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Community Structure of Zooplanktonic Organisms in Lake Akşehir*

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Abstract: In this study, the abundance and seasonal distribution of rotifer and crustacean zooplankton were examined. A negative correlation beetween rotifers and crustaceans in terms of their abundancy rates was observed. Copepods were most abundant and comprised 43.3 %; rotifers comprised 34 % and cladocerans comprised 22.6% of the total zooplanktonic organisms. Copepods were abundant in autumn whereas rotifers were abundant in spring and autumn but cladocerans were abundant in summer periods.

Some zooplanktonic organisms recorded in all samples throughout the study period were *Filinia, Hexarthra, Brachionus, Asplanchna, Keratella, Arctodiaptomus spinosus and Diaphanosoma lacustris.*

Key Words: Rotifera, Cladocera, Copepoda, Biomass, Seasonal distribution

Akşehir Gölü Zooplanktonik Organizmalarının Kommunite Yapısı

Özet: Bu çalışmada, rotiferlerin ve kabuklulara ait zooplanktonik organizmaların mevsimsel dağılımları ve bollukları incelenmiş ve aralarında negatif bir korelasyon olduğu saptanmıştır.

Toplam zooplanktonun sayısal olarak % 43.3 ünü Copepoda, % 34 ünü Rotifera ve % 26 sını Cladocera oluşturmaktadır. Copepodlar genellikle sonbaharda, rotiferler ilkbahar ve sonbaharda yoğunken, kabuklular yaz aylarında yoğun olarak gözlenmiştir.

Tüm örnekleme dönemi boyunca gölde tespit edilen zooplanktonik organizmalardan bazıları şunlardır.*Filinia, Hexarthra, Brachionus, Asplanchna, Keratella; Arctodiaptomus spinosus ve Diaphanosoma lacustris.*

Anahtar Sözcükler: Rotifera, Cladocera, Copepoda, Biyomas, Mevsimsel Dağılım

Introduction

Although many recent studies have appeared concerning zooplankton taxonomy in Turkey (1-8), there is a great need for ecological studies of lake ecosystems.

Lake Akşehir is shallow and large, and is an "A" class wetland of central Anatolia. The lake is very important for ornithology, fisheries and the native crayfish. The lake is connected to lake Eber by Taşköprü stream. Recently the water color and structure of the lake have been affected both by indrustrial pollution from the alkoloid factory located near lake Eber and sewage effluent of Akşehir.

The aim of this paper is to report the short term changes in the species composition and seasonal distribution of zooplanktonic organisms between 1991 and 1992.

Study area

Coordinates: 38° 31'N-31° 28'E

Altitude: 960 m

Surface Area: 33500 ha

Lake Akşehir is located between the Sultan and Emir Mountains in central Anatolia.The lake is fed mainly by Taşköprü stream, lake Eber, Adıyan and Engelli streams and rain as well snow water (9-12), (Figure 1).

During the study period, the following macrophytes species were observed: *Ceratophyllum demersum, Phragmites australis, Potamogeton pectinatus, Bulbuschoenus maritimus, Tamarix* sp., *Cirsium alatum, Pseudocreticum* sp., *Galega officinalis, Plantago lanceolata, Najas marina,* and *Ranunculus saniculifolius*.

