

1-1-2000

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ŞAHİN, BÜLENT (2000) "Algal Flora of Lakes Aygir and Balikli (Trabzon, Turkey)," *Turkish Journal of Botany*. Vol. 24: No. 1, Article 5. Available at: <https://journals.tubitak.gov.tr/botany/vol24/iss1/5>

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Algal Flora of Lakes Aygır and Balıklı (Trabzon, Turkey)

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Received: 19.02.1998

Accepted: 30.07.1999

Abstract: The algal flora of lakes Aygır and Balıklı were studied qualitatively between June and September 1996. The flora of Lake Aygır was found to consist of 48 species, 26 belonging to *Bacillariophyta*, 17 to *Chlorophyta*, 4 to *Cyanophyta* and 1 to *Euglenophyta*. The flora of Lake Balıklı was found to consist of 71 species, 34 belonging to *Bacillariophyta*, 29 to *Chlorophyta*, 7 to *Cyanophyta* and 1 to *Euglenophyta*.

The compositions of the species in the two lakes were similar. The main species of the algal flora of the lakes were members of Desmidiaceae.

Key Words: Phytoplankton, epipellic, epilithic, algal flora, Lake Aygır, Lake Balıklı.

Aygır ve Balıklı Göllerinin (Trabzon, Türkiye) Alg Florası

Özet: Aygır ve Balıklı göllerinin alg florası Haziran ve Eylül tarihleri arasında kalitatif olarak incelenmiştir. Aygır gölü florasında *Bacillariophyta* (26), *Chlorophyta* (17), *Cyanophyta* (4) ve *Euglenophyta* (1)'ya ait olmak üzere toplam 48 tür tespit edilirken, bu sayı Balıklı gölünde *Bacillariophyta* (34), *Chlorophyta* (29), *Cyanophyta* (7) ve *Euglenophyta* (1) olmak üzere toplam 71 tür olmuştur.

Her iki göldeki tür kompozisyonu birbirine benzemektedir. Floranın ana türleri *Desmidiaceae* üyeleridir.

Anahtar Sözcükler: Fitoplankton, Epipelik, Epilitik, Alg florası, Aygır Gölü, Balıklı Gölü.

Introduction

There are many small and large lakes in the eastern Black Sea region of Turkey. While some of them are near the shore, most are located on the tops of mountains, and the surroundings are used as picnic areas in summer.

Lakes Aygır and Balıklı, which are glacier lakes, are situated, respectively, at 2700m and 2600m above sea-level and located on 50-52° N altitude, 36-38° E longitude on Haldizan Mountain in Trabzon. These lakes have areas of 3.75 km² (Lake Aygır) and 4.25 km² (Lake Balıklı), respectively (Figure 1). The surfaces of both lakes were covered with ice from about December to April.

The aim of this study was to determine the algal flora of these two lakes.

Materials and Methods

Collections were made during the snow-free period from June to September in 1996. The number of sampling stations per watercourse depended on the size of the lakes.

The samples were taken in 30-day periods.

Two sampling stations in each of the lakes were chosen to study phytoplankton. Water samples were taken from the horizontal and at 10m depth by plankton net (55 µm). Water samples were filtered with Whatman GF/A glass fibre filter paper to identify the algae. All algae except *Bacillariophyta* were identified in temporary slides made from filtered samples, but members of *Bacillariophyta* were identified on permanent slides.

In order to study benthic algae, four sampling stations at Lake Aygır and six sampling stations at Lake Balıklı were chosen. The collections were made in 20-30cm of water about 50-100cm from shore. Vascular plants were absent at all stations in the lakes. Epipellic and epilithic algae were collected. Methods of collection and laboratory examination were similar to those outlined in Round (1) and Sladeckova (2).

At the time of sampling, water temperature and pH were measured by mercury thermometer and WTW Digi 88 model pH meter. Dissolved oxygen concentration was measured according to the method of Winkler (3). The

other physical and chemical analyses were performed in the Local-Central Food Laboratory according to the standard methods (4).

Taxonomic identifications were made according to Husted (5, 6), Patrick and Reimer (7, 8), Huber-Pestalozzi (9), Prescott (10), Lind and Brook (11), Dillard (12) and Hardley (13), and algae were classified according to the system of Round (14). The main species of flora were photographed with an Olympus BH-2 research microscope.

Results

The physical and chemical analysis of lakes Aygır and Balıklı are presented in Table 1.

Algal Flora

Of a total of 48 species determined in Lake Aygır, 26 belong to *Bacillariophyta*, 17 to *Chlorophyta*, 4 to *Cyanophyta* and 1 to *Euglenophyta*. Lake Balıklı was found to contain 71 species, 34 of which belong to *Bacillariophyta*, 29 to *Chlorophyta*, 7 to *Cyanophyta* and 1 to *Euglenophyta* (Table 2).

Table 1. Physical and chemical analysis of lakes Aygır and Balıklı.

