

Bray-Curtis similarity index illustrates eight clustering groups of species (Figure 3 A). Groups 7 and 8 have subclusters grouped by similarity of ostracod assemblages. Most ostracods determined in this study have been found in the continental shelf of the Sea of Marmara. Therefore most of them are high tolerant and abundant species and they grouped together with in the seventh clustering group (Table 3). Bray-Curtis similarity index illustrates five clustering groups of stations (Figure 3 B). The level of similarity among station with a cluster is highly related to habitat type and depth as seen in Figure 3 B (Table 1). Because C-1, C-2, C-3, C-4, C-5 ,C-6 are coastal stations and grouped together with. Also W-1, W-2, W-3, W-4, W-5 stations grouped together with in the west side of the Kapıdağ peninsula.

The significant correlations among the 36 species and 10 environmental variables according to the results of the Spearman correlation analysis are shown in Table 5. Depth, mud percentage, and transparency of the water were the most effective ecological parameters on the ostracod species according to Spearman correlations on the Kapıdağ Peninsula coastline.

While there was no significant relationship between the number of species and physicochemical parameters at the stations, a positive correlation was found between the number of individuals and total calcium carbonate and species numbers (Table 6).

The relationship between the physicochemical variables and species composition on the Kapıdağ Peninsula coastline is illustrated by the CCA biplot in Figure 4 The lengths of the arrows on the CCA graph show the strong effect of environmental variables on the distribution of ostracods (Figure 4). According to the results of the CCA, mud percentage and TCC content were the factors most affecting ostracod species on the Kapıdağ Peninsula coastline. Also species composed groups coherent with Bray-Curtis dendrograms (Figure 3) that shown with dashes in Figure 4.

Table 3. Determined environmental variables in habitats of living ostracod species on the coasts of Kapıdağ Peninsula. (Abbreviations: Sal= salinity, DO = dissolved oxygen; T = temperature; TOC = total organic carbon; TCC = total calcium carbonate; ORP = oxidation-reduction potential; SD = Secchi depth; MP = mud percentage; TNI = total number of individuals).

Species Code	Depth (m)	Sal. (‰)	DO (mgL^{-1})	pH	T (°C)	TOC (%)	TCC (%)	MP (%)	ORP	SD (m)	TNI
Achx	0-30	17.7-27.9	1.2-14.6	7.4-8.7	7.5-27	0.29-2.41	0.7-85.85	0.3-70.8	(-85); 610.3	0.5-10.5	129
Acon	0-30	12.5-29.2	1.2-14.7	6.6-8.7	7.5-30	0.02-2.89	0.3-85.85	0.3-94.2	(-104.1);672.3	0.5-13	291
Apra	0-30	12.5-29.2	1.2-14.7	6.6-8.7	7.5-30	0.02-2.89	0.3-85.85	0.3-94.2	(-85);672.3	0.5-12	312
Bber	1-30	17.1-28.2	1.2-15.3	6.6-8.7	7.5-27	0.02-3.5	0.7-85.9	2.4-74.1	(-85);623.6	1-11.0	120
Bden	5-10	19-24.7	1.6-14.3	7.6-8.2	7.5-16.5	0.52-2.1	4.6-22.1	10.6-13.4	35.4;610.3	2.7-10.0	9
Bsub	1-30	19-27.5	1.2-14.3	7.4-8.2	8.0-17.0	0.59-2.89	0.4-22.1	2.2-70.8	(-85);610.6	1.0-12.0	72
Cant	0-30	12.7-29.2	1.2-15.3	6.6-8.7	7.5-27	0.02-2.41	0.3-85.9	0.3-94.2	(-85);672.3	0.5-12.0	225
Cbat	1-30	17.7-29.2	2.0-9.9	7.4-8.2	8.0-18.0	0.5-2.1	0.7-22.1	2.4-94.2	(-38.4);364.8	1.0-12.0	48
Ccar	0-30	17.7-29.2	1.2-15.3	6.6-8.7	7.5-27	0.02-2.3	0.3-85.85	0.4-94.2	(-84.3);599.5	0.5-12.0	117
Cdif	0-30	16.8-25.9	2.0-13.2	7.2-8.7	8.0-27.0	0.5-2.1	0.3-22.1	0.4-94.2	54.5-592	0.5-10	36
Cedw	0-30	21.2-25.9	2.0-10.5	7.0-8.2	8.0-27.0	0.47-2.1	0.3-17.98	0.4-94.2	54.5-672.3	0.5-10	42
Celo	0-30	12.5-29.2	1.2-14.6	6.6-8.7	7.5-30.0	0.02-2.89	0.3-85.9	0.3-94.2	(-85);672.3	0.5-12	207
Cqua	0-10	17.7-25.4	2.0-13.2	7.6-8.7	8.0-28.0	0.29-2.1	0.6-22.1	0.3-13.4	54.5-413.1	0.5-10	39
Ctor	0-20	12.5-25.4	1.3-13.2	7.4-8.7	10.7-29	0.06-1.7	0.6-5.8	0.3-0.6	50-643.3	0.50	30
Cvar	10-20	18.3-25	1.2-14.3	7.6-8.2	7.7-27	0.64-2.1	0.4-85.9	0.9-13.4	(-40.6);389.4	2.7-10.5	36
Halb	0-1	12.5-23.7	2.7-15.3	7-8.5	7.5-27	0.02-1.7	1.2-4.06	0.4-58.3	62.3-620.9	0.5-1	24
Lgib	0-30	12.5-28.4	1.2-15.3	7.1-8.7	7.5-30	0.02-3.5	0.3-85.9	0.3-94.2	(-104.1);643.3	0.5-13	318
Llac	0-30	17.1-28.4	1.2-15.3	7.0-8.7	7.5-27	0.42-3.5	0.3-85.85	0.3-94.2	(-104.1);610.3	0.5-13	105
Lmin	0-30	17.1-28.4	1.2-15.3	6.6-8.7	7.5-30	0.02-3.5	0.3-85.9	0.3-94.2	(-85);623.6	0.5-12	315
Lrom	0-30	12.7-29.2	1.2-15.3	6.6-8.7	7.5-30	0.02-3.5	0.3-85.9	0.3-94.2	(-104.1);623.6	0.5-13	369
Lste	0-30	12.7-28.4	1.2-15.3	6.6-8.7	7.5-30	0.02-3.5	0.3-85.9	0.3-94.2	(-84.3);672.3	0.5-12	312
Ltum	0-30	17.1-28.4	1.2-15.3	6.6-8.7	7.5-30	0.02-3.5	0.3-85.9	0.3-94.2	(-104.1);672.3	0.5-13	300
Nmed	0-20	17.1-25.4	1.3-15.3	6.6-8.7	7.5-30	0.02-2.89	0.3-8.2	0.4-74.1	(-57.6);643.3	0.5-12	129

