

SEASONAL DISTRIBUTION PATTERNS OF MARINE CLADOCERANS IN THE SURFACE WATERS OF GULLUK BAY

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ABSTRACT

In this study, seasonal abundances and distribution of Cladocera species were investigated in Gulluk Bay, Mugla. Sampling operations were performed in four stations during April-October 2017. Zooplankton samples were taken horizontally by WP2 UNESCO plankton net with 200 micrometer mesh size. Five Cladocera species which are *P. avirostris*, *P. tergestina*, *E. spinifera*, *P. polyphemoides*, *P. intermedius* were determined in the study area. Other zooplankton groups in the samples were copepods, appendicularians, chaetognaths and meroplankton. *P. polyphemoides* was found in all sampling months except July. Maximum mean abundance of *P. polyphemoides* was observed 317 ind./m³ in April. *P. avirostris* showed maximum abundances in May and June but these values were not very high. *P. intermedius* was found in September and October in the samples. *P. tergestina* was dominant Cladocera species in May, June, July, August and September. Maximum abundance of *E. spinifera* was determined in June (mean 105 ind./m³).

Keywords: Cladocera, Gulluk Bay, Abundance, Marine

Introduction

Cladocerans play important role in the food chain both they are first consumer phytoplankton and transfer the energy to other steps and they constitute one of the main diets of pelagic fish and fish larvae (Modigh et al., 1996, Lipej et al., 1997, Marazzo and Valentin, 2000, 2001, Ozel, 2005). Cladocerans increase the numbers of populations in certain months and sometimes show high abundances than copepods.

The number of studies on marine cladocerans is low in Turkey coasts. Aker and Ozel (2006) determined six cladocera species in Izmir Bay while Ozel (1977) identified five species. Okuş and Yuksek (2006) studied on cladocerans in Gokova bay and found four species. Also, Gulsahin (2008) determined five cladocera species which are *Pleopis polyphemoides*, *Podon intermedius*, *Penilia avirostris*, *Pseudoevadne tergestina*, *Evadne spinifera* in the inner part of the Gokova Bay. Ozturk et al. (2006) found five cladocerans in Gulluk and Gokova Bays in August 2006. Also, *P. avirostris* was dominant cladoceran in this study. Some of other studies were conducted in

Turkey coasts were given in Table 1. In this study, seasonal abundances and distributions of cladocera species in Gulluk Bay were investigated.

Materials and Methods

This study was performed northern region of the Gulluk Bay. Sampling were conducted at four stations during April-October 2017 (Figure 1). Gulluk Bay is located on south eastern Aegean Sea in Turkey. The bay which has high marine production, is one of the important fishing area in terms of both aquaculture and fishing activities (Demirak et al., 2001, Cerim, 2017).

Zooplankton samples were taken horizontally by WP2 Unesco plankton net with 200 micrometer mesh size. Then, the samples were placed in plastic jars and fixed with 5% formaldehyde solution and then they were conveyed to Mugla Sitki Kocman University Faculty of Fisheries laboratories. Cladocera species and other zooplankton groups were counted under Olympus SZX16 stereomicroscope. Counting was performed with 2 ml sub-samples with three repetitive. The averages of the results are taken and the abundance values are calculated.

Table 1. Some studies on Cladocera species in Turkey.

