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Research Article

Net Diatom (Bacillariophyceae) Flora of Lake Gölköy (Bolu)

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Abstract: The diatom flora of Lake Gölköy was studied monthly over 2 years (June 2003-June 2005) from 3 littoral and 2 vertical stations in Lake Gölköy (Bolu, Turkey). A total of 119 diatom taxa were identified, most of them belonging to Naviculaceae (48.7%) Kützing, Fragilariceae (16.8%) Hustedt, Surirellaceae (11.8%) Kützing, and Bacillariaceae (6.7%) Ehrenberg, from which many species (*Asterionella formosa* Hassall, *Aulacoseria granulata* (Ehrenberg) Simonsen, *Cyclotella praetermis* Lund, *Cymbella cistula* Kirchner, *Fragilaria biceps* (Kützing) Lange-Bertalot, *F. crotonensis* Kitton, *F. dilata* (Brebisson) Lange-Bertalot, *Navicula radiosa* Kützing, and *Nitzschia sigmoidae* (Nitzsch) Smith) were found each month at all stations. Species richness was especially high in the autumn (November-December 2003 and September-October 2004) during the study periods.

Key Words: Lake Gölköy, Diatom, Systematic, Species diversity

Gölköy Gölü Net Diyatome (Bacillariophyceae) Florası

Özet: Gölköy Gölü diyatome florası üç kıyısal ve iki vertikal istasyonda aylık olarak iki yıl boyunca (Haziran 2003-Haziran 2005) çalışılmıştır. *Naviculaceae* (%48,7) Kützing, *Fragilariceae* (%16,8) Hustedt, *Surirellaceae* (%11,8) Kützing, ve *Bacillariaceae* (%6,7) sınıflarına ait toplam 119 diyatomenin tanımlandığı yerde birçok tür (*Asterionella formosa* Hassall, *Aulacoseria granulata* (Ehrenberg) Simonsen, *Cyclotella praetermis* Lund, *Cymbella cistula* Kirchner, *Fragilaria biceps* (Kützing) Lange-Bertalot, *F. crotonensis* Kitton, *F. dilata* (Brebisson) Lange-Bertalot, *Navicula radiosa* Kützing, ve *Nitzschia sigmoidae* (Nitzsch) Smith) bütün istasyonlardan her ay bütün istasyonlarda bulunmuştur. Çalışma süresince, tür zenginliği özellikle sonbahar aylarında (Kasım-Aralık 2003 ve Eylül-Ekim 2004) artmıştır.

Anahtar Sözcükler: Gölköy Gölü, Diyatome, Sistematik, Tür Çeşitliği

Introduction

In the region of Bolu, previous studies have focused on certain groups of animals such as ostracods (Külköylüoğlu, 2004, 2005, Külköylüoğlu & Dügel, 2004), and Orthopterans (Ünal, 1997), and plants (Davis et al., 1988). The area is known for its variety of habitats, and these studies increased our understanding of its species diversity, but little attention has been given to phytoplankton, and especially diatoms. Previous studies on this taxonomic group were performed in certain areas including Lake Abant (Obalı et al., 2002; Çelekli & Külköylüoğlu, 2006), Lake Yedigöller (Atıcı & Obalı, 2002), Lake Yeniçağa (Kılınç, 2003) and Akkaya Spring (Çelekli & Külköylüoğlu, 2006). Until the present study, nothing was known about the diatoms of Lake Gölköy, which is one of the largest dam lakes in the Bolu area. The present study investigated diatom species composition and their seasonal occurrence in Lake Gölköy over 2 years.

Materials and Methods

Lake Gölköy (31°, 31' E, 40°, 42' N, 730 asl) (Figure 1), which is 10 km east of Bolu, was originally built on a wetland area in the early 1970s to provide water for irrigation of agricultural land and as a water body for commercial fishing. The lake receives 2 major inflows: from the Abant creek in the north-east and the Mudurnu creek in the south-west of the lake. Both creeks carry nutrient-rich water from chicken farms, agricultural areas, and villages (Külköylüoğlu, 2005). The lake area fluctuates seasonally between 150 and 180 ha on

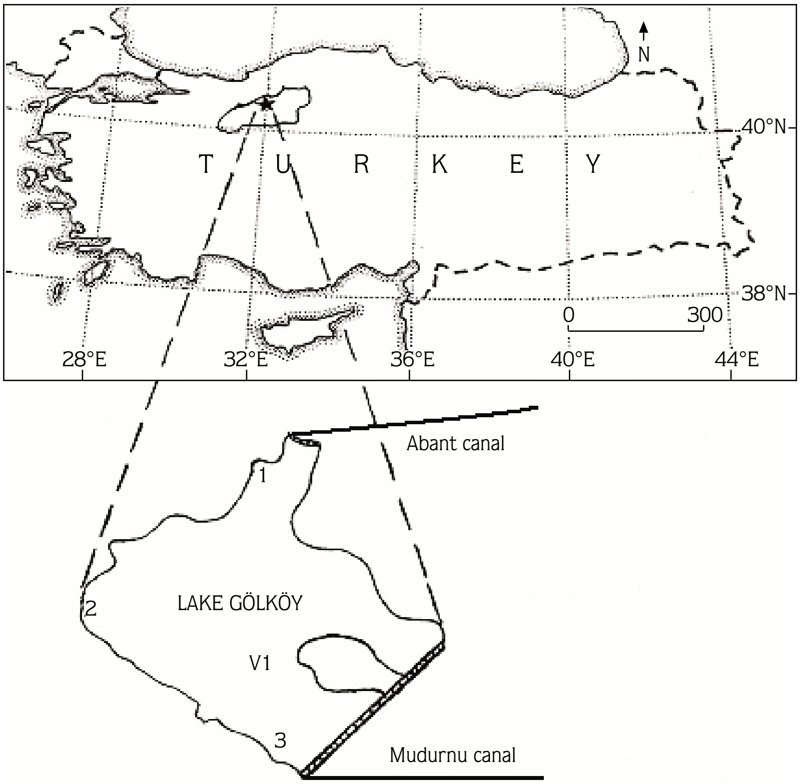

Figure 1. Map of Lake Gölköy and location of the sampling stations.

average, with a maximum depth of 20 m between 2003 and 2005. During summer and autumn, the lake water level drops to around 6-8 m.

