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Seasonal changes in zooplankton community structure in Lake Küçükçekmece, İstanbul, Turkey

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Abstract: The zooplankton community of Lake Küçükçekmece includes individuals from freshwater groups Rotifera and Cladocera, and also marine species *Acartia clausi* of the subclass Copepoda; *Tintinnopsis nana*, *Favella* sp. Jorgensen, 1924, and *Strobilidium spiralis* from the group Ciliata; *Micronereis* sp. Linnaeus, 1758 and *Spio* sp. Fabricius, 1785 from the class Polychaeta; *Pleurobrachia pileus* from the phylum Ctenophora; and *Gammarus* sp. Fabricius, 1775 from the order Amphipoda. Rotifera was the dominant group for each season studied. In autumn, dominant specimens included *Bosmina longirostris*, *Spio* sp. Fabricius, 1785, *Pleurobrachia pileus*, the cypris and nauplius larva of *Balanus* sp., and veliger larva. In winter, dominant species included *Synchaeta pectinata*, *Filinia longirostris*, and *Epiphanes* sp. Ehrenberg, 1832. In spring, dominate species included *Asplanchna priodonta* and *Strobilidium spiralis*. In summer, the dominant species was *Brachionus plicatilis*. *Polyarthra major*, *Filinia longiseta*, *Keratella cochlearis*, and *Brachionus*, which were found in the lake, are indicator species of eutrophication. Marine species *Tintinnopsis nana* peaked during spring at the first and second sampling stations, while *Acartia clausi* peaked during summer at the second station.

Key words: Zooplankton, seasonal distribution, Lake Küçükçekmece, correlation

Küçükçekmece Gölü zooplankton gruplarının mevsimsel dağılımı

Özet: Rotifera ve Cladocera grubu üyeleri tatlı su ortamına ait oldukları halde, Copepoda grubundan *Acartia clausi*, Ciliate grubundan *Tintinnopsis nana*, *Favella* sp. Jorgensen, 1924, *Strobilidium spiralis*, Polychaeta grubundan *Micronereis* sp. Linnaeus, 1758 ve *Spio* sp. Fabricius, 1785, Amphipoda grubundan *Gammarus* sp. Fabricius, 1775 deniz ortamı canlıları olarak göl zooplanktonunda yer almışlardır. Rotifera grubu her mevsim baskın olmuştur. Sonbahar mevsiminde *Bosmina longirostris*, *Spio* sp. Fabricius, 1785, *Pleurobranchia pileus*, *Balanus* sp.'nin cypris, nauplius larvası ve bivalvlerin veliger larvası; kış mevsiminde *Synchaeta pectinata*, *Filinia longirostris* ve *Epiphanes* sp. Ehrenberg, 1832; ilkbahar mevsiminde *Asplachna priodonta*, *Strobilidium spiralis*; yaz mevsiminde *Brachionus plicatilis* yüksek sayısal değerlere ulaşmışlardır. Gölde tespit edilen *Polyarthra major*, *Filinia longiseta*, *Keratella cochlearis* ve *Branchionus* türleri ötrofikasyonun indikatör türleridir. Denizel türlerden *Tintinnopsis nana* 1. ve 2. istasyonda ilkbahar mevsiminde, *Acartia clausi* ise 2. istasyonda yaz mevsiminde en yüksek değerine ulaşmıştır.

Anahtar sözcükler: Zooplankton, mevsimsel değişim, Küçükçekmece Gölü, korelasyon

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Introduction

The process of eutrophication in shallow lakes can greatly change the community structure of aquatic organisms. Such changes mainly start with phytoplankton, known as the first step in the food chain (Yıldız et al., 2007). According to Bekleyen (2003), zooplankton constitutes the food source of organisms at higher tropic levels, and some are of high economic value in lake ecosystems. Since the majority of species are filter feeders, this serves to cleanse the water column of suspended matter and hence contributes significantly to the improvement of water quality (Haberman, 1998). Additionally, some studies have shown that certain species of zooplankton are usually considered to be useful indicators of water quality, trophic status, and pollution (Michaloudi et al., 1997; Marneffe et al., 1998).

Lake Küçükçekmece is one of the major lakes in the Marmara Region of Turkey that have been exposed to pollution. To date, very few scientific studies have been published on the subject of algal blooms and the death of fish, especially in summer, in Lake Küçükçekmece.

Lake Küçükçekmece has a serious pollution problem due to several factors, including heavy industrialization, insufficient infrastructure, rapid population increase, and the discharging of domestic and industrial waste water into the lake (Akşehirli, 2005).

Seasonal distribution of zooplankton groups of Lake Küçükçekmece was investigated during a period of 1 year, between November 2005 and December 2006. With its connection to the sea, Lake Küçükçekmece is one of the special lagoons in the world. The lagoon is connected to the sea with a ford that is 1.5 m in depth. Thus, the water of the lake is semisalty. The present study examined the zooplankton composition and seasonal changes in this lake, which becomes an estuary at some times when the lake water is mixed with seawater.

