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Benthic Algae (Except Bacillariophyta) and Their Seasonal Variations in Karagöl Lake (Borçka, Artvin-Turkey)

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Abstract: Seasonal variation in the species composition of the benthic algae of Karagöl Lake was investigated from April to October in 2001 and 2002. The benthic algal flora consisted of 38 taxa belonging to the divisions Chlorophyta, Cyanophyta, Euglenophyta, and Chrysophyta. In general, Chlorophyta were dominant in terms of species number and abundance during the study period. The distribution range of the benthic algae composition and dominant species differed from each other at all stations. Benthic algal growth was mostly influenced by water temperature and light.

Key Words: Benthic algae, seasonal variations, Karagöl Lake

Karagöl'ün (Borçka, Artvin-Türkiye) Bacillariophyta Dışındaki Bentik Algleri ve Mevsimsel Değişimi

Özet: Karagöl'ün bentik alglerinin kompozisyonundaki mevsimsel değişimler Nisan-Ekim 2001 ve 2002 yıllarında incelenmiştir. Bentik alg florası Chlorophyta, Cyanophyta, Euglenophyta ve Chrysophyta bölümlerine ait toplam 38 taksondan oluşmuştur. Araştırma süresince Chlorophyta tür sayısı ve yoğunluk bakımından dominant olmuştur. Örnekleme istasyonlarındaki alglerin kompozisyonunun mevsimsel dağılım oranları ve dominant türlerin birbirinden farklı olduğu tesbit edilmiştir. Bu araştırmada, su sıcaklığı ve ışık bentik alglerin gelişmesinde etkili olmuştur.

Anahtar Sözcükler: Bentik algler, mevsimsel değişim, Karagöl

Introduction

The importance of benthic algae in shallow lakes has been reported by many researchers (Wetzel, 1964; Moss, 1969; Khonder & Dokulil, 1988). Investigations on the population dynamics, biomass, and production of benthic algae suggest that they might sometimes exceed total phytoplankton production and, therefore, cannot be neglected when the total primary production of aquatic ecosystems is assessed (Moss, 1969; Khonder& Dokulil, 1988).

Seasonal variation, composition, and production of benthic algae are affected considerably by the physical and chemical properties of water and sediment structure. Benthic algae, which are mostly autotrophic organisms, receive most of their nutrition from dissolved chemicals in water. Thus, many authors think that they should be good indicators of the prevailing conditions in an aquatic environment. As such, algae are widely used as biomonitors to accurately assess eutrophication, pollution, and water quality (Round, 1984; Nather Khan, 1990).

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There is little information on the ecology and composition of benthic algae in high altitude mountain lakes in Turkey (Şahin, 1998, 2000, 2001, 2002; Şahin & Akar, 2005). This is primarily due to their remote location and to logistical problems in reaching them.

The purpose of the present study was to investigate the abundance and species composition of benthic algae, and to examine the physical and chemical properties of the lake water.

Materials and Methods

Karagöl Lake is located at lat 41°52 30 N, long 41°52 40 E at an elevation of approximately 1465 m a.s.l. in a national park in Artvin, Turkey. The lake has a surface area of 10 ha and maximum depth of 7 m. Two streams (Heba and Savgule streams) enter the lake and outflow is via Çosedinara Stream (Figure 1). The climate of the region is generally cool and rainy in summer, and cold and snowy in winter (annual means temperature: 14.4 °C; maximum: 42.4 °C; minimum: –5.7 °C; annual precipitation: 708.3 mm) (T.C. Çevre Bakanlığı Devlet Meteoroloji İşleri Genel Müdürlüğü, 2002). Terrestrial vegetation consists of trees, shrubs, and herbs, including *Abies nordmanniana* (Stev.) Mattf., *Picea orientalis* (L.) Link, *Fagus orientalis* Lipsky, *Juglans regia* L., *Rhododendron ungernii* Trautv., *R. caucasicum* Pallas, and *Rubus caucasicus* Focke (Kırsal Çevre ve Ormancılık Sorunlarını Araştırma Derneği, 1994).