* This study is a part of PhD dissertation

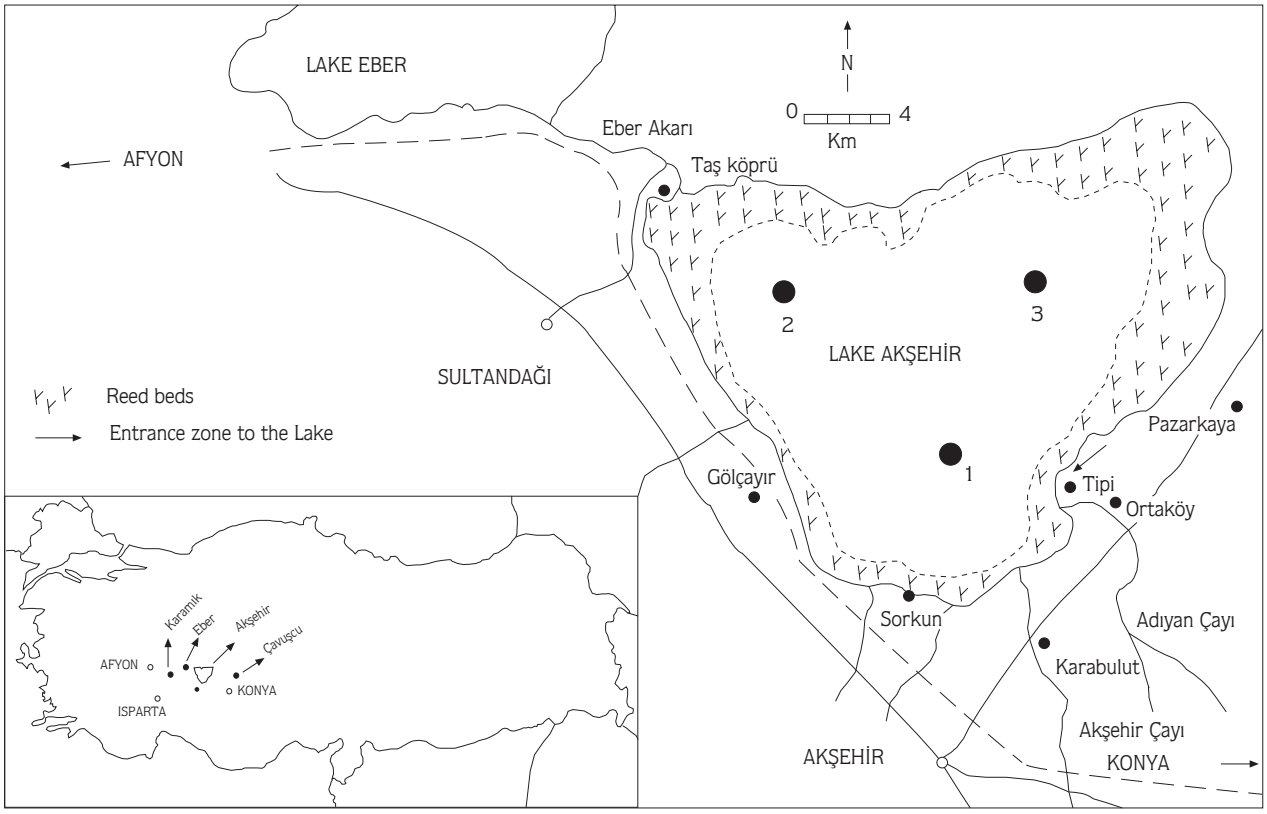

Figure 1. Sampling area

The following phytoplanktonic organisms appeard most during the surveys: *Achnanthes, Cocconeis, Cyclotella, Cymbella, Diatoma, Epithemia, Fragillaria, Gomphonema, Gyrosigma, Caloneis, Asterionella, Amphora* (Bacillariophyta); *Anabaena, Chrococcus, Lygbya, Oscillatoria, Merismopedia* (Cyanophyta); *Closterium, Cosmarium, Oocystis, Euastrum, Chylamydomonas* (Chlorophyta); *Ceratium, Peridinium* (Dinophyta); *Euglena, Phacus, Trachelomonas* (Euglenophyta); *Cryptomonas* (Cryptophyta)

The fishes observed in the lake in 1991 were as follows *Cyprinus carpio, Esox lucius, Leuciscus cephalus, Leuciscus lepidus, Alburnus orontis, Gobio gobio, Cobitis taenia, Neomachileus angorae* and *Cyprinus carpio* (11). However during the sampling period the most abundant organisms were *Cyprinus carpio, Esox lucius and Leuciscus cephalus.*

Materials and Methods

During this study, samples were collected monthly from three stations using a plankton net of 44 µm mesh size and a Patalas sampler with a volume of 3.5 L and hauling through the water column. The samples were fixed with formaldehyde in 4 % and then, they were concentrated. One to ten ml of each sample were counted until 200 individuals at least or 10 % of the sample volume were enumerated using an inverted microscope (13) and 95 % confidence limits were fitted to calculate the mean population estimates. Rotifera and Crustacean species were identified from the literature (14-20).