Literature	Study area	Cladocera species
Tarkan, 2000	Gokceada	<i>E. nordmanni</i> , <i>P. avirostris</i> , <i>E. spinifera</i>
Tarkan et al., 2001	Gokceada	<i>E. nordmanni</i> , <i>P. avirostris</i> , <i>E. spinifera</i> , <i>P. tergestina</i> , <i>P. intermedius</i>
Toklu and Sarihan, 2003	Iskenderun Bay	<i>P. avirostris</i> , <i>P. tergestina</i> , <i>E. spinifera</i>
Buyukates and Inanmaz, 2007	Kepez Harbour, Dardanelles Strait	<i>P. polyphemoides</i> , <i>E. nordmanni</i> , <i>P. avirostris</i>
Isinibilir, 2007	Gulluk Bay	<i>P. tergestina</i> , <i>E. spinifera</i> , <i>P. avirostris</i> , <i>P. leuckarti</i> , <i>P. polyphemoides</i>
Buyukates and Inanmaz, 2010	Kepez Harbour, Dardanelles Strait	<i>P. polyphemoides</i> , <i>E. nordmanni</i> , <i>P. avirostris</i>
Terbiyik Kurt and Polat, 2014	Iskenderun Bay	<i>P. avirostris</i> , <i>P. tergestina</i> , <i>E. spinifera</i> , <i>P. polyphemoides</i> , <i>P. intermedius</i>
Alıçlı et al., 2014	Gulf of Erdek, The Marmara Sea	<i>E. spinifera</i> , <i>P. polyphemoides</i> , <i>P. avirostris</i>
Toklu-Alicli and Sarihan, 2016	Iskenderun Bay	<i>E. spinifera</i> , <i>P. tergestina</i> , <i>P. avirostris</i> , <i>P. polyphemoides</i>
Terbiyik Kurt and Polat, 2017	Iskenderun Bay	<i>E. spinifera</i> , <i>P. avirostris</i> , <i>P. polyphemoides</i> , <i>P. schmackeri</i> , <i>P. intermedius</i> , <i>P. tergestina</i>
Terbiyik Kurt et al., 2018	Iskenderun Bay	<i>P. avirostris</i> , <i>E. spinifera</i> , <i>P. tergestina</i> , <i>E. nordmanni</i> , <i>P. polyphemoides</i> , <i>P. intermedius</i>

Therefore, temperature, salinity and dissolved oxygen values were measured with YSI Multiprobe system on the surface of the stations.

Results

Mean temperature values of the area were between 19.3-27.92°C from April to October. Minimum temperature was 19°C in April at station 1 and maximum temperature was measured as 28.41°C in August at station 3. Also in August, maximum salinity was determined (38.65 ppt) at stations 1 and 2. Minimum salinity was 34.98 ppt in April at station one. Dissolved oxygen (DO) values were varied between 5.56 mg/l (August) and 7.25 mg/l (September). Monthly mean values of temperature, salinity and DO were given in Figures 2 and 3.

Five cladocera species which are *P. avirostris*, *P. tergestina*, *E. spinifera*, *P. polyphemoides*, *P. intermedius* were determined in the study area. Other zooplankton groups in the samples were copepods, appendicularians, chaetognaths and meroplankton.

P. tergestina was dominant cladocera species in May, June, July, August and September. *P. polyphemoides* was found in high numbers in April. Also, *P. intermedius* was the first cladoceran in abundance in October. Copepods were dominant zooplankton groups in all sampling months and cladocerans followed copepods in abundance. Also,

dinoflagellates were observed commonly in the samples. *Noctiluca scintillans* was found in April, May and June. This species showed high abundance in April and total abundance was reached 332 ind./m³. *Ceratium spp.* were commonly observed in April, May, June, September and October. Copepods composed 64% of total zooplankton abundance in April while cladocerans form of 23%. Five cladocera species which are *P. tergestina*, *E. spinifera*, *P. polyphemoides*, *P. avirostris* and *P. intermedius* were determined in the samples. *P. polyphemoides* was the most abundant cladoceran with mean abundance 317 ind./m³. In May, these four cladocerans were observed with high abundances. Mean abundance of *P. tergestina* was 163 ind./m³ at four stations. Abundances of other cladocerans were showed in Figures 4 and 5.

Five cladocerans were found in the samples in June (Figure 4). Dominant species was *P. tergestina* which was 549 ind./m³ in totally four stations. *E. spinifera* was the second species with total abundance was 421 ind./m³. *P. intermedius* was determined only at fourth station with 4 ind./m³. Total zooplankton and cladoceran density decreased in July. *P. tergestina*, *E. spinifera* and *P. avirostris* were observed in the samples. Mean abundance of *P. tergestina* which was dominant cladocera species was 47 ind./m³ at four stations (Figure 5). In August, only two cladoceran which were *P. tergestina* and *P. polyphemoides*

