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Species composition and diversity of epipelic algae in Balık Lake (Şavşat-Artvin, Turkey)

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Abstract: The species composition and diversity of the epipelic algae of Balık Lake were investigated between May and October 2008. A total of 39 taxa were determined, and *Cyclotella meneghiniana, Craticula cuspidata, Closterium strigosum, Cocconeis placentula* var. *euglypta,* and *Amphora ovalis* were the most conspicuous algae, regarding frequency of occurrence and relative abundance in the epipelic algal flora. While the highest total cell number of the epipelic community was 26,214 cells/cm^2 in October, the lowest was 23,644 cells/cm^2 in July. The highest species diversity index (H') value was 2.26, in June.

Key words: Epipelic algae, seasonal variation, diversity, Balık Lake, Turkey

Balık Gölü (Şavşat-Artvin, Türkiye) epipelik alglerinin tür kompozisyonu ve çeşitliliği

Özet: Balık Gölü epipelik alglerinin tür kompozisyonu ve çeşitliliği 2008 yılının Mayıs ve Ekim ayları arasında incelenmiştir. Toplam 39 takson tespit edilmiştir. *Cyclotella meneghiniana, Craticula cuspidata, Closterium strigosum, Cocconeis placentula* var. *euglypta* ve *Amphora ovalis* epipelik alg florasının nispi bolluğu ve bulunuş sıklığı açısından göze en çok çarpan türleri olmuştur. Epipelik kommunitenin en yüksek yoğunluğu Ekim ayında 26.214 hücre/cm^2 iken, en düşük yoğunluk Temmuz ayında 23.644 hücre/cm^2'dir. En yüksek çeşitlilik indeksi (H') Haziran ayında 2,26'dır.

Anahtar sözcükler: Epipelik algler, mevsimsel değişim, çeşitlilik, Balık Göl, Türkiye

Introduction

Epipelic algae live on the soft bottom sediments and cover a considerable area in most lakes (Björk-Ramberg, 1984). They perform a range of ecosystem functions including biostabilisation of sediments, regulation of benthic-pelagic nutrient cycling, and primary production (Poulickova et al., 2008). Despite their significance, many aspects of the geographical distribution, biodiversity, and ecology of epipelic algae are poorly understood (Hasler et al., 2008).

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Although there are a number of high mountain lakes in the Black Sea region of Turkey, there is only little information on the ecology and composition of epipelic algae (Şahin, 2000, 2001, 2002, 2004, 2008, 2009; Şahin & Akar, 2005; Gönülol et al., 2009). Apart from the study done by Kolaylı and Şahin (2008, 2009), there are no published articles on the lakes of Artvin.

The aim of this study was to investigate the species composition and diversity of epipelic algae of Balık Lake.

Materials and methods

Balık Lake is located at latitude 41°17′24″N and longitude 42°29′82″E in Artvin in the Eastern Black Sea region of Turkey (Figure 1). The surface area of the lake is approximately 0.006 km^2, the average depth is 15 m, and the elevation is 1656 m above sea level.

In order to examine the epipelic algal flora of Balık Lake one station was chosen. The number of sampling stations depended on the size of the lake. Collections were made during the snow-free period from May to October in 2008. The samples were performed on a monthly basis from 15-30 cm depth and 50-100 cm offshore. Vascular plants and stones were absent at the station.

The epipelic algal community was sampled by means of a glass tube 0.8 cm in diameter and 100 cm in length. The pipe was moved in a circular direction over the surface of the sediment, releasing the thumb to take up sediment (Round, 1953). Samples were transferred into plastic bottles and fixed with 4% formalin.

