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The Relationship between Seasonal Variation in Phytoplankton and Zooplankton Densities in Hirfanlı Dam Lake (Kırşehir, Turkey)

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Abstract: Phytoplankton and zooplankton densities in Hirfanlı Dam Lake were studied between July 1999 and June 2000. In addition, phytoplankton biomass was measured using chlorophyll a concentration. The density of *Cladocera* at the surface and that of *Rotifera* at the bottom were low in the summer months. For phytoplankton, *Cyclostephanos dubius* (Fricke) Round was dominant. The variation in the density of organisms did not follow a known pattern. Species composition, seasonal distribution and species density variations show that the lake was advanced mesotrophic. The lake was alkaline and, from time to time, there was an odor in the littoral regions where algal bloom occurred.

Key Words: Hirfanlı Dam Lake, phytoplankton, zooplankton, density, seasonal variation

Hirfanlı Baraj Gölü Fitoplankton ve Zooplankton Yoğunluklarının Mevsimsel Değişimi Arasındaki İlişki (Kırşehir-Türkiye)

Özet: Hirfanlı Baraj Gölü fitoplankton ve zooplankton yoğunluğu Temmuz 1999 – Haziran 2000 yılları arasında incelenmiştir. Ayrıca, fitoplankton biyoması için klorofil a konsantrasyonu ölçülmüştür. Yaz aylarında yüzeyde *Cladocera*, derinde *Rotifera* üyeleri düşük yoğunluklarda; fitoplanktonda ise *Cyclostephanos dubius* (Fricke) Round dominanttır. Organizma yoğunluklarının mevsimsel dağılımı beklenen düzende gerçekleşmemiştir. Tür kompozisyonu, mevsimsel dağılım ve organizma yoğunluklarındaki değişimler gölün ileri mezotrofik olduğunu göstermektedir. Göl alkali ve alg patlamalarının olduğu kıyı bölgelerinde zaman zaman kokuşmalar olmaktadır.

Anahtar Sözcükler: Hirfanlı Baraj Gölü, fitoplankton, zooplankton, yoğunluk, mevsimsel değişim

Introduction

Species composition and seasonal variation in densities are important in determining the trophic level of lakes. In some monitoring models, the relationship between phytoplankton and zooplankton is employed (1-5). However, the evaluation of phytoplankton and zooplankton together allows one to establish connections between fish fauna and their development in the habitat. In Turkey, these evaluations are done at different times on different groups of organisms. Hirfanlı Dam Lake, built on Kızılırmak River, has an active volume of 2.0447 $\times 10^{10}$ m^3. Hydroelectric production, irrigation and fishing are carried out in the lake, and it is threatened by erosion.

Materials and Methods

Four sampling stations were chosen in different areas of the reservoir (Figure 1). Station 1 is in a popular fishing area, station 2 is exposed to sewage from the town, station 3 is at a location where intensive farming is undertaken, and station 4 is located at the entrance of the Kızılırmak River into the lake. Samples of phytoplankton and zooplankton were taken monthly from the surface of the lake with a 2-l plastic bottle, with an Hydro-Bioss water sampler at the depths of 0.5, 1, 5, and 10 m. In addition, from a depth of 5 m vertical water sampling was done with a plankton net (55 µm mesh size) between July 1999 and June 2000. One liter of the water sample was fixed with 4% of formaldehyde and allowed to settle. The density of zooplankton was counted 4 times using a 1-ml sample on counting slides (6). For phytoplankton

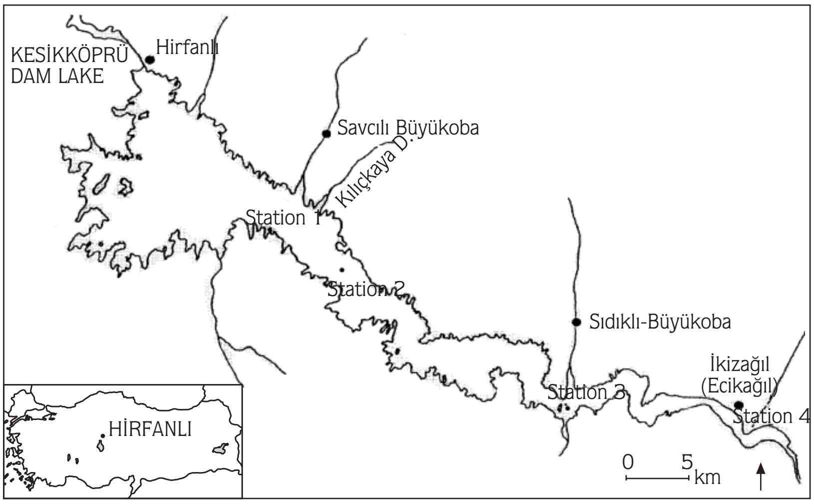


Figure 1. The sampling stations in Hirfanlı Dam Lake.

density, the Lackey drop counting method was used (7). Samples taken with a plankton net were fixed with 250 ml of water containing formaldehyde. The total number of organisms in a vertical water sample is obtained from the volume with $\pi r^2 h$ filtered water. This value was used in calculating the number of organisms in 1 m^3 of sample (Figure 10). All slides were examined under a Nikon light microscope. Zooplankton groups were identified according to the literature (8,9). Furthermore, chlorophyll *a* concentration was measured using a spectrophotometric method with hot methanol (10). Temperature and dissolved oxygen (YSI 30/25 FT model oxygen meter), salinity, and conductivity (YSI 55/25 FT model conductivity meter) were measured in situ (Figures 2-6). Other analyses were carried out only once at the Hacettepe Üniversitesi Uygulama ve Araştırma Merkezi (Research Center of Hacettepe University, Ankara) (only at stations 1 and 4) and the results are given in Table 1.

