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Interstitial harpacticoid (Copepoda, Harpacticoida) fauna inhabiting mediolittoral zone of the Gulf of Saros (Turkey)

Orkan METİN, Alp ALPER*, Serdar SAK

Balıkesir University, Faculty of Science and Literature, Department of Biology, Balıkesir.

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Abstract

The study was aimed to reveal interstitial harpacticoid copepod fauna of the Gulf of Saros (Turkey), where no detailed research has been done before on this subject. The samples were collected from 30 stations located along the mediolittoral zone of the gulf between 2013 and 2014. As a result, a total of 72 species/subspecies belonging to 44 genera in 15 families were identified. All identified taxa except Tryphoema gallipoliensis Alper et al., 2018 are new records for the study area, besides 16 species were also recorded for the first time from the Turkish seas.

Keywords: *New record, biodiversity, meiofauna, Aegean Sea.*

Saros Körfezi'nin (Türkiye) mediolitoral bölgesinde yaşayan kumiçi harpaktikoid (Copepoda, Harpacticoida) faunası

Öz

Bu çalışma, daha önce bu konuda detaylı bir araştırma yapılmamış olan Saros Körfezi'nin (Türkiye) kumiçi harpaktikoid kopepod faunasını ortaya çıkarmayı amaçlamıştır. Örnekler körfezin mediolitoral bölgesi boyunca yer alan 30 istasyondan 2013-2014 yılları arasında toplanmıştır. Sonuç olarak, 15 familya içerisindeki 44 cinse ait toplam 72 tür/alttür tespit edilmiştir. Tryphoema gallipoliensis Alper vd., 2018 dışında tespit edilen tüm taksonlar çalışma alanı için yeni kayıt olup, 16 tür de Türkiye denizlerinden ilk kez kaydedilmiştir.

Anahtar kelimeler: *Yeni kayıt, biyoçeşitlilik, mayofauna, Ege Denizi*

*Alp ALPER, alpalper80@gmail.com, http://orcid.org/0000-0001-5507-4072
Orkan METİN, orkanmetin10@gmail.com, http://orcid.org/0000-0002-5876-1246
Serdar SAK, serdarsak@gmail.com, http://orcid.org/0000-0002-4955-3162

1. Introduction

Faunistic studies are of great importance for determining biodiversity, for identifying new taxa and for analyzing faunas in a regional or global context. The results of the faunistic researches are used in many fields of science such as agriculture, forestry, marine, ecology and environmental protection [1-3]. Turkey has a rich biodiversity compared to other European countries due to its geographical location and geological history [4-6]. However, there is no sufficient information in the literature about the diversity of some invertebrates of Turkey such as harpacticoid copepods. Unexplored faunistic richness prevents sustainable use of biologic resources and of rational evaluation of habitat reserves [7]. The first study on the Harpacticoida fauna of Turkey was conducted by Noodt [8] and as a result 52 species/subspecies were reported from the sea of Marmara. Two more studies were carried out until the beginning of the 2000's by Băcescu [9] and Gündüz [10], and only three harpacticoid species were added to Turkish fauna. After that the studies have accelerated and many literatures about harpacticoids were published in Turkey (see [11]) thus the number of harpacticoid species identified from the Turkish Seas was raised to 210 [12]. Recently six new species were added by several authors [13-17] so the number of species has reached to 216. Although the taxonomical researches about harpacticoids of Turkey have increased in the last 15 years, it would not be wrong to say that these studies are quite far from to reveal the real harpacticoid diversity. The knowledge about marine harpacticoid fauna of Turkey is the tip of the iceberg; since most of the studies - as in this study - have focused on the mediolittoral zone of certain beaches so far then almost nothing is known about the Harpacticoida fauna living in the other zones. Moreover, many rocky shores are available on the Turkish coastline and studies about phytal harpacticoids inhabiting these areas are also very limited. Published data about marine harpacticoids is very limited for some coasts of Turkey. For instance, the number of harpacticoid species recorded from the entire Black Sea coast of Turkey is only 6, even though over than 200 species were reported from Bulgarian Black Sea coast [18, 19]. Gulf of Saros is one of the regions in Turkey where detailed information about harpacticoids is not available therefore this study was carried out to reveal interstitial Harpacticoida fauna inhabiting mediolittoral zone of the Gulf of Saros.