Date	Lake Aygır				Lake Balıklı			
	9.6.1996	14.7.1996	25.8.1996	7.9.1996	9.6.1996	14.7.1996	25.8.1996	7.9.1996
Parameters								
Wat. Tem. (°C)	4.5	15.5	16.5	16	4.5	14	16.5	16
pH	7.11	7.15	7.08	7.10	7.10	7.15	7.03	7.05
Dis.Ox.(mg/l)	12	9.7	9.5	9.5	12	9.9	9.5	9.5
Total Hard.	1	1	2.25	1	1	1	3	1
Or. Subtan.	2.64	3.28	0.96	1.28	2.64	3.6	1.28	1
Ca ⁺⁺ (mg/l)	4	5.01	5.01	4	4	10.02	4	4
Mg ⁺⁺ (mg/l)	-	9.12	2.4	4.86	-	6.08	4.86	4.86
Cl ⁻ (mg/l)	0.03	0.03	0.01	0.03	0.02	0.03	0.03	0.03
SO ₄ ⁻ (mg/l)	-	2	1	-	-	-	-	-
NO ₂ -N(mg/l)	0.004	0.004	0.003	0.004	0.003	0.003	0.002	0.002
NH ₂ -N(mg/l)	0.04	0.04	0.05	0.04	0.08	0.09	0.04	0.04

Table 2. List of algae determined in lakes Aygır and Balıklı.

Species	Lake Aygır			Lake Balıklı		
	1	2	3	1	2	3
Division : <i>Bacillariophyta</i>						
Class : <i>Centrobacillariophyta</i>						
Order : <i>Centrales</i>						
<i>Aulacosira italica</i> (Ehr.) Simenson	+	+	+	+	+	+
Order : <i>Pennales</i>						
<i>Amphora ovalis</i> Kütz.		+				
<i>A. ovalis</i> var. <i>pediculus</i> Kütz.				+		
<i>Ceratoneis arcus</i> Kütz.		+		+	+	+
<i>C. arcus</i> var. <i>amphioxys</i> Rabh.				+		+
<i>C. arcus</i> var. <i>linearis</i> Holmboe						+

<i>Cymbella affinis</i>				+		
<i>C. cistula</i> (Hemprich) Grun.	+	+	+	+	+	
<i>C. helvetica</i> Kütz.	+		+		+	+
<i>C. minuta</i> Hilse ex Rabh.		+	+		+	+
<i>C. tumida</i> (Bred ex Kütz.) V.H.				+	+	+
<i>Diatoma anceps</i> (Ehr.) Grun.	+	+	+			+
<i>Didymoshenia geminata</i> (Lyng.) M.S.	+	+	+	+	+	+
<i>Epithemia argus</i> Kütz.		+	+	+	+	
<i>Eunotia pectinalis</i> var. <i>minor</i> (Kütz.) Rabenhorst	+		+	+		
<i>Gyrosigma acuminatum</i> (Kütz.) Rabh.		+			+	
<i>Gomphonema acuminatum</i> var. <i>clavus</i> (Breb.) Grun.	+	+	+	+		+
<i>G. constrictum</i> Ehr.		+	+		+	+
<i>G. olivacoides</i> Hust.		+	+			+
<i>Hantzschia amphioxys</i> (Ehr.) Grun.	+	+				+
<i>Navicula cryptocephala</i> Kütz.		+			+	
<i>N. radiosa</i> Kütz.		+	+		+	
<i>Pinnularia braunii</i> (Grun.) Cleve					+	
<i>P. borealis</i> Ehr.						+
<i>P. gibba</i> W. Sm.		+				
<i>P. interrupta</i> W. Smith					+	
<i>P. maior</i> (Kütz.) Cleve	+	+	+	+	+	+
<i>P. mesolepta</i> Ehr.					+	
<i>P. sp.</i>	+					
<i>Stauroneis anceps</i> Ehr.						+
<i>Surirella angustata</i> Kütz.		+			+	
<i>S. capronii</i> Brebisson				+	+	
<i>S. ovata</i> Kütz.		+			+	
<i>S. tenera</i> Gregory		+			+	
<i>S. robusta</i> var. <i>splendida</i> (Ehr.) Van Heurck	+	+	+	+	+	
<i>Synedra ulna</i> (Nitzsch) Ehr.					+	+
<i>Tabellaria fenestrata</i> (Lyngby) Kütz		+			+	+
<i>T. flocculosa</i> (Roth.) Kütz.					+	+
Division : <i>Chlorophyta</i>						
Class : <i>Chlorophyceae</i>						
Order : <i>Chlorococcales</i>						
<i>Pediastrum boryanum</i> (Trup.) Meneghini	+	+	+		+	+
<i>P. duplex</i> Meyen				+		
<i>P. integrum</i> var. <i>scutum</i> Raciborski					+	+
<i>P. muticum</i> Kuetzing		+				
<i>P. sp.</i>				+		
Class : <i>Oedogoniophyceae</i>						
Order : <i>Oedogoniales</i>						
<i>Bulbochaete</i> sp.		+	+			
<i>Oedogonium</i> sp.						+
Class : <i>Conjugatophyceae</i>						
Order : <i>Mesotaeniales</i>						
<i>Netrium</i> sp.					+	
Order : <i>Desmidiiales</i>						
<i>Closterium littorale</i> Gay.				+	+	
<i>C. ralfsii</i> var. <i>ralfsii</i> Breb.				+		