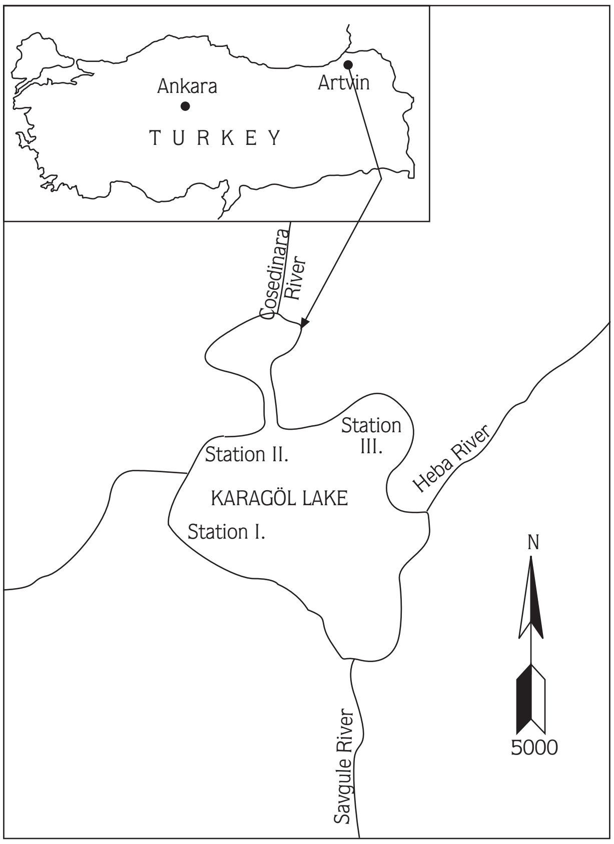

Figure 1. Map of Karagöl Lake.

Samples were collected during the snow-free period from April to October in 2001 and 2002. The samples were taken on a monthly basis and collected from 3 stations at a depth of 20-30 cm, 50-100 cm offshore. A PVC-pipe 0.8 cm in diameter was used for sampling the surface sediment at stations I and II, and the probes were immediately transported to the laboratory. At each sampling station sediment samples were taken from an area of about 15 cm^2, and were used for identification and enumeration of all epipelic algae within 2-3 days of collection (Round, 1953). In order to study the epiphytic algae, *Equisetum* spp. were collected from all stations and brought to the laboratory. Epipelic and epiphytic algae were preserved in a 4% formaldehyde solution. All algae were identified on multiple temporary slides.

At the time of sampling, water temperature and pH were measured using a mercury thermometer and a WTW Digi 88 model pH meter. Dissolved oxygen was analysed according to the method of Winkler (Yaramaz, 1988). Other chemical analyses were performed according to the standard methods (APHA, 1995).

The taxonomic identification of algae was carried out according to Prescott (1973), Coesel (1983, 1991), Lenzenweger (1996, 1999), John et al. (2003), and Wotowski and Hindák (2005).

Results and Discussion

Environmental conditions

During the sampling period, water temperature showed large seasonal fluctuation. Mean surface water temperature was 13 °C. Maximum water temperature (21 °C) was measured in June 2001 and minimum (5 °C) in April 2002. The pH of Karagöl Lake was relatively constant, ranging from 7.1 to 7.8. Dissolved oxygen was between 8.5 and 12.3 mg l^{-1}. The concentration of Ca^{++} showed seasonal variation and ranged between 8.8 and 19.6 mg l^{-1}. Maximum Mg^{++} concentration was observed in August 2001 (12.2 mg l^{-1}) and minimum (5.2 mg l^{-1}) in July and September 2002. Total hardness ranged between 24 and 89 mg $CaCO_3$ l^{-1}.

Benthic Algal Flora

The benthic algal flora of Karagöl Lake consisted of epipelic (25 taxa) and epiphytic (19 taxa) algal communities. In all, 38 taxa were recorded; with 22 taxa Chlorophyta was the richest in species composition. Chlorophyta was followed by Cyanophyta (10 taxa), Euglenophyta (4 taxa), and Chrysophyta (2 taxa) at the 3 stations (Table).