Monthly collections were performed from 3 littoral and 2 vertical stations at the lake between June 2003 and June 2005. Littoral samples were collected with a plankton net (45 µm mesh size, 20 cm diameter). Two vertical samplings were performed from 4 deeper parts of the lake (surface, 4, 7, and 10 m) with a 2.5-l Van Dorn bottle. Geographical data (elevation, latitude, and longitude) were recorded with a geographical positioning system (GPS).

Lake water collected from the surface to some pre-selected depths for composite plankton samples was preserved with acetic lugol-glycerol solution in polyethylene bottles. After the concentrated samples were brought to the laboratory, temporary and permanent slides of phytoplankton were made for species identification under the light microscope at 400X, 800X, and 1000X magnification. Organic constituents of the diatoms were removed from the debris to observe the details and for visualisation of ornamentations of the valves as described by Simonsen (1974). The shapes of some diatoms were photographed with the attachment of a BX 51 Olympus microscope camera. For species identification, the systematic keys given by Krammer & Lange-Bertalot (1991a, 1991b, 1999a, 1999b), Patrick & Reimer (1966, 1975), Round et al., (1990), and Wehr & Sheath (2003) were used.

Descriptive information about each diatom collected from different stations includes size range, and costa and stria counts for all specimens. In the species description, the first measurements are those found in this study, while the values given in brackets come from the literature. The materials analysed are kept in the Department of Biology, Abant İzzet Baysal University, Bolu.

Results

Composition of Diatoms

A total of 119 diatoms taxa were identified, belonging to 4 genera and 10 taxa, and 29 genera and 109 taxa from the orders Centrales and Pennales, respectively.

BACILLARIOPHYCEAE

CENTRALES

Thalassiosiraceae Hasle 1973

Aulacoseria Thwaites 1848

A. granulata (Ehrenberg) Simonsen 1979, (Figure 2. a, b).

Valves 11-16 µm (5-24 µm) in length and 7-12 µm (4-30 µm) in diameter, 5-6 (5-9) puncta per 10 µm (Krammer & Lange-Bertalot, 1991a, Figure 16: 1, 2; 17: 1-10; 18: 1-14).

A. islandica (O.Müller) Simonsen 1979.

Valves 15-20 µm (4-21 µm) in length and 7-10 µm (3-28 µm) in diameter, 11-12 (12-18) puncta 10 µm (Krammer & Lange-Bertalot, 1991a, Figure 22: 1-12).

Cyclotella (Kützing) Brebisson 1838.

C. bodanica Grunow 1878

Valves 21-62 µm (20-80 µm) in diameter, valves are discoid (Krammer & Lange-Bertalot, 1991a, Figure 53: 1-6; 54: 1-4b; 55: 1-7b; 56: 3a-5; 57: 1-5; 58: 1-6; 61: 1-5b).

C. meneghininana Kützing 1844, (Figure 2. c).

Valves 17-19 µm (10-20 µm) in diameter, valve circular (Krammer & Lange-Bertalot, 1991a, Figure 44: 1-10).

C. ocellata Pantocsek 1901, (Figure 2. d, e).

Valves 14-17 µm (6-25 µm) in diameter, the outer of valves is slightly flat circular (Krammer & Lange-Bertalot, 1991a, Figure 50: 1-11, 13, 14; 51: 1-5).