During the sampling period, dissolved oxygen, conductivity, salinity, pH, temperature and Secchi depth were measured in the pelagial zone of the lake using portable instruments (YSI 33 SCT meter, YSI 51 B oxygen meter and pH meter).

Results

The rotifera species recorded from the lake, are given below. The crustacean species and genera are given in Table 2. The zooplanktonic community of the lake is composed of mainly Copepoda, Rotifera and Cladocera. A total of 36 Rotifera, 2 Copepoda and 6 Cladocera species were

identified. Copepoda comprised 43 %, Rotifera 34 % and Cladocera 22.6 % of the total zooplankton density.

The measured physical parameters are given in Table 1, the seasonal distribution of the zooplankton of Lake Akşehir is given in Table 2 and also in Figures 2-3.

Identified Rotifera species

1. Fam.: Brachionidae
   1. *Brachionus quadridentatus* HERMANN, 1783
   2. *Brachionus plicatilis* (O. F. M., 1986)
   3. *Brachionus urceolaris* (O. F. M., 1773)
   4. *Brachionus rubens* EHRENBERG, 1838)
   5. *Brachionus calyciflorus* PALLAS, 1766
   6. *Brachionus angularis* GOSSE, 1851
   7. *Keratella quadrata* (O. F. M., 1786)
   8. *Keratella cochlearis* (GOSSE,1851)
   9. *Anuraeopsis fissa* (GOSSE, 1851)
2. Fam.: Euchlanidae
   10. *Euchlanis dilatata* EHRENBERG, 1832
3 Fam.: Trichotridae
   11. *Trichotria pocillum* (O. F. M., 1773)
4 Fam.: Colurellidae
   12. *Colurella colurus* (EHRENBERG, 1830)
   13. *Colurella uncinata* (O. F. M., 1773)
   14. *Lepadella patella* (O. F. M., 1786)
5 Fam.: Lecanidae
   15. *Lecane luna* (O. F. M., 1776)
   16. *Lecane (M.) lamellata* (DADAY, 1893)
   17. *Lecane nana* (MURRAY, 1913)
   18. *Cephalodella gibba* (EHRENBERG., 1838)
6. Fam.: Gastropodidae
   19. *Ascomorpha saltans* (BARTSCH, 1870)
   20. *Ascomorpha ovalis* (BERGENDAHL, 1892)
7. Fam.: Synchaetidae
   21. *Synchaetae pectinata* EHRENBERG, 1832
   22. *Synchaeta oblonga* EHRENBERG, 1831
   23. *Polyarthra vulgaris* CARLIN, 1943
   24. *Polyarthra dolichoptera* IDELSON, 1925
8. Fam.: Asplanchnidae
   25. *Asplanchna priodonta* GOSSE, 1850
   26. *Asplanchna (A). girodi* (DE GUERNE, 1888)
   27. *Asplanchna (A) sieboldi* (LEYDIG, 1854)
9. Fam.: Testudinellidae
   28. *Testudinella patina* (HERMANN, 1783)
   29. *Pompholyx complanata* GOSSE, 1851

Table 1. Measured physical parameters in Lake Akşehir

Date	T(°C)	O_2 (mg/L)	EC µS/cm	Salinity (‰)	PH	Depth (m)	Secchi D.(cm)
5/9/90	20.5	7.8	597	0.2	9	3	35
30/10/90	13	8.5	3000	0.2	8	2	30
25/12/90	3	13.2	1600	2	9	2	35
4/5/91	26	7.4	4780	3.25	9.5	3.25	50
8/6/91	25	7.8	4500	3	9.5	2.4	30
24/8/91	21.5	7.8	4200	2.5	9.5	2.25	30
16/11/91	23	7.8	3800	2.5	9	2.2	30
30/11/91	6.5	7.3	2850	2.3	8.7	2	30
18/4/92	15	8.3	3100	2.5	8.35	2	25
26/6/92	15	8.3	4200	4	9.5	2.8	40
12/7/92	22	8.9	3880	2.5	7.68	3	30
1/8/92	19.7	8.7	3900	2.5	9.56	2.8	25
6/8/92	13	8.9	3800	2.3	10	3	33
29/8/92	22.7	9	4350	2.5	8.72	2.8	30
10/10/92	15.5	9.6	3900	2.9	8.6	2.5	35