Table 3. Determined environmental variables in habitats of living ostracod species on the coasts of Kapıdağ Peninsula. (Abbreviations: Sal= salinity, DO = dissolved oxygen; T = temperature; TOC = total organic carbon; TCC = total calcium carbonate; ORP = oxidation-reduction potential; SD = Secchi depth; MP = mud percentage; TNI = total number of individuals). Continued.

Species Code	Depth (m)	Sal. (‰)	DO (mgL^{-1})	pH	T (°C)	TOC (%)	TCC (%)	MP (%)	ORP	SD (m)	TNI
Pcer	10-30	18.3-25.9	2.0-12.0	7.4-8.1	7.7-15	0.76-1.9	0.4-5.22	0.9-94.2	(-40.6);389.4	7.5-10	12
Pfus	0-30	12.5-29.2	1.2-14.7	6.6-8.7	7.5-30	0.02-2.89	0.3-85.9	0.3-94.2	(-85);672.3	0.5-12	180
Pint	0-30	12.7-29.2	1.2-14.7	6.6-8.7	7.5-30	0.02-2.89	0.3-85.9	0.3-74.1	(-85);672.3	0.5-12	216
Pjon	10	22.6-29.2	1.8-12.0	7.6-7.9	9.5-18.0	0.64-1.41	0.4-7.31	0.9	182.5-599.5	7.5-10	9
Pmac	0-30	17.5-29.2	1.2-14.7	6.6-8.7	7.5-30	0.02-2.89	0.3-85.9	0.3-94.2	(-85);672.3	0.5-12	237
Ppar	0-30	12.5-29.2	1.2-14.7	6.6-8.7	7.5-30	0.02-2.89	0.3-14.5	0.3-94.2	(-104.1);672.3	0.5-13	171
Psim	0-30	12.5-29.2	1.2-14.7	6.6-8.7	7.5-30	0.02-2.89	0.3-85.9	0.3-74.1	(-85);672.3	0.5-12	201
Sacu	1-30	17.7-25.9	1.6-7.3	7.6-8.0	7.5-26.5	0.29-1.3	2.7-8.2	4.3-19.8	62.3-610.3	1-10.5	18
Umar	5-30	21.9-27.5	1.2-9.6	7.6-8.1	7.5-26	0.7-2.58	2.32-9.3	10.6-70.8	(-85.0);610.3	4-10.5	27
Xaur	0-30	12.5-28.2	1.2-15.3	7.0-8.7	7.5-30	0.02-3.5	0.3-85.9	0.3-94.2	(-85);672.3	0.5-10.5	351
Xcom	0-30	17.1-28.4	1.2-15.3	6.6-8.7	7.5-30	0.02-3.5	0.3-85.9	0.3-94.2	(-85);672.3	0.5-12	315
Xdec	0-30	12.5-29.2	1.2-15.3	7.0-8.7	7.5-30	0.02-3.5	0.3-85.9	0.3-94.2	(-104.1);672.3	0.5-13	234
Xdis	0-30	17.1-28.4	1.2-15.3	6.6-8.7	7.5-30	0.02-3.5	0.3-85.9	0.3-94.2	(-104.1);672.3	0.5-13	285

It has been determined that the salinity tolerance ranges of ostracod species on the Kapıdağ Peninsula coastline were between mesohaline to polyhaline. Salinity ranges of the identified ostracod species are shown in Figure 5. Seven ostracod species (*B. berchoni, B. dentata, C. diffusa, C. variabilis, P. ceratoptera, P. jonesii,* and *U. margaritifera*) were observed only in polyhaline conditions.

DISCUSSION

The number of ostracod species (36 ostracod species and 5841 individuals) obtained from the Kapıdağ Peninsula coastline was considerably lower than that obtained from Bandırma Bay and Erdek Bay (112 ostracod species and 37550 individuals) [22] (Figure 6). The information obtained from the current study's results indicates that increasing the number of samples will not always provide the expected increase in the number of species and individuals.

