



Seasonal Changes of Zooplankton Species and Groups Composition in Iskenderun Bay (North East Levantine, Mediterranean Sea)

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ABSTRACT

This study was carried out between January 2002 and November 2002 in the northern part of Iskenderun Bay (off shore of Yumurtalık-Kokar Cape) in the northeastern Mediterranean to determine seasonal changes of zooplankton. Samples were collected seasonally at 13 stations using WP2 net of 200 µm mesh by vertical and horizontal hauls. 29 species of copepods, 4 species of cladocera, 11 groups of holoplankton and 9 groups of meroplankton were determined in spring; 17 species of copepods, 4 species of cladocera and 8 groups of holoplankton and meroplankton, respectively, were determined in summer; 23 species of copepods, 2 species of cladocera, 10 groups of holoplankton and 7 groups of meroplankton were determined in autumn and 34 species of copepods, 12 groups of holoplankton and 7 groups of meroplankton were determined in winter. Lessepsian species were recorded in the area such as *Calanopia elliptica*, *Labidocera pavo*, *Pontellina plumata*, *Centropages furcatus*.

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Authors' Contribution

BTA collected and identified the zooplankton samples. ES and BTA wrote the article together.

Key words

Copepoda, Zooplankton
Iskenderun Bay

INTRODUCTION

Zooplankton hold significant importance in aquatic environments in that they constitute the first consumer step and second reproducer step in the food chain, they convert vegetal protein in phytoplankton into animal protein and they constitute the basic nutrients of invertebrate and vertebrate animal organisms requiring animal protein. Therefore the abundance and diversity of zooplankton depends on environmental conditions. The more diverse zooplankton is in an environment, the more abundant are the animal organisms that feed on zooplankton.

The Gulf of Iskenderun has had an important place in the Mediterranean, especially after joining of the migrant species from the Red Sea after opening of the Suez Canal. There are several zooplankton studies in different regions of Mediterranean (Kimor and Wood, 1975; Lakkis, 1984; Weikert and Trinkaus, 1990; Gotsis-Skretas *et al.*, 1992; Gücü *et al.*, 1992; Siokou-Frangou *et al.*, 1996; Mazzocchi *et al.*, 1997; Uysal *et al.*, 2002; Unal *et al.*, 2002; Dönmez *et al.*, 2006; Isari *et al.*, 2006; Zenginer-Yılmaz and Besiktepe, 2010; Mazzocchi *et al.*, 2014). However, the number of studies on the Gulf of Iskenderun are limited (Gökalp, 1972; Dönmez, 1998; Uysal and Shemeleva, 2002; Toklu and Sarıhan, 2003;

Terbiyık Kurt and Polat, 2013, 2014, 2015).

This study provides information on distribution and seasonal changes of zooplankton in the Gulf of Iskenderun, a part of Northeast Mediterranean which is an important fishing ground in the Mediterranean coast.

MATERIALS AND METHODS

Iskenderun Bay has a length of approximately 65km, a width of 35km and spans an area of 2247 square kilometers. Its maximum depth is at the entrance point to the Mediterranean and measures approximately 100 m. From this location, the depth exhibits irregular changes to the north-east line. The gulf has the same wide continental shelf in the northeast Mediterranean. Therefore the average depth of the gulf is only about 70 m. The gulf is exposed to the Sea Breezes active between June-September, and to the west winds in winters. The area is also exposed to winds from north and northeast, locally named "Yarıkkaya" which can blow for 3-5 days reach up to a speed of 50km/h, and also to South Winds from south and southeast (Aydın, 1999). The Gulf is also affected by many industrial facilities, mainly iron-steel, fertilizer and petroleum pipelines, and also by agricultural activities conducted at the gulf coast.

Zooplankton samples were seasonally collected between the dates January 2002 - November 2002, at the offshore of Yumurtalık-Kokar cape in the Gulf of Iskenderun, horizontally and vertically from 12 stations and only horizontally from 1 station (13.Station). The depth of these 13 stations ranged between 20 and 70 meters (Fig.1). Zooplankton samples were collected

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during daytime (08:00-12.00 am) using standard WP2 plankton net (200 μ m mesh size and 57 cm diameter) and preserved with 4% formaldehyde solution. Afterwards the samples were loaded into the sampling tank and deposited into a Dollfus-Cuve counting chamber (sub-sample), where they were counted under a stereomicroscope (Özel, 1992). Among the samples, copepods and cladocera were analyzed at species or genus level, while other holoplankton and meroplankton were analyzed at group level.