Discussion and Conclusion

A total of 189 taxa, comprising 174 phytoplanktonic organisms (11) and 15 zooplanktonic organisms (Table 2) were identified in Hirfanlı Dam Lake. The majority of the zooplanktonic species identified had been observed in a previous study (12).

Seasonal variation in phytoplankton and zooplankton:

While *Cyclotella ocellata* Pantocsek, a centric diatom, is the dominant diatom in lakes in Turkey (13-17), *Cyclostephanos dubius* was the dominant and widespread diatom in Hirfanlı Dam Lake. *Peridinium cinctum* (Muell.) Ehr., *Ceratium hirundinella* (O.F. Muell.) Dujardin, *Asterionella formosa* Hassall, *Microcystis aeruginosa* Kuetz. and some species of *Chlamydomonas* were also identified. These species sometimes show increases in density, especially in early summer and autumn in Hirfanlı Dam Lake. However, *Nitzschia palea* (Kützing) W. Smith, *Navicula pupula* Kützing and *Navicula cryptocephala* Kützing, characteristic species of domestic sewage contaminated waters (18), were rare in Hirfanlı Dam Lake phytoplankton but frequent and abundant in the benthic flora. Zooplanktonic groups of organisms of Hirfanlı Dam Lake were similar to those of Kesikköprü Dam Lake (19), Seyfe Lake (9) and Akşehir Lake (20). In late spring and autumn, at stations 1 and 2, phytoplankton and zooplankton showed increases at the surface, and the disappearance of zooplankton in summer and early autumn was an interesting occurrence. Another important finding was that at station 1, in April 2000, at a depth of 10 m, 15,333 ind. l^{-1} zooplankton were found (Figure 7). In May, at the same depth, this number was reduced (512 ind. l^{-1}) whereas it reached the highest value at the surface (1281 ind. l^{-1}). This shows that, to a great extent, the migration of zooplankton is related to feeding behavior (5). In addition, at station 2, the increase in phytoplankton at the surface in autumn and that of zooplankton at the surface and at 0.5 m in spring were more conspicuous compared to other sampling times (Figure 8). This was probably as a result of an

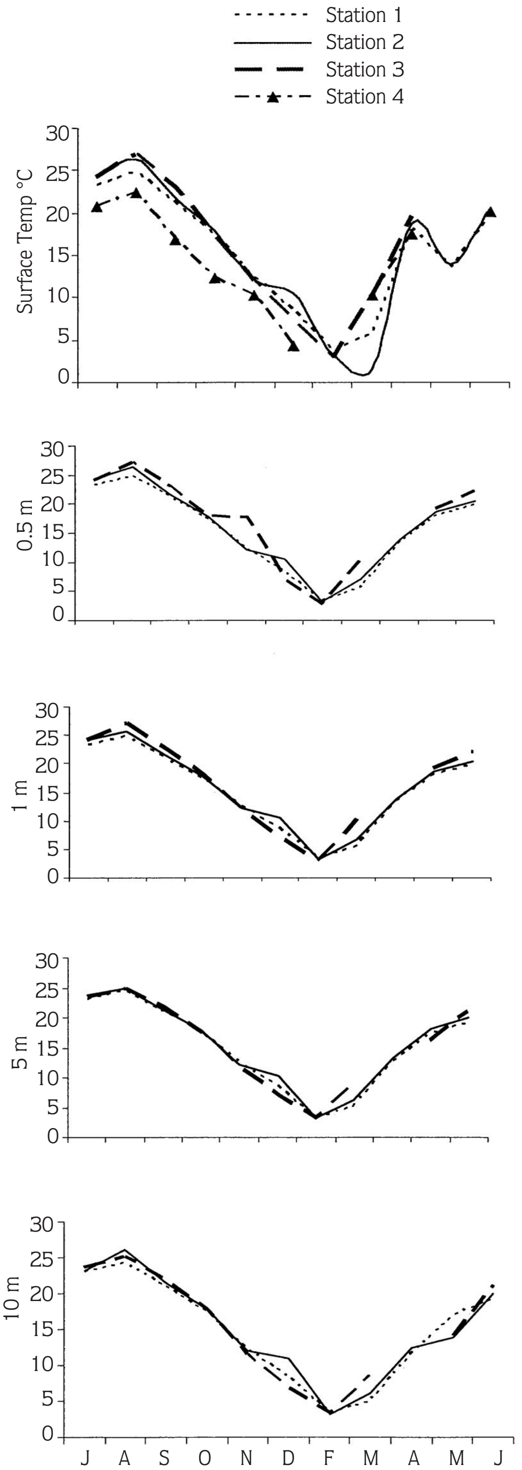


Figure 2. The seasonal variation in temperature in Hirfanlı Dam Lake (ºC).