The species diversity rate is higher in the spring (26 species) and summer (24 species) seasons compared with the fall (20 species) and winter (20 species) seasons. However, according to the Spearman correlation analysis, no significant relationship was found between the number of species and the ecological parameters. Also, a positive correlation was detected between species of *L. gibberosa, B. berchoni, B. dentata,* and *X. aurantia* and the amount of total calcium carbonate (TCC) in sediments. The effect of the TCC was supported by the CCA results as shown in Figure 4. Similarly, a positive correlation has previously been found between species numbers and TCC in studies performed on Bandırma Bay and Erdek Bay [23,24].

In addition to ecological parameters, the distribution of ostracod species is also affected by the composition of vegetation, predation pressure, sediment structure,

Table 4. Calculated species diversity indices for each station according to seasons (NS: number of species; NI: number of individuals).

Spring	N1	N2	N3	N4	N5	W1	W2	W3	W4	W5	E1	E2	E3	E4	E5	C1	C2	C3	C4	C5	C6
NS	23	19	13	14	12	25	25	26	18	11	15	14	6	21	10	24	15	15	11	9	23
NI	84	81	51	63	39	147	129	126	123	66	54	45	36	87	45	102	66	60	39	39	84
Shannon H'	1.332	1.228	1.075	1.1	1.068	1.288	1.341	1.337	1.161	0.959	1.155	1.136	0.709	1.296	0.945	1.341	1.141	1.151	1.004	0.911	1.332
Pielou's J'	0.978	0.96	0.965	0.96	0.989	0.921	0.959	0.945	0.925	0.921	0.982	0.991	0.911	0.98	0.945	0.972	0.97	0.978	0.964	0.955	0.978
Margaleff D	18.189	18.339	20.497	19.452	21.998	16.149	16.583	16.664	16.747	19.236	20.203	21.171	22.489	18.046	21.171	17.425	19.236	19.683	21.998	21.998	18.189
Summer																					
NS	19	15	12	11	13	23	19	19	16	22	19	16	11	16	15	19	16	15	19	19	24
NI	99	75	45	75	63	126	93	135	111	114	108	51	39	87	69	87	63	66	81	102	111
Shannon H'	1.249	1.086	1.056	0.947	1.053	1.292	1.161	1.218	1.103	1.251	1.18	1.195	1.021	1.132	1.116	1.218	1.157	1.113	1.245	1.239	1.322
Pielou's J'	0.977	0.924	0.978	0.909	0.946	0.949	0.944	0.953	0.916	0.932	0.923	0.992	0.981	0.94	0.949	0.953	0.961	0.946	0.973	0.969	0.958
Margaleff D	16.536	17.599	19.961	17.599	18.34	15.712	16.764	15.491	16.134	16.044	16.229	19.326	20.741	17.015	17.946	17.015	18.34	18.136	17.291	16.429	16.134
Fall																					
NS	10	6	7	3	7	18	19	18	17	19	16	15	17	8	10	11	17	16	17	20	15
NI	39	30	21	9	33	99	102	78	84	105	57	57	75	24	33	54	78	69	69	90	57
Shannon H'	0.975	0.736	0.845	0.477	0.822	1.169	1.186	1.212	1.16	1.236	1.172	1.14	1.187	0.903	0.987	0.983	1.166	1.133	1.205	1.249	1.14
Pielou's J'	0.975	0.946	1	1	0.973	0.931	0.927	0.966	0.942	0.967	0.973	0.969	0.965	1	0.987	0.944	0.948	0.941	0.979	0.96	0.969
Margaleff D	20.741	22.341	24.958	34.582	21.732	16.536	16.429	17.441	17.149	16.327	18.794	18.794	17.599	23.909	21.732	19.049	17.441	17.946	17.946	16.886	18.794
Winter																					
NS	18	19	13	12	9	18	23	23	16	20	14	17	10	20	15	14	11	14	16	7	14
NI	57	69	42	36	27	72	117	114	96	81	42	60	30	60	45	48	39	45	66	21	45
Shannon H'	1.247	1.257	1.103	1.079	0.954	1.195	1.249	1.273	1.118	1.25	1.146	1.211	1	1.301	1.176	1.129	1.004	1.136	1.123	0.845	1.136
Pielou's J'	0.993	0.983	0.99	1	1	0.952	0.917	0.935	0.929	0.961	1	0.984	1	1	1	0.985	0.964	0.991	0.933	1	0.991
Margaleff D	19.933	19.034	21.562	22.489	24.452	18.844	16.923	17.016	17.657	18.339	21.562	19.683	23.695	19.683	21.171	20.818	21.998	21.171	19.236	26.471	21.171

The species abundance of Kapıdağ Peninsula's coastline is shown in Figure 2. Loxoconcha stellifera was observed as the dominant species in spring, A. prasina in summer, L. rhomboidea in fall, and X. aurantia in winter.