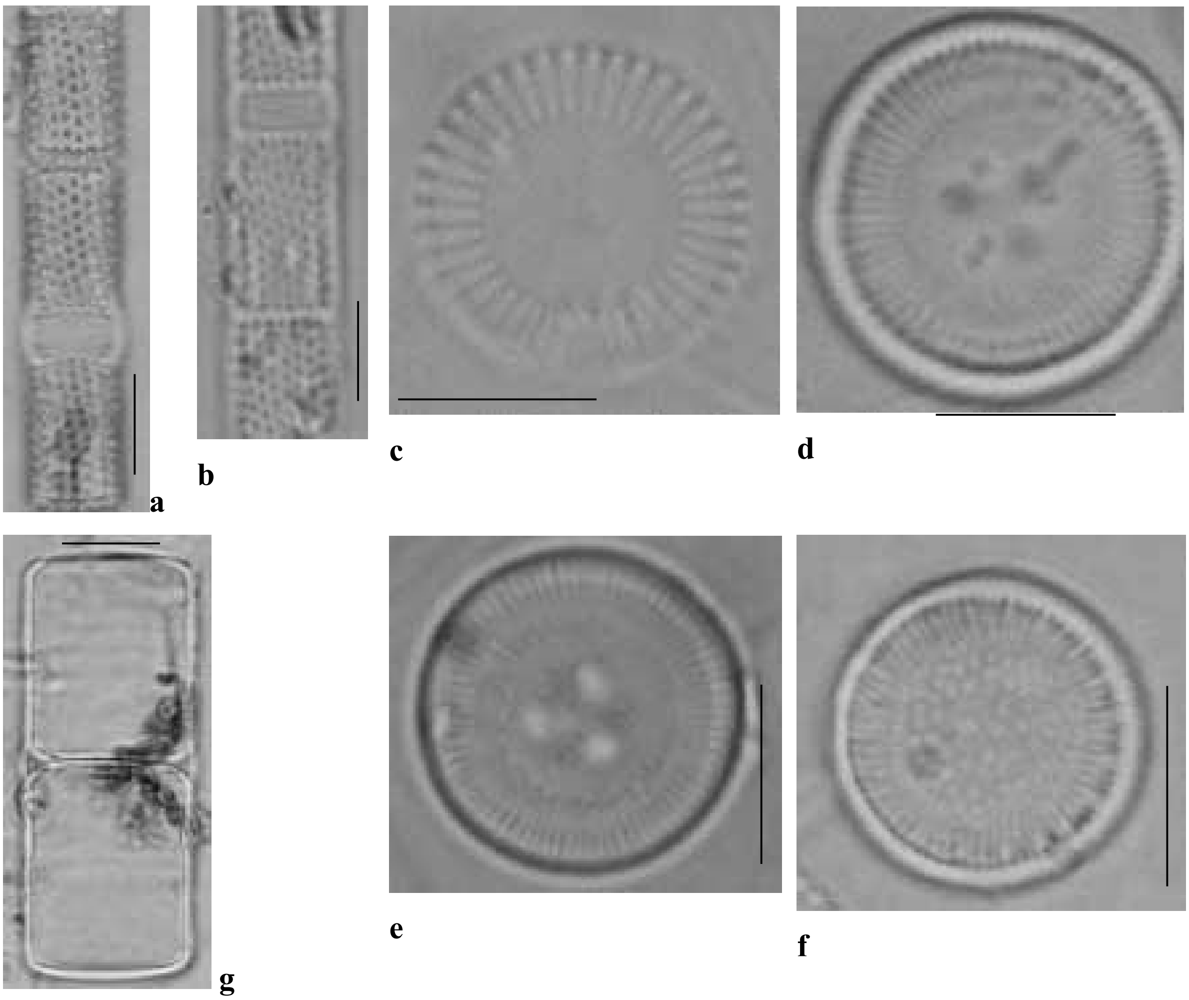

Figure 2. a, b) *Aulacoseria granulata*, c) *Cyclotella meneghiniana*, d, e) *C. ocellata*, f) *C. praetermisa*, g) *Melosira varians* (Scale 10 µm).

C. praetermisa Lund 1951, (Figure 2. f).

Valves 16-20 µm (8-25 µm) in diameter, valves are discoid, 12-13 (13-19) striae in 10 µm (Krammer & Lange-Bertalot, 1991a, Figure 60: 7-10).

Stephanodiscus Ehrenberg 1846

Stephanodiscus sp.

Valves 11-14 µm in diameter, valves are discoid, 14-16 areole in 10 µm.

Melosiraceae Kützing 1844

Melosira Agardh 1827

M. dickiei (Thwaites) Kützing 1849.

Valves 8.5-9 µm (7-10 µm) in length and 11-12 µm (10-20 µm) in diameter (Krammer & Lange-Bertalot, 1991a, Figure 9: 1-13).

M. lineata Agardh 1824

Valves 19-22 µm (13-23 µm) in length and 24-26 µm (6-40 µm) in diameter (Krammer & Lange-Bertalot, 1991a, Figure 7: 1-9).

M. varians Agardh 1827, (Figure 2. g).

Valves 11-13 µm (4-14 µm) in length and 10-12 µm (8-35 µm) in diameter (Krammer & Lange-Bertalot, 1991a, Figure 3: 8; 4: 1-8).

PENNALES

Araphidineae

Fragilariceae Hustedt 1930

Asterionella Hassall 1850

A. formosa Hassall 1850

Valves 74-119 µm (30-160 µm) in length and 2.5-5 µm (1.3-6 µm) in width, 23-25 (24-28) striae 10 µm (Krammer & Lange-Bertalot, 1991a, Figure 103: 1-9; 104; 9, 10).

Diatoma Borry 1824

D. anceps Agardh 1812

Valves 21-35 µm (12-85 µm) in length and 5-6 µm (4-7 µm) in width, 17-18 (18-20) striae 10 µm (Krammer & Lange-Bertalot, 1991a, Figure 102: 4-10).

D. tenuis Agardh 1812, (Figure 3. a).

Valves 28-81 µm (22-120 µm) in length and 3-4 µm (2-5 µm) in width, 7-8 (6-10) striae 10 µm (Krammer & Lange-Bertalot, 1991a, Figure 96: 1-9, 10).

D. vulgaris Borry 1824

Valves 30-57 µm (8-75 µm) in length and 12.5-16 µm (7-18 µm) in width, 8 (5-12) striae 10 µm (Krammer & Lange-Bertalot, 1991a, Figure 91: 2, 3; 93: 1-12; 94: 1-13; 95: 1-7; 97: 3-5).

Fragilaria Lyngbye 1819

F. biceps (Kützing) Lange-Bertalot 1991, (Figure 3. b)

Valves 287-382 µm (160-750 µm) in length and 8-9 µm (7-10 µm) in width, 7-10 (7-9) striae 10 µm (Krammer & Lange-Bertalot, 1991a, Figure 121: 1-5).

F. capucina Desmazieres 1925, (Figure 3. c)

Valves 25-32 µm (10-100 µm) in length and 3.75-4 µm (2-6.5 µm) in width, 9-11 (9-22) striae 10 µm (Krammer & Lange-Bertalot, 1991a, Figure 108: 1-8).

F. capucina Desmazieres var. **mesolepta** (Rabenhorst) Rabenhorst 1864

Valves 22-33 µm (10-100 µm) in length and 4-4.5 µm (2-6.5 µm) in width, 12-15 (9-22) striae 10 µm (Krammer & Lange-Bertalot, 1991a, Figure 110: 14-21, 23, 24).

F. capucina Desmazieres var. **vaucheriae** (Kützing) Lange-Bertalot 1980.

Valves 25-28 µm in length and 4 µm (4-5 µm) in width, 9-10 (9-14) striae 10 µm (Krammer & Lange-Bertalot, 1991a, Figure 108: 10-15).

F. construens (Ehrenberg) Grunow 1862.

Valves 17-19 µm (4-35 µm) in length and 4-5 µm (2-12 µm) in width, 13-14 (12-20) striae 10 µm (Krammer & Lange-Bertalot, 1991a, Figure 132: 1- 34; 129: 21-27; 131: 5, 6).

F. crotonensis Kitton 1869

Valves 31-84 µm (40-170 µm) in length and 3-4 µm (2-5 µm) in width, 16 (15-18) striae 10 µm (Krammer & Lange-Bertalot, 1991a, Figure 116: 1-4).

F. dilata (Brebisson) Lange-Bertalot 1986, (Figure 3. d)

Valves 124-383 µm (120-500 µm) in length and 7.5-9 µm (7-10 µm) in width, 7 (6-11) striae 10 µm (Krammer & Lange-Bertalot, 1991a, Figure 123: 1-3).