<i>C. sp.</i>	+	+		+	+	
<i>Cosmarium blyttii</i> Wille var. <i>blyttii</i>						+
<i>C. botrytis</i> Meneg. ex Ralfs					+	
<i>C. dentiferum</i> Corda ex Nordst.						+
<i>C. pseudoholmii</i> Borge				+		
<i>C. punctulatum</i> Breb. var. <i>punctulatum</i>				+		
<i>C. subcostatum</i> var. <i>minus</i> (W. & G. S. West) Först						+
<i>C. sp.</i>	+	+		+	+	
<i>Euastrum ansatum</i> Ehr. ex Ralfs var. <i>ansatum</i>					+	
<i>E. oblongum</i> Ralfs		+			+	
<i>E. pinnatum</i> Ralfs		+				
<i>E. verrucosum</i> Ehrenb. ex Ralfs var. <i>rhomboideum</i> Lund.		+				
<i>Micrasterias americana</i> (Ehr.) Ralfs		+				
<i>M. denticulata</i> Breb.		+			+	
<i>M. rotata</i> (Grev.) Ralfs					+	
<i>Penium margaritaceum</i> (Ehr.) ex Breb var. <i>margaritaceum</i>					+	
<i>Pleurataenium trabecula</i> (Ehr.) ex Nag. var. <i>trabecula</i>	+	+			+	+
<i>P. minutum</i> (Ralfs) Delp. var. <i>minutum</i>					+	
<i>Spondylosium planum</i> (Wolle) West & West						+
<i>Staurastrum pilosum</i> (Naeg.) Arch.						+
<i>S. polytrichum</i> (Petry) Breb.				+		
<i>S. punctulatum</i> Breb.	+	+	+	+	+	
<i>S. sp.</i>		+	+	+	+	
Order : <i>Zygnemales</i>						
<i>Maugeotia sp.</i>			+		+	
<i>Spirogyra sp.</i>	+	+	+	+	+	+
<i>Zygnema sp.</i>				+		+
Division : <i>Cyanophyta</i>						
Class : <i>Cyanophyceae</i>						
Order : <i>Chroococcales</i>						
<i>Chroococcus dispersus</i> var. <i>minor</i> G. M. Smith				+		
<i>Chroococcus sp.</i>						+
<i>Merismopedia elegans</i> A. Braun				+	+	
<i>M. glauca</i> (Ehrenb.) Naegeli					+	
<i>M. sp.</i>				+		
<i>Microcystis aeruginosa</i> Kuetz.		+	+			
<i>M. sp.</i>				+		
Order : <i>Hormogonales</i>						
<i>Oscillatoria amoena</i> (Kuetz.) Gomont				+		
<i>O. formosa</i> Bory.		+	+			+
<i>O. limosa</i> (Roth) C. A. Agardh					+	+
Division : <i>Euglenophyta</i>						
Order : <i>Euglenales</i>						
<i>Euglena sp.</i>				+		
<i>Trachelomonas sp.</i>						+

1: Phytoplankton, 2: Epipellic, 3: Epilithic.

Phytoplankton

A total of only 17 species of algae was recorded from this community in Lake Aygır. Of these, 11 belong to *Bacillariophyta* and 6 to *Chlorophyta*. In Lake Balıklı, phytoplankton consisted of 27 species, of which 13 were *Bacillariophyta*, 11 were *Chlorophyta* and 3 were *Cyanophyta* (Table 2)

The main species of this community belonged to *Chlorophyta* especially *Desmidiaceae*. *Closterium* sp., *Cosmarium* sp., *Staurastrum polytrichum* (Petry) Breb., *S. punctulatum* Breb. and *S.* sp. were the most frequently encountered.

In both lakes, members of the *Pennales* were not common, while *Centrales* was represented only by *Aulacosira italica* (Ehr.) Simenson.

On the other hand, while the *Cyanophyta* were represented by *Merismopedia elegans* A. Braun, *M.* sp. and *Microcystis* sp. in Lake Balıklı, members of *Euglenophyta* were not observed.

Epipellic Communities

A total of 38 species of algae was recorded from the epipellic community in Lake Aygır, of which 22 belong to *Bacillariophyta*, 14 to *Chlorophyta* and 2 to *Cyanophyta*. In Lake Balıklı, this community consisted of 46 species, of which 24 belong to *Bacillariophyta*, 19 to *Chlorophyta* and 3 to *Cyanophyta* (Table 2).

Suirella robusta var. *splendida* (Ehr.) Van Heurck was the most abundant algae and *Pinnularia maior* (Kütz.) Cleve was always the second in significance in both lakes. Other common epipellic diatoms included *Cymbella minuta*