2. Material and methods

The Gulf of Saros is located in the northwestern part of Turkey and has a coastline about 75 km in length. The gulf was announced as a Special Environmental Protection Area in 2010 by the Cabinet Decree of the Turkish Government [20]. Harpacticoid copepods were collected from 30 stations located along the intertidal zone of the gulf (Figure 1 and Table 1). The stations were sampled 3 times between May 2013 and February 2014 using the Karaman-Chappuis [21] method. Collected samples were placed in 100 mL polypropylene containers then preserved in 4% formalin solution in situ. Water temperature, dissolved oxygen, pH and salinity were measured in situ using YSI 556MPS portable instrument. Extraction of the specimens were made under SZX-16 stereomicroscope. Harpacticoids were prepared according to Alper et al. [22] then identified under an Olympus BX-50 microscope. The slides were sealed with Entellan or transparent nail polish, the residual material deposited in 70% ethanol. All specimens were deposited in collection of Department of Biology, Faculty of Science and Literature, Balıkesir University. The map was produced using the tool on seaturtle.org website. The Roman numerals (I, II, III) given in Table 1-3 indicates the sampling dates and represents

the seasons spring, autumn and winter respectively. Huys et al. [23], Wells [24] and other relevant literature were used for identification.

Table 1. Sampling dates and coordinates of the stations.

Station No.	Localities	Coordinates		Sampling dates		
				I	II	III
S1	Seddülbahir (Ertuğrul Cove)	N 40.04268°	E 26.18462°	25.05.2013	29.09.2013	23.02.2014
S2	İkiz Cove (X Beach)	N 40.06317°	E 26.17724°			
S3	Kabatepe Beach	N 40.21166°	E 26.27507°			
S4	500 m. north of ANZAC Cove	N 40.24949°	E 26.28117°			
S5	Suvla Cove (Anafartalar)	N 40.31423°	E 26.24087°			
S6	Ece Harbour	N 40.36253°	E 26.32375°			
S7	Sazlık Cove (Tayfurköy Village)	N 40.42616°	E 26.43385°			
S8	Kömür Harbour (Fındıklı Village)	N 40.45619°	E 26.51112°			
S9	Yeniköy Village	N 40.49364°	E 26.58605°	26.05.2013	28.09.2013	22.02.2014
S10	Güneş Sitesi (Ocaklı Village)	N 40.50872°	E 26.63656°			
S11	Güneyli Village	N 40.50796°	E 26.69637°			
S12	Baklaburnu Beach (Bolayır Village)	N 40.54768°	E 26.74718°			
S13	Saros Holiday Village	N 40.57180°	E 26.81890°		—	—
S14	Gökçetepe	N 40.63769°	E 26.61267°		28.09.2013	22.02.2014
S15	Gökçetepe Picnic Area	N 40.63119°	E 26.59244°			
S16	İtalyan Cove (Kale Cove)	N 40.59603°	E 26.51068°			
S17	Mecidiye Beach	N 40.60632°	E 26.49046°		27.09.2013	21.02.2014
S18	Danışment Beach	N 40.59914°	E 26.41403°			
S19	Harbour of Yaylaköy Village	N 40.60576°	E 26.37153°			
S20	1st Tuzla beach (Vakıf Motel)	N 40.59773°	E 26.24320°	26.05.2013		
S21	Sultaniçe	N 40.59211°	E 26.14025°			
S22	Altınkum (Gaziömerbey Village)	N 40.65168°	E 26.06587°			
S23	Enez Beach	N 40.68969°	E 26.05796°			
SY1	East of Sazlıdere Village	N 40.64288°	E 26.72029°	—	28.09.2013	22.02.2014
SY2	Evreşe Beach (Kavakköy Village)	N 40.61662°	E 26.83228°	—		
SY3	Enderkent Holiday Village	N 40.58335°	E 26.83727°	—		
SY4	Karaağaçlı Cove	N 40.43955°	E 26.45517°	—	29.09.2013	23.02.2014
SY5	Koyun Harbour	N 40.38705°	E 26.36 411°	—		
SY6	Kanlısırt Beach	N 40.23109°	E 26.27644°	—		
SY7	Kum Limanı Holiday Village	N 40.16248°	E 26.24680°	—		