F. lapponica Grunow 1881.

Valves 17-21 µm (10-40 µm) in length and 3.5-5 µm (3-6 µm) in width, 7-8 (6-10) striae 10 µm (Krammer & Lange-Bertalot, 1991a, Figure 134: 1-8).

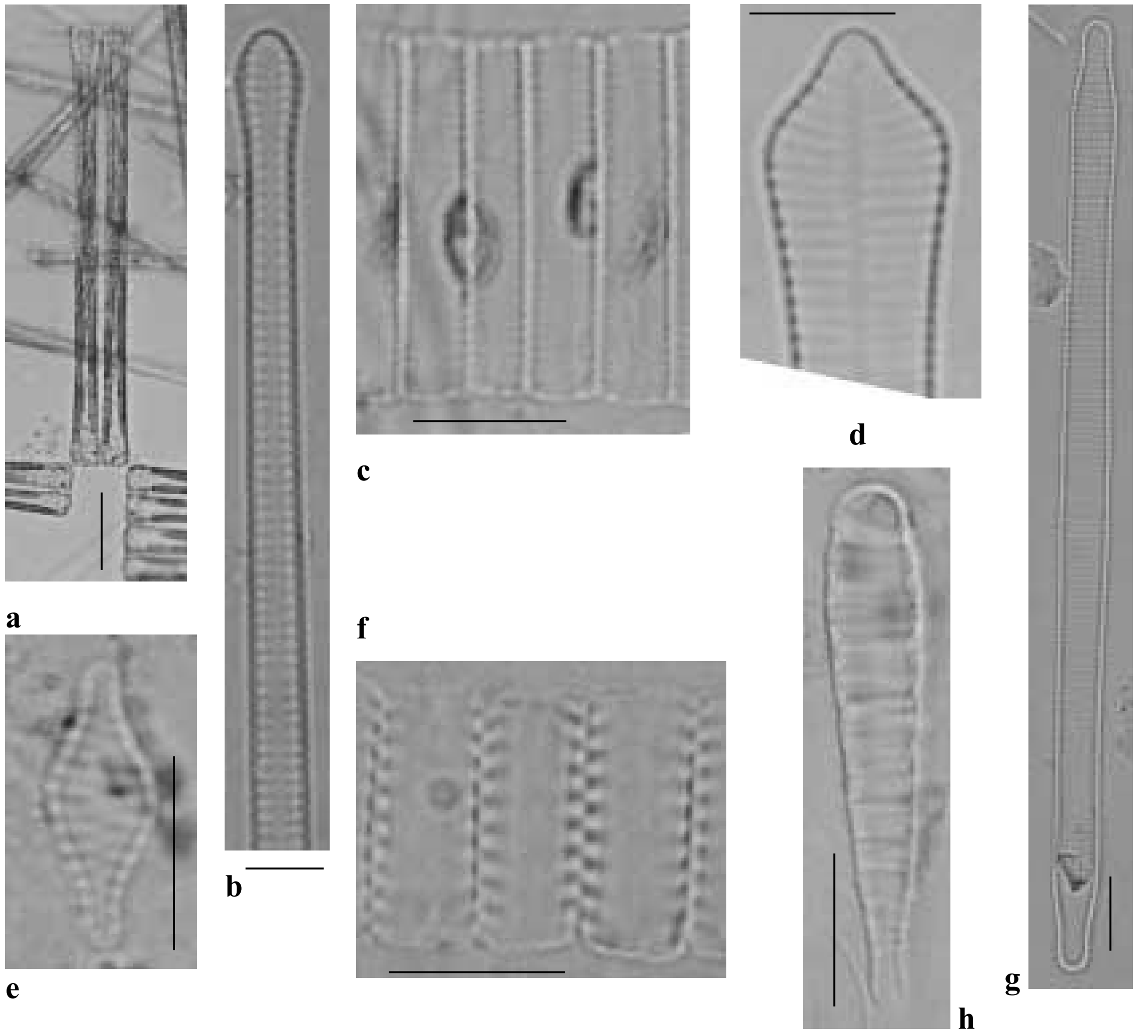

Figure 3. a) *Diatoma tenuis*, b) *Fragilaria biceps*, c) *F. capucina*, d) *F. dilata*, e, f) *F. pinnata*, g) *F. ulna*, h) *Meridion cirqulare* (Scale 10 µm).

Fragilaria leptostauron Husted var. martyi Lange-Bertalot 1991.

Valves 17-31 µm (15-36 µm) in length and 12-15 µm (10-23 µm) in width, 7-8 (5-11) striae 10 µm (Krammer & Lange-Bertalot, 1991a, Figure 133: 28-31).

F. pinnata Ehrenberg 1843, (Figure 3. e, f)

Valves 15-17 µm (3-60 µm) in length and 5-7 µm (2-8 µm) in width, 7-9 (5-12) striae 10 µm (Krammer & Lange-Bertalot, 1991a, Figure 112: 15, 16; 117: 3; 131: 3, 4).

F. ulna (Nitzsch) Lange-Bertalot 1980, (Figure 3. g)

Valves 93-487 µm (27-600 µm) in length and 3-7.5 µm (1.5-9 µm) in width, 8-9 (7-15) striae 10 µm (Krammer & Lange-Bertalot, 1991a, Figure 119-122).

F. ulna (Nitzsch) Lange-Bertalot var. danica (Kützing) Lange-Bertalot 1980.

Valves 168-232 µm in length and 3.5-4.75 µm in width, 11-12 striae 10 µm (Krammer & Lange-Bertalot, 1991a, Figure 122: 9).

F. ulna (Nitzsch) Lange-Bertalot var. acus (Kützing) Lange-Bertalot 1980.

Valves 185-232 µm in length and 3-4 µm in width, 11 striae 10 µm (Krammer & Lange-Bertalot, 1991a, Figure 122: 9).

F. virescens Ralfs 1843.

Valves 15-32 µm (10-120 µm) in length and 7-8 µm (6-10 µm) in width, 14-15 (13-19) striae 10 µm (Krammer & Lange-Bertalot, 1991a, Figure 119-122).

Meridion Agardh 1824

M. circulare (Greville) C.A.Agardh 1831, (Figure 3. h)

Valves 27-35 µm (10-82 µm) in length and 5 µm (4-8 µm) in width, 3 (2-5) costae in 10 µm, (Krammer & Lange-Bertalot, 1991a, Figure 100: 1-3; 101:1-14; 102: 1-3).