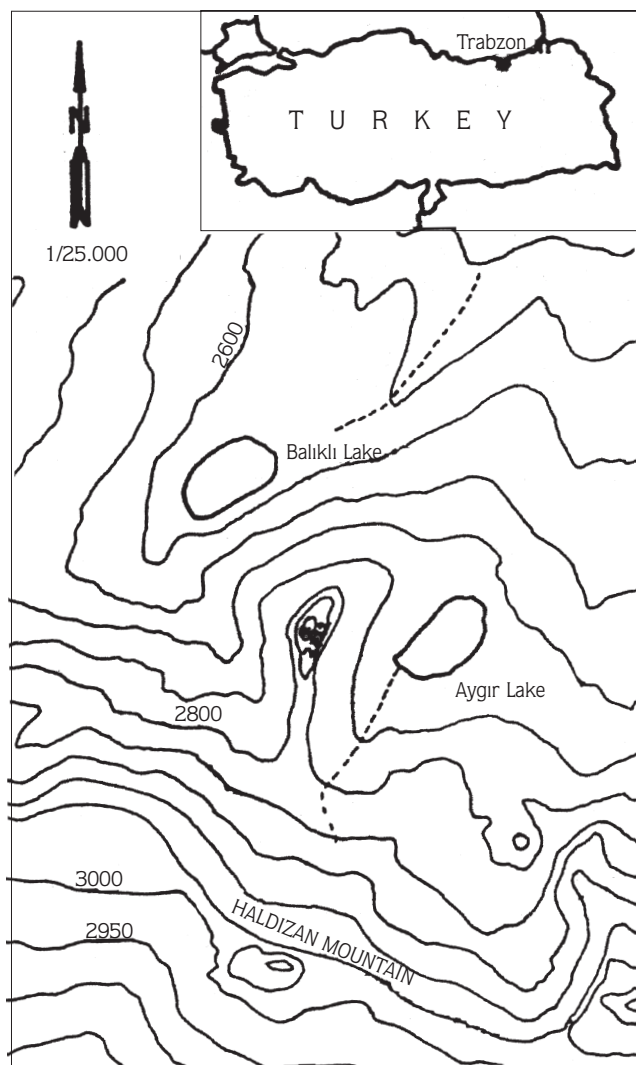


Figure 1. Map of the study area.