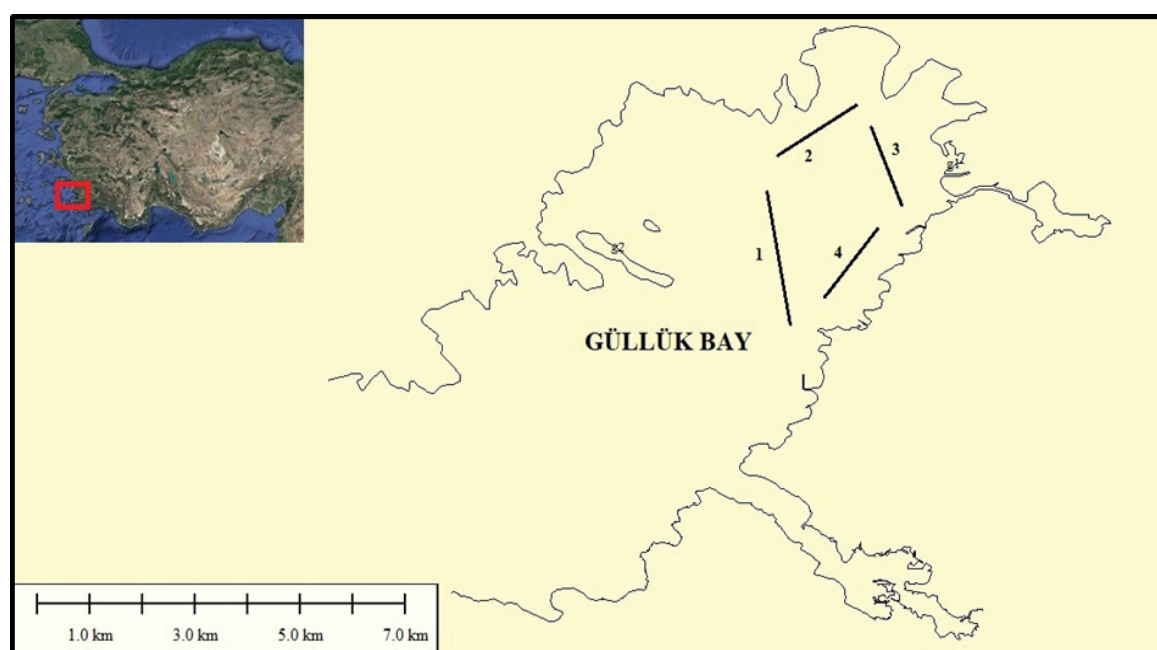


Figure 1. Study area and sampling stations in the Gulluk Bay.



Figure 2. Monthly mean temperature and salinity values.

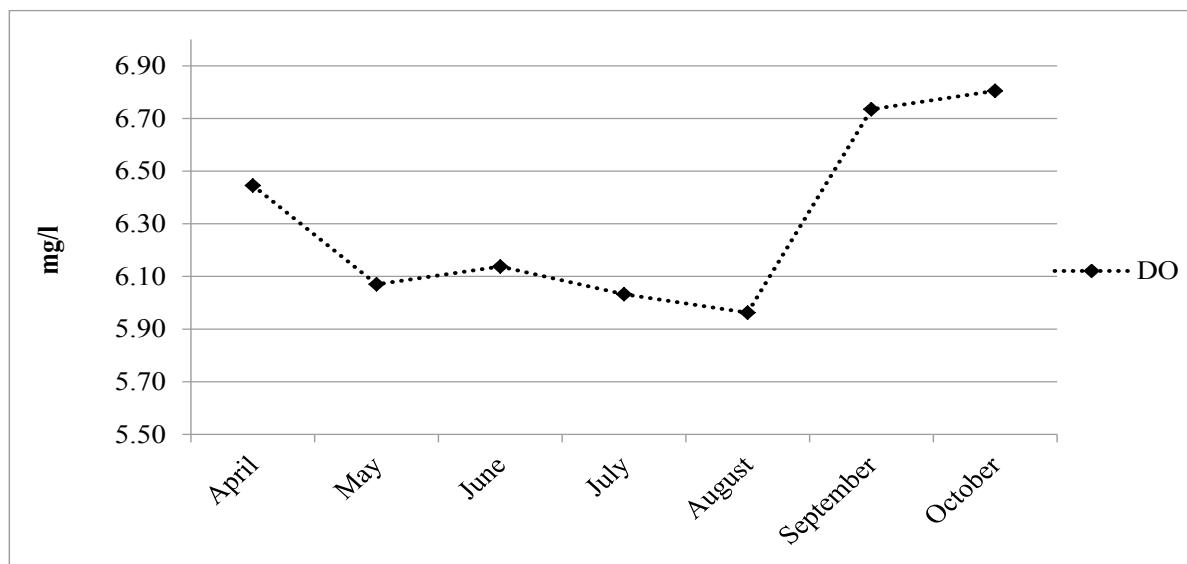


Figure 3. Monthly mean dissolved oxygen values.