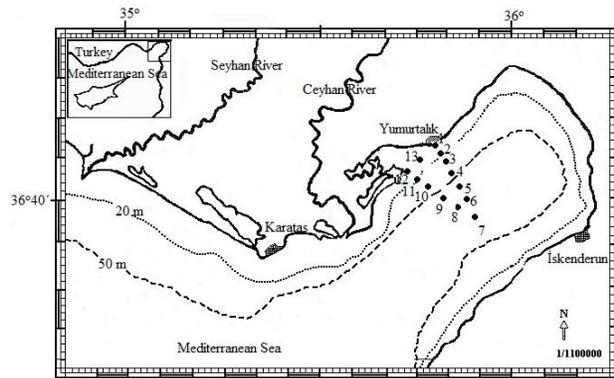


Fig. 1. Locations of sampling stations in İskenderun Bay.

Water temperature and salinity were measured with a salinometer model YSI.

Zooplankton identifications was performed according to Rose (1933), Brodskii (1950), Tregouboff and Rose (1957), Grice (1961), Kasturirangan (1963), Owre and Foyo (1967), Frost and Fleminger (1968), Boltovskoy (1981), Dussart and Defaye (1995), Özel (1996), Palomares *et al.* (1998), Bradford-Grieve *et al.* (1999), Bradford-Grieve (1999) and Todd *et al.* (2003).

Systematic classification and nomenclature of zooplankton species were made according to WORMS (2015).

Presence/absence data were used to Bray-Curtis Similarity index to determine the similarity among the sampling stations. The non-parametric Multidimensional Scaling test was performed using the Primer 6 software (Clarke and Warwick, 2001).

RESULTS

The sea surface temperature and salinity ranged from 16.6 to 29.3°C and 33.1 to 36.7‰, respectively (Fig.2).

Based on seasonal zooplankton distribution, 29 species of copepods, 4 species of cladocera, 11 groups of holoplankton and 9 groups of meroplankton were determined in spring; 17 species of copepods, 4 species

of cladocera and 8 groups of holoplankton and meroplankton, respectively, were determined in summer; 23 species of copepods, 2 species of cladocera, 10 groups of holoplankton and 7 groups of meroplankton were determined in autumn and 34 species of copepods, 12 groups of holoplankton and 7 groups of meroplankton were determined in winter (Table ID).

While the copepoda constituted 59% of the total zooplankton in horizontal spring haul, it constituted 69% of the vertical winter hauls. Cladocera constituted 41% of the total zooplankton in horizontal summer haul, it constituted 35% of the winter haul. Other holoplankton was determined as 34% in horizontal autumn haul and 35% in vertical haul. Meroplankton was determined as 15% in horizontal summer haul, while 17% in vertical spring haul (Fig.3).

Differences of sampling stations were shown clearly by MDS analysis, according to four seasons (Fig. 4).

Differences were observed in the seasonal availabilities of copepod species found in the research. For example, *Acartia (Acartiura) clausi*, *Calocalanus pavo*, *Corycaeus* spp., *Clausocalanus arcuicornis*, *Clausocalanus furcatus*, *Centropages violaceus*, *Euterpina acutifrons*, *Farranula rostrata*, *Mecynocera clausi*, *Oithona helgolandica*, *Oithona plumifera*, *Oithona setigera*, *Oncea* spp., *Paracalanus parvus* and *Temora stylifera*, among the copepods, were observed in every season. Other species, namely *Acartia grani*, *Acartia latisetosa*, *Acartia negligens*, *Calanus gracilis*, *Candacia ethiopica*, *Lucicutia ovalis*, *Paraeuchaeta hebes*, *Saphirina angusta*, *Saphirina gemma* were only found in spring; *Calanopia elliptica*, *Microsetella rosea*, *Pontellina plumata* and *Saphirina nigromaculata* were only observed in autumn; *Acartia discaudata*, *Aetideus giesbrechti*, *Calocalanus pavoninus*, *Calocalanus styliremis*, *Copilia mediterranea*, *Copilia quadrata*, *Macrosetella gracilis*, *Phaenna spinifera*, *Pleuromamma gracilis*, *Saphirina metallina*, *Saphirina ovatolanceolata*, *Scolecithricella tenuiserrata* and *Scolecithrix bradyi* were only observed in winter, *Calanus minor* was observed in spring, autumn and winter, *Calanus tenuicornis* was observed in spring and summer, *Calocalanus elegans*, *Candacia armata* and *Centropages furcatus* were observed in autumn and winter, *Centropages kröyeri* and *Pontella mediterranea* were observed in spring and summer, *Clytemnestra rostrata* was observed in summer, autumn and winter, *Euchaeta marina* was observed in spring, autumn and winter, *Labidocera brunescens* was observed in spring, summer and autumn, *Labidocera pavo* was observed in summer and spring, *Lubbockia squillimana* and *Lucicutia flavicornis* were observed in spring, autumn and winter, *Oithona nana* was observed in spring, summer and