At least 3 water-mounted slides were examined for algae and living diatoms from the station to obtain an estimate of algal relative abundance (Round, 1953). At least 300 algal cells were counted at 400×

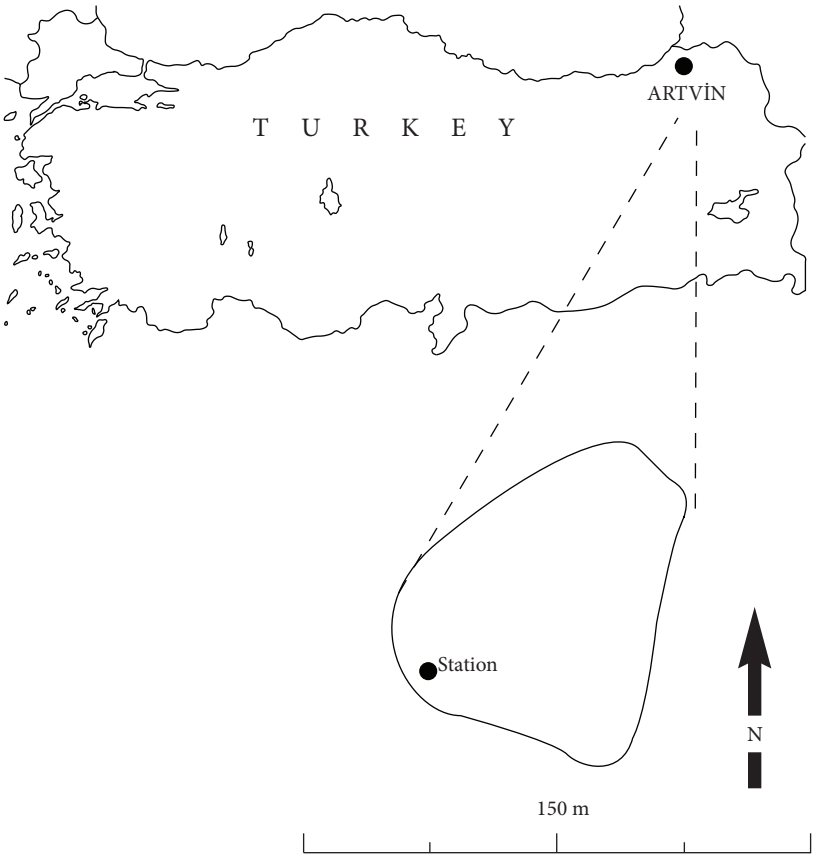

Figure 1. Map of the study area.

magnification. Permanent slides for the identification of diatoms were prepared from the same sample after boiling in a 1:1 mixture of concentrated H_2SO_4 and HNO_3. The acid cleaned diatoms were mounted in Naphrax medium with a high refractive index (Round, 1953). Identifications were carried out at 400× magnification.

Taxonomic identifications were carried out according to John et al. (2003), Krammer and Lange-Bertalot (1986, 1988, 1991a, 1991b), Round et al. (1990), Sims (1996), Lenzenweger (1996), and Wotowski and Hindák (2005).

During sampling, water temperature and pH were measured using a mercury thermometer and a WTW Digi 88 model pH meter, respectively. Dissolved oxygen concentration was measured according to the method of Winkler (Yaramaz, 1988). Photographs were taken with a Leica DM 2500 microscope.

To evaluate the richness and diversity of the epipelic community of Balık Lake, the Shannon-Weaver species diversity index (H) was used (Shannon and Weaver, 1949):

$$H = \sum_{i=1}^{s} Pi \log Pi$$

where *s* is total number of species in the sample, and *Pi* is the proportion of the number of individuals in the *i*-th species to the total number of individuals.

Results and discussion

Environmental conditions

The water temperature of the Balık Lake ranged from 8 to 24 °C (mean 16 °C) during the sampling period. pH values varied between 7.2 and 7.9 (mean 7.5). Accordingly, the lake water was slightly alkaline. Dissolved oxygen concentrations were measured between 8.20 and 11.40 mg L^{-1}.