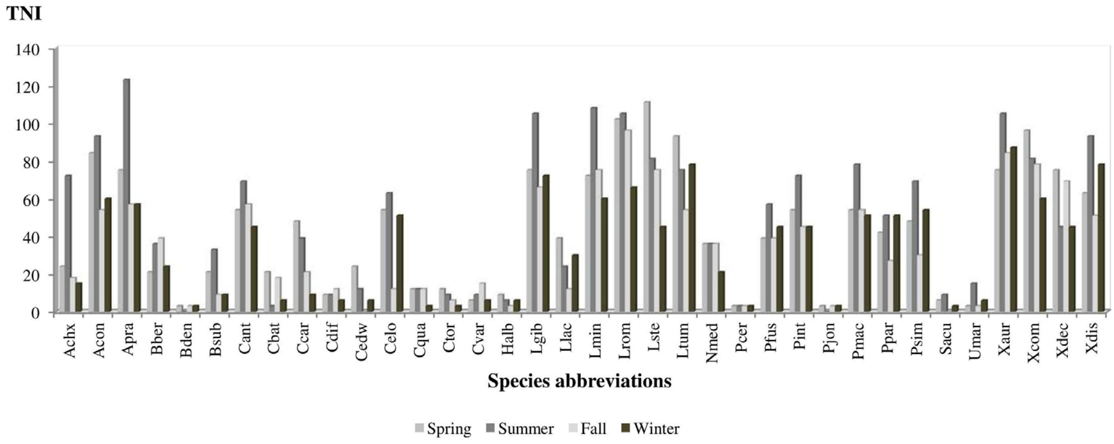

Figure 2. Total number of individuals (TNI) for each species according to season.

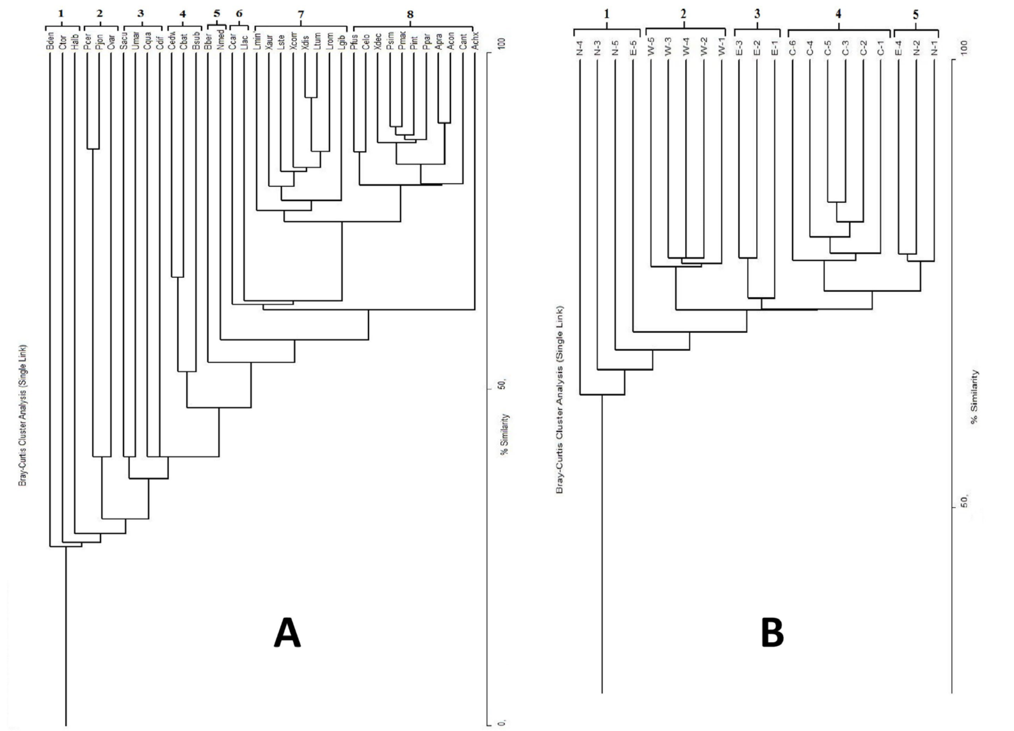

Figure 3. Dendrogram built by Bray-Curtis cluster analysis for the 36 ostracod species determined from 21 sampling stations. A. similarity of ostracod species; B. similarity of stations.

Table 5. Significant correlations between species abundance and environmental parameters according to the Spearman correlation coefficients. (Abbreviations are the same as Table 2-3: **P<0.01, *P<0.05).

Spring	Achx	Nmed	Bber	Cant	Ccar	Cqua	Bden	Cvar	Bsub	Cbat	Cedw	Acon	Apra	Umar	Pjon	Pcer	Cdif	Celo
Depth	-,323**	-,315**	ns	ns	ns	ns	ns	,240*	,269*	,216*	ns	ns	ns	ns	ns	ns	ns	ns
Sal	ns	ns	ns	ns	,226*	ns	ns	ns	ns	ns	ns	ns	ns	,253*	ns	ns	ns	ns
DO	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
pH	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	-,296**
T	,285**	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
TCC	ns	ns	,326**	ns	ns	ns	,220*	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
TOC	ns	ns	ns	ns	ns	ns	ns	ns	,285**	ns	ns	ns	ns	ns	ns	ns	ns	ns
MUD	-,316**	ns	,371**	ns	ns	ns	ns	ns	ns	ns	ns	-,294**	-,375**	ns	ns	ns	ns	ns
ORP	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
SECCİ	-,276*	-,265*	ns	ns	ns	ns	ns	,296**	,252*	ns	ns	ns	ns	ns	ns	ns	ns	ns
	Llac	Halb	Sacu	Lgib	Lmin	Lrom	Lste	Ltum	Ppar	Pfus	Pint	Pmac	Psim	Xaur	Xcom	Xdis	Xdec	Ctor
Depth	,227*	-,286**	ns	ns	ns	ns	ns	ns	-,230*	ns	ns	-,231*	-,254*	ns	ns	ns	-,338**	-,380**
Sal	,276*	-,350**	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
DO	ns	ns	ns	ns	ns	ns	,247*	ns	ns	ns	ns	ns	ns	ns	ns	ns	,342**	ns
pH	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
T	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
TCC	ns	ns	ns	,389**	ns	ns	ns	ns	-,360**	ns	ns	ns	ns	,381**	ns	ns	ns	ns
TOC	,252*	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
MUD	,414**	ns	ns	ns	,288**	ns	ns	ns	-,227*	ns	ns	-,261*	-,293**	ns	ns	ns	-,321**	-,374**
ORP	ns	ns	ns	ns	ns	ns	ns	ns	,232*	ns	ns	ns	,285**	ns	ns	ns	ns	ns
SECCİ	,290**	-,285**	ns	ns	ns	ns	ns	ns	-,288**	ns	-,241*	-,296**	-,338**	ns	ns	ns	-,338**	-,378**