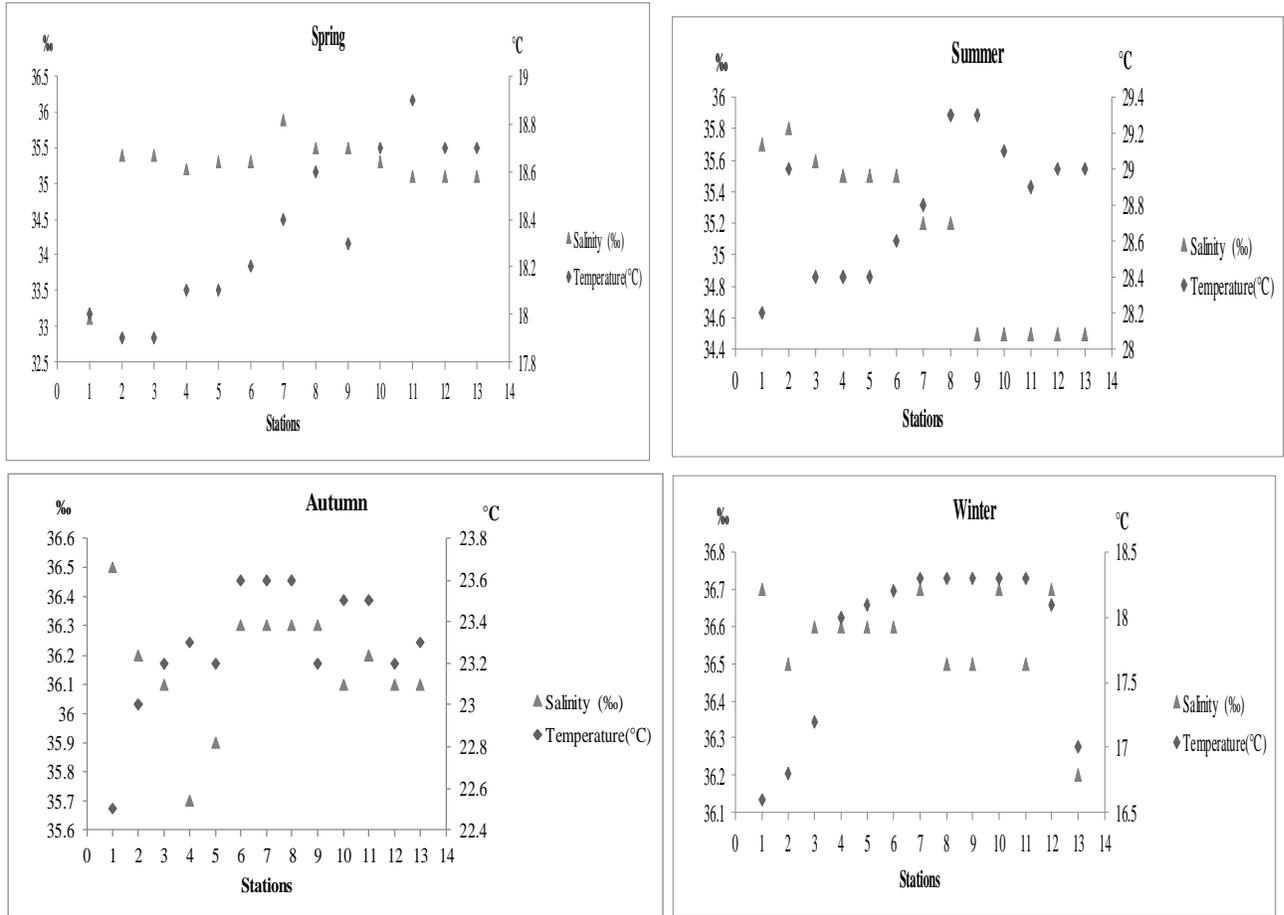


Fig. 2. Seasonal variations of surface temperature (°C) and salinity (‰) in Iskenderun Bay.