Materials and methods

Study area

Lake Küçükçekmece is located 15 km west of İstanbul and covers an area of 15.22 km^2. The north-south length of Lake Küçükçekmece is 10 km, and it is 6 km wide at the widest point. It is located in the Marmara Region, in İstanbul. Lake Küçükçekmece is located at 41°00′N, 28°43′W (Akşehirli, 2005). Lake Küçükçekmece is one of the special lagoons in the world due to its connection to the sea. The lagoon is connected to the sea by a ford that is 1.5 m deep, which is why the water of the lake is semisalty.

In order to determine the zooplankton composition of Lake Küçükçekmece, 2 stations were chosen (Figure 1). Sampling was performed once every month between November 2005 and December 2006. No sampling could be performed in January, May, or September of 2006.

Samples of zooplankton were taken from the surface and vertically, at depths of 0-2.5 m, 2.5-5 m, and 5-7.5 m. Surface samples were taken by horizontal towing with a normal plankton net (diameter: 30 cm, length: 1 m, mesh width: 55 μm), and vertical samples were taken with a closing net. All of the samples were fixed with 4% formol.

Water temperature and some meteorological features were measured at the lake, while features such as pH, nitrate, nitrite, phosphate, salinity, turbidity, and chlorophyll were measured at a laboratory (Strickland and Parsons, 1972; Boyd and Tucker, 1992). Water temperature was measured with a mercury-in-glass thermometer with increments of 0.1 °C. Salinity was measured with a salinometer (YSI Incorporated, Yellow Springs, Ohio, USA). Turbidity, NO_2, NO_3, and PO_4 were measured with a Shimadzu UV-1601 spectrophotometer.

A Leitz inverted plankton microscope was used to count and a Nikon research microscope was used to identify and measure the zooplankton samples.

Identifying rotifers depends on the features of the loricates, coronas, and trophies of planktonic species. Trophy morphology is used with most rotifers, especially those that have no loricate. To this end, a drop of KOH or NaOH (4%) is added to a sample put in a few drops of water. A trophy cleaned this way is ready for diagnosis.

Samples were prepared according to Edmondson's (1959) method and were examined and identified with a Nikon research microscope. Related literature was referred to in the identification of organisms (Edmondson, 1959; Scourfield and Harding, 1966;

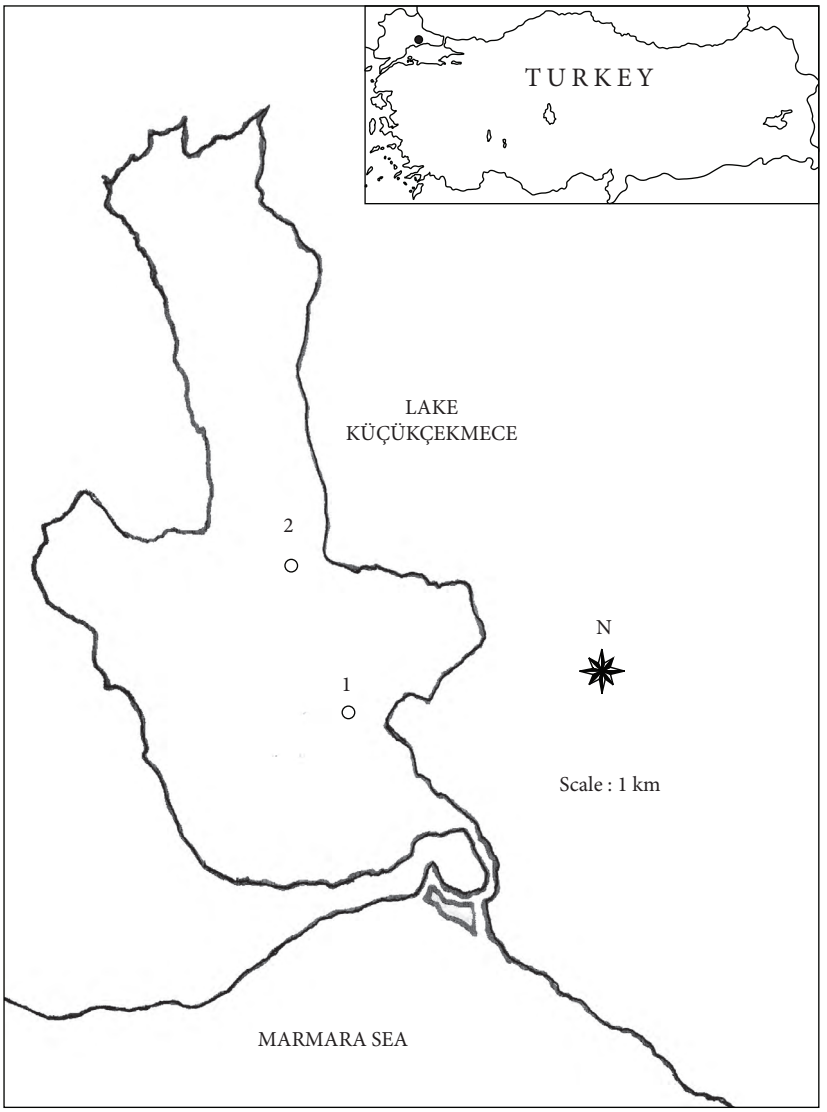

Figure 1. Map showing sampling stations in Lake Küçükçekmece. Coordinates of first sampling station: 40°59′43″N, 28°45′13″E. Coordinates of second station: 41°00′27″N, 28°44′53″E.