Table. List of the epipelic and epiphytic algae in Karagöl Lake.

Taxa	1	2
Chlorophyta		
Chlorophyceae		
Chlorococcales		
Ankistrodesmus falcatus (Chodat) Chodat	+	
Oocystis sp.		+
Scenedesmus armatus (Chod.) G.M.Smith	+	+
Ulotrichales		
Ulothrix cylindrica Prescott		+
Chaetophorales		
Stigeoclonium flagelliferum Kütz.		+
Oedogoniophyceae		
Oedogoniales		
Bulbochaete sp.		+
Oedogonium sp. 1		+
Oedogonium sp. 2		+
Bryopsidophyceae		
Cladophorales		
Cladophora sp.	+	+
Conjugatophyceae		
Desmidiales		
Closterium costatum Corda ex Ralfs	+	
Cl. ehrenbergi Menegh. ex Ralfs	+	
C. littorale Gay.	+	
C. striolatum Ehrenb. ex Ralfs	+	
Cosmarium difficile Lütkemüller	+	
C. impressulum Elfving		+
C. leave Rabenhorst var. *leave*	+	
C. regnellii Wille var. *pseudoregnellii* (Messik.) Krieger & Gerloff	+	
C. subcrenatum Hantzsch	+	
C. subundulatum Wille		+
Euastrum insulare (Witrock) J.Roy	+	
Micrasterias rotata (Greville) Ralfs ex Ralfs		+
Zygnemales		
Spirogyra sp.		+
Chrysophyta		
Chrysophyceae		
Chrysomonodales		
Dinobryon sp.		+
Synura sp.		+
Cyanophyta		
Cyanophyceae		
Chroococcales		
Merismopedia elegans A.Braun	+	
Hormogonales		
Anabaena sp.	+	
Oscillatoria formosa Bory.	+	
O. limnetica Lemmerman	+	+
O. limosa (C.Agardh) Gomont	+	
O. princeps Vaucher		+
O. sancta (Kützing) Gomont	+	
O. subbrevis Schmidle	+	+
O. tenuis (C.Agardh) Gomont	+	
Rivularia sp.	+	+
Euglenophyta		
Euglenophyceae		
Euglenales		
Euglena oxyuris Schmarda	+	+
Phacus circulatus (Pochmann)	+	
Trachelomonas hispida (Perty) Stein	+	
T. volvocina Ehrenberg	+	

1: Epipelic. 2: Epiphytic.

Chlorophyta was predominant and comprised 57.89% of all recorded taxa. Cyanophyta represented 26.31% of all recorded taxa, whereas Euglenophyta species (10.52%) and Chrysophyta (5.26%) made up only an insignificant part.

During the study period the greatest number epipelic algae cells (7971 cells/cm^2) at station I was recorded in August 2001 and the lowest (1028 cells/cm^2) was recorded in April 2002 (Figure 2). At station II, the highest number of epipelic algae cells (5397 cells/cm^2) was recorded in May 2001 and the lowest (1028 cells/cm^2) was recorded in April 2002 (Figure 2). The epipelic algae showed similar seasonal variation in 2001 and 2002; however, the range of distribution of the epipelic algal composition and dominant species differed from each other at all stations. A greater abundance of epipelic algae was recorded at station I than at station II throughout the study. Additionally, photographs of some species are shown in Figure 3.

Members of the Desmidiales were the most commonly encountered unicellular Chlorophyta. *Euastrum insulare*, for example, reached its greatest abundance (3598 cells/cm^2) at station I in August 2001. The same pattern was exhibited by *Closterium striolatum* (1285 cells/cm^2) at station II in July 2001. *Cosmarium regnellii* var. *pseudoregnellii* (length: 15 µm; width: 10 µm; isthmus: 3 µm) is a new record for Turkey (Şahin, 2005). Many authors have reported that water alkalinity is one of the main factors affecting the occurrence of desmid species (Brook, 1981; Ruzicka, 1981; Lenzenweger, 1996). Desmids prefer primarily acidic and pH-circumneutral waters; however, Fehér (2003) reported that many desmid species were found in alkaline lakes and wetlands in southern Hungary. Desmid species were also reported to be abundant and common in many alkaline lakes in Turkey (Gönülol & Obalı, 1986; Gönülol & Çomak, 1993; Şahin, 1998).