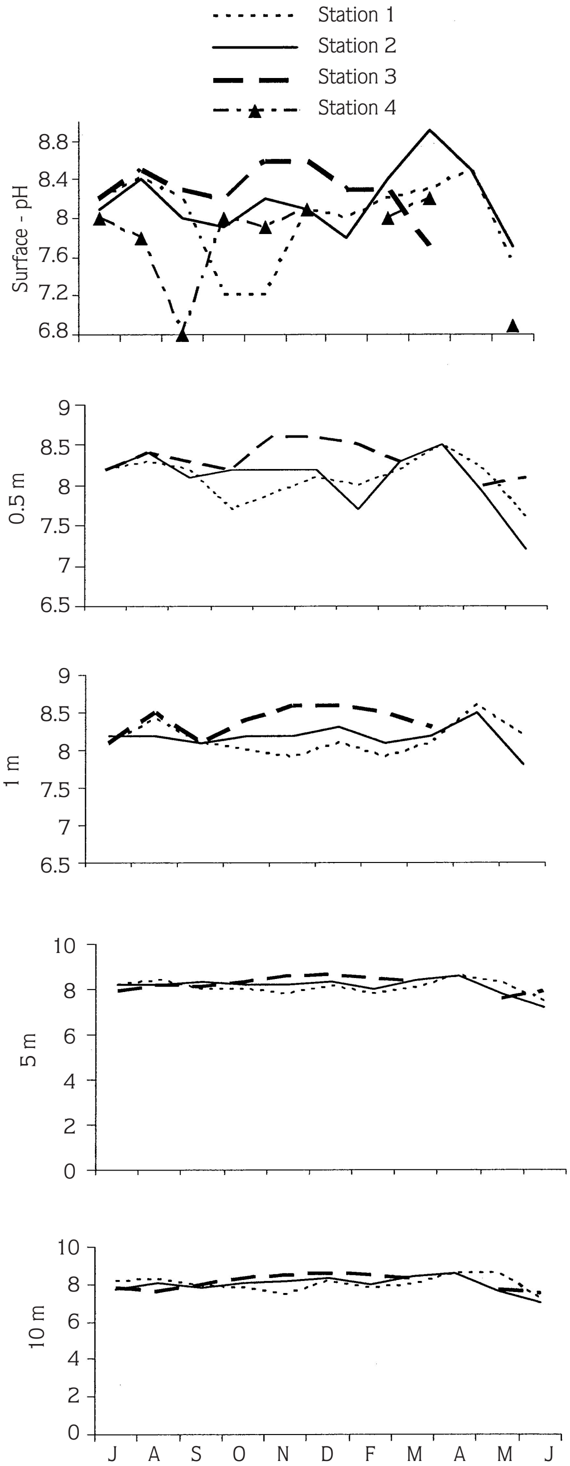


Figure 3. The seasonal variation in pH in Hirfanlı Dam Lake.

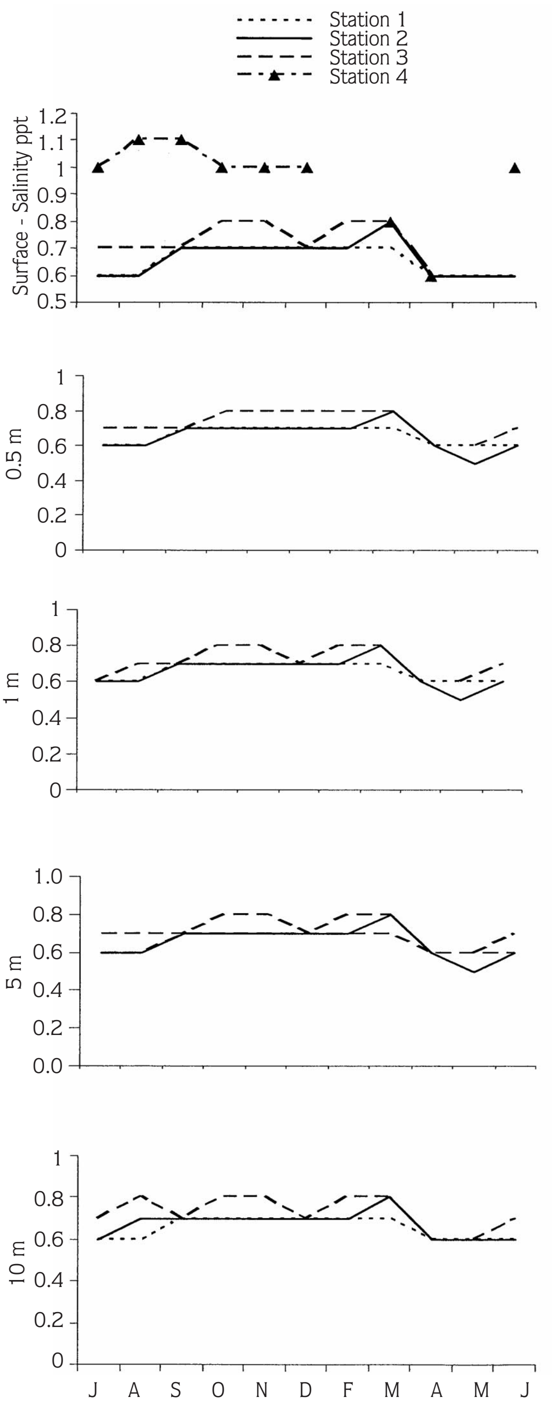


Figure 4. The seasonal variation in salinity in Hirfanlı Dam Lake.