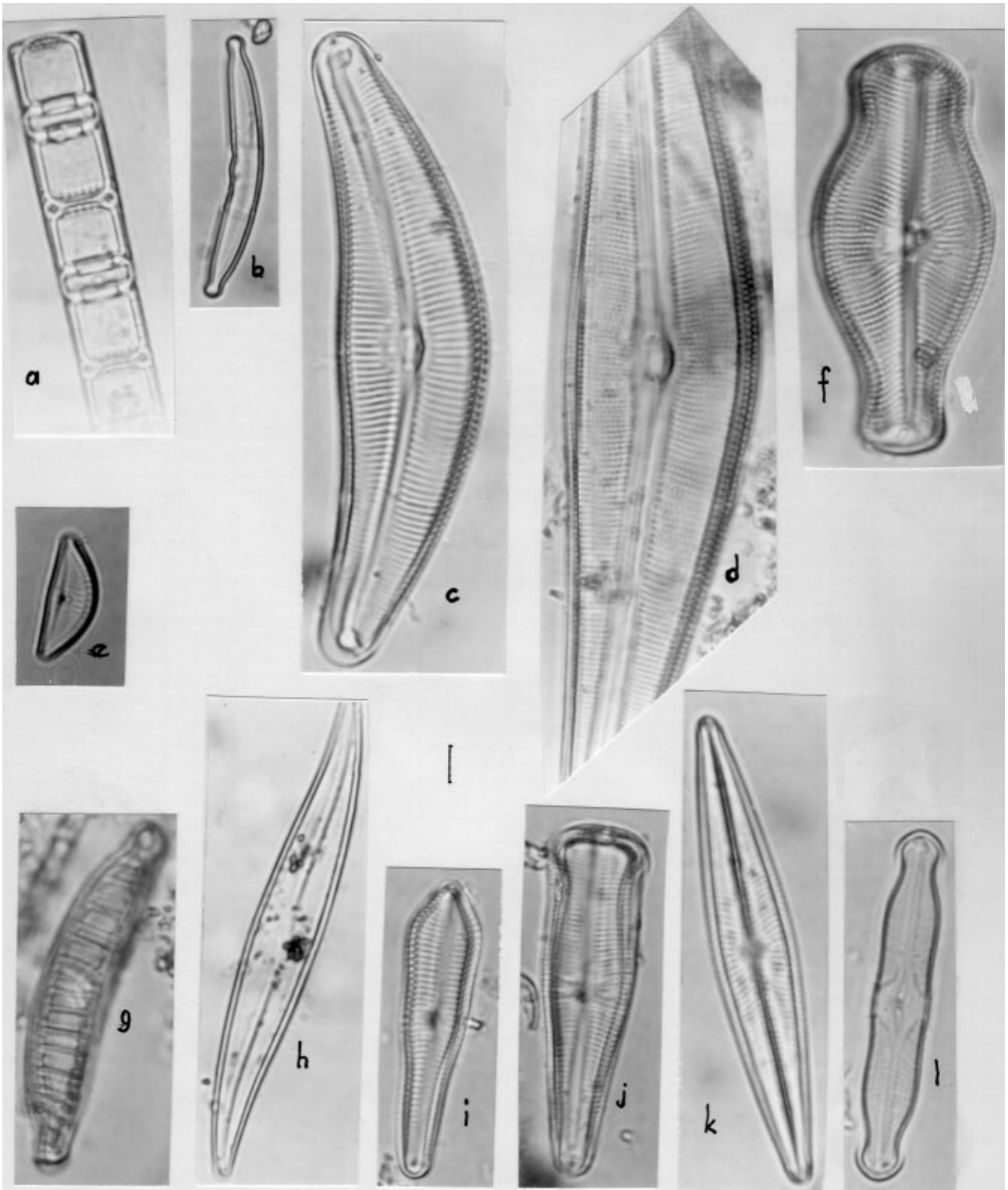


Figure 2. a. *Aulacosira italica*, b. *Ceratoneis arcus*, c. *Cymbella cistula*, d. *C. helvetica*, e. *C. minuta*, f. *Didymosphenia geminata*, g. *Epithemia argus*, h. *Gyrosigma acuminatum*, i. *Gomphonema acuminatum* var. *clavus*, j. *G. constrictum*, k. *Navicula radiosa*, l. *Pinnularia mesolepta*. (Scale 10 µm).

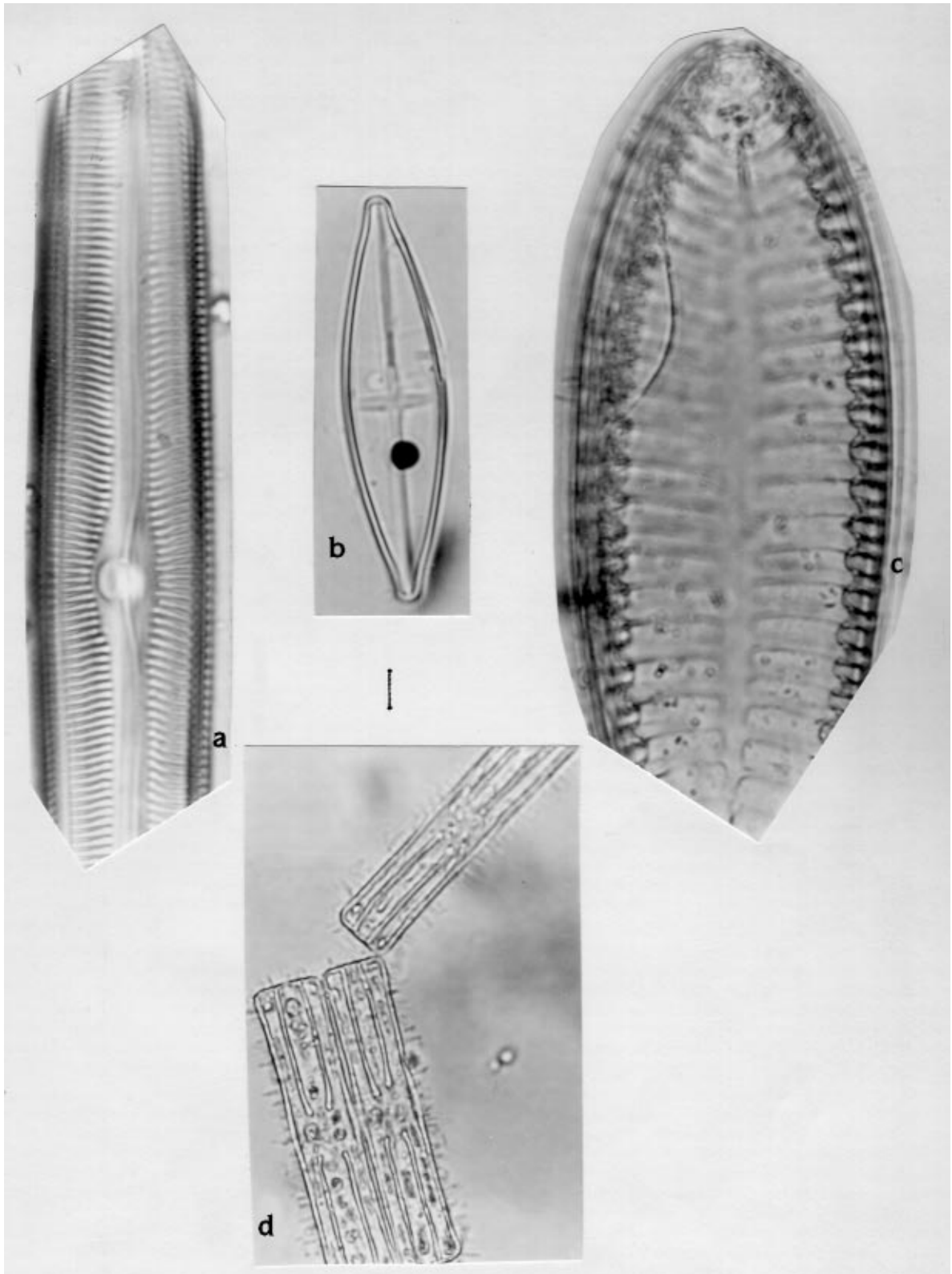


Figure 3. a. *Pinnularia maior*, b. *Stauroneis anceps*, c. *Surirella capronii*, d. *Tabellaria fenestrata* (Girdle view) (Scale 10 μ).