Epipelic algal flora

The epipelic algal flora of Balık Lake consisted of 39 taxa. Of these, 31 belong to the Bacillariophyta, 4 to the Euglenozoa, 3 to the Cyanobacteria, and 1 to the Charophyta divisions. The identified species are listed in Table 1. Photographs of some species are shown in Figure 2.

In the present study, all taxa were found to belong to 22 families. The best represented family is *Bacillariaceae* and comprises 12.82% of all recorded taxa. Medvedeva (2001) pointed out that diverse families are of great diagnostic importance in floristic analyses.

Bacillariophyta was the dominant group in terms of species number and density, and comprised 79.48% of all recorded taxa. The same result was observed in many lakes in the East Black Sea region of Turkey (Şahin, 2000, 2001, 2002, 2004, 2008; Şahin & Akar, 2005). Moore (1974) and Round (1984) pointed out that diatoms are usually the most common elements of epipelic communities. It is well known that the members of the Bacillariophyta are sensitive to a wide range of limnological and environmental variables, and that their community structure may quickly respond to changing physical, chemical, and biological conditions in the environment (Mooser et al., 1996).

During the study period, while the highest total cell number of the epipelic community was 26,214 cells/cm^2 (in October), the lowest was 23,644 cells/cm^2 (in July) (Figure 3). Most of the species in the epipelic community exhibited variations during the study. *Craticula cuspidata*, for example, reached its peak (14,906 cells/cm^2) and represented 59.18% of the total taxa in September. The same pattern was observed with *Cyclotella meneghiniana* (12,336 cells/cm^2) in May and represented 48% of the total taxa. While *Closterium strigosum* reached its peak (4626 cells/cm^2) in July, *Cocconeis placentula* var. *euglypta* reached its peak (2056 cells/cm^2) in June, August, and October. *Amphora ovalis* reached its peak (1799 cells/cm^2) in August (Figure 4).

Nather Khan (1990) explained that the species of *Craticula* were common and abundant in both organically enriched and non-enriched areas. Round (1956a) reported that species of *Amphora*, *Cocconeis*, *Cymbella*, and *Navicula* were common in calcareous and slightly alkaline waters. The present study supported this finding, since the results of chemical analyses of the Balık Lake water showed that it is slightly alkaline. Round (1984) reported that *Cyclotella* species are considered planktonic. However, *Cyclotella meneghiniana* was found in the epipelic community of Balık Lake. The same situation was

Table 1. List of the epipelic algae in Balık Lake.

Taxa	
Division:	**Bacillariophyta**
Class:	**Coscinodiscophyceae**
Order:	**Aulacoseriales**
Family:	**Aulacoseriaceae**
	Aulacoseira muzzanensis (Meister) Krammer
Class:	**Mediophyceae**
Order :	**Thalassiosirales**
Family:	**Stephanodiscaceae**
	Cyclotella meneghiniana Kützing (Figure 2a, b)
Class:	**Bacillariophyceae**
Order:	**Fragilariales**
Family:	**Fragilariaceae**
	Staurosira construens Ehrenberg (Figure 2c)
	Ulnaria ulna (Nitzsch) P.Compére in Jahn et al.
Order :	**Achnanthales**
Family:	**Cocconeidaceae**
	Cocconeis placentula Ehrenberg var. *euglypta* (Ehrenberg) Grunow (Figure 2d)
Order :	**Thalassiophysales**
Family:	**Catenulaceae**
	Amphora ovalis (Kützing) Kützing (Figure 2e)
Order :	**Cymbellales**
Family:	**Cymbellaceae**
	Cymbella cistula (Hemprich & Ehrenberg) Kirchner
	C. cymbiformis C.Agardh (Figure 2f)
	Encyonema minutum (Hilse in Rabenhorst) D.G.Mann in Round et al. (Figure 2g)
Family:	**Gomphonemataceae**
	Gomphonema acuminatum Ehrenberg
	G. clavatum Ehrenberg
	G. olivaceum (Hornemann) Brébisson var. *olivaceoides* (Hustedt) lange-Bertalot
Order:	**Naviculales**
Family :	**Diploneidaceae**
	Diploneis elliptica (Kützing) Cleve
Family:	**Naviculaceae**
	Navicula cryptocephala Kützing
	N. gysingensis Foged
Family:	**Neidiaceae**
	Neidium affine (Ehrenberg) Pfitzer
Family :	**Pleurosigmatophyceae**
	Gyrosigma acuminatum (Kützing) Rabenhorst
Family :	**Pinnulariaceae**
	Pinnularia appendiculata (C.Agardh) Cleve
	P. brebissonii (Kützing) Rabenhorst
	P. maior (Kützing) Rabenhorst
	P. viridis (Nitzsch) Ehrenberg (Figure 2h)