Tetracyclus Ralfs 1843

T. rupestris (Braun) Grunow 1881

Valves 23-25 µm (4-30 µm) in length and 9-10 µm (3-12 µm) in width, 3 (3-5) costae in 10 µm, (Krammer & Lange-Bertalot, 1991a, Figure 89: 8-20).

Raphidineae

Achnanthaceae Kützing 1844

Achnanthes Bory 1822

A. minutissima var. **minutissima** Kützing 1833

Valves 8-13 µm (5-25 µm) in length and 3-3.5 µm (2.5-4 µm) in width, 24-26 (20-30) striae in 10 µm, (Krammer & Lange-Bertalot, 1991a, Figure 32: 1-24; 35: 1, 2).

Cocconeis Ehrenberg 1838

C. pediculus Ehrenberg 1838

Valves 17-29 µm (12-54 µm) in length and 15-18 µm (7-37 µm) in width, 18-20 (16-24) striae 10 µm and 21 (18-23) puncta 10 µm (Krammer & Lange-Bertalot, 1991b, Figure 55: 1-8).

C. placentula Ehrenberg 1838

Valves 33-46 µm (7.5-98 µm) in length and 18-34 µm (8-40 µm) in width, 16-18 (14-23) striae 10 µm and 17 (15-20) puncta 10 µm (Krammer & Lange-Bertalot, 1991b, Figure 49: 1-4; 50: 1, 2, 5; 51: 1-9; 52: 1-13; 53: 1-19; 54: 1-12).

C. placentula Ehrenberg var. **lineata** Grunow 1884

Valves 28-49 µm (10-80 µm) in length and 16-17 µm in width, 18-20 (18-23) striae 10 µm (Krammer & Lange-Bertalot, 1991b, Figure 49: 1; 50: 1-13).

C. rugosa Sovereing 1960

Valves 33-38 µm (18-63 µm) in length and 23-25 µm (12-52 µm) in width, 14-15 (14-16) striae 10 µm and 16 (15-20) puncta 10 µm (Patrick and Reimer, 1966, Figure 15: 13-14).

Eunotiaceae Kützing 1844

Eunotia Ehrenberg 1837

E. bilunaris (Ehrenberg) Mills 1934

Valves 91-119 µm (10-150 µm) in length and 4 µm (1.9-6 µm) in width, 19-24 (11-28) striae in 10 µm, (Krammer & Lange-Bertalot, 1991a, Figure 137; 138: 10-24).

Naviculaceae Kützing 1844

Amphora Ehrenberg in Kützing 1844

A. aequalis Krammer 1980.

Valves 21-29 µm (18-37 µm) in length and 4.5-5 µm (4.7-5.5 µm) in width, 15 (15-17) striae 10 µm (Krammer & Lange-Bertalot, 1999a, Figure 150: 18-22; 13:6; 18: 2).

A. ovalis (Kützing) Kützing 1844, (Figure 4. a).

Valves 29-48 µm (30-105 µm) in length and 18-21 µm (17-50 µm) in width, 11-12 (10-13) striae 10 µm (Krammer & Lange-Bertalot, 1999a, Figure 149: 1, 2; 2: 7-9; 7: 7, 8).

Anomoeoneis Pfitzer 1871.

A. sphaerohora (Ehrenberg) Pfitzer 1871 (Figure 4. b).

Valves 58-106 µm (25-200 µm) in length and 49-54 µm (12-60 µm) in width, 14-17 (13-20) striae 10 µm (Krammer & Lange-Bertalot, 1999a, Figure 92: 1-6; 93: 1-3).

Caloneis Cleve 1894

C. silicula (Ehrenberg) Cleve 1894.

Valves 45-49 µm (13-120 µm) in length and 8.7-9 µm (5-20 µm) in width, 16-17 (15-20) striae 10 µm (Krammer & Lange-Bertalot, 1999a, Figure 172: 1-13; 7: 6; 9: 3).

Cymbella Agardh 1830

C. affinis Kützing 1844, (Figure 4. c).

Valves 47-58 µm (20-70 µm) in length and 8-11 µm (7-16 µm) in width, 8-10 (9-11) mid-dorsal and end 12-13 (12-14) striae 10 µm (Krammer & Lange-Bertalot, 1999a, Figure 125: 1-22; 10: 1).

C. amphicephala Naegeli 1849

Valves 22-29 µm (16-40 µm) in length and 8-9 µm (6-9 µm) in width, 13 (12-15) mid-dorsal and end 19