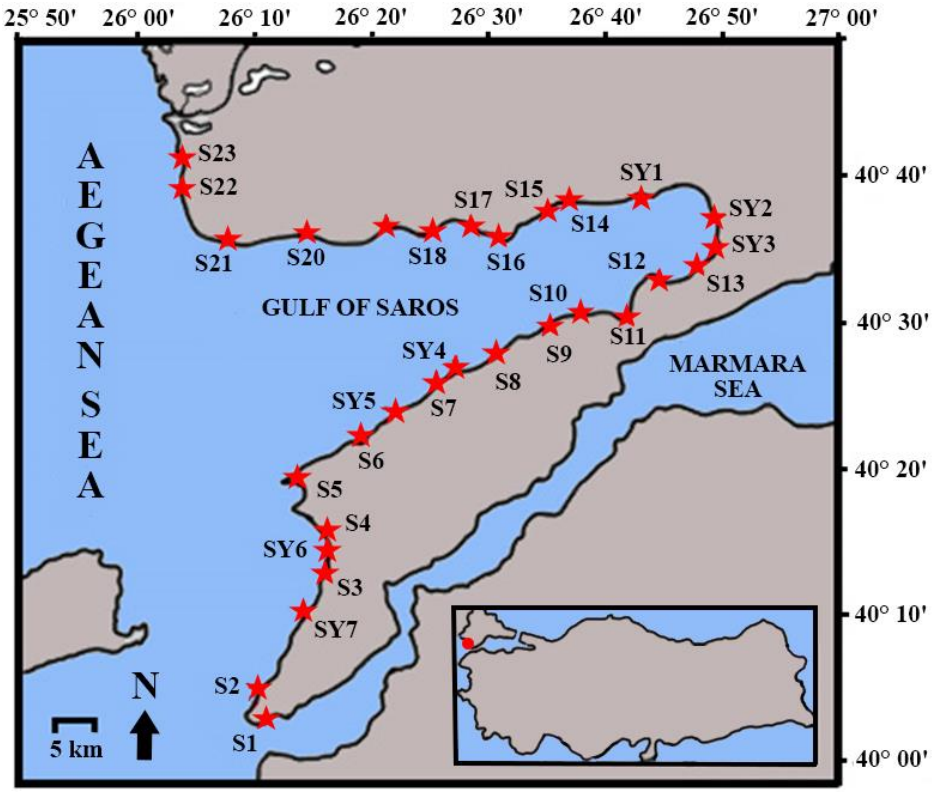

Figure 1. The sampling stations and the study area

3. Results

A total of 72 species belonging to 15 families were identified. Some species were identified at genus level as they could not be identified with available keys and literature. Identified taxa according to stations and their distributions in Turkey are given in Table 2. Measured environmental parameters at the study area are given in Table 3.

Table 2. List of harpacticoids and their localities determined in these study and comparison with the previous records from Turkey. A: Noodt [8], B: Karaytuğ & Huys [25], C: Huys et al. [26], D: Karaytuğ & Sak [27], E: Sak et al. [28], F: Pulat et al.[29], G: Alper et al. [22], H: Sönmez et al. [30], I: Kaymak et al. [31], J: Sönmez et al. [32], K: Köroğlu et al. [33], L: Alper et al. [34], M: Sönmez et al. [35], N: Karaytuğ & Koçak [11], O: Yıldız & Karaytuğ [12], P: Sönmez et al. [36], Q: Alper et al. [13].

Taxa	(Samplings) Station no.	Distribution in Turkey
AMEIRIDAE Monard, 1927		
Ameira atlantica mediterranea Kunz, 1975	(I) S6. (II) S8.	New Record
Ameira minuta Boeck, 1865	(II) S3, SY4. (III) SY4.	New Record
Ameira parvula (Claus, 1866)	(I) S4, S5, S9, S18, S20, S21. (II) S1, S3, S18, SY3, SY5, SY6. (III) S3, S9, S16, SY6.	D, G, J

Table 2. (continued)