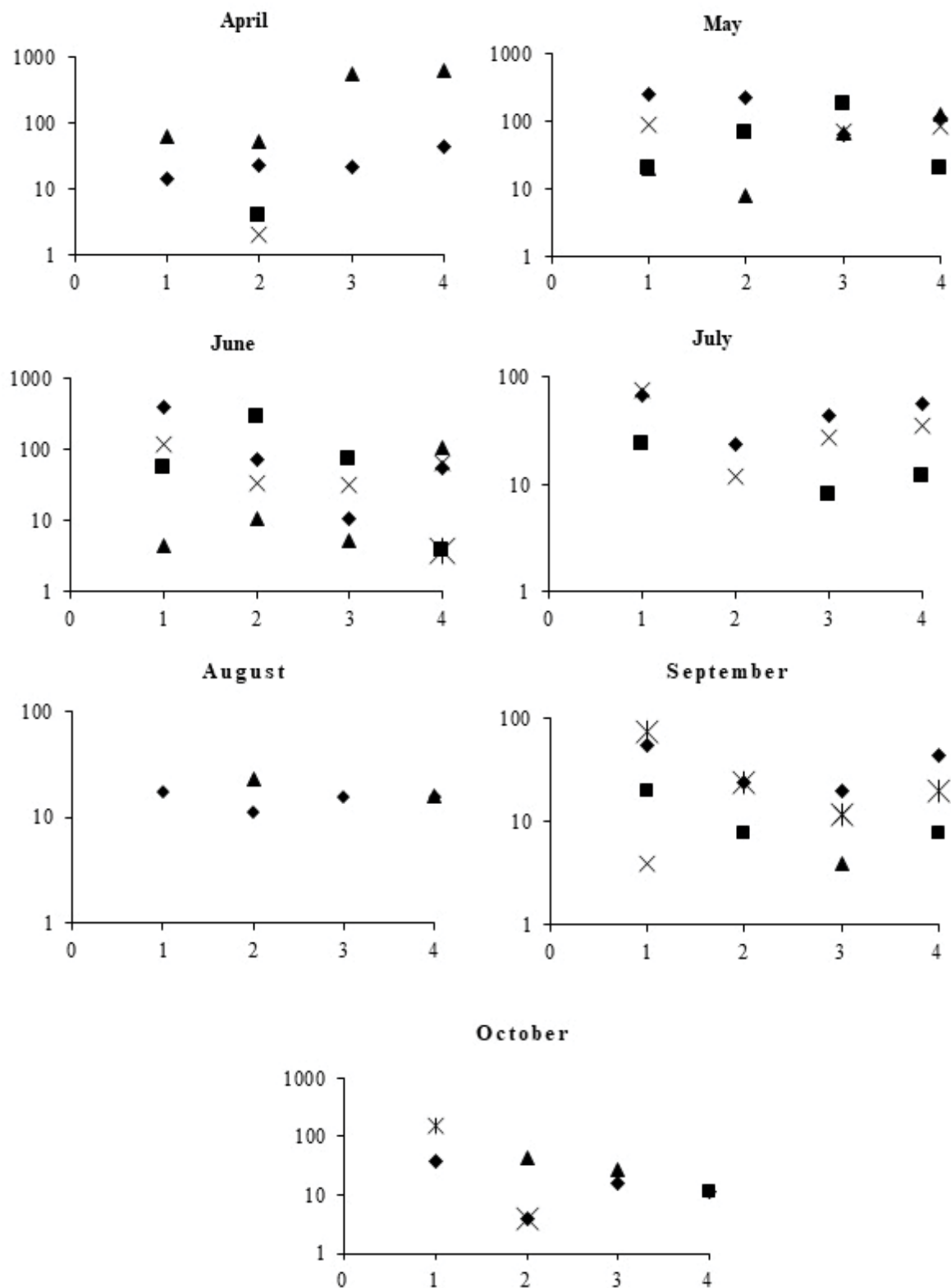
were found. *P. polyphemoides* was determined at second (23 ind./m³) and fourth (16 ind./m³) stations (Figure 5). Mean abundance of *P. tergestina* was 15 ind./m³ at all stations.