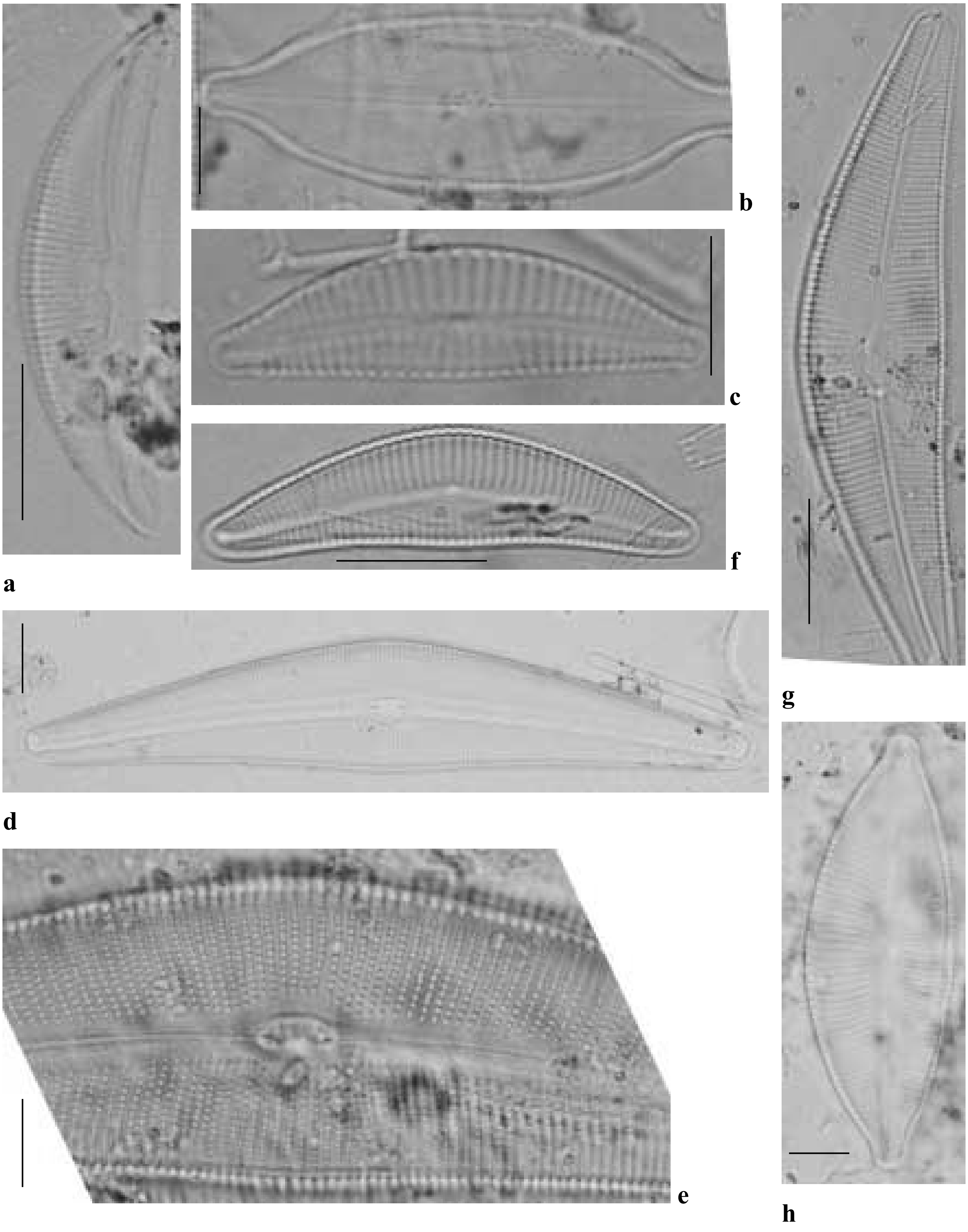

Figure 4. a) *Amphora ovalis*, b) *Anomoeoneis sphaerophora*, c) *Cymbella affinis*, d, e) *C. aspera*, f, g) *C. cistula,* h) *C. subcuspidata* (Scale 10 μm).

(17-20) striae 10 µm (Krammer & Lange-Bertalot, 1999a, Figure 142: 3-21).

C. aspera (Ehrenberg) Peragallo 1849, (Figure 4. d, e)

Valves 91-175 µm (70-265 µm) in length and 21-31 µm (20-48 µm) in width, 8-9 (7-10) mid-dorsal and end 11 (11-12) striae 10 µm (Krammer & Lange-Bertalot, 1999a, Figure 131: 1; 7: 1; 8: 2; 11: 5).

C. cistula (Ehrenberg) Kirchner 1878, (Figure 4. f, g)

Valves 62-108 µm (35-120 µm) in length and 15-17.5 µm (13-25 µm) in width, 8-9 (7-10) mid-dorsal and end 12 (12-14) striae 10 µm (Krammer & Lange-Bertalot, 1999a, Figure 127: 8-11; 128. 1-6; 10: 5).

C. cuspidata Kützing 1844

Valves 33-51 µm (28-66 µm) in length and 13-17 µm (14-20 µm) in width, 10-11 (8-12) mid-dorsal striae 10 µm (Krammer & Lange-Bertalot, 1999a, Figure 146: 1-4).

C. subcuspidata Krammer 1982, (Figure 4. h)

Valves 62-87 µm (54-100 µm) in length and 21-24 µm (19-31 µm) in width, 8-9 (8-11) mid-dorsal striae 10 µm, 14-15 (15) end striae 10 µm (Krammer & Lange-Bertalot, 1999a, Figure 146: 6, 7; 15: 1).

C. cymbiformis Agardh 1830

Valves 33-41 µm (25-95 µm) in length and 13-14 µm (8-15 µm) in width, 9 (8-10) mid-dorsal and end 11 (11-15) striae 10 µm (Krammer & Lange-Bertalot, 1999a, Figure 129: 2-9; 5: 5; 12: 5).

C. ehrenbergii Kützing 1844

Valves 97-123 µm (50-225 µm) in length and 33.5-38 µm (19-50 µm) in width, 6 (6-9) mid-dorsal and end 10 (10-12) striae 10 µm (Krammer & Lange-Bertalot, 1999a, Figure 144. 1-6).

C. gracilis (Ehrenberg) Kützing 1844

Valves 23-28 µm (22-57 µm) in length and 5-6.5 µm (4,5-9 µm) in width, 10-11 (9-14) mid-dorsal striae 10 µm (Krammer & Lange-Bertalot, 1999a, Figure 120: 1-16; 12: 3b; 13: 3).

C. helvetica Kützing 1844

Valves 70-117 µm (22-170 µm) in length and 11-23 µm (8-27 µm) in width, 9 (8-12) mid-dorsal and end striae 10 µm (Krammer & Lange-Bertalot, 1999a, Figure 132: 2-4; 133: 1-8).

C. leptoceros (Ehrenberg) Kützing 1844

Valves 17-35 µm (15-60 µm) in length and 8-12 µm (7-13 µm) in width, 9-11 (9-13) mid-dorsal striae 10 µm (Krammer & Lange-Bertalot, 1999a, Figure 143: 1-13).

C. lanceolata (Ehrenberg) Kirchner 1878

Valves 67-97 µm (60-220 µm) in length and 19-21 µm (18-32 µm) in width, 9 (9-10) mid-dorsal and 13-14 (13-16) end striae 10 µm (Krammer & Lange-Bertalot, 1999a, Figure 124: 1-8).

C. minuta Hilse ex Rabenhorst 1862

Valves 17-21 µm (7-32 µm) in length and 4-6.5 µm (3.9-7 µm) in width 11-13 (10.5-15) mid-dorsal striae 10 µm (Krammer & Lange-Bertalot, 1999a, Figure 119: 1-13; 16: 4).