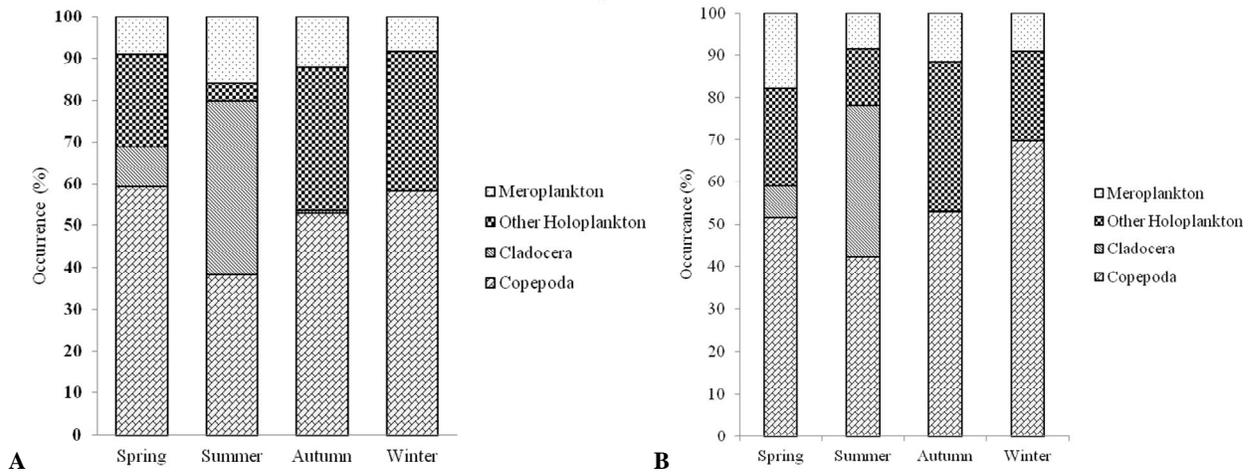


Fig. 3. Seasonal occurrence (%) of zooplankton in Iskenderun Bay. A, horizontal; B, vertical.