Dussard, 1967, 1969; Harding and Smith, 1974; Pontin, 1978; Sharma and Sharma, 1997; Ueda et al., 1997; Ricci and Melone, 2000; Sorensen, 2002; Dahms et al., 2006).

The research data were evaluated quantitatively. Spearman correlation analysis was performed using the SPSS program (v. 10), in order to determine the community structure. The Sorensen similarity index was applied to determine the similarities between the numbers of species at the 2 sampling stations.

Results

Physical and chemical data

Some physical and chemical parameters are given in Table 1.

Table 1. Some physical and chemical parameters.

Parameters	Station 1 (Minimum and maximum)	Station 2 (Minimum and maximum)
Temperature (°C)	6 and 26 °C	6 and 26 °C
pH	6.50 and 7.64	6.66 and 7.67
Turbidity (nm)	0.060 and 0.146 nm	0.059 and 0.170 nm
Nitrite	1.055 and 1.304 mg L^{-1}	1.040 and 1.319 mg L^{-1}
Nitrate	1.154 and 8.720 mg L^{-1}	1.109 and 14.209 mg L^{-1}
Phosphate	0.803 and 2.107 mg L^{-1}	0.948 and 1.322 mg L^{-1}
Salinity	6.7‰ and 14.7‰	6.7‰ and 14.7‰

Zooplankton composition

The zooplankton composition of Lake Küçükçekmece is composed of organisms that live in freshwater and those that live in marine environments. The freshwater groups identified were Rotifera, Copepoda and Cladocera; the marine groups were Ciliata, Copepoda, Amphipoda, Polychaeta, and Ctenophora. Freshwater organisms were found to be more abundant than marine organisms (Figure 2). In total, 23 holoplankton and 3 meroplankton groups, 26 taxa, and 4 different types of larva were found.

In Lake Küçükçekmece, the Rotifera group was represented by 13 species, the Copepoda group by 3 species, the Cladocera group by 2 species, the Ciliata group by 4 species, the Polychaeta group by 2 species, the Ctenophora group by 1 species, and the Amphipoda group by 1 species. In addition, 4 different types of larva were found (Figure 3).

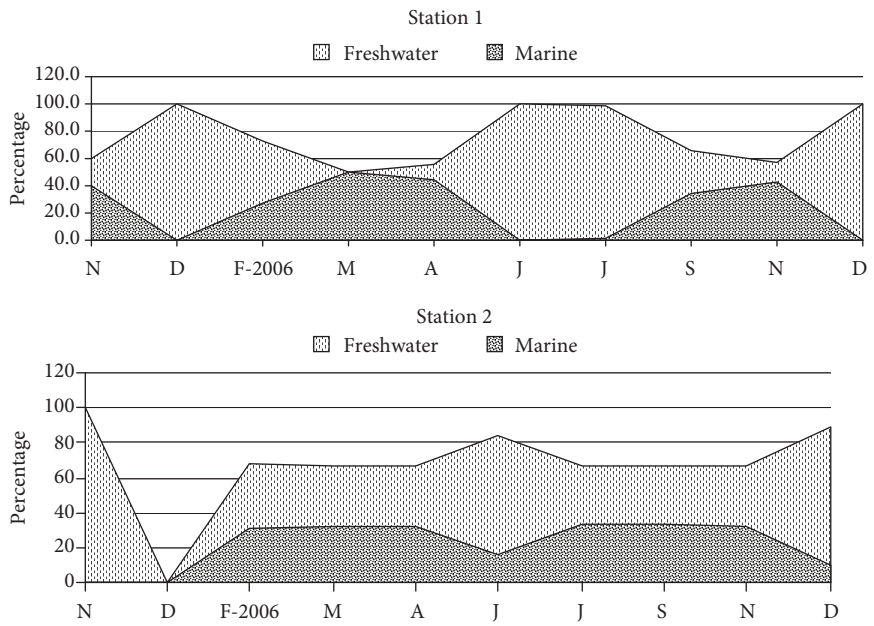

Figure 2. Percentages of the aggregate numbers of freshwater and marine zooplankters.

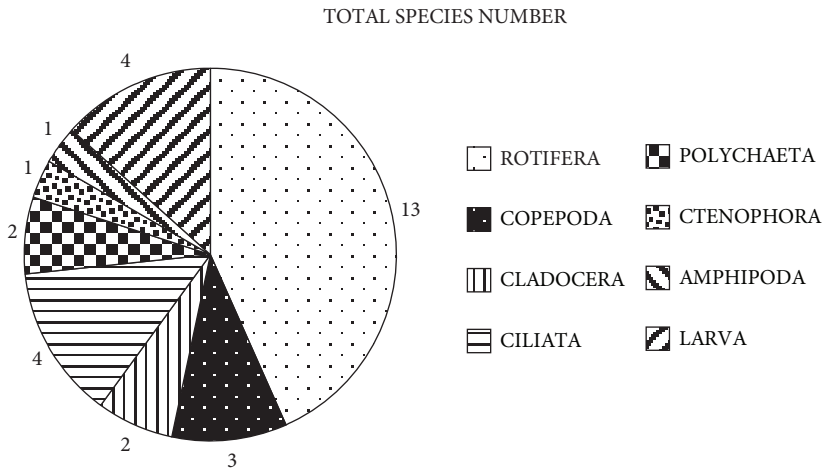

Figure 3. The distribution of the number of species belonging to zooplankton groups.