Table 6. Spearman correlation matrix between ecological parameters with number of species and individuals. (Abbreviations are the same as Table 3: NS = number of species; NI = number of individuals; **P<0.01, *P<0.05).

Ecological Parameters	Depth	Sal	DO	pH	T	TCC	TOC	MP	ORP	SD	NS	NI
Depth	1,000											
Sal	,623**	1,000										
DO	-,226*	-,239*	1,000									
pH	ns	ns	,616**	1,000								
T	ns	ns	ns	ns	1,000							
TCC	,478**	,277*	-,273*	ns	ns	1,000						
TOC	,584**	,541**	ns	ns	-,314**	,291**	1,000					
MUD	,776**	,492**	ns	ns	ns	,370**	,434**	1,000				
ORP	-,274*	-,081	-,477**	-,622**	-,229*	-,229*	-,055	-,147	1,000			
SD	,924**	,554**	-,273*	ns	ns	,433**	,488**	,691**	-,256*	1,000		
NS	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	1,000	

chemical material residues in the sediment, and wave motion in the water, as are other living organisms living in the aquatic environment [46]. For this reason, the species diversity may have differed among the different stations due to the influence of the above-mentioned factors.

Aurila convexa, C. antiquata, C. elongata, L. gibberosa, P. fuscum, and *X. decipiens* were shown to have a wide distribution in this study. *Loxoconcha rhomboidea* (369 individuals), *X. aurantia* (351 individuals) *L. gibberosa* (318 individuals), *L. minima* (315 individuals), *X. communis* (315 individuals), *A. prasina* (312 individuals), and *L. stellifera* (312 individuals) were the most abundant species on the Kapıdağ Peninsula coastline.

Aurila convexa is known to be a cosmopolitan Mediterranean species [30]. It is also common in the Sea of Marmara and has been recorded in northern parts of the Aegean Sea [33], as well as in the Black Sea in brackish water systems as a polyhaline species [27]. It is widely distributed in the littoral and sublittoral zones of most Turkish coastlines [21]. *Aurila convexa* was observed at all the stations in the present study at high frequency (77.4%), with a wide range of ecological parameters and at higher numbers than other species, showing a significant negative correlation with mud percentage.

Aurila prasina is a typical near-shore species and has been reported in a variety of marine habitats in the Aegean Sea, the Black Sea, as well as lagoon environments [21]. In accordance with other studies, we determined a high number of individuals of this species from 20 stations (excepting E-3 station), in mesohaline to polyhaline conditions at depths ranging from 0.5 to 30 m. Its frequency was 70.2 %, and it showed a significant negative correlation with mud percentage, similar to *A. convexa*. *Carinocythereis antiquata* occurs in all types of bottom sediments, from shallow water to 71 m depths in the Adriatic Sea [30]. It is also a common species in the Mediterranean Sea [30]. Concordantly, we observed this species at all stations from 0.5 m to 30 m, in a variety of ecological environments at 66.7% frequency. No correlation detected between this species and ecological parameters.

Cushmanidea elongata is a common species in the Mediterranean Sea and the Aegean Sea [21]. We observed this species at all stations in mesohaline to polyhaline conditions, although the number of individuals was not high, at 65.5% frequency. It showed a significant negative correlation with pH.

Loxoconcha gibberosa has been identified in the Aegean Sea and the Sea of Marmara [21]. We determined this species at all the stations on the Kapıdağ Peninsula coastline, from mesohaline to polyhaline salinity conditions, with a high number of individuals and at 78.6% frequency. A significant positive correction was detected between TCC and this species.