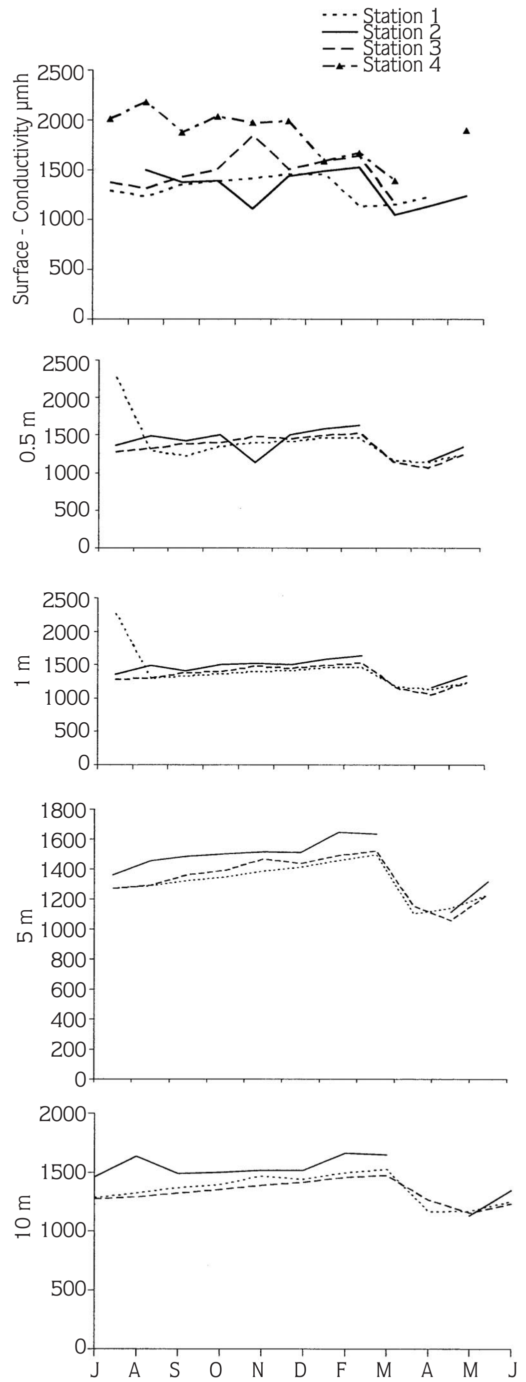


Figure 5. The seasonal variation in conductivity in Hirfanlı Dam Lake.

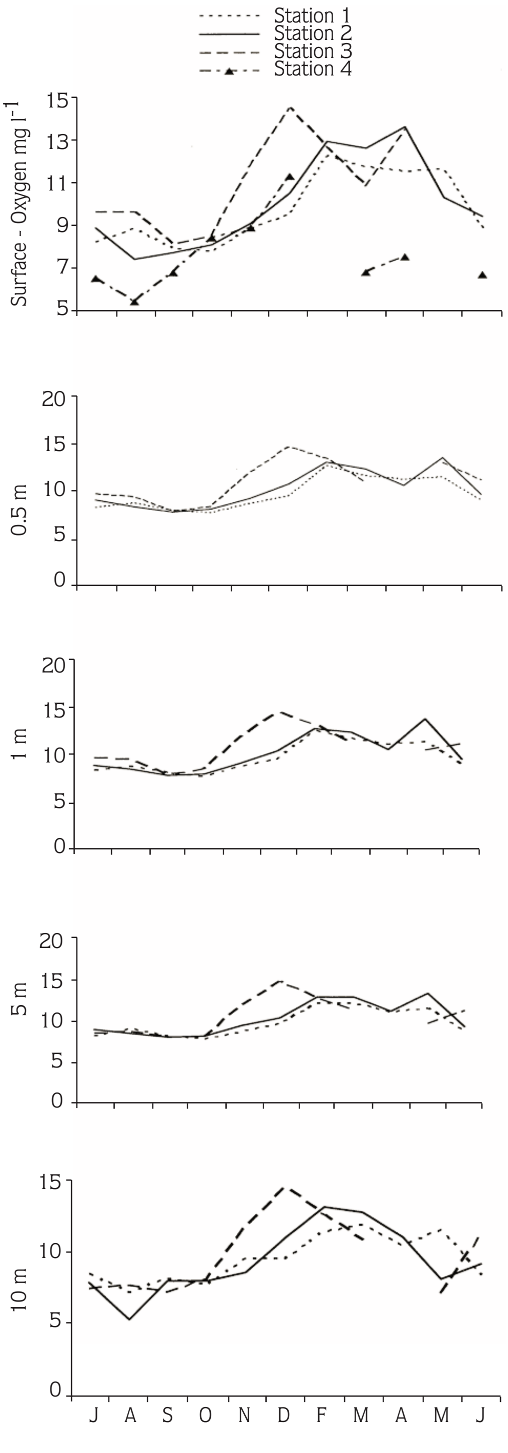


Figure 6. The seasonal variation in oxygen in Hirfanlı Dam Lake.

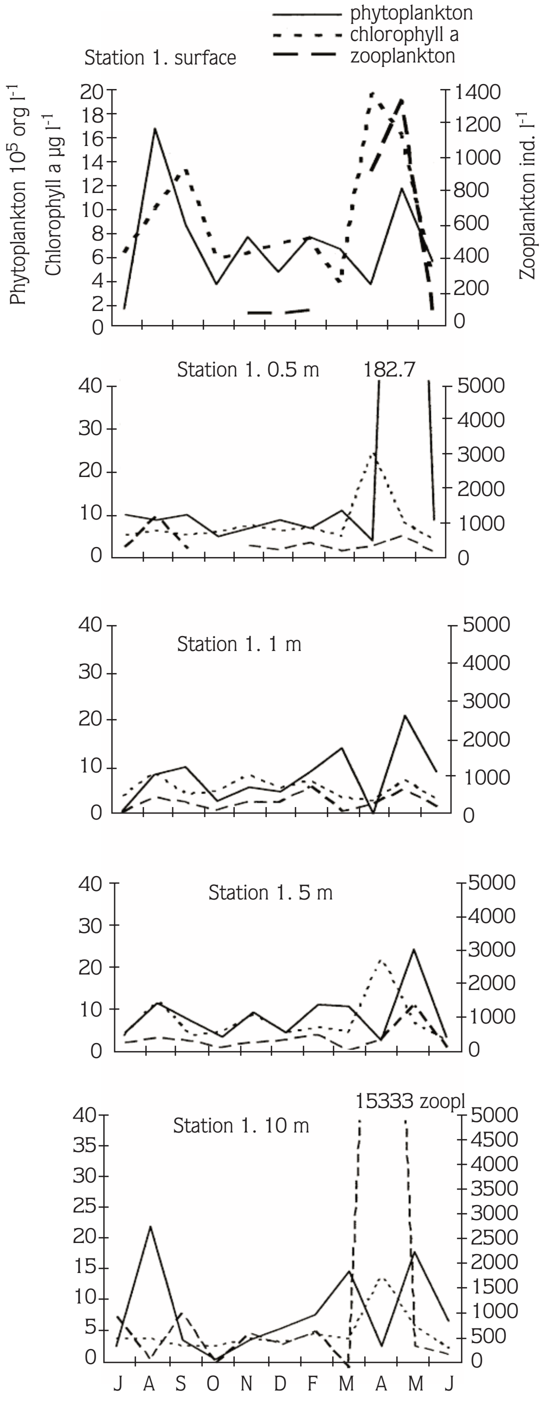


Figure 7. Hirfanlı Dam Lake, Turkey, 1999-2000; Seasonal changes in the density of phytoplankton and zooplankton (assessed by organism number) and concentration of chlorophyll a (station 1).