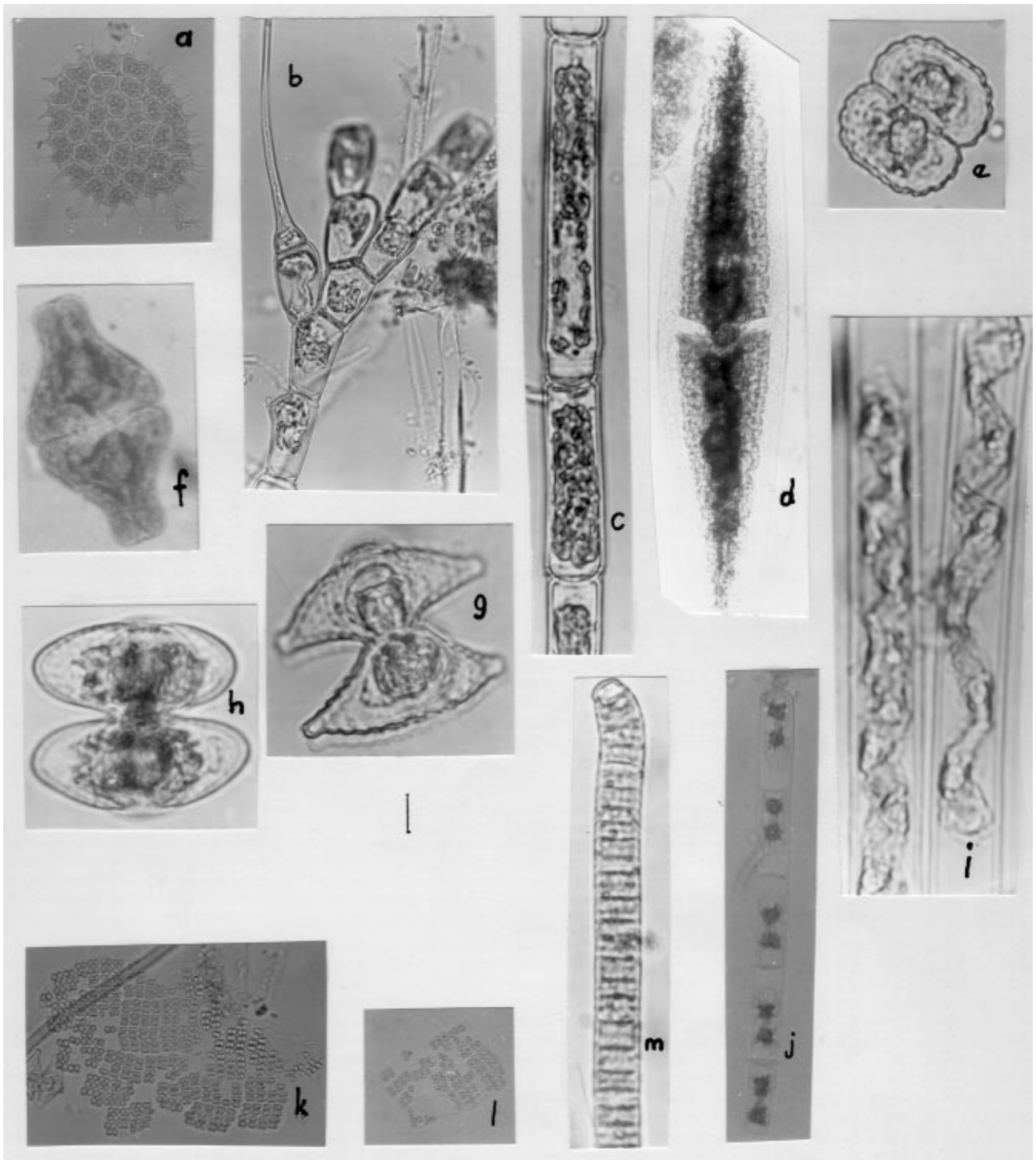


Figure 4. a. *Pediastrum boryanum*, b. *Bulbochaete* sp., c. *Oedogonium* sp., d. *Closterium* sp., e. *Cosmarium subcostatum* var. *minus*, f. *Euastrum ansatum* var. *ansatum*, g. *Staurastrum* sp., h. *S.* sp., i. *Spirogyra* sp., j. *Zygnema* sp., k. *Merismopedia elegans*, l. *M.* sp., m. *Oscillatoria limosa*. (Scale 10 μ).