Table 2. Counted Zooplanktonic Organisms of Lake Akşehir in Different Sampling Dates (ind/m^3)

	5/9/90	25/12/90	4/5/91	8/6/91	24/8/91	12/10/91	16/11/91
COPEPODA							
Calanoid Copepoda	186(131-259)	2290(929-5632)	3801(762-18927)	6456(1573-26468)	75(24-146)	2382(2246-2523)	23547(8611-69957)
Copepodit	316(126-779)	19860(8205-48060)	9332(2696-32287)	2041(852-4876)	145(135-152)		11220(6130-20531)
Nauplius	309(73-1275)	191(33-1048)	22908(20093-26114)	4786(778-29385)	537(493-654)	6280(5868-6718)	17021(10637-27232)
Cyclopoid Copepoda		76(5-956)				4415(4012-4855)	12023(212-678096)
CLADOCERA							
Diaphanosoma lacustris		234(116-467)		698(390-1190)	1788(1040-3056)		6166(581-65285)
Other Cladocera species	1348(1035-1751)	234(64-832)	36507(547-427714)	6918(3997-11967)		10964(10245-11730)	
ROTIFERA							
Brachionus calyciflorus	56(7-389)					56(96-127)	
B.urceolaris	112 (96-127)				46(14-133)		
B.angularis			38018(10472-138004)	4897(693-34522)			
B.quadridentatus			1999(337-11793)	1809(103-29305)	1590(453-5564)		
B.plicatilis		33(19-51)	2884(1601-5190)		235(62-707)		
Keratella quadrata	76 (19-280)		314(61-1561)	954(301-2305)	24(11-42)	105(26-420)	
K.cochlearis	4 (0-32)						
Anuraeopsis fissa			758(226-2523)				
Lecane luna	118 (110-124)	30(4-155)	867(273-2338)				
Hexarthra spp.	73 (20-237)		95(30-325)	118(28-495)	75(25-225)	3530(1176-10589)	
Filinia spp.			11841(4320-32443)	9388(825-13899)	3100(3096-10850)	1540(549-4311)	
Ascomorpha spp.			225(179-280)				
Lecane nana			227(89-568)				
L. lamellata			83(17-380)				7586(2605-22073)
Lepadella patella			225(179-280)				21887(13678-35237)
Asplanchna spp.				152(58-385)		158(30-837)	324(65-1577)
Euchlanis sp.				45(12-145)			
Polyarthra sp.				27(6-98)			

	30/11/91	18/4/92	26/6/92	12/7/92	1/8/92	29/8/92	10/10/92
COPEPODA							
Calanoid Copepoda (Female)	11749(916-150384)	1072(770-1489)	1318(539-3214)	1698(811-3547)	73(47-108)	776(83-7310)	380(120-1188)
Calanoid Copepoda (Male)	11482(6413-20550)	243(156-347)		275(67-1101)	22(9-43)	200(80-478)	138(114-163)
Copepodit	18543(1243-306824)	1905(1189-3047)	2754(586-12915)	8128(4299-1536)	53(26-103)	2138(135-33565)	288(235-350)
Nauplius	19634(12270-31412)	10715(10401-11035)	1120(639-1939)	5248(3915-7031)	457(327-634)	1517(229-9965)	1585(953-2629)
CLADOCERA							
Diaphanosoma lacustris	10750(8268-13974)	5210(1487-18234)		5012(2397-10474)	134(116-151)	2137(89-50218)	331(157-690)
Other Cladocera species					2310(1540-3464)		
ROTIFERA							
Brachionus calyciflorus		43(8-190)					
Keratella quadrata		570(90-3010)				6(0-99)	
Hexarthra spp.	2495(795-7806)	1412(1044-1905)		724(424-1229)	145(102-199)	660(240-1670)	2570(1316-5010)
Filinia spp.	6025(3089-11748)	680(140-3263)	1385(553-3461)	15136(6333-36174)	31(17-51)	3890(2945-5133)	660(634-686)
Asplanchna spp.		3236(2327-4497)	76(11-463)	275(224-334)		224(202-245)	62(37-97)
Brachionus angularis				38(8-190)	78(62-93)		

95% Confidence limits of counted zooplanktonic organisms are shown in parentheses