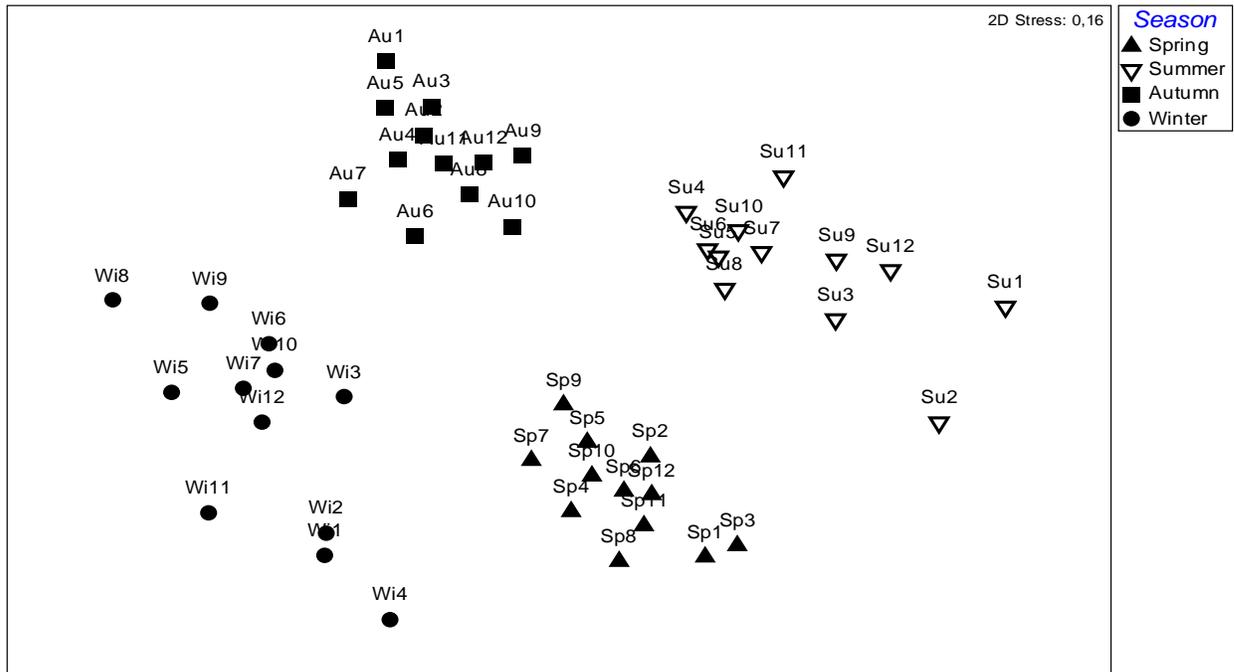


Fig. 4. Defined groups by multidimensional scaling analysis (MDS)

winter, *Paracandacia simplex* was observed in spring and autumn, and *Pontellopsis regalis* was observed in summer and autumn (Table IC). As mentioned above, among the copepod species acquired, *Calanopia elliptica*, *Labidocera pavo*, *Pontellina plumata* and *Centropages furcatus* are included in the lessepsian species.

Diversity of species among copepods was the highest in winter with 40 species, and the lowest in summer with 22 species.

Copepodite and nauplius larvae were encountered in every season.

Among the cladocera, *Evadne spinifera*, *Evadne tergestina* and *Penilia avirostris* were encountered in spring, summer and autumn, while *Pleopis polyphemoides* was encountered only in summer. No cladocera were observed in winter. The reason may be due to decreasing water temperature in winter.

Among the holoplankton; copepoda, appendicularia, chaetognatha, doliolida, medusae, pteropoda, salpidae and siphonophora were encountered in every season, amphipoda was encountered in spring and winter, cumacea was encountered in winter, foraminifera was encountered in summer, autumn and winter, heteropoda and ostracoda was encountered in spring, autumn and winter, and radiolaria was encountered in spring and winter.

Among the meroplankton; fish egg and larvae, cirripedia, decapoda, echinoderm, gastropoda and

polychaeta larvae were encountered in all four seasons. Bivalvia larvae were observed in spring, summer and autumn and stomatopod were observed in spring, summer and autumn.

Copepoda, cladocera and other holoplanktonic and meroplanktonic organisms were encountered in all seasons and mostly in all stations (Table I). It can be said that this situation is caused by the considerable similarity in terms of salinity and other measured physical parameters between the stations, which are scattered in a small area.

DISCUSSION

This study analyzes the groups and seasonal distributions of holoplankton and meroplankton in the 13 stations ranging in depth between 20m and 70m in the Gulf of Iskenderun (Yumurtalık-Kokar Cape offshore). Copepod and cladocera were provided as the species from the holoplankton group. 13 holoplankton, 9 meroplankton groups and 58 copepod and 4 cladocera species among holoplankton were determined in the study.

Similar results have also been reported in other studies: Gücü *et al.* (1992), in their study conducted in in the Northern Cilician basin of eastern Mediterranean Sea (Turkish Coast), reported 39 copepoda species, 11 holoplankton species and 8 meroplankton species; Uysal

Table I.- Seasonal succession of the zooplankton groups and species in study area in terms of the 13 stations.