Table 1. Some chemical characteristics of water in November.

Parameter	NO_3–N	NO_2–N	$PO_{4(ortho)}$	NH_3	Na^+	K^+	Ca^{++}	Mg^{++}	CO_3^{--}	HCO_3^{-}	Cl^-
Method	ASTMD992	419	424E	512AA	309A	309A	309A	309A	403	403	407A
Station 1	0.0000	0.0036	0.1350		150.00 6.525	8.000 0.204	98.000 4.890	27.000 2.220	18.750 0.625	152.500 2.500	242.833 6.850
Station 4	3.0990	0.0078	0.3630		210.00 9.135	7.000 0.179	140.00 6.986	30.000 2.467	34.380 1.146	285.907 4.687	329.685 9.300
Parameter	SO_4-	BOD	COD	SiO_2	(NTU)	FE^{++}	Total Hard. $CaCO_3$	Tot. Diss. Subs. TDS	Tot. Susp Subs. TSS		
Methods	426C			425C		303A	Merck	209D	209D		
Station 1	161.421 3.360	8.110	14	7.936	6.120	0.061	355.50	1014.4	12.0		
Station 4	160.273 3.336	10.980	25	18.313	28.60	0.263	472.65	1267.2	34.0		

Note: Results are given in ppm (1st line) and meq/l (2nd line). Methods: Standard Methods for the Examination of Water and Wastewater (16th Edition).

Table 2. Zooplanktonic taxa identified in Hirfanlı Dam Lake.

	SURFACE	DEPTH
I. ARTHROPODA		
Crustaceae		
Copepoda		
Copepodit – larvae – (*Nauplius* larvae)	+	+
Cyclops – larvae –	+	+
Cyclops strenius Fisch	+	+
Diaptomus sp. (*Calanoid* copepod)	+	+
Eudiaptomus vulgaris (Schmeil, 1896)	+	+
Cladocera		
Daphnia longispina (O.F. Müller, 1776)	+	+
D. pulex (Leydig, 1860)	+	+
Bosmina longirostris (O.F. Müller, 1785)	+	+
Cyderus sp.	–	+
Amphipoda		
Gammarus pulex (Linnaeus, 1758)	+	+
II. ROTIFERA		
Keratella quadrata (O.F. Müller, 1786)	+	+
K. cochlearis (Gosse, 1851)	+	+
Filinia longiseta (Ehrenberg, 1834)	+	+
Brachionus sp.	+	+
Kellicottia longispina (Kellicott, 1879)	+	+
Asplancha priodonta (Gosse, 1850)	+	+
Polyarthra vulgaris (Carlin, 1943)	+	+