Types and species of zooplankton found in Lake Küçükçekmece:

ROTIFERA

1 *Asplanchna priodonta* (Gosse, 1850)
2 *Brachionus plicatilis* (Müller, 1786)
3 *Cephalodella* sp. (Bory de St. Vincent, 1826)
4 *Epiphanes* sp. Ehrenberg, 1832
5 *Filinia longiseta* (Ehrenberg, 1834)
6 *Hexarthra mira* (Hudson, 1871)
7 *Lecane luna* (Müller, 1776)
8 *Keratella cochlearis* (Gosse, 1851)
9 *Keratella quadrata* (Müller, 1786)
10 *Notholca acuminata* Ehrenberg, 1832
11 *Philodina* sp. Ehrenberg, 1830
12 *Polyarthra major* Burckhardt, 1900
13 *Synchaeta pectinata* Ehrenberg, 1832

COPEPODA

1 *Canthocamptus* sp. Westwood, 1836
2 *Cyclops vicinus* Uljanin, 1875

CLADOCERA

1 *Bosmina longirostris* (Müller, 1785)
2 *Daphnia pulex* Leydig, 1860

CILIATA

1 *Paramecium* sp. Müller, 1773
2 *Strobilidium spiralis* Leegaard, 1915

LARVA

1 Nauplius larva

Types and species of marine zooplankton found in Lake Küçükçekmece:

COPEPODA

1 *Acartia clausi* Giebrecht, 1889

CILIATA

1 *Favella* sp. Jorgensen, 1924
2 *Tintinnopsis nana* Lehmann, 1908

CTENOPHORA

1 *Pleurobrachia pileus* (Müller, 1776)

POLYCHAETA

1 *Micronereis* sp. Linnaeus, 1758
2 *Spio* sp. Fabricius, 1785

AMPHIPODA

1 *Gammarus* sp. J.C. Fabricius, 1775

LARVA

1 Nauplius larva (*Balanus* sp. Darwin, 1854)
2 Cypris larva (*Balanus* sp. Darwin, 1854)
3 Bivalve larva (veliger larva)

Seasonal distribution of zooplankton

Six groups were determined at each of the stations at Lake Küçükçekmece. The groups present at the first station were Rotifera, Copepoda, Cladocera, Ciliata, Polychaeta, and Amphipoda; the groups present at the second station were Rotifera, Copepoda, Cladocera, Ciliata, Polychaeta, and Ctenophora.

When the distribution of the aggregate numbers of individuals belonging to the zooplankton groups was examined according to the stations and depths, high values were obtained at the first station in March and April of 2006 at the depths of 0-2.5 m and 5-7.5 m, and at the second station in December 2005 in the surface sample and in July 2006 at the depths of 2.5-5 m and 5-7.5 m (Figure 4).

First station

Surface sample

Eleven species of rotifers were identified. Among these species, *Synchaeta pectinata* reached its highest value of 17,162 ind m^{-3} in November 2005. *Brachionus plicatilis*, *Synchaeta pectinata*, and *Keratella cochlearis* reached their lowest value of 1 ind m^{-3} in November 2006.

Bosmina longirostris was found to be the only species of the Cladocera group and had a density of 17 ind m^{-3} in November 2005 and 6 ind m^{-3} in November 2006.

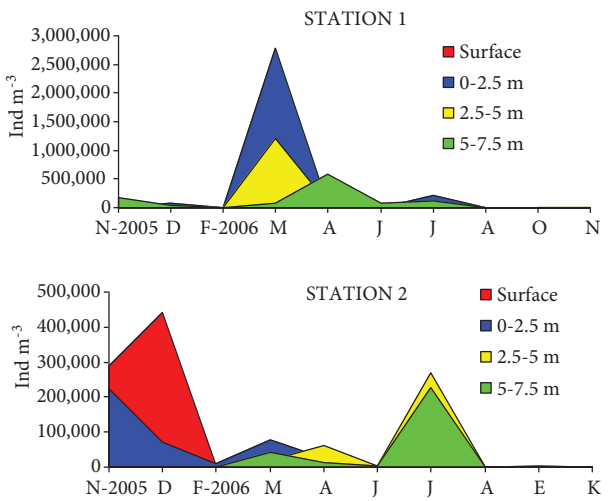

Figure 4. Depth distribution of the aggregate number of individuals belonging to zooplankton groups.

The Copepod group was represented by 2 species. *Acartia clausi* was found to be present at 42 ind m^{-3} in July 2006 and 5 ind m^{-3} in November 2006. *Cyclops vicinus* was found to be present at 40 ind m^{-3} in March 2006, 4 ind m^{-3} in June 2006, and 1 ind m^{-3} in November 2006.

Tintinnopsis nana of the Ciliata group was most abundant (385 and 182 ind m^{-3}, respectively) in March and April 2006, and least abundant (9 ind m^{-3}) in February 2006 (Table 2).