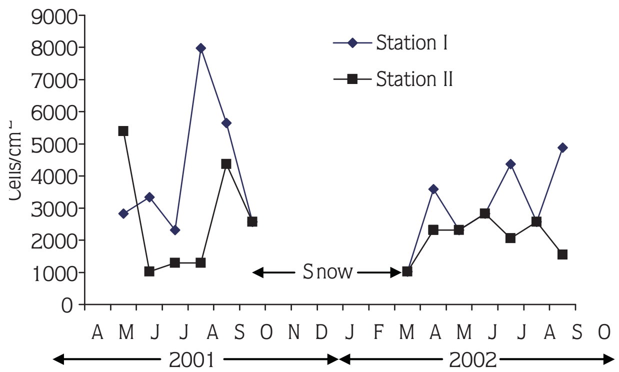

Figure 2. Seasonal variation in total benthic algae in Karagöl Lake.

Oscillatoria was the most commonly observed Cyanophyta genus. The occurrence of members of the blue-green algae, especially *Oscillatoria limnetica* (1799 cells/cm^2 at station I) and *O. sancta* (1028 cells/cm^2 at station II) in summer and autumn was notable, thus supporting Round's (1984) view that the blue-green algae *Anabaena* and *Oscillatoria* grow better and are more common in the summer months. In addition, members of Cyanophyta are known to be abundant in eutrophic waters and on sediments polluted with organic matter (Round, 1984).

Euglenophyta was represented by species of *Euglena*, *Phacus*, and *Trachelomonas*. The existence of Euglenophyta in the lake water is proof that the water is rich with organic substances (Palmer, 1980).

Among the epiphytic algal flora, filamentous Chlorophyta were represented by members of the genera *Bulbochaete*, *Cladophora*, *Oedogonium* and *Spirogyra*, which were sterile and could not be identified. The other identified algae of the epiphytic algal flora were unimportant at all of the stations.

One important aspect of the benthic algal distribution in Karagöl Lake was intermixing with phytoplankton. Members of the Chrysophyta (*Dinobryon* and *Synura*), for example, were found in the epipelic community in Karagöl Lake. *Dinobryon* and *Synura* species were reported to be planktonic organisms (Hutchinson, 1967). We can say that the presence of benthic algae species together with those of phytoplankton may have be the result of wind affecting the water surface in shallow lakes.

Müller (1994) reported that algal biomass and growth were positively correlated with light intensity and water temperature. The growth of benthic algae in Karagöl Lake supports this finding, because the density of benthic algae was low in early spring, when water temperature was low. Higher temperatures supported the growth and density of benthic algae in Karagöl Lake, which were at their highest levels in May and August (Figure 2).

In conclusion, snow, light, and water temperature were important factors in regulating the growth of