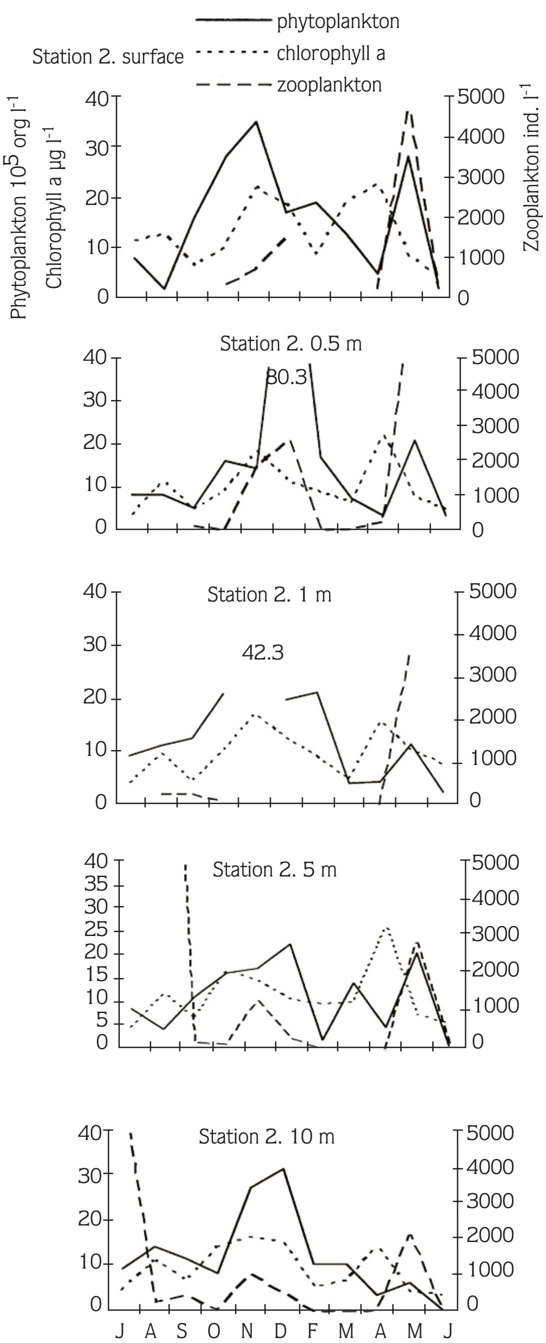


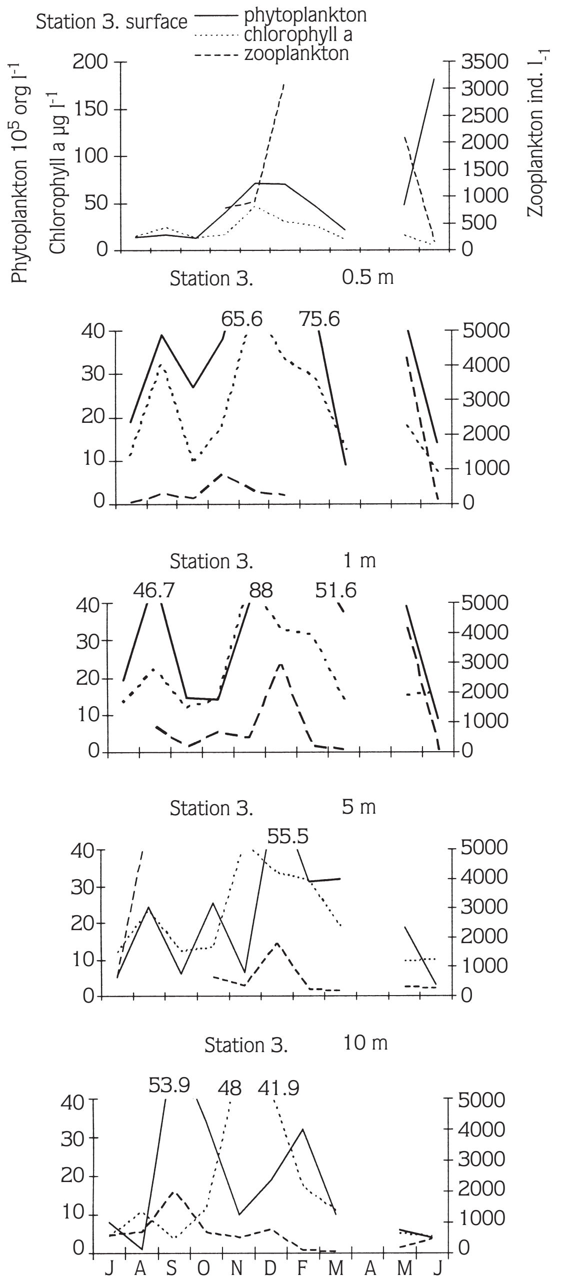
Figure 8. Hirfanlı Dam Lake, Turkey, 1999-2000; Seasonal changes in the density of phytoplankton and zooplankton (assessed by organism number) and concentration of chlorophyll a (station 2).

increase in algae at the surface and the discriminatory feeding habit. The fact that in spring *Chlamydomonas* spp., *Cyclostephanos dubius, Melosira varians* Agardh, and *Dactylococcopsis acicularis* Lemmermann and in autumn *Oscillatoria* spp., *Euglena* spp., and *Nitzschia* spp. showed increases might explain this situation.

In terms of the density and species composition of phytoplankton and zooplankton, station 3 was the most productive region. Irregular increases and decreases were observed in zooplankton (Figure 9). For instance, while phytoplankton density showed an increase at the surface in late spring 2000, zooplankton numbers showed a decrease. Density of phytoplankton reached its maximum value (181×10^5 org. l^{-1}) in June 2000. Chlorophyll *a* concentration for this month was 4.732 µg l^{-1} and that of the previous month was 15.341 µg l^{-1}. There was no simultaneous increase in chlorophyll *a* concentration with an increase in phytoplankton density. This situation was observed in the other months and depths. This shows that chlorophyll *a* concentration in addition to the quantity of organisms is also related to species diversity (21,22). Zooplankton reached its maximum value (3145 ind. l^{-1}) in December 1999. After the increase in the larvae of *Polyartha* and *Synchaeta* in the same month, zooplankton were not observed until May 2000. However, throughout all the seasons, members of *Cladocera* were rather low in number in zooplankton. An increase in phytoplankton was followed by a parallel increase in zooplankton in spring. Competition for food amongst members of *Cladocera* and their consumption by predators allowed the development of *Asplanchna* sp., *Keratella* spp., and *Synchaeta* larvae from *Rotifera*.

Station 4 is at the entrance of Kızılırmak River into the lake. As a result of alluvial entry into the lake, light penetration sometimes is very low, especially in spring (20 cm). At this station, benthic species such as *N. palea, N. fonticola* Grunow in Cleve & Möller, *N. hantzschiana* Rabenhorst, and *Diatoma vulgaris* Bory, and planktonic organisms such as *M. varians* species were conspicuous. Zooplankton were not observed at the water surface at station 4, being on the river side.

At stations 1-3, zooplankton numbers increased from time to time, following an increase in phytoplankton in samples taken vertically, from a depth of 5 m. The number of phytoplankton at station 3 in July was approximately $47{,}000 \times 10^3$ org. m^{-3} and in August it reached $62{,}000 \times 10^3$ org. m^{-3} (Figure 10).