The nauplius larva of *Balanus* sp. and bivalve larvae were identified. Numbers of nauplius larvae were highest (86 ind m^{-3}) in December and lowest (12 ind m^{-3}) in April. Only 3 ind m^{-3} of *Balanus* nauplius larva were detected in November 2006. In October 2006, 5 ind m^{-3} of bivalve larva were found.

Gammarus sp. Fabricius, 1775 of Amphipoda was detected once, in June 2006 (4 ind m^{-3}).

Sample from depths of 0-2.5 m:

From the Rotifera group, *Brachionus plicatilis* showed its highest number of 189,469 ind m^{-3} in July 2006, and *Lecane luna* showed its highest number of 129,936 ind m^{-3} in December 2006.

From the Copepoda group, *Acartia clausi* reached 2746 ind m^{-3} in July 2006 and *Cyclops vicinus* reached 61 ind m^{-3} in November 2005.

Bosmina longirostris of Cladocera was detected in low numbers (only 31 and 9 ind m^{-3}) in November and December 2005. The maximum number recorded was 2746 ind m^{-3} and the minimum was 9 ind m^{-3}. Ciliata was represented by 4 species. Among those species, *Tintinnopsis nana* (1,311,111 ind m^{-3}), *Strobilidium spiralis* (1,342,579 ind m^{-3}), and

Paramecium sp. Müller, 1773 (104,889 ind m^{-3}) reached its highest value in March 2006, while 15,337 ind m^{-3} of *Favella* sp. Jorgensen, 1924 were detected in the sample obtained in November 2005.

Nauplius larvae showed their highest value (20,978 ind m^{-3}) in March 2006 and lowest value (306 ind m^{-3}) in November 2006.

Sample from depths of 2.5-5 m:

Rotifera was represented by 10 species. From this group, *Lecane luna* showed the highest value, with 280,764 ind m^{-3} in December 2006.

Table 2. Monthly distribution of marine species (ind m^{-3}).

Station 1.	**Species**	**N**	**D**	**F-2006**	**M**	**A**	**J**	**J**	**S**	**N**	**D**
Surface	*Acartia clausi*							42		5	
Surface	*Tintinnopsis nana*			9	385	182					
Surface	*Gammarus* sp. Fabricius, 1775						4				
Surface	*Balanus* naup.									3	
Surface	Bivalve larva								5		
0-2.5 m	*Acartia clausi*		9					2746		306	
0-2.5 m	*Favella* sp. Jorgensen, 1924	15,357									
0-2.5 m	*Strobilidium spiralis*				1,342,579						
0-2.5 m	*Tintinnopsis nana*			1245	1,311,111	47,972					
2.5-5 m	*Acartia clausi*									465	
2.5-5 m	*Tintinnopsis nana*			483	935,734	66,955					
2.5-5 m	*Spio* sp. Fabricius, 1785									233	
5-7.5 m	*Acartia clausi*							2859		1100	
5-7.5 m	*Favella* sp. Jorgensen, 1924	539									
5-7.5 m	*Tintinnopsis nana*				4,312,155	301,911					
5-7.5 m	*Balanus* naup.									275	
5-7.5 m	Bivalve larva								951		
	Total	**15,896**	**9**	**1737**	**7,901,964**	**417,020**	**4**	**5647**	**951**	**2387**	**0**
Station 2.	**Species**	**N**	**D**	**F-2006**	**M**	**A**	**J**	**J**	**S**	**N**	**D**
Surface	*Acartia clausi*				43			324			
Surface	*Tintinnopsis nana*			3465	236	157					
Surface	*Pleurobrachia pileus*								4		
Surface	*Balanus* naup.									13	
Surface	Bivalve larva								951		
0-2.5 m	*Acartia clausi*				3154			1274		200	
0-2.5 m	*Tintinnopsis nana*			4280	67,374	15,219					
0-2.5 m	*Micronereis* sp. Linnaeus, 1758										283
2.5-5 m	*Acartia clausi*					374	164	10,474			
2.5-5 m	*Tintinnopsis nana*				16,357	38,715					
2.5-5 m	*Balanus* cypris lar.									218	
5-7.5 m	*Acartia clausi*							28,592		764	
5-7.5 m	*Tintinnopsis nana*				36,399	8277			679		
	Total	**0**	**0**	**7745**	**123,563**	**62,742**	**164**	**40,664**	**683**	**1195**	**283**

The number of *Bosmina longirostris* individuals from the Cladocera group was found to be 413 ind m^{-3} in the sample obtained in April 2006.

From the Copepoda group, *Acartia clausi* reached 465 ind m^{-3} in November 2006 and *Cyclops vicinus* reached 10,757 ind m^{-3} in March 2006.

Tintinnopsis nana from the Ciliata group reached its highest value (935,734 ind m^{-3}) in March 2006.

The number of *Spio* sp. Fabricius, 1785 in the Polychaeta group was found to be 233 ind m^{-3} in November 2006.

Sample from depths of 5-7.5 m:

Within the Rotifera group, *Asplanchna priodonta* and *Synchaeta pectinata* showed their highest values (78,273 ind m^{-3} and 514,372 ind m^{-3}) in April 2006, *Brachionus plicatilis* showed its highest value (102,930 ind m^{-3}) in July 2006, and *Lecane luna* showed its highest value (92,399 ind m^{-3}) in December 2006.