Five cladoceran were observed in September and *P. tergestina* (mean 36 ind./m³) and *P. intermedius* (mean 33 ind./m³) showed maximum abundance compared to other cladocerans (Figure 4). *P. polyphemoides* was determined only at station 3 with abundance of 4 ind./m³. In October, *P. intermedius* was found only at station 1 with abundance of 153 ind./m³. Mean abundances of *P. tergestina* and *P. polyphemoides* were 17 ind./m³. *P. avirostris* was seen

only at station 2 with low abundance. Also, *E. spinifera* was found only at station 4 (11 ind./m³).

Copepods showed maximum abundance which was 4089 ind./m³ in May. Second peak was in September in this group. Appendicularians were found in the samples only in April, May and June. Maximum mean abundance of this species was 83 ind./m³ in April.

Meroplankton consisted of nauplius, zoea, fish eggs and larvae, mysis, stomatopod and echinopluteus larvae. Abundance of meroplankton increased in May and June, and decreased in July and August. Then, in September it was seen that meroplankton raised in small numbers.



◆ *P. tergestina*, ■ *E. spinifera*, ▲ *P. polyphemoides*, × *P. avirostris*, * *P. intermedius*

Figure 4. Distribution and abundances of Cladocerans according to the stations (Horizontal lines show stations and vertical lines show abundances).