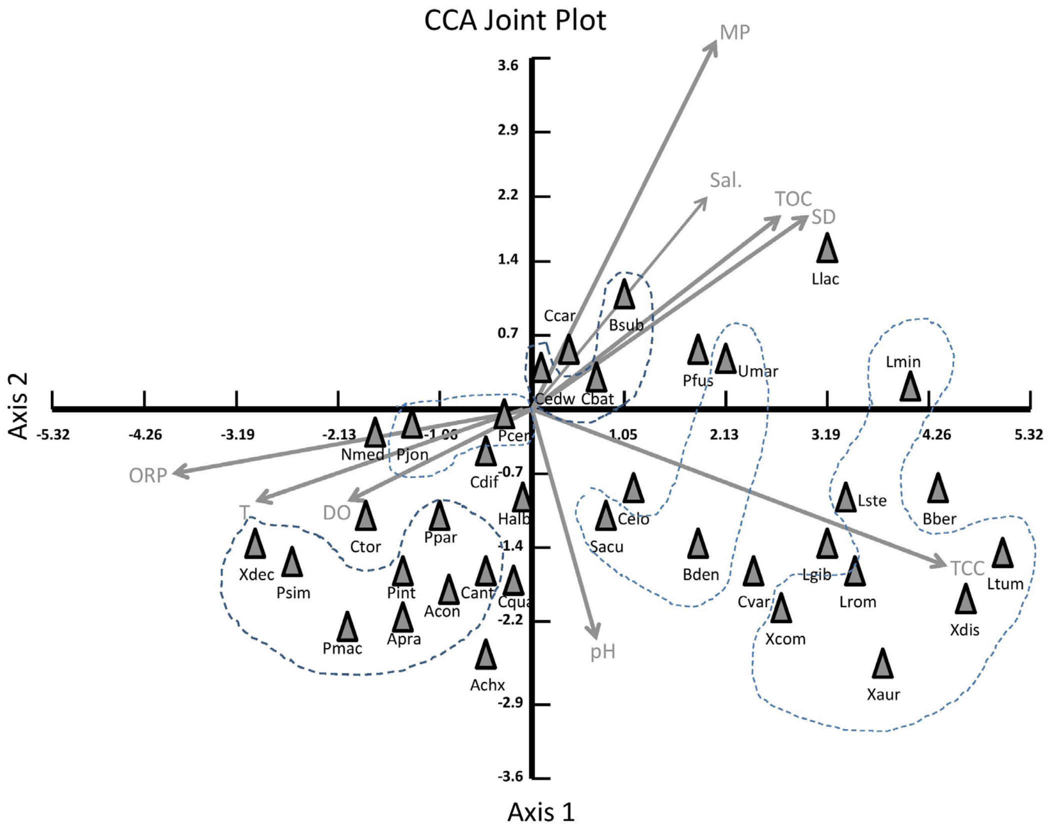

Figure 4. Canonical correspondence analysis (CCA) plot showing relationships between environmental variables and the 36 species. Eigenvalues 0.121-axis 1; 0.089-axis 2; percentage 23.945-axis 1; 17.543-axis 2; Cumulative Percentage 23.945-axis 1; 41.488-axis 2; Cumulative Constr. Percentage 23.945-axis1; 41.488-axis 2; Species-environment correlations 1-axis 1; 1-axis 2. (The dashes show the species groups that composed compatible with Bray-Curtis dendrograms)

Loxoconcha minima prefer a near-shore environment with sandy, silt, and pelite substrates [30]. We observed this species abundantly at 19 stations (excepting N-4 and N-5) at a frequency of 70.2% (Table 2). It has previously been identified on the coasts of the Mediterranean Sea and the Sea of Marmara [21]. This species showed a significant positive correlation with mud percentage.

Xestoleberis aurantia has been found as a euryhaline species in northeast England [46]. This species is known as a marine brackish littoral species, but has also been reported in freshwater and oligohaline shallow-water environments [47]. We observed *X. aurantia* from mesohaline to polyhaline environments at 18 stations. It was observed in the present study with a wide range of ecological parameters at high numbers, at a frequency of 66.7%. A positive correlation was detected with TCC.

Xestoleberis communis was observed at 18 stations (excepting N-3, N-4, N-5) with a wide range of ecological parameters but particularly in polyhaline conditions, and at a frequency of 73.8%. This species has been identified as a dominant species and is widely distributed in the Mediterranean Sea [28,48]. No correlation was detected between this species and the studied ecological parameters.

We determined *X. decipiens* at all the stations in mesohaline to polyhaline conditions. The number of individuals was not high but the species was widely distributed in different ecological environments at a frequency of 78.6%. It has been identified on most Turkish coastlines in recent studies [21]. This species showed negative correlations with depth, mud percentage, and Secchi depth, and a positive correlation with dissolved oxygen.

Loxoconcha rhomboidea was observed as the most abundant species on the Kapıdağ Peninsula coastline, with the highest individual numbers and at a frequency of 75.0%. It was found in mesohaline to polyhaline conditions at 19 stations (excepting N-3 and N-4). This is a very common species, widely found in littoral and sublittoral zones of most Turkish coasts [21]. It has been reported at 1–57 m depths in the Mediterranean Sea