No members of the Cladocera group were found.

Acartia clausi from the Copepoda group was present at 2859 and 1100 ind m^{-3} in July and October 2006. *Canthocamptus* sp. Westwood, 1836 reached 515 ind m^{-3} in June 2006.

Tintinnopsis nana and *Favella* sp. Jorgensen, 1924 from the Ciliata group were detected. *Tintinnopsis nana* reached its peak with 4,312,155 ind m^{-3} in March 2006. However, *Favella* sp. Jorgensen, 1924 was detected only in November 2005 (539 ind m^{-3}).

Second station

Surface sample:

Within the surface samples of the second sampling station, *Synchaeta pectinata* of the Rotifera group peaked at 434,820 ind m^{-3} in December 2005. The next most abundant species was *Brachionus plicatilis*, with 5176 ind m^{-3}. Within the Copepoda group, *Acartia clausi* was found at a concentration of 324 ind m^{-3} in July 2006, *Cyclops vicinus* was recorded at 3 ind m^{-3} in June 2006, and *Canthocamptus* sp. Westwood, 1836 was recorded at 7 ind m^{-3} in October 2006.

Bosmina longirostris from the Cladocera group was dominant with 629 ind m^{-3} in November 2005; *Tintinnopsis nana*, from Ciliata, was dominant with 3465 ind m^{-3} in February 2006; and *Pleurobrachia pileus* from the Ctenophora group was dominant with 4 ind m^{-3} in November 2006. Of the larvae, nauplius larva was dominant with 47 ind m^{-3} in April 2006, *Balanus* nauplius larva was dominant with 13 ind m^{-3} in November 2006, and bivalve larvae were dominant with 951 ind m^{-3} in October 2006.

Sample from depths of 0-2.5 m:

When the samples from 0-2.5 m were examined, among species from the Rotifera group, *Asplanchna priodonta* reached 5392 ind m^{-3} in December 2005, *Brachionus plicatilis* reached 77,282 ind m^{-3} in July 2006, *Synchaeta pectinata* reached 21,997 ind m^{-3} in November 2005, *Lecane luna* reached 23,309 ind m^{-3} in December 2006, and *Epiphanes* sp. Ehrenberg, 1832 reached 4280 ind m^{-3} in February 2006. *Filinia longiseta* and *Cephalodella* sp. were detected only once, in December 2005 and November 2006 (640 and 200 ind m^{-3}), respectively.

From the Copepoda group, *Acartia clausi* peaked at 3154 ind m^{-3} in March 2006 and *Cyclops vicinus* peaked at 238 ind m^{-3} in April 2006. *Bosmina longirostris* from the Cladocera group peaked at 476 ind m^{-3} in February 2006. *Tintinnopsis nana* from the Ciliata group peaked at 67,374 ind m^{-3} in March 2006. *Micronereis* sp. Linnaeus, 1758 from Polychaeta peaked at 283 ind m^{-3} in December 2006. Of the larva specimens, nauplius larva peaked at 1557 ind m^{-3} in March 2006.

Sample from depths of 2.5-5 m:

When the samples from 2.5-5 m were examined, from the Rotifera group, *Asplanchna priodonta* reached 13,401 ind m^{-3} in April 2006, *Brachionus plicatilis* reached 238,811 ind m^{-3} in July 2006, *Synchaeta pectinata* reached 8190 ind m^{-3} in April 2006, *Keratella cochlearis* reached 940 ind m^{-3} in December 2006, *Polyarthra major* reached 1885 ind m^{-3} in December 2006, and *Lecane luna* reached 31,089 ind m^{-3} in December 2006.

Acartia clausi from Copepoda reached 10,474 ind m^{-3} in July 2006. From the Cladocera group, *Bosmina longirostris* reached 745 ind m^{-3} in April 2006 and *Daphnia pulex* reached 940 ind m^{-3} in December 2006. From the Ciliata group, *Tintinnopsis nana* reached 38,715 ind m^{-3} in April 2006 and *Paramecium* sp. Müller, 1773 reached 2355 ind m^{-3} in March 2006. Nauplius larva reached 4190 ind m^{-3} in July 2006 and the cypris larva of *Balanus* was detected in November 2006 (218 ind m^{-3}).

Sample from depths of 5-7.5 m:

When the samples from 5-7.5 m were examined, it was seen that from the Rotifera group, *Asplanchna priodonta* reached 2191 ind m^{-3} in April 2006, *Brachionus plicatilis* reached 191,564 ind m^{-3}, and *Synchaeta pectinata* reached 1948 ind m^{-3} in July 2006. *Keratella quadrata* reached 130 ind m^{-3} in April 2006. *Polyarthra major* reached 6115 ind m^{-3} in December 2006. *Cephalodella* sp. reached 510 ind m^{-3} in November 2006 and *Lecane luna* reached 48,917 ind m^{-3} in December 2006. *Acartia clausi* from the Copepoda group reached 28,592 ind m^{-3} in July 2006. *Bosmina longirostris* from the Cladocera group reached 130 ind m^{-3} in June 2006. *Tintinnopsis nana* from the Ciliata group reached 36,399 ind m^{-3} in April 2006. Nauplius larva reached 2859 ind m^{-3} in July 2006.