C. proxima Reimer 1975

Valves 41-81 µm (38-128 µm) in length and 19-24 µm (14-26 µm) in width, 8-9 (7-10) mid-dorsal and 9 (7-14) end striae 10 µm (Krammer & Lange-Bertalot, 1999a, Figure 128: 9; 129: 1).

C. silesiaca Bleisch 1864

Valves 17-23 µm (15-46 µm) in length and 8.5-11 µm (6.5-14.2 µm) in width, 11-12 (10.5-15) mid-dorsal and 15 (14-20) end striae 10 µm (Krammer & Lange-Bertalot, 1999a, Figure 117: 1-24).

C. schimanskii Krammer 1982

Valves 152-162 µm (145-175 µm) in length and 31-32 µm (29-35 µm) in width, 8 (7-8) mid-dorsal and 9-10 (10-11) end striae 10 µm (Krammer & Lange-Bertalot, 1999a, Figure 132: 1).

Didymosphaenia Schmidt nom. cons.

D. geminata Schmidt 1899

Valves 67-76 µm (60-140 µm) in length and 26-35 µm (25-43 µm) in width, 8-9 (8-10) striae (Krammer & Lange-Bertalot, 1999a, Figure 166: 15).

Diploneis Ehrenberg 1844

D. elliptica (Kützing) Cleve 1891

Valves 34-37 µm (20-130 µm) in length and 16.5 µm (10-60 µm) in width, 11 (8-14) striae 10 µm, and 12 (12-14) alveolus 10 µm (Krammer & Lange-Bertalot, 1999a, Figure 108: 1-6).

D. pseudovalis Hustedt 1930 (Figure 5. a).

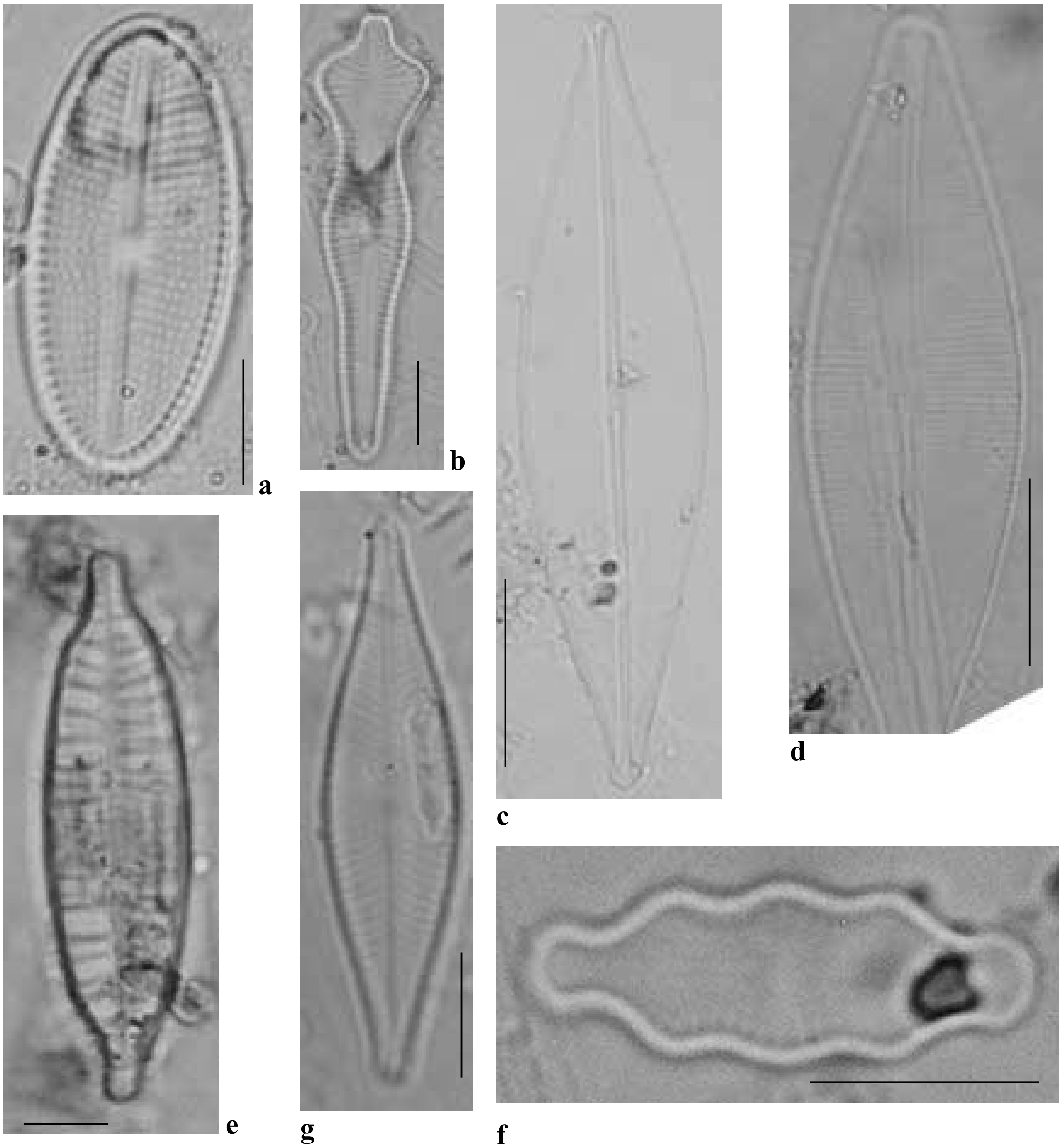

Figure 5. a) *Diploneis pseudovalis* b) *Gomphonema acuminatum*, c-e) *Navicula cuspidata*, f) *N. nivalis* g) *N. trivialis* (Scale 10 µm).

Valves 19-24 µm (16-31 µm) in length and 10-12 µm (9-14 µm) in width, 11 (8-12) striae 10 µm, and 19 (18-22) puncta 10 µm (Krammer & Lange-Bertalot, 1999a, Figure 108: 11-13).