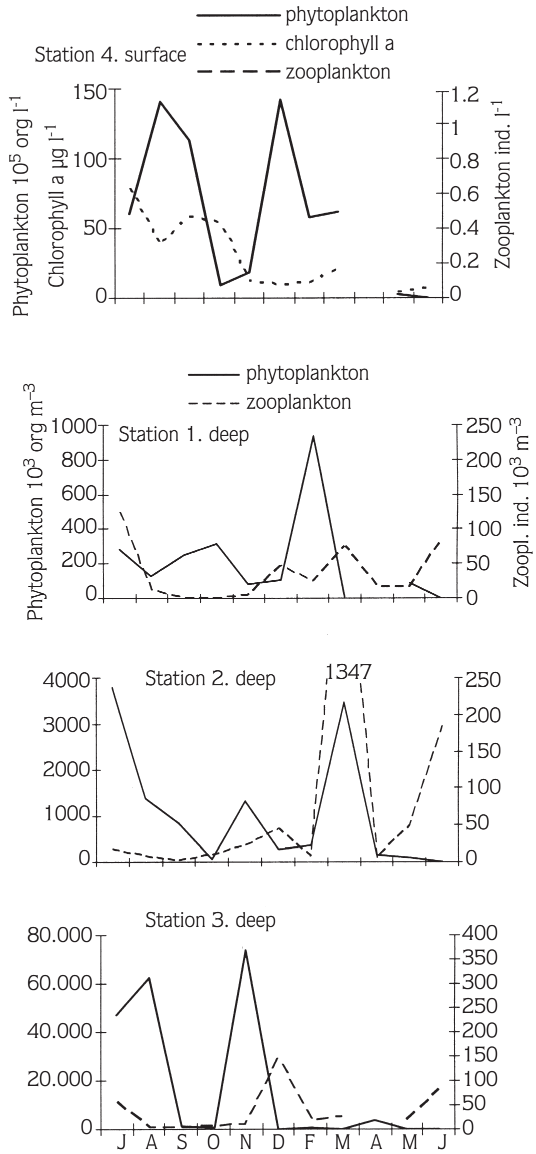


Figure 9. Hirfanlı Dam Lake, Turkey, 1999-2000; Seasonal changes in the density of phytoplankton and zooplankton (assessed by organism number) and concentration of chlorophyll a (station 3 and 4).

Figure 10. Hirfanlı Dam Lake, Turkey, 1999-2000; Seasonal changes in the density of phytoplankton and zooplankton (with 5 m vertical sampling, water volume: 0.353 m^3).

Aphanizomenon floss-aquae (L.) Ralfs formed 96% of the algal bloom. In July 1999, the same species constituted 98% of the algal density at the station 2 (3700×10^3 org. m^{-3}). The decrease in zooplankton in these months might have been due to low quantities of nutrients (5).

In terms of indicator organisms, Hirfanlı Dam Lake is of eutrophic character, haboring *Microcystis* (22), *Oscillatoria* (23), *Fragilaria* (24), and *Cyclostephanos.* In contrast, mesotrophic species such as *C. hirundinella, Pediastrum Boryanum* (Turp.) Meneghini (25), *A. formosa* (26), and *Dinobryon Tabellariae* (Lemm.) Pascher were frequently encountered. In addition to these, nonmotile greens, e.g., *Oocystis* and *Coelastrum* (27) species, sometimes showed good growth in summer. In some months, where the density of organisms was high (except at station 1), the amount of chlorophyll *a* was 1-15 µg l^{-1}.

In May 2000, the density of phytoplankton at station 1 was $18{,}270 \times 10^3$ org. l^{-1} and, in December 1999, at station 2 it was 8032×10^3 org. l^{-1} and at station it was $14{,}188 \times 10^3$ org. l^{-1} and in June 2000, at station 3 it was $18{,}100 \times 10^3$ org. l^{-1}, reaching their maximum values. At other lakes, the following maximum values were recorded: Hafik Lake (14) 7569 org. ml^{-1}, Beytepe-Alap Pond (15) 3540 org. ml^{-1}, Tortum Lake (28) 489 org. ml^{-1}, Suat Uğurlu Dam Lake (29) 23,837 cells ml^{-1}, Tercan Dam Lake (30) 2857 org. ml^{-1}, Bayındır Dam Lake (31) 3265 org. ml^{-1}, Altınapa Dam Lake (17) 4874 org. ml^{-1}, Çubuk-I Dam Lake (32) 13,641 org. ml^{-1}, Kurtboğazı Dam Lake (16) 5021 cells ml^{-1}, Gölbaşı Lake (33) 250,000 cells ml^{-1}, Orduzu Dam Lake (34) 691 ind. ml^{-1}, and Sultan Sazlığı (35) 18,159 cells ml^{-1}.

Environmental conditions:

The pH of the lake was between 7 and 8.63, being slightly alkaline. Salinity was 0.6-0.8 ppt but was 1.0-1.1 ppt at station 4. Conductivity in natural waters is 20-180 µmhos/cm at this station; conductivity was always high in relation to salinity (max. 2180 µmhos/cm) as a result of the input of mineralized nutrients. Dissolved oxygen concentration was within conventional values for lakes and reservoirs (7.49-14.5 mg l^{-1}). While the values for temperature at the surface were high (12.4-27 °C) in summer and early spring, dissolved oxygen concentration varied between 5.45 and 11.05 mg l^{-1}. In contrast, the fall in values of temperature in late autumn and spring (2.9-19 °C) was followed by an increase in dissolved oxygen concentration (6.81-14.5 mg l^{-1}). Temperature and dissolved oxygen concentration at 1-, 5-, and 10-m depths showed similar profiles with those of the surface. As seen in Figures 7-10, the growth levels of zooplankton and phytoplankton were not directly related to only temperature and dissolved oxygen concentration. In addition to the above parameters, nutrients and feeding pattern in the lake had important effects on the growth of organisms.

These results showed that Hirfanlı Dam Lake is under the threat of eutrophication. The irregularity in variation in the quality and quantity of phytoplankton was mostly as a result of increases in nutrient concentrations. In addition, erosion and alluvional inputs caused by the Kızılırmak River have increased the sediments. Water temperature variation as a result of the hydroelectric plant and irrigation activities are the reasons for the frequent changes in the chemical and biological composition of the dam lake. Members of *Cladocera* observed in low quantity and a high biomass value species of *Rotifera* that grow well in a polluted medium have effects on the species diversity of fish and their quantity. In-flow of allochthonous input to the lake should be carefully monitored. Nitrogenous fertilizer usage should be limited, farming near the lake side should be prohibited, and untimely fishing should be banned. This is because, with increasing trophic level, Hirfanlı Dam Lake is generally of advanced mesotrophic character but from time to time showed a eutrophic character.