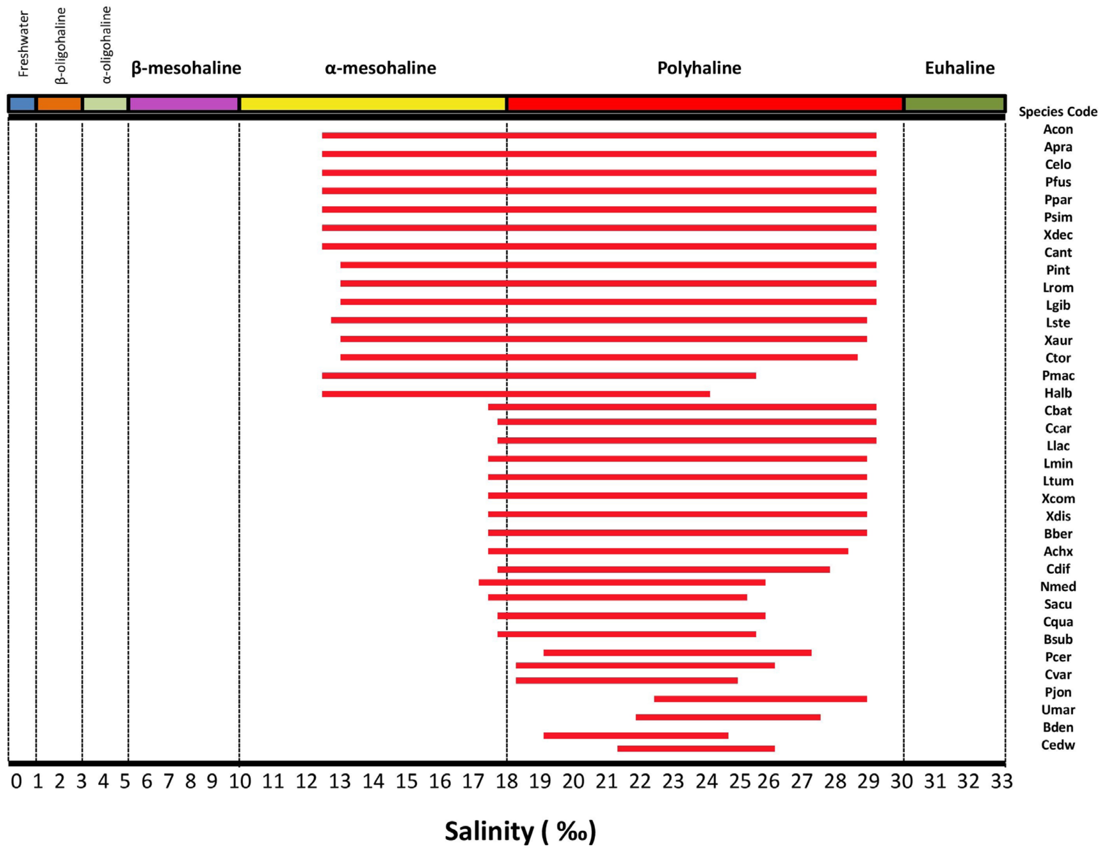

Figure 5. The ostracod species and their salinity records from Kapıdağ Peninsula.

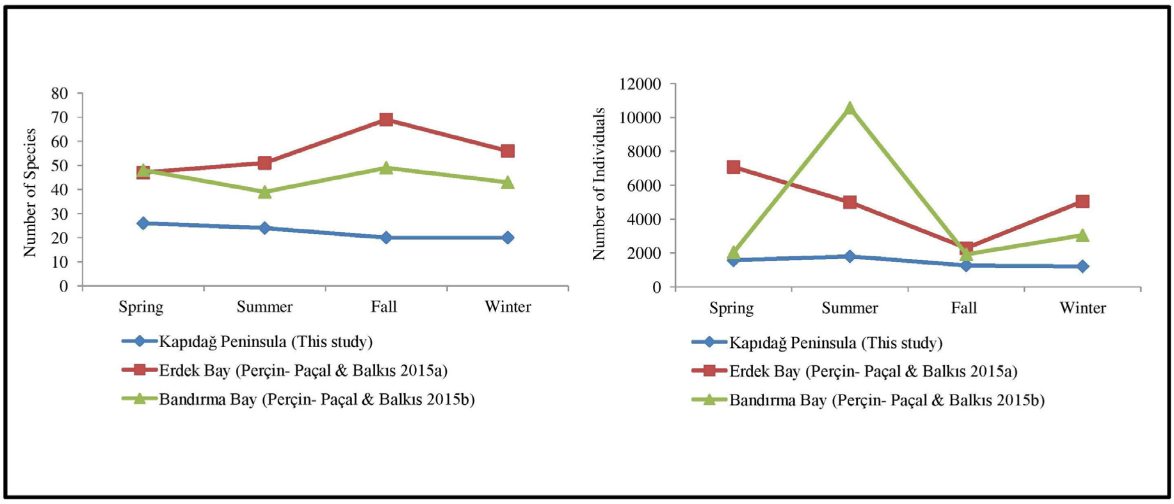

Figure 6. Seasonal numbers of ostracod species and numbers of individuals determined in the current study compared to other studies.

[28,33]. No correlation was detected between this species and our ecological parameters.

Loxoconcha stellifera was observed at 0.5-30 m depths in this study, in high numbers and at a frequency of 75.0%, from mesohaline to polyhaline conditions. The species has been observed at 3.5-33 m on muddy and sandy sediments in the Aegean Sea [28,33]. It also lives in the littoral and sublittoral zones of most Turkish coasts [21]. A positive correction was observed between this species and dissolved oxygen.

Although *Paradoxostoma fuscum* is not found widely on Turkish coastlines [21], we observed this species at all the stations, from mesohaline to polyhaline conditions at 64.3% frequency. No correlation was detected between this species and the ecological parameters.

A greater number of ostracod species and individuals were observed in the Bandırma and Erdek bays at the same depths in the years of 2006-2007 [23,24]. When the current study's findings on habitat variables are compared with the studies mentioned above, it was noted that DO, salinity, and temperature were lower in the current study (Table 7).

In 2008, an environmental problem occurred due to the formation of mucilage formed by the proliferation of diatoms together with bacteria throughout the Sea of Marmara. Some studies stated that because of this, living creatures in the Sea of Marmara were adversely affected [49,50]. This could explain the decrease in ostracod species and the number of individuals and changes in ecological parameters since the previous research on Kapıdağ Peninsula. [22-24].