COPEPODA	7/11/92
Calanoid Copepoda (Female)	1445(1362-1530)
Calanoid Copepoda (Male)	426(420-429)
Copepodit	1412(1014-1961)
Nauplius	1023(810-1287)
CLADOCERA	
Diaphanosoma lacustris	660(256-1688)
Other Cladocera species	
ROTIFERA	
Brachionus calyciflorus	
Keratella quadrata	
K.cochlearis	
Hexarthra spp.	
Hexarthra spp.	1690(712-4004)
Filinia spp.	580(85-3885)
Asplanchna spp.	368(16-7579)
Brachionus angularis	

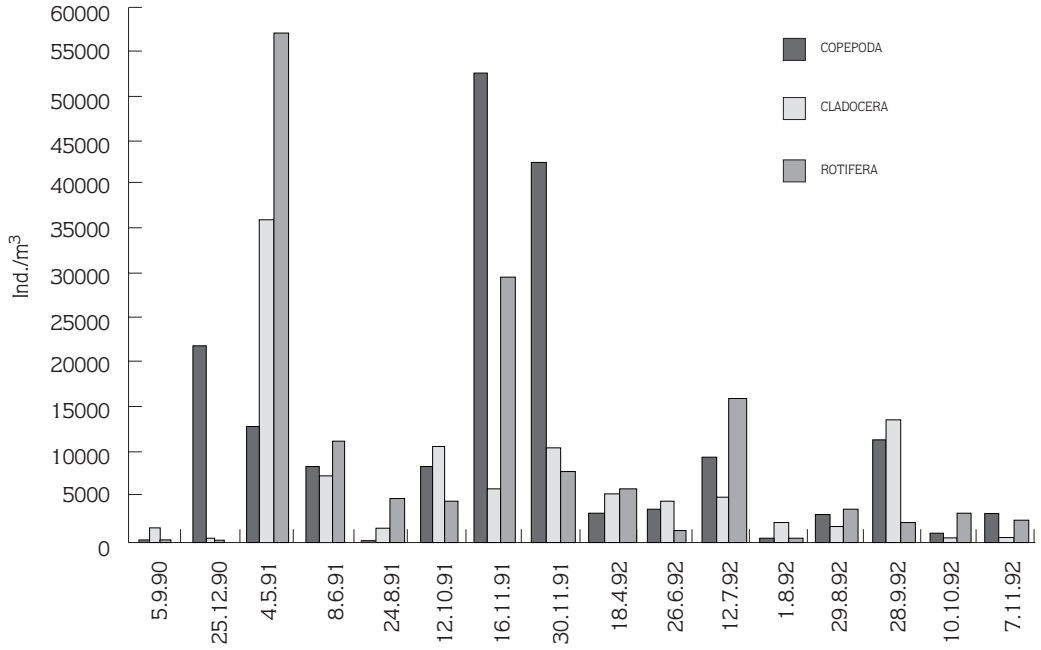

Figure 2. Seasonal distribution of zooplankton during the sampling period

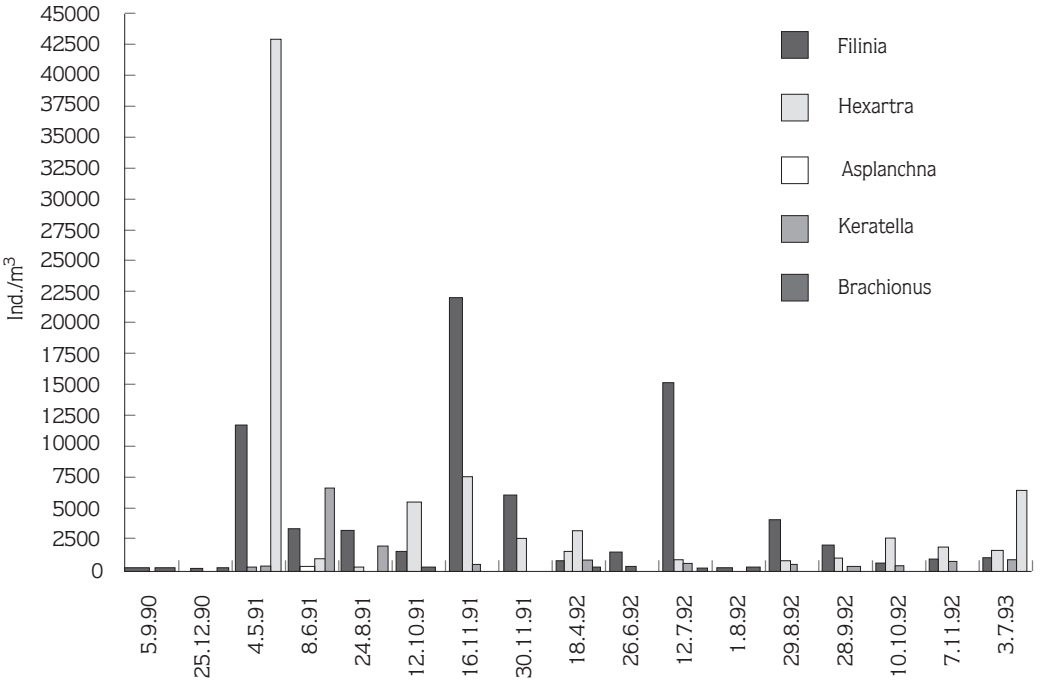

Figure 3. Seasonal distribution of rotifers during the sampling period

10. Fam.: Conochilidae

30. *Conochilus natans* (SELIGO, 1900)

11. Fam.: Hexarthridae

31. *Hexarthra mira* (HUDSON, 1871)

32. *Hexarthra fennica* (LEVANDER, 1892)

12. Fam.: Filinidae

33. *Filinia longiseta* (EHRENBERG, 1834)

34. *Filinia terminalis* (PLATE, 1886)

35. *Filinia pejleri* HUTCHINSON, 1964

13. Fam.: Philodinidae

36. *Philodina megalotrocha* EHRENBERG, 1832

Identified Cladocera and Copepoda Species

Moina macrura

Daphnia longispina

Diaphanosoma lacustris

Alona rectangula

Chydorus sphaericus

Bosmina longirostris

Scaphaloberis mucronata

Arctodiaptomus spinosus

Acanthodiaptomus denticornis

Cyclops sp.

Among crustacean species *Arctodiaptomus spinosus* and *Acanthodiaptomus denticornis* had high density within the total zooplanktonic community. These species were found at all the stations throughout the year. Especially in autumn periods, they reached maximum abundance. Among cladoceran, *Diaphanosoma lacustris* was dominant. This species reached maximum density in summer and autumn periods (14454 ind./m^3). The total number of copepods varied from 148 ind./m^3 in August 1992 to 51000 ind./m^3 in October 1991. Whereas the total number of Cladocera varied from 331 ind./m^3 in October 1992 to 36507 ind./m^3 in May 1991.