Statistical analysis

The Sorensen similarity index was used to examine the similarities in the numbers of species present at the 2 stations. The results showed that the similarities decreased from the lake surface to the bottom of the sampling range (Table 3).

Physicochemical characteristics of the lake water were obtained only from the surface samples at the first and the second stations. Therefore, the correlation values below refer to the surface samples.

In the surface sample of the first station, a positive correlation was identified between water temperature and *Acartia clausi*, the nauplius larva of *Balanus*, and *Gammarus* sp. Fabricius, 1775, and a negative correlation was identified between water temperature and *Lecane luna*, *Synchaeta pectinata*, and *Bosmina longirostris*. There was a positive correlation between salinity and *Acartia clausi* and *Brachionus plicatilis*, and a negative correlation between salinity and *Asplanchna priodonta*, *Tintinnopsis nana*, and *Polyarthra mira*. There was a positive correlation between nitrite and *Keratella cochlearis*, *Tintinnopsis nana*, *Cyclops vicinus*, and *Gammarus* sp. Fabricius, 1775, and a negative correlation between nitrite and *Lecane luna*, *Bosmina longirostris*, nauplius larva, and *Hexarthra mira*. There was a positive correlation between nitrate and *Keratella cochlearis*, *Gammarus* sp. Fabricius, 1775, *Canthocamptus* sp. Westwood, 1836, and *Notholca acuminata*, and a negative correlation between nitrate and *Bosmina longirostris*, nauplius larva, *Brachionus plicatilis*, and *Lecane luna*. There was a positive correlation between phosphate and *Gammarus* sp. Fabricius, 1775, *Keratella cochlearis*, and the nauplius larva of *Balanus*, and a negative correlation between phosphate and *Lecane luna*, nauplius larva, *Bosmina longirostris*, and *Polyarthra mira*.

The correlations that were detected in the surface sample of the second station were as follows: positive correlation between water temperature and *Acartia clausi*, *Brachionus plicatilis*, and *Lecane luna*, and negative correlation between water temperature and *Asplanchna priodonta*, *Bosmina longirostris*, and *Synchaeta pectinata*; positive correlation between salinity and nauplius larva of *Balanus*, *Pleurobrachia pileus*, *Brachionus plicatilis*, and *Synchaeta pectinata*, and negative correlation between salinity and *Tintinnopsis nana*, *Epiphanes* sp. Ehrenberg, 1832, *Cyclops vicinus*, and *Philodina* sp. Ehrenberg, 1830; positive correlation between nitrite and *Tintinnopsis nana*, *Cyclops vicinus*, *Canthocamptus* sp. Westwood, 1836, *Philodina* sp. Ehrenberg, 1830, and *Epiphanes* sp. Ehrenberg, 1832, and negative correlation between nitrite and *Bosmina longirostris*, *Asplanchna priodonta*, and *Synchaeta pectinata*; positive correlation between nitrate and *Pleurobrachia pileus* and nauplius larva

Table 3. Sorensen similarity index between the stations in terms of the number of species depending on depth: S = 2a/(2a + b + c).

Depths	a	b	c	S
Surface	13	4	3	0.79
0-2.5 m	10	6	2	0.72
2.5-5 m	8	4	6	0.62

of *Balanus*, and negative correlation between nitrate and *Asplanchna priodonta*, *Acartia clausi*, *Brachionus plicatilis*, and *Lecane luna*; positive correlation between phosphate and nauplius larva of *Balanus*, *Pleurobrachia pileus*, *Acartia clausi*, and *Brachionus plicatilis*, and negative correlation between phosphate and *Bosmina longirostris*, *Asplanchna priodonta*, and *Synchaeta pectinata*.

Spearman correlation values indicated that at the first station, there were directly proportional correlations between temperature and salinity ($P < 0.01$, $r = 0.82$), temperature and nitrite ($P < 0.01$, $r = 0.70$), phosphate and nitrite ($P < 0.01$, $r = 0.86$), phosphate and nitrate ($P < 0.01$, $r = 0.82$), *Lecane luna* and *Brachionus plicatilis* ($P < 0.01$, $r = 0.77$), *Lecane luna* and *Hexarthra mira* ($P < 0.01$, $r = 0.77$), *Canthocamptus* sp. Westwood, 1836 and *Notholca acuminate* ($P < 0.01$, $r = 1$), *Lecane luna* and nauplius larva ($P < 0.01$, $r = 0.75$), nitrite and nitrate ($P < 0.05$, $r = 0.70$), phosphate and *Gammarus* sp. Fabricius, 1775 ($P < 0.05$, $r = 0.65$), nauplius larva and *Brachionus plicatilis* ($P < 0.05$, $r = 0.66$), and nauplius larva and *Hexarthra mira* ($P < 0.05$, $r = 0.69$).