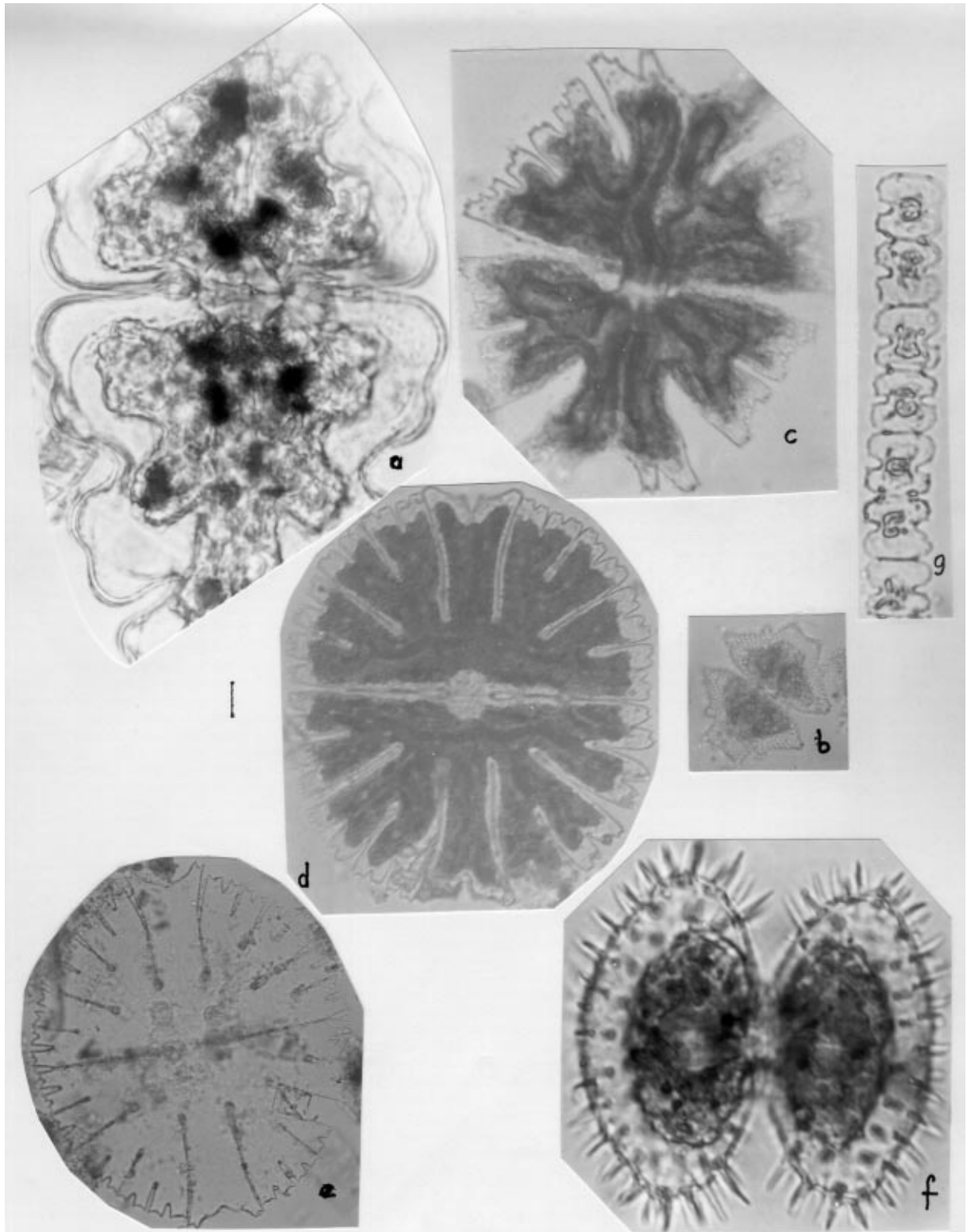


Figure 5. a. *Euastrum oblongum*, b. *E. verrucosum* var. *rhomboideum*, c. *Micrasterias americana*, d. *M. denticulata*, e. *M. rotata*, f. *Staurastrum pilosum*, g. *Spondylosium planum*. (Scale 10 μ).

Hilse ex Rabh., *C. cistula* (Hemprich) Grun and *Didymosphenia geminata* (Lyng.) M.S.

Members of *Chlorophyta* were encountered in both lakes throughout the investigation. The most common species were *Pediastrum boryanum* (Trup.) Meneghini and *Staurastrum punctulatum*. Filamentous *Chlorophyta* were represented by unidentified species of *Mougeotia* (C.A. Agardh) Wittrock (Lake Balıklı) and *Spirogyra* Link. In the epipelagic flora of both lakes, members of *Cyanophyta* were not significant, while *Euglenophyta* was not represented.

Euastrum oblongum Ralfs (L:172.5 µm, W: 75 µm, Lake Aygır), *E. verrucosum* Ehr. ex Ralfs var. *rhomboideum* Lund (L:110-120 µm, W:100-105 µm, Lake Aygır), *Micrasterias americana* (Ehr.) Ralfs (L: 175 µm, W: 150 µm, Lakes Aygır and Balıklı), *M. denticulata* Breb. (L: 245-260 µm W: 220-235 µm, Lakes Aygır and Balıklı) *M. rotata* (Grev.) Ralfs (L:280 µm, W: 250 µm, Lake Aygır) and *Staurastrum pilosum* (Naeg.) Arch. (L:42.5 µm, W:37.5 µm, Lake Balıklı) are recorded for the first time in Turkey.

Epilithic communities

In Lake Aygır, this community consisted of 28 species, of which 15 belong to *Bacillariophyta*, 8 to *Chlorophyta*, 4 to *Cyanophyta* and 1 to *Euglenophyta*. A total of 33 species of algae was recorded from the epilithic community in Balıklı lake, of which 19 belong to *Bacillariophyta*, 10 to *Chlorophyta*, 3 to *Cyanophyta* and 1 to *Euglenophyta* (Table 2).

The most common diatoms in both lakes were *Cymbella cistula*, *C. minuta*, *Didymosphenia geminata* and *Gomphonema constrictum* Ehr.