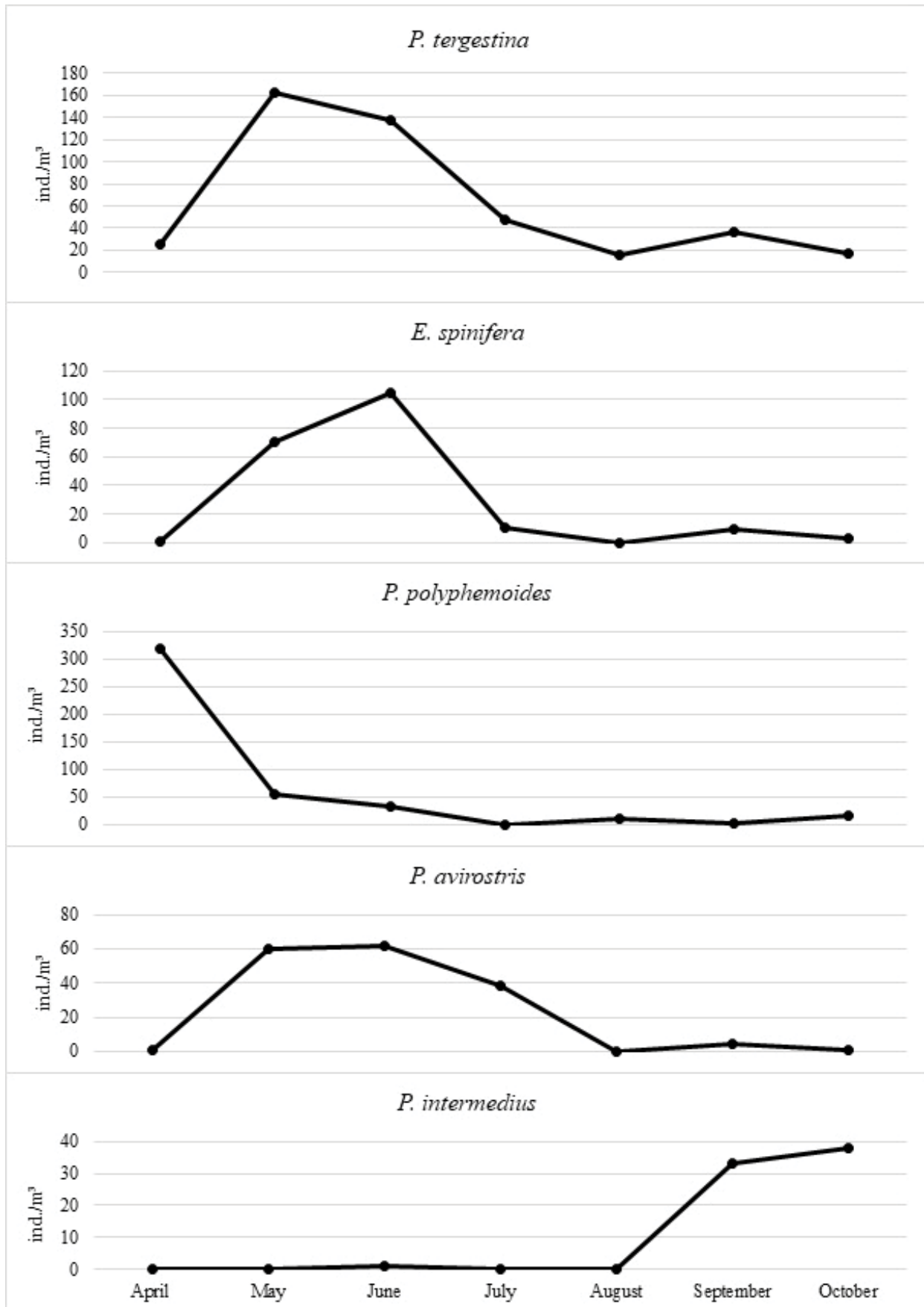


Figure 5. Monthly abundances of Cladocera species in the study area.

Discussion

In this study, seasonal variations of cladocera species in Gulluk Bay were studied. Cladocerans are found occasionally more than copepods in the Aegean Sea (Christou and Stergiou, 1998, Siokou-Frangou, 1996). In our study, cladocerans did not exceed copepods in abundance. *P. tergestina* and *E. spinifera* are warm water species (Della Croce and Venugopal, 1972). Maximum abundances of these species were determined in May and June respectively when the water temperature was 20°C-25°C. The second peak was observed in September in both species. *P. polyphemoides* distributes in warm waters of the coastal areas (Della Croce and Venugopal, 1972). But, this species was mostly recorded in cool waters such as Baltic Sea (Vourinen and Ranta, 1987), Sweden coasts (Ericksson, 1974) and North Pacific (Uye, 1982). In this study, as temperature increases abundances of this species decrease. Toklu-Alicli and Sarihan (2016) recorded four cladocera species between January and November 2002 in İskenderun Bay. *P. polyphemoides* was only found in winter because of the high water temperature values in the bay. In this study, *P. polyphemoides* was found in all sampling months except July. Maximum mean abundance of *P. polyphemoides* was observed 317 ind./m³ in April and then sharp decrease was observed in numbers of this species. *P. avirostris* showed maximum abundances in May and June but these values were not very high. It was thought that, abundance of this species was low because of the high salinity of the area. *P. avirostris* is euryhalin species but shows high abundances in low salinity waters (Lakkis, 1980). *P. intermedius* was found in September and October in the samples. It was thought that this species distributes at temperatures below 25°C in the area. *P. intermedius* prefers cool waters and distributes mainly North Atlantic and North Pacific. Also, it was found North Sea, the Black Sea, Baltic Sea, Iceland, Norway and Turkey coasts (GBIF Secretariat, 2017).

According to Terbiyik Kurt and Polat (2014) five cladocera species which are same in this study were found in İskenderun Bay between 2008-2011. Highest total cladocera abundances were determined in April in the İskenderun Bay. In this study, total cladocera abundance

was maximum in May (1389 ind./m³). Temperature values of the two bays approximately same in April and May. Also, in another study was conducted in İskenderun Bay, *E. spinifera* was the most abundant cladoceran (Terbiyik Kurt et al., 2018). This species showed high numbers in May and August in our study. But, in other months mean abundance of *E. spinifera* was not exceed 11 ind./m³.

Aquaculture activities were sustained densely in Gulluk Bay. Especially in summer fish farm production was high. Fish farms caused to increase nutrient values in the bay (Demirak et al., 2006). Therefore, high nutrients increase primary productivity and thus plankton abundances. Gulluk Bay showed high abundances and diversity of zooplankton in this study. Abundance of *P. polyphemoides* was higher than other cladocera species with 317 ind./m³ mean abundance in April. In Gokova Bay, *P. polyphemoides* was found only in June, October and November in small numbers. Also, cladocera abundances were low than Gulluk Bay in horizontal hauls (Gulşahin and Tarkan, 2012). It was thought that this differences depend on nutrient levels of the two bays. Zooplankton of Gulluk Bay were studied in only one research previously. According to Isinibilir (2007) five cladocera species which are *P. tergestina*, *E. spinifera*, *P. avirostris*, *P. leuckarti* and *P. polyphemoides* were determined in the bay in August 2006. *P. avirostris* was the dominant cladoceran and *P. tergestina* was the second. In our study, *P. leuckarti* was not seen in the samples. Also, *P. polyphemoides* was dominant in May and *P. intermedius* was first species in abundance in October. In other months the dominant species was *P. tergestina*.

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