Table 1. (Continued).

Taxa	
Family:	**Sellaphoraceae**
	Sellaphora pupula (Kützing) Mereschkovsky
Family:	**Stauroneidaceae**
	Craticula cuspidata (Kutzing) D.G.Mann in Round et al. (Figure 2i)
	Stauroneis anceps Ehrenberg (Figure 2j)
Order:	**Surirellales**
Family :	**Surirellaceae**
	Cymatopleura solea (Brebisson) W.Smith
Order:	**Rhopalodiales**
Family :	**Rhopalodiaceae**
	Rhopalodia gibba (Ehrenberg) O.Müller
Order:	**Bacillariales**
Family :	**Bacillariaceae**
	Hantzschia amphioxys (Ehrenberg) Grunow (Figure 2k)
	Surirella robusta (Ehrenberg) van Heurck
	S. spiralis Kützing
	S. tenera W.Gregory
	S. turgida W.Smith (Figure 2l)
Division:	**Charophyta**
Class:	**Zygnematophyceae**
Order:	**Zygnematales**
Family:	**Closteriaceae**
	Closterium strigosum Brébisson (Figure 2m)
Division:	**Cyanobacteria**
Class:	**Cyanophyceae**
Order:	**Nostocales**
Family:	**Nostocaceae**
	Anabaena sp.
Order:	**Oscillatoriales**
Family:	**Phormidiaceae**
	Phormidium limosum (Dilllwyn) P.C.Silva
Order:	**Pseudanabaenales**
Family:	**Pseudanabaenaceae**
	Spirulina maior (Kützing) Gomont
Division:	**Euglenozoa**
Class:	**Euglenophyceae**
Order:	**Euglenales**
Family:	**Euglenaceae**
	Euglena gracilis Klebs
	E. hemichromata Skuja
	E. limnophila Lemmermann
	Phacus caudatus Hübner