Among rotifers, *Brachionus angularis, B. quadridentatus, B. plicatilis, Keratella quadrata, Hexarthra, Filinia* and *Asplanchna* were abundant organisms. The highest percentages of rotifers was found in May, June and November 1991, July 1992 and July 1993. The total number of rotifers varied from 63 ind./m^3 in December 1990 to 57536 ind./m^3 in May 1991 (Figure 3).

Although the horizontal distribution of the zooplanktonic organisms was nearly uniform, usually copepods and rotifers were dominant at the first and second stations, while cladocerans were abundant at the third station.

During the spring period, some rotifers such as *Brachionus angularis* were the most abundant species at the first station, *Brachionus quadridentatus* at the first and second stations, *B. plicatilis* at the second and third stations, *Anuraeopsis fissa* at the first, *Filinia longiseta* at the second and third stations, *Lecane luna* at the second, *L. nana* at the first, *Keratella quadrata* at the first and *Diaphanosoma lacustris* at the second and third stations. In this period Copepoda had 1850 individuals per m^3 at the first station, 11418 individuals per m^3 at the second station and 2753 ind./m^3 at the third station (Figures 2-3).

In June 1991, phytoplanktonic organisms were dominant at the first station in parallel to the high number of the rotifers of *Brachionus angularis* (18890), *B. quadridentatus* (4934), *Filinia* (9163) and *Keratella quadrata* (1410) individuals per m^3. At the same time, Copepoda at the first station had 16916 individuals, at the second station 3392 individuals and at the third station 4832 individuals per m^3 respectively. It was observed that larger cladocerans were abundant at the second and third stations. Among rotifers, *Fİlinia* and *Asplanchna* were abundant at the second and third stations also. In summer periods cladocerans were more abundant than copepods and rotifers respectively.