Ameira sp 1.	(I) S2, S9, S12, S21, S22, (II) S2, S8S10, S12, S14, S15, S17, S18, S22, SY6. (III) S2, S5, S9, S10, S17, S23.	----------
Ameira sp 2.	(I) S6, S8, S9, S19, SY5. (III) S6, S8, S16, S22.	----------
Ameiropsis reducta Apostolov, 1973	(III) S21.	G
Filexilia attenuata (Thompson I. C., 1893)	(III) S21.	D
Filexilia brevipes (Kunz, 1954)	(III) S18, S19.	New Record
Filexilia marinovi Conroy-Dalton & Huys, 1997	(II) S2. (III) S1, S2.	G
Leptomesochra eulitoralis Noodt, 1955	(I) S19–S21, S23. (II) S3, S17, S20, S21. (III) S3, S17, S18, S20–S22, SY7.	New Record
Leptomesochra sp.	(I) S20. (II) S18.	----------
Nitokra affinis Gurney, 1927	(I) S7, S8. (II) S1, S8.	J
Nitokra pontica Jakubisiak, 1938	(II) S8–S10.	New Record
Nitokra spinipes Boeck, 1865	(II) S7. (III) S7.	A, D
Nitokra typica Boeck, 1865	(I) S9.	K
Parevansula mediterranea Guille & Soyer, 1966	(I) S20.	New Record
Pseudoleptomesochrella halophila (Noodt, 1952)	(I) S2, S20. (II) S4, S20. (III) S3, S4, S16, S22, SY5–SY7.	E
Psyllocamptus eridani Ceccherelli, 1988	(I) S12. (III) S11, S12, S22, SY5.	L, O
Psyllocamptus minutus G.O. Sars, 1911	(II) S1, S21. (III) S1, S2.	A, D
Psyllocamptus sp.	(I) S6. (II) S11, S12. (III) S22.	----------
ARENOPONTIIDAE Martínez Arbizu & Moura, 1994		
Arenopontia nesaie Cottarelli, 1975	(I) S1, S5, S12, SY2, SY7. (III) S1, S5, S12, SY2, SY7.	E, L
Arenopontia sp.	(I) S3, S5, S14, S22. (II) S20. (III) S17.	----------
Psammoleptastacus barani Sak, Huys & Karaytuğ, 2008	(II) S17, S22.	E, L
CANTHOCAMPTIDAE Brady, 1880		
Mesochra pygmaea (Claus, 1863)	(I) S3, S16.	A, L
Taurocletodes tumenae Karaytuğ & Huys, 2004	(I) S2, S4, S9, S14, S19, S22, S23. (III) S3, S4, S6–S8, SY4 , SY5.	B
Itunella sp.	(I) S14.	New Record
CLETODIDAE Scott T., 1904		
Enhydrosoma sp.	(I) S9.	----------
DARCYTHOMPSONIIDAE Lang, 1936		
Leptocaris biscayensis (Noodt, 1955)	(II) S12, S17. (III) S21, SY7.	K, L, O
Leptocaris insularis (Noodt, 1958)	(I) S21, S22. (II) S21. (III) S4, S23.	New Record
ECTINOSOMATIDAE Sars, 1903		
Arenosetella germanica Kunz, 1937	(I) S3, S5, S8, S17, S18, S21, S22. (II) S1, S4, S5,	D, G,

Table 2. (continued)