Although the measured average DO was at appropriate survival levels in this study, it decreased to 1.2 mgL^{-1} at W-3 and W-4 stations, especially during winter. It has been observed in general that DO significantly decreases with depth in all seasons. In previous studies, although the measured DO was higher, the decrease of DO with depth has been observed in Bandırma Bay and Erdek Bay [23,24]. It is well known that the DO in surface waters is higher due to photosynthetic activities and DO reduces with depth. Increase of phytoplankton biomass in response to excessive inputs of nutrients and higher organic loads in eutrophic systems lead to an increase in bacterial activity and a decrease in DO levels [51]. When the DO level falls below 5 mgL^{-1}, oxygen-sensitive invertebrate and fish species are negatively affected [52]. The amount of the DO measured in the current study was lower than in previous studies [23,24]; therefore, the adverse effects of low DO on organisms that live in the study area of the Kapıdağ Peninsula are inevitable.

Secchi disk visibility in oligotrophic waters is 20–40 m, in mesotrophic waters 10–20 m, and in eutrophic waters, less than 10 m [53]. Secchi depths ranged between 0.5 and 13 m in the current study. These values show that the study area is in the mesotrophic water category. The Secchi depth measurements from this study are very similar to previous ones: 3–13 m in the Bandırma and Erdek bays in the years of 2006-2007 [23-24].

Erdek Bay and Bandırma Bay are affected by heavy pollutants coming from numerous industrial facilities and human settlements [50]. The northeastern part of Kapıdağ Peninsula contains higher levels of phosphates than other regions [50]. Waters from Susurluk River and Kara River spill into Bandırma Bay and pollute the surface waters [50]. The presence of a white-meat processing plant and a fertilizer factory also causes intense pollution in this region [54]. According to the Integrated Coastal Area Plan of Bursa Province (2015) [55], the Sea of Marmara is less polluted, but Bandırma Bay and Gemlik Bay are at a mid-level stage polluted and were found to be prone to intense pollution. As can be inferred from the results of the current study, the decrease in the number of ostracod species and individuals and the decrease in the quality of the environmental variables (DO, salinity, and temperature) suggest that negative changes in the water quality of Kapıdağ Peninsula's coastline are because of pollution. These polluted environments allow for the advance of cosmopolitan species with wide ecological tolerance through the elimination of low-tolerance species. Already, the existence of environmental tolerant species *L. stellifera* [56,57], *A. prasina* [57], *L. rhomboidea* [56,57], and *X. aurantia* [57] and the reduction of the number of ostracod species are suggested by our findings.

Although the results of this study have not been thoroughly evaluated in terms of pollutants on the surface waters, the results show that the Kapıdağ Peninsula coastline has an ecosystem that requires measurement in terms of pollutants.

The present study establishes a sharp decline in ostracod species numbers. This evident decline can be attri-

Table 7. Comparative ecology of the Kapıdağ Peninsula coastline (this study 2011-2012) and the Erdek and Bandırma bays in the years of 2006-2007 [23,24].

Depth	Ecological Parameters	Kapıdağ Peninsula This study (2011-2012) (Mean values)	Erdek Bay [23] (2006-2007) (Mean values)	Bandırma Bay [24] (2006-2007) (Mean values)
0-0.5 m	Salinity (‰)	20.3	24.8	24.5
	Dissolved oxygen (mg/l)	6.9	10	9.6
	Temperature (°C)	16.4	17.7	17.4
	Total organic carbon (%)	0.8	0.4	0.4
	Total calcium carbonate (%)	2.8	4.8	4.1
	Mud percentage (%)	0.5	0.39	1.09
1 m	Salinity (‰)	20.7	24.7	24.2
	Dissolved oxygen (mg/l)	6.8	8.9	9.1
	Temperature (°C)	15.2	16.9	17.5
	Total organic carbon (%)	0.7	0.5	0.5
	Total calcium carbonate (%)	2.7	2.6	1
	Mud percentage (%)	21.7	4.96	1
5 m	Salinity (‰)	21.4	25	24.9
	Dissolved oxygen (mg/l)	6.3	8.1	8.4
	Temperature (°C)	14.9	16.2	16.1
	Total organic carbon (%)	0.8	0.7	0.4
	Total calcium carbonate (%)	3	62.8	1.3
	Mud percentage (%)	19.9	15.82	1.5
10 m	Salinity (‰)	21.8	25.2	25.7
	Dissolved oxygen (mg/l)	6.7	7.6	8.1
	Temperature (°C)	14.3	15.8	16.5
	Total organic carbon (%)	1.1	1.3	1.6
	Total calcium carbonate (%)	7	71.1	17.1
	Mud percentage (%)	29.5	37.24	31
20 m	Salinity (‰)	24.1	30.2	27.7
	Dissolved oxygen (mg/l)	5	7.2	7.8
	Temperature (°C)	12	14.1	13.5
	Total organic carbon (%)	1.7	0.8	1.2
	Total calcium carbonate (%)	30.8	48.7	57.9
	Mud percentage (%)	24.4	47.07	48.03
30 m	Salinity (‰)	27.5	36	35.5
	Dissolved oxygen (mg/l)	4.5	6	6.3
	Temperature (°C)	14.1	15.5	15.4
	Total organic carbon (%)	2.1	1.5	2.4
	Total calcium carbonate (%)	7.2	14.1	11.9
	Mud percentage (%)	31.6	91.02	85.99

buted to low dissolved oxygen levels at depth, which is evidence of the adverse effects of anthropogenic activities on the marine ecosystem on the Kapıdağ Peninsula coastline.

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