In Lake Akşehir the clear water period was observed in May (21).The clear water period is caused by grazing herbivorous zooplankton (22,23) In Lake Akşehir an early peak of small, rapidly growing algae was followed by a short period of clear water and transparency in mid May. During this period Secci depth was measured as 50 cm, which was the highest value for the lake (Table 1). In the summer period, large algae and blue green algae developed after the clear water phase (8). It was observed that in Elmacı, (21) the same results were obtained during the period between June 1992 and November 1993. The decline in algal populations could be a consequence of nutrient limitation, sedimentation and the grazing effect of large bodied grazers.

During the study period, among phytoplankton, Bacillariophyta were dominant in terms of the species diversity and frequency; Cyanophyta and Chlorophyta were also dominant but the members of other divisions were not numerous in Lake Akşehir.

Discussion

Most of the studies dealing with this topic have shown that the increase in nutrients and the corresponding higher phytoplankton biomass result in higher zooplankton biomass (24-29). In Lake Akşehir zooplankton biomass was higher in the spring and early summer periods when the nanoplanktonic algae were dominant.

In the eutrophic lakes, herbivorous zooplanktonic organisms can effectivelly reduce the phytoplankton biomass vulnerable to grazing, at the begining of the growing season (24,26). After an early spring pulse a period of low phytoplankton standing crop is usually observed, caused most likely by high grazing pressure exerted by large bodied filter feeding herbivorous species. However, community grazing rates can vary seasonally and among sites. Community grazing rates were positively related to zooplankton biomass and the size of organisms in a community (30-35).

Also, interactions between invertebrate predators and their preys are reflected in quantitative changes in community dynamics (32) and planktivorous fish control the zooplankton populations especially in the summer months (33). In the presence of planktivorous fish, the proportion of cladocerans decreases and phytoplankton as well as bacteria, flagellates and rotifers are able to proliferate (34-35). Hurlbert (35) observed that lakes with fish usually have a sparse zooplankton dominated by cyclopoid copepods and chydorid cladocerans; the opposite conditions tend to have an abundant zooplankton dominated by calanoid copepods and daphnids. In Lake Akşehir the same result was observed as the calanoid copepods were higher in number than cyclopoids.

Herzig (28) noted that strong wind conditions on the lake and the resulting turbulences cause a mechanical stress on the soft-bodied Cladocera. Among rotifers, *Hexarthra* is also sensitive to temperature and wind action. Herzig and Koste (36) also observed that low temperature and high amount of wind generated suspended particles which can negativelly influence the development of *Hexarthra* population and of several cladocerans (36). In Lake Akşehir, strong wind action might affect the horizontal distribution of the organisms as is the case in other lakes in the area (8).

In deep and stratified lakes, more phytoplankton cause higher densities of zooplankton. The changes in zooplankton abundance, fecundity and size might have been closely corelated with the amount of planktonic algea (37). In such lakes phytoplankton is the basic and frequent food source of the zooplankton community and higher phytoplankton biomass results in higher zooplankton biomass. However, many scientists have found that zooplankton feed on detritus (38,39). In Neusiedlersee it was shown that *Arctodiaptomus spinosus* and *Diaphanosoma brachyrum* may be found without an algal food source. In such shallow lakes the direct grazing food chain seems to be increasingly replaced by the indirect detritus food chain. The role of phytoplankton as a main food source is taken over by bacteria and detritus originating from the bottom (25,39).

In Lake Akşehir the salinity degree was between 0.2 and 4 %. In these lakes, such as Neusiedlersee, *Arctodiaptomus spinosus* was more abundant than the others. Species such as *Brachionus* spp., *Filinia* spp., *Keratella* spp., which can be regarded as the indicators of eutrophy, were present in the lake (8). Among phytoplankton, especially Diatomea such as *Camphylodiscus, Surirella, Cyclotella* and *Diatoma* were dominant and they can also be regarded as indicators of eutrophy and they occur in highly alkaline waters (40).

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