	S10, S17, S22, SY7. (III) S3–S5, S10, S17, S21, S22, SY6, SY7.	
Arenosetella sp.	(I) S9.	----------
Ectinosoma melaniceps Boeck, 1865	(I) S7, S9. (II) S1, S3, S6, SY4, SY7. (III) S17, SY4.	A, D, H
Ectinosoma reductum Bozic, 1955	(I) S4. (II) SY4. (III) S6, S16, SY4,	H, L
Ectinosoma soyeri Apostolov, 1975	(I) S2, S6, S20–S23. (II) S2, S6– S10, S15, S17, S18, S20–S23, SY5, SY6. (III) S2, S6–S10, S15–S18, S20, –S23, SY5–SY7.	G, H, K
Glabrotelson bodini (Apostolov, 1974)	(I) S1, S2, S17.	G, H, L
Halectinosoma herdmani (T. Scott, 1894)	(I) S9, S17, S18. (II) SY3. (III) S11, S16.	G
Microsetella norvegica (Boeck, 1865)	(I) S7. (II) S1, S6, S7, S20, SY5. (III) S5, S23, SY5.	G, H, L, N
Klieosoma sp.	(I) S17.	New Record
LAOPHONTIDAE T. Scott, 1905		
Afrolaophonte pori Masry, 1970	(II) S4, S20–S22. (III) S4, S6, S8, S21.	G, L, O, P
Heterolaophonte stroemi (Baird, 1934)	(I) S4. (II) S2, S21.	D
Heterolaophonte sp.	(II) S6.	----------
Klieonychocamptus kliei (Monard, 1935)	(I) S20, S23. (II) S2, S3, S14, S18, S20, S21, S23, SY6, SY7. (III) S2, S16, S18–S20, S22, S23, SY6.	D, O
Klieonychocamptus ponticus (Serban & Plesa, 1957)	(I) S9, S21. (II) S3, S6, S9, S10, S12, S21. (III) S3, S8, S11, S17, S21, SY7.	I, L
Lipomelum adriaticum (Petkovski, 1955)	(I) S9. (II) S2.	L, O
Paralaophonte brevirostris (Claus, 1863)	(I) S3, S4, S9. (III) S2.	A, F, G, L, O
Paralaophonte asellopsiformis Lang, 1965	(III) S3.	New Record
Laophonte elongata barbata Lang, 1934	(I) S16.	New Record
LATIREMIDAE Bozic, 1969		
Delamarella obscura Huys, Karaytuğ & Cottarelli, 2005	(I) S2, S4, S9, S16, S17, S19, S23. (II). S17, S20. (III) S2.	C, D, G, L
LEPTASTACIDAE Lang, 1948		
Paraleptastacus holsaticus Kunz, 1937	(I) S10. (II) S9, S10. (III) S9.	New Record
LONGIPEDIIDAE Boeck, 1865		
Longipedia coronata Claus, 1862	(II) S4.	New Record
MIRACIIDAE Dana, 1846		
Amphiascoides brevifurca (Czerniavsky, 1868)	(I) S4.	A, J
Amphiascopsis cinctus (Claus, 1866)	(II) SY7.	D, G, J, L, N
Bulbamphiascus imus (Brady, 1872	(II) S10.	D, J
Psammotopa vulgaris Pennak, 1942	(II) SY2. (III) SY7.	J, L
Robertsonia knoxi (Thompson I.C. & Scott A., 1903	(II) S23, SY3.	A, J
Robertgurneya smithi Hamond, 1973	(II) SY7.	J, L

Table 2. (continued)

Robertgurneya sp.	(I) S20.	----------
Sarsamphiascus angustipes (Gurney, 1927)	(I) S8, S16, S18, S19. (II) S3, S4, S19, SY6.	A, J, L, O
Sarsamphiascus minutus (Claus, 1863)	(II) SY7. (III) SY4.	G, J, L
Eoschizopera (P) gligici (Petkovski, 1957)	(I) S1. (II) S3, S12. (III) S4, S12, S21, S22, SY5, SY6.	D, J, L
Schizopera brusinae Petkovski, 1954	(I) S2, S6, S9, S19. (III) S6, S17, S23.	D, G, J, L
Schizopera pontica Chappuis & Serban, 1953	(I) S1–S3. (II) SY2.	New Record
Schizopera pratensis Noodt, 1958	(I) S14.	J
Schizopera sp.	(I) S2, S7, S12, S16, S18, S19. (II) S3, S17. (III) S4, S21.	----------
PARAMESOCHRIDAE Lang, 1944		
Apodopsyllus arenicolus (Chappuis, 1954)	(I) S12. (II) S1, S11, S12. (III) S1, S11, S12, SY7.	New Record
Diarthrodella ergeneae Sönmez, Karaytuğ & Sak, 2015	(I) S19. (II) S15.	M
Emertonia constricta (Nicholls, 1935)	(I) S3, S17, S22. (II) S3, S4, S17, S18, S20, S21, SY6. (III) S3, S4, S8, S16–S21, SY5, SY6.	D, G, L
Emertonia masryi (Bodin, 1979)	(II) S1, S11, SY2. (III) S1, S5, S11, SY2, SY7.	New Record
Emertonia sp.	(II) S11.	----------
PARASTENHELIIDAE Lang, 1936		
Parastenhelia spinose (Fischer, 1860)	(I) S22. (II) SY7.	G, L, O
RHIZOTRICHIDAE Por, 1986		
Tryphoema gallipoliensis Alper, Sak & Metin, 2018	(II) SY2. (III) SY2.	Q
TETRAGONICIPITIDAE Lang, 1944		
Phyllopodopsyllus briani Petkovski, 1955	(I) S2. (II) S2, S19, S22, S23.	D, O

Table 3. Measured environmental parameters at the study area (SD: standard deviation, Max.: maximum, Min: minimum).