Zooplankton groups and species	Seasons and Stations																																																																		
	Spring													Summer													Autumn													Winter																											
	1	2	3	4	5	6	7	8	9	10	11	12	13	1	2	3	4	5	6	7	8	9	10	11	12	13	1	2	3	4	5	6	7	8	9	10	11	12	13	1	2	3	4	5	6	7	8	9	10	11	12	13															
COPEPODA																																																																			
<i>Acartia (Acartiura) clausi</i>	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+						
<i>Acartia discoidata</i>																																																																			
<i>Acartia grani</i>	+																																																																		
<i>Acartia latisetosa</i>																																																																			
<i>Acartia negligens</i>																																																																			
<i>Aetideus giesbrechti</i>																																																																			
<i>Calanopia elliptica</i>																																																																			
<i>Calanus</i>																																																																			
<i>Calanus gracilis</i>																																																																			
<i>Calanus minör</i>																																																																			
<i>Calanus tenuicornis</i>																																																																			
<i>Calocalanus elegans</i>																																																																			
<i>Calocalanus pavo</i>																																																																			
<i>Calocalanus pavoninus</i>																																																																			
<i>Calocalanus styliremis</i>																																																																			
<i>Candacia armata</i>																																																																			
<i>Candacia ethiopia</i>																																																																			
<i>Centropages furcatus</i>																																																																			

Continued

Zooplankton groups and species	Seasons and Stations																																																	
	Spring									Summer									Autumn									Winter																						
	1	2	3	4	5	6	7	8	9	10	11	12	13	1	2	3	4	5	6	7	8	9	10	11	12	13	1	2	3	4	5	6	7	8	9	10	11	12	13											
Medusae	+																																																	
Ostracoda																																																		
Pteropoda																																																		
Radiolaria																																																		
Salpidae																																																		
Siphonophora																																																		
Fish larvae																																																		
Fish egg																																																		
Bivalvia larvae																																																		
Cirripedia larvae																																																		
Decapod larvae																																																		
Echinoderm larvae																																																		
Gastropod larvae																																																		
Polychaeta larvae																																																		
Stomatopod larvae																																																		

et al. (2002), in their study in northern levantine basin, reported 200 copepoda species; Toklu and Sarihan (2003), in their study conducted in Yumurtalık-Botaş coastline, reported 33 copepoda and 3 cladocera; Lakkis et al. (2005), in their study conducted in the Gulf of İskenderun, reported 34 copepoda species; Lakkis and Toklu Alicli (2007) in their study conducted in the Gulf of Iskenderun, reported 7 holoplankton and 5 meroplankton groups; Toklu Aliçlı et al. (2009), in their study conducted in the Gulf of Iskenderun (Yumurtalık-Sugözü coasts), reported 36 copepods, 4 cladocera, 9 holoplankton and 7 meroplankton groups; Zenginer Yılmaz and Beşiktepe (2010), in their study conducted in Mersin Bay, reported 17 holoplankton groups and 9 meroplankton groups and in their study conducted in the Gulf of İskenderun, reported 30 copepod species and 4 cladocera species.

Terbiyik-Kurt and Polat (2013), in their study conducted in the same location, reported that the species *Paracalanus parvus*, *Oithona plumifera* and *Clausocalanus furcatus* were the most common copepoda species in the region. In this study, the copepods *Acartia (Acartiura) clausi* *Calocalanus pavo*, *Corycaeus* spp., *Clausocalanus arcuicornis*, *Clausocalanus furcatus*, *Centropages violaceus*, *Euterpina acutifrons*, *Farranula rostrata*, *Mecynocera clausi*, *Oithona helgolandica*, *Oithona plumifera*, *Oithona setigera*, *Oncea* spp., *Paracalanus parvus* and *Temora stylifera*, likewise, were observed in every season.

Toklu and Sarihan (2003), in their study conducted in the same location, did not encounter any cladocera in winter, in this study no cladocera were observed in winter. Terbiyik-Kurt and Polat (2013), in their study conducted in the location, attributed the abundance of Cladocera in spring to the increase in *Penilia avirostris*. While Lakkis and Toklu (2007), in their study conducted in the same location, determined Cladocera to be dominant in summer, this study determines Cladocera dominant at the rate of 41% in horizontal haul and at 35% in vertical haul.

Lessepsian species were recorded in the area such as *Calanopia elliptica*, *Labidocera pavo*, *Pontellina plumata*, *Centropages furcatus* (Lakkis et al., 2005; Toklu Aliçlı et al., 2009). In this study, these species were reported as lessepsian species.

As a result, the study determined the zooplankton groups and species in the Gulf of Iskenderun and information was provided on seasonal changes of these groups and species. The findings acquired in the study contributes to the literature by providing additional information on the bio-diversity in the bay, while constituting a source for future studies.

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Statement of conflict of interest

Authors have declared no conflict of interest.

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