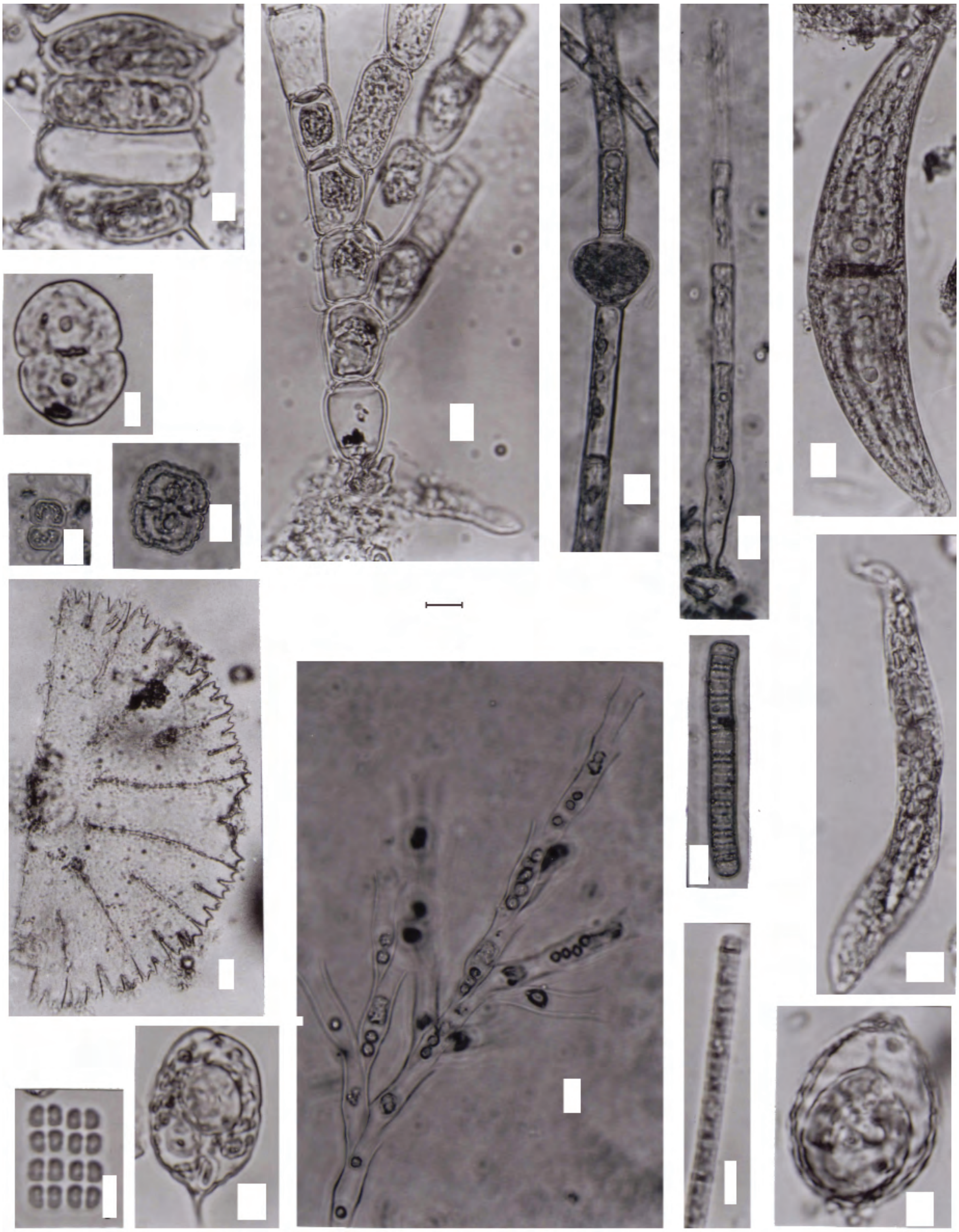

Figure 3. *Scenedesmus armatus* (Chod.) G.M.Smith (a), *Bulbochaete* sp. (b), *Oedogonium* sp. 1 (c), *O.* sp. 2 (d), *Closterium ehrenbergi* Menegh. ex Ralfs (e), *C. leave* Rabenh. var. *leave* (f), *C. regnelli* var. *pseudoregnellii* (Messik.) Krieger & Gerloff (g), *C. subcrenatum* Hantzsch (h), *Micrasterias rotata* (Grev.) Ralfs ex Ralfs (ı), *Dinobryon* sp. (i), *Merismopedia elegans* A.Braun (j), *Oscillatoria limosa* (Roth.) Cl. Agardh (k), *O. subbrevis* Schmidle (l), *Euglena oxyuris* Schmarda (m), *Phacus orbicularis* Hübner (n), *Trachelomonas hispida* (Perty) Stein (o). Scale: 10 µm.

benthic algae. It was determined that Karagöl Lake is mesotrophic in character, due to its morphology, the physical and chemical properties of its water, and the presence of algal flora.

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