	Water temperature (ºC)			**Dissolved O2 (mg/lt)**		
	I	**II**	**III**	**I**	**II**	
Mean±SD	22.88±1.08	24.68±1.75	12.97±1.45	6.30±1.68	7.19±1.54	
Max.	24.87	27.18	16.05	8.78	8.83	
Min.	21.18	20.72	10.28	2.45	3.68	
	Salinity (ppt)			**pH**		
	I	**II**	**III**	**I**	**II**	**III**
Mean±SD	33.61±1.78	32.70±3.66	35.81±6.47	7.82±0.26	7.72±0.22	8.11±0.26
Max.	35.72	34.90	39.01	8.10	8.01	8.93
Min.	27.43	17.95	8.51	7.09	7.06	7.72

4. Discussion

A total of 72 species within 15 families were identified. All identified taxa except *Tryphoema gallipoliensis* are new records for the studied area. According to the published data two genera (*Itunella* and *Klieosoma),* 16 species are recorded for the first time from Turkish coasts. In this study, the family Ameiridae is the most specious taxon with 20 species, followed by Miraciidae with 14 species, Ectinosomatidae and Laophontidae with 9 species each, Paramesochridae with 5 species, Arenopontiidae and Canthocamptidae with 3 species each, Darcythompsoniidae with 1 species. The remaining 7 families were represented with 1 species each. *Ectinosoma soyeri* which found at 17 different stations and in all samplings was the most common and abundant species. On the contrary, some species (*Ameiropsis reducta, Amphiascoides brevifurca, Amphiascopsis cinctus, Arenosetella* sp., *Bulbamphiascus imus, Emertonia* sp., *Enhydrosoma* sp., *Filexilia attenuata, Heterolaophonte* sp., *Itunella* sp., *Klieosoma* sp., *Laophonte elongata barbata, Longipedia coronata, Nitokra typica, Paralaophonte asellopsiformis, Parevansula mediterranea, Robertgurneya smithi, Robertgurneya* sp., *Schizospera pratensis, Tryphoema gallipoliensis*) were found in just one samplings, at only one stations, and their abundance are very low (maximum five specimens, except *Robertgurneya* sp.). The families Ameiridae, Miraciidae and Ectinosomatidae are known to be sediment associated and eurytopic [37, 38]. Therefore, they are the most common families in many faunistic studies carried out on the interstitial habitat in worldwide [39-44] as well as in Turkey [11, 12, 22, 27, 34]. In this study, in terms of species richness the family Ameiridae ranked first followed by Miraciidae and Ectinosomatidae. In terms of species diversity, autumn was ranked first with 50 species followed by spring and winter with 49 and 42 species respectively. Water temperature is a prime determinant of harpacticoid occurrence and development, increasing water temperature generally increases the rate of harpacticoid reproduction and lifespan [37, 45, 46]. The mean temperature of the sea water determined at the studied area was much higher in spring and summer than in winter (Table 3) and apparently increasing water temperature caused an increase in harpacticoid diversity. Harpacticoids inhabiting interstitial habitats are sensitive to oxygen depletion in the sediments [37, 47, 48]. In this study, the mean dissolved oxygen levels were determined higher than 5 mg/L (Table 3), therefore, it can be speculated that the level of dissolved oxygen was not an important factor on species diversity of the harpacticoids living in the studied area. Most harpacticoid species prefers slightly alkaline conditions between 7.2 and 7.7 [49]. The seasonal mean pH values determined in the study area were between 7.72±0.22 and 8.11±0.26 (Table 3), no remarkable change was observed during the studied period. Therefore, it is thought that the changes of pH values do not have a significant effect on the harpacticoid diversity. The studies have revealed that salinity levels between 30‰ and 40‰ are important for development of various harpacticoid species [50-52]. The seasonal mean salinity levels in this study were determined between 32.70±3.66‰ and 35.81±6.47‰ (Table 3), no significant change was observed. In this study, it can be speculated that the water temperature was the most effective parameter on the seasonal harpacticoid species diversity.

The total number of harpacticoid species reported from the Turkish coasts were 216 so far (see Introduction). With the addition of 16 species recorded for the first time in this faunistic study, the total number of harpacticoid species reported from Turkish seas are reached to 232.

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