At the second station, there were directly proportional correlations between temperature and salinity ($P < 0.01$, $r = 0.86$), *Pleurobrachia pileus* and the nauplius larva of *Balanus* ($P < 0.01$, $r = 1$), *Asplanchna priodonta* and *Synchaeta pectinata* ($P < 0.01$, $r = 0.83$), *Brachionus plicatilis* and *Lecane luna* ($P < 0.01$, $r = 0.77$), temperature and phosphate ($P < 0.05$, $r = 0.73$), salinity and phosphate ($P < 0.05$, $r = 0.75$), nitrite and nitrate ($P < 0.05$, $r = 0.70$), nitrite and *Tintinnopsis nana* ($P < 0.05$, $r = 0.65$), *Tintinnopsis nana* and *Epiphanes* sp. Ehrenberg, 1832 ($P < 0.05$, $r = 0.64$), *Canthocamptus* sp. Westwood, 1836 and *Philodina* sp. Ehrenberg, 1830 ($P < 0.05$, $r = 1$), *Canthocamptus* sp. Westwood, 1836 and *Epiphanes* sp. Ehrenberg, 1832 ($P < 0.05$, $r = 0.75$), and *Philodina* sp. Ehrenberg, 1830 and *Epiphanes* sp. Ehrenberg, 1832 ($P < 0.05$, $r = 0.75$).

Discussion

The zooplankton species of Lake Küçükçekmece include organisms that live in freshwater and those that live in marine environments. The groups found in the freshwater environment were Rotifera, Copepoda, and Cladocera; the marine groups were Ciliata, Copepoda, Amphipoda, Polychaeta, and Ctenophora.

Zooplankton species are important indicators for lakes since most of them are used to determine the quality, the trophic level, and the level of pollution of lakes. For example, the *Keratella* and *Brachionus* species of Rotifera are indicators of productive lakes, while the *Filinia* and *Polyarthra* species of Rotifera are indicators of polluted water (Emir, 1994). Some species belonging to these genera were detected in Lake Küçükçekmece.

Demirhindi (1972) determined the taxonomies of planktonic organisms and ascertained their seasonal distributions in lagoons and brackish water lakes over a period of 3 years in 9 lakes (Meliç, Gala, Bafa, Güllük, Köyceğiz, Apolyont, Manyas, Salda, and Yarışlı). The results showed that Cladocera and Copepoda were the dominant groups in all of the lakes studied (Tellioğlu, 1998). However, the results of the present study indicate that Rotifera is the dominant group in Lake Küçükçekmece.

According to Stemberger and Gannon (1978), while oligotrophic lakes are represented by Copepoda fauna, large groups of small herbivorous zooplankters (Rotifera and Cladocera) are found in advanced eutrophic lakes. In other words, the Rotifera group forms an important part of the biomass in eutrophic lakes. In the present study, the Rotifera group appeared as the dominant group in Lake Küçükçekmece.

In their research in the Bristol Channel and the Severn Estuary, Collins et al. (1982) included *Pleurobrachia pileus* (83%) in real estuarine species and *Acartia clausi* in euryhaline marine species in April 1974. A strong relationship was demonstrated between the assemblages and salinity. The ctenophore *Pleurobrachia pileus* Müller was fairly ubiquitous in its distribution, although it was never assigned to the stenohaline marine assemblage.

Niermann et al. (1998) indicated that 1 of the 2 dominant Ctenophora species in the Black Sea is *Pleurobrachia pileus*. It was shown that the biomass of this species reached 200-260 g m^{-3} in July 1992 and August 1993 in the southern part of the Black Sea. In the present research, this species was detected at

the level of 4 ind m^{-3} at the second station in October 2006.

Erkan et al. (2000) indicated that *Acartia clausi* was found in the upper part of the water, and that temperature and light had little effect on its vertical distribution. In the present study, a positive correlation was found at the first and the second stations between this species and temperature ($r = 0.50$ and $r = 0.48$).

The composition of freshwater zooplankton species of Lake Küçükçekmece generally resembles the composition of zooplankton species of other lakes.

The results of some physicochemical analyses of the water of the lake showed that the lake is polluted by human-related household wastes. Turbidity was found to be high in spring, summer, and autumn, when pollution rises. The presence of saprophytic Ciliata species in Lake Küçükçekmece and the fact that they reached high numbers in certain periods (spring, March 2006) indicate that the lake is rich in organic matter.

Eutrophication refers to elevated nutrient levels in water. The most important indicator of eutrophication is the excess multiplication of algae. This event often occurs in Lake Küçükçekmece under appropriate conditions.

Chlorophyll values of Lake Küçükçekmece ranged between 10.18 and 56.74 mg m^{-3} at the first station, and between 5.77 and 63.32 mg m^{-3} at the second station. These results show that the lake is at the eutrophic level.

The patchy nature of zooplankton distribution is mostly explained as a response to a complex series of environmental factors operating at various scales of different biotic and abiotic components (Lam-Hoai et al., 2006).

Lake Küçükçekmece, which has an apparent feature of eutrophication, is a lake connected to the sea via a ford. Therefore, sea water mixes with the lake water in summer and autumn, when the water level of the lake decreases. This ingress and egress of saltwater is thought to be one of the factors that affect the composition of zooplankton and therefore the number of individuals. In spite of these features, Lake Küçükçekmece includes most of the zooplankton species belonging to main groups such as Rotifera, Copepoda, and Cladocera, which are also found in other freshwater lakes in Turkey.

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