D. puella (Schumann) Cleve 1894

Valves 15-18 µm (13-25 µm) in length and 8-11 µm (8-14 µm) in width, 13 (13-18) striae 10 µm, and 17 (16-20) puncta 10 µm (Krammer & Lange-Bertalot, 1999a, Figure 109: 15, 16).

Gomphonema Ehrenberg 1832

G. acuminatum Ehrenberg 1832, (Figure 5. b).

Valves 30-75 µm (20-120 µm) in length and 5-12.5 µm (5-17 µm) in width, 12 (8-13) striae 10 µm (Krammer & Lange-Bertalot, 1999a, Figure 160: 1-12).

G. angustum Agardh 1831

Valves 65-68 µm (12-130 µm) in length and 7 µm (3-12 µm) in width, 7-8 striae 10 µm (Krammer & Lange-Bertalot, 1999a, Figure 155: 1-21).

G. augur Ehrenberg 1840

Valves 32-41 µm (17-130 µm) in length and 8-11 µm (8-20 µm) in width, 8 (7-15) striae 10 µm (Krammer & Lange-Bertalot, 1999a, Figure 157: 1-8; 158: 1-6).

G. gracile Ehrenberg 1838

Valves 37-48 µm (20-100 µm) in length and 4.5-7 µm (4-8 µm) in width, 8-9 (4-11) striae 10 µm (Krammer & Lange-Bertalot, 1999a, Figure 156: 1-11; 154: 26, 27).

G. olivaceum (Hornemann) Brebisson 1838

Valves 18-19 µm (8-45 µm) in length and 4.5 µm (3.5-13 µm) in width, 10 (9-16) striae 10 µm (Krammer & Lange-Bertalot, 1999a, Figure 165: 1-18).

G. parvulum (Kützing) Kützing 1849

Valves 16-24 µm (10-36 µm) in length and 4-7 µm (4-8 µm) in width, 8-12 (7-20) striae 10 µm (Krammer & Lange-Bertalot, 1999a, Figure 154: 1-25).

G. subtile Ehrenberg 1843

Valves 27-32 µm (24-50 µm) in length and 4-6.5 µm (3.5-8 µm) in width, 12 (10-14) striae 10 µm (Krammer & Lange-Bertalot, 1999a, Figure 162: 10-13).

G. truncatum Ehrenberg 1832

Valves 18-29 µm (13-75 µm) in length and 8-13 µm (7-17 µm) in width, 10 (9-12) striae 10 µm (Krammer & Lange-Bertalot, 1999a, Figure 159: 11-18).

Gyrosigma Hassall 1843

G. acuminatum (Kützing) Rabenhorst 1853

Valves 78-158 µm (60-180 µm) in length and 12-15 µm (11-18 µm) in width, 17-18 (16-22) median striae 10 µm (Krammer & Lange-Bertalot, 1999a, Figure 114: 4, 8).

G. attenuatum (Kützing) Rabenhorst 1853

Valves 218-248 µm (150-240 µm) in length and 25 µm (23-26 µm) in width, 13-14 (14-16) median striae 10 µm (Krammer & Lange-Bertalot, 1999a, Figure 114: 5, 7, 9; 4: 5, 6; 15: 3; 16: 2, 6).

Navicula Borry 1822

N. clementis Kützing 1844

Valves 27-35 µm (15-50 µm) in length and 11-13 µm (7-15 µm) in width, 8-9 (8-15) striae 10 µm (Krammer & Lange-Bertalot, 1999a, Figure 47: 1-9; 53: 3).

N. crytocephala Kützing 1844

Valves 24-29 µm (20-40 µm) in length and 5-6 µm (5-7 µm) in width, 15-16 (14-17) striae 10 µm (Krammer & Lange-Bertalot, 1999a, Figure 31: 8-14).

N. cuspidata (Kützing) Kützing 1844, (Figure 5. c-e)

Valves 32-85 µm (30-150 µm) in length and 17-33 µm (13-44 µm) in width, 12 (11-19) striae 10 µm (Krammer & Lange-Bertalot, 1999a, Figure 43: 1-8).

N. menisculus Schumann 1867

Valves 17-25 µm (15-50 µm) in length and 8-9 µm (7.5-12 µm) in width, 7-8 (8-12) striae 10 µm (Krammer & Lange-Bertalot, 1999a, Figure 32: 16-25).

N. nivalis Ehrenberg 1854, (Figure 5. f).

Valves 13-28 µm (12-42 µm) in length and 6-9 µm (5.5-13 µm) in width, 18 (17-24) striae 10 µm (Krammer & Lange-Bertalot, 1999a, Figure 61: 17-20).

N. radiosa Kützing 1844

Valves 72-112 µm (40-120 µm) in length and 11-12 µm (7.5-15 µm) in width, 10-11 (10-12) striae 10 µm (Krammer & Lange-Bertalot, 1999a, Figure 29: 1-4).

N. reinhardtii (Grunow) Grunow 1877

Valves 47-68 µm (35-70 µm) in length and 14-16 µm (11-18 µm) in width, 8-9 (7-9) striae 10 µm (Krammer & Lange-Bertalot, 1999a, Figure 40: 1, 2).

N. rhynchocephala Kützing 1844

Valves 46-61 µm (35-80 µm) in length and 11-13 µm (9-14 µm) in width, 10-11 (7-12) striae 10 µm (Krammer & Lange-Bertalot, 1999a, Figure 30: 5-8; 31: 1, 2).

N. trivialis Lange-Bertalot 1980, (Figure 5. g)

Valves 37-58 µm (25-65 µm) in length and 10-12 µm (8-12.5 µm) in width, 11-12 (11-13) striae 10 µm (Krammer & Lange-Bertalot, 1999a, Figure 35: 1-4).

Nedium Pfitzer 1871

N. dubium (Ehrenberg) Cleve 1894

Valves 38 µm (30-58 µm) in length and 10 µm (10-16 µm) in width, 18 (16-24) striae 10 µm (Krammer & Lange-Bertalot, 1999a, Figure 99: 1-7).

N. iridis (Ehrenberg) Cleve 1894

Valves 84-112 µm (37-300 µm) in length and 18-24 