Unicellular *Chlorophyta* especially members of *Desmidiaceae*, were common in the epilithic communities in both lakes. Although attached *Chlorophyta* were represented by unidentified species of *Bulbochaete* C.A. Agardh (Lake Aygır), *Oedogonium* Link (Lake Balıklı), *Mougeotia*, *Spirogyra* and *Zygnema* C.A. Agardh (Lake Aygır), these species were not common in the epilithic communities of either lake.

The only common member of *Cyanophyta* was *Microcystis aeruginosa* Kuetz., especially in Lake Aygır in August. The other species were not significant. *Euglenophyta* were represented by unidentified species of *Euglena* and *Trachelomonas*.

Spondylosium planum (Wolle) West & West (L:10 µm, W:12.5 µm, isthmus:5 µm, Lake Balıklı) is also recorded for the first time in Turkey.

Conclusion

A total of 86 species were determined in the algal flora of both lakes, 38 belong to *Bacillariophyta*, 36 to *Chlorophyta*, 10 to *Cyanophyta* and 2 to *Euglenophyta* (Table 2).

Although the species compositions in the two lakes were similar, the number of species in Lake Balıklı was higher than that of Lake Aygır, which has a lesser area than Lake Balıklı.

The main ecological factors of light, temperature and ice affected the development of the algal flora in lakes Aygır and Balıklı. Moore (15) reported that ice may simply have a delaying effect on the development of the flora, and once the water becomes warm, the same basic ecological factors can be applied to both subarctic and temperature zone populations. However, there is no doubt that the continuous light conditions contributed substantially to the development of the flora. Other factors such as wave action and diurnal temperature variation also had an effect on the flora. No one single factor appeared to control the development of algal flora, but all these factors, combined had a controlling effect on algal development (16).

The similarity in the species composition of the algal flora in the two lakes was due to the similarity in nutrient and temperature conditions throughout the study area. Since the samples were collected at the same level, the photoperiod was also similar. In addition, the stations were located in the same depth of water and 50-100cm from shore.

However, there were some differences, especially regarding members of *Desmidiaceae*. While *Cosmarium pseudoholmi* Borge, *C. punctulatum* Breb. var. *punctulatum*, *Euastrum pinnatum* Ralfs, *E. verrucosum* var. *rhomboideum* and *Micrasterias americana* were identified in Lake Aygır, *Closterium littorale* Gay, *C. ralfsii* var. *ralfsii* Breb., *Cosmarium blyttii* Wille var. *blyttii*, *C. botrytis* Meneg. ex Ralfs, *C. dentiferum* Corda ex Nordst, *C. subcostatum* var. *minus* (W. & G. S. West) Först, *Euastrum ansatum* Ehr. Ex Ralfs var. *ansatum*, *Micrasterias rotata*, *Penium margaritaceum* (Ehr.) ex Breb. var. *margaritaceum*, *Pleurotaenium minutum* (Ralfs) Delp. var. *minutum*, *Spondylosium planum*, *Staurastrum pilosum* and *S. polytrichum* were identified in Lake Balıklı.

On the other hand, a complication was observed between the algal flora of phytoplankton and benthic habitats in both lakes because of wave actions.

Many algal species are useful indicators of trophic conditions in lakes and rivers (7). Rawson (17) indicated

that *Ceratium hirundinella* (O. F. Müller) Schrank (*Peridiniaceae*), *Pediastrum boryanum* (Trup.) Meneghini and *P. dublex* Meyen were characteristic species of mesotrophic lakes. While *Ceratium hirundinella* was not observed, *Pediastrum boryanum* and *P. dublex* were found, especially in Lake Balıklı. *Microcystis aeruginosa* is also a characteristic species of mesotrophic lakes (17). This species was common in the epilithic flora of Lake Aygır in August. *M. aeruginosa* has been reported to develop water-blooms in Kurtboğazı Dam (18), Bafra Balık Lakes (19), Lake Mogan (20) and Lake Karamik (21).

The members of *Desmidiaceae* were characteristic species of oligotrophic lakes, as reported by Hutchinson (22). In both lakes, members of *Desmidiaceae* were the most frequently encountered. Gönülol (23) pointed out that while *Desmidiaceae*, especially members of the *Cosmarium* and *Closterium*, were found to be very common in eutrophic and mesotrophic lakes, these

species were not common in oligotrophic lakes in Turkey. *Staurastrum* spp., being the most important species of the flora, are very common members of oligotrophic lakes (17). In addition, *Didyomosphenia geminata*, *Tabellaria fenestrata* (Lyngby) Kütz. And *T. flocculosa* (Roth) Kütz. are good indicators of oligotrophic conditions (7, 8, 17).

The compound index also indicates the fertility of the lakes (24). Compound index values (*Cyanophyceae* + *Chlorococcales* + *Centrales* + *Euglenales* / *Desmidiaceae*) have been found to be 0.5 in Lake Aygır and 0.8 in Lake Balıklı. Nygard (24) pointed out that this index gives the most result between June and August.

It has been determined that lakes Aygır and Balıklı have oligotrophic lake characteristics, due to their morphometric structure, the physical and chemical properties of the water and the presence of algal flora.

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