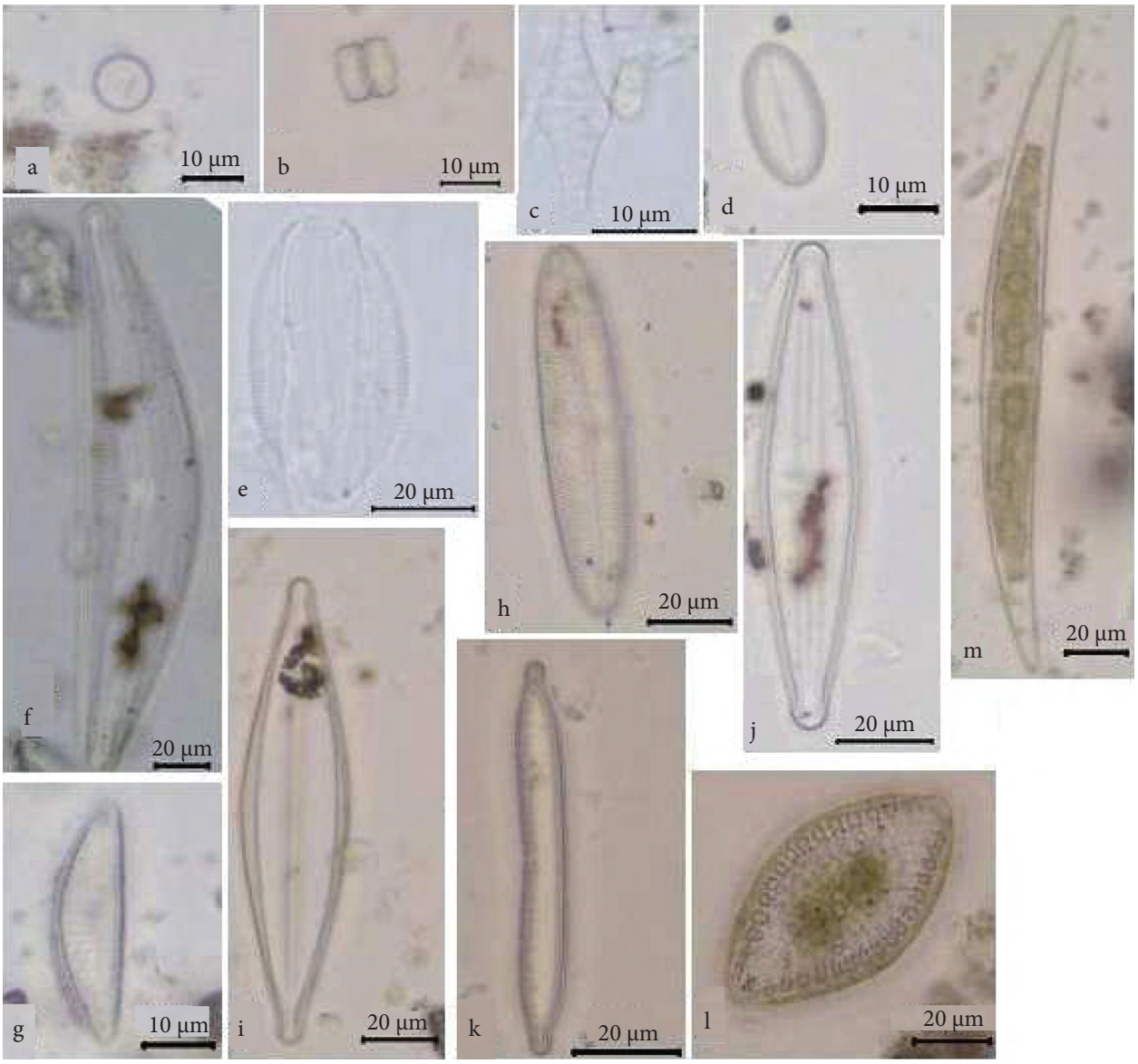

Figure 2. a and b. *Cyclotella meneghiniana*, c. *Staurosira construens*, d. *Cocconeis placentula* var. *euglypta*, e. *Amphora ovalis*, f. *Cymbella cymbiformis*, g. *Encyonema minutum*, h. *Pinnularia viridis*, i. *Craticula cuspidata*, j. Stauroneis *anceps*, k. *Hantzschia amphioxys*, l. *Surirella turgida,* m. *Closterium strigosum*.

observed in Gölbaşı Lake (Çetin et al., 2002). We can say that the presence of epipelic algae species together with those of phytoplankton may be a result of wind affecting the surface of water in shallow lakes. *Cyclotella* spp. are indicator species for transition to eutrophy (Round, 1956b).

Euglenozoa are known to be abundant in eutrophic waters and sediments polluted with organic matter (Round, 1984). In the Balık Lake, Euglenozoa were represented by 4 species and constituted 10.25% of the total taxa.