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References

1. Noges T. Zooplankton–phytoplankton interactions in lakes Vorsjarv, Peipsi (Estonia and Yaskhan (Turkmenia). Hydrobiologia 343: 175-184, 1997.
2. Tallberg P, Horppila J, Vaisane A et al. Seasonal succession of phytoplankton and zooplankton along a trophic gradient in a eutrophic lake-implications for food web management. Hydrobiologia 412: 81-94, 1999.
3. Ventela AM, Saarikari V, Vuorio K. Vertical and seasonal distributions of micro-organisms, zooplankton and phytoplankton in a eutrophic lake. Hydrobiologia 363: 229-240, 1998.
4. Mayer J, Dokulil MT, Salbrechter M et al. Seasonal successions and trophic relations between phytoplankton, zooplankton, ciliate and bacteria in a hypertrophic shallow lake in Vienna, Austria. Hydrobiologia 343: 165-174, 1997.
5. Elmacı A, Obalı O. Phytoplankton zooplankton interactions. Çevre-Ekoloji Dergisi 23: 16-20, 1997.
6. Wetzel RG, Likens GE. Limnological analyses. WB Saunders Co, New York, 1991.
7. Bakan N, Atay D. Göllerde fitoplankton populasyonları ve kantitatif analiz metodları (Spesific subject). AÜ Fen Bil. Enst. SÜ-608 Ankara, 1988.
8. Segers H, Emir N, Mertens J. Rotifera from north and northeast Anatolia (Turkey). Hydrobiologia 245: 179-189, 1992.
9. Altındağ A, Sözen M. Seyfe (Kırşehir) gölü Rotifera faunasının taksonomik yönden İncelenmesi, Tr J of Zoology 20: 221-230, 1996.
10. Youngman RE. Measurement of chlorophyll *a* water research center. Tec. Rep. TR-82, 1978.
11. Baykal T. Açıkgöz İ. The algae of Hirfanlı Dam Lake. Kırşehir Eğitim Fak. Dergisi 5: 115-136, 2004.
12. Yiğit S, Altındağ A. A taxonomical study on the zooplankton fauna of Hirfanlı Dam Lake (Kırşehir) Turkey. G U J of Science 18: 563-567, 2005.
13. Temel M. Sapanca Gölü fitoplanktonu. İstanbul Üniversitesi Su Ürünleri Dergisi 1: 41-64, 1992.
14. Kılınç S. A study in the seasonal variation of phytoplankton in Hafik Lake (Sivas–Turkey). Tr J of Botany 22: 35-41, 1991.
15. Ünal Ş. Seasonal variation of the phytoplankton in the Beytepe and Alap Ponds. Doğa Bilim Dergisi A2 8: 121-137, 1984.
16. Aykulu G, Obalı O. Phytoplankton biomass in the Kurtboğazı Dam Lake. Communications C_2 24: 2-44, 1981.
17. Yıldız K. Algae communities Altınapa Dam Lake Part I: Phytoplankton community. Doğa Bilim Dergisi A_2 9: 419-427, 1985.
18. Cirik S, Cirik Ş. Gölcük'ün (Bozdağ – İzmir) planktonik algleri. İstanbul Üniversitesi Su Ürünleri Dergisi 3: 131-150, 1989.
19. Yiğit S. Seasonal fluctuation in the Rotifer fauna of Kesikköprü Dam Lake (Ankara, Turkey). Turk J Zool 26: 341-348, 2002.
20. Çetinkaya O. A study on water quality, plankton and benthic fauna of the Akşehir Lake. Tatlı Su Kaynaklarının Korunması ve Çevre Sorunları Sempozyumu, Isparta. 413-429, 1991.
21. Brian M. Ecology of fresh waters. Blackwell Science Ltd, Oxford, 1998.
22. Patrick R, Reimer, CW. The diatoms of the United States. Acad Nat Sci Philadelphia Monogr., 1975.
23. Palmer CM. Algae and water pollution, New York Castle House Pub. Ltd, 1980.
24. Hutchinson GE. A treatise on limnology Vol: II Introduction to lake biology and the limnoplankton, John Wiley, London, 1967.
25. Cirik S, Cirik Ş. Beyşehir Gölü su florası ve mevsimsel değişimleri. EÜ Su Ürünleri Fak. Su Ürünleri Dergisi, 8: 155-174, 1991.
26. Conk M, Cirik S. Eğirdir Gölü fitoplanktonu üzerinde bir araştırma. Tatlı Su Kaynaklarının Korunması ve Çevre Sorunları Sempozyumu, Isparta. 393-411, 1991.
27. Wehr JD, Sheath RG. Freshwater algae of North America. Academic Press, New York, 2003.
28. Altuner Z. A qualitative and quantitative studies on the phytoplankton taken from one station in Tortum Lake. Doga Bilim Dergisi 8-2: 161-182, 1984.
29. Gönülol A, Yazıcı N. Suat Uğurlu Baraj Gölü Fitoplanktonunun araştırılması. (F.085 O.M.U. araştırma Fonu), 1992.
30. Altuner G, Gürbüz H. A study on the phytoplankton of the Tercan Dam Lake, Turkey. Tr J of Botany 18: 443-450, 1994.
31. Gönülol A. Studies on the phytoplankton of the Bayındır Dam Lake. Communications, C 3: 21-38, 1985.
32. Gönülol A, Aykulu G. Studies on the algal flora of the Çubuk-I Dam Lake I. Seasonal changes of phytoplankton composition and density. Doğa Bil. Dergisi A_2 8: 330-342, 1984.
33. Naz M, Türkmen M. Phytoplankton biomass and species composition of Lake Gölbaşı (Hatay-Turkey). Turk J Biol 29: 49-56, 2005.
34. Çetin KA, Şen B. Seasonal distribution of phytoplankton in Orduzu Dam Lake (Malatya, Turkey). Turk J Bot 28: 279-285, 2004.
35. Akbulut A. The relationship between phytoplanktonic organisms and chlorophyll *a* in Sultan Sazlığı. Turk J Bot 27: 421-425, 2003.