Round (1984) notified that Cyanobacteria grow in eutrophic waters and on organically polluted sediment in summer and autumn. In addition, it has been suggested that *Phormidium* spp., which are indicators of pollution, are more prolific in polluted

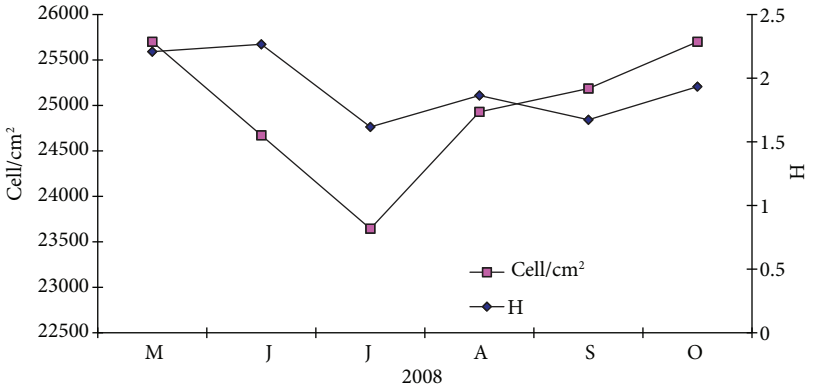

Figure 3. The seasonal variations in the total organism and species diversity of the epipelic algal community.

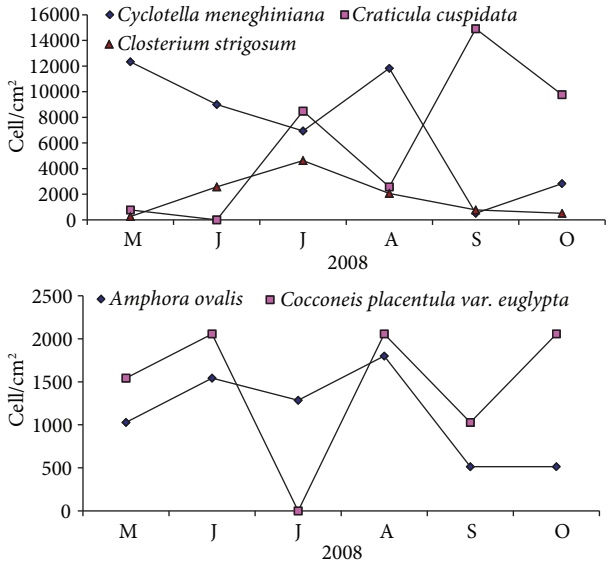

Figure 4. Seasonal variations in the density of common epipelic algae.

regions (Şen et al., 1990). Cyanobacteria were represented by 3 species and constituted 7.69% of the total taxa in our study area.

Charophyta were represented only by 1 species and make up an insignificant portion (2.56%) of the epipelic algal flora in Balık Lake.

A number of previous reviews focused on phytoplankton diversity (Harris, 1986). In general, when using a diversity index such as Shannon-Weaver, phytoplankton diversity has a strong seasonal component (Margelef, 1958). However, little is known concerning the diversity of epipelic algae in lakes in Turkey (Şahin, 2004; Akar & Şahin, 2006). In Balık Lake, it was observed that the seasonal changes in diversity showed an inverse pattern with species number (Figure 3). This means that species evenness decreased with increasing size of the algal population. *Craticula cuspidata* and *Staurosira construens*, for example, increased and occupied 55.87% of the total algal flora in October, when total cell number increased. The same trend was true in May, when *Cyclotella meneghiniana* occupied 48% of the algal flora (Figure 3). The decrease in diversity index values during these months was probably caused by the high relative abundance of the dominant species. In June, when total species number was small, the dominant species (*Cyclotella meneghiniana*) occupied only 36.45% of total species number, and such a low relative abundance resulted in a high diversity index (Figure 3). According to May (1975), the Shannon-Weaver diversity index is related to both the total number of species and their relative abundances, and can be designated as a positive function of total number of species.

In conclusion, the species found in Balık Lake mainly reflect the trophic state of the lake, which is eutrophic, as can be seen from the existence of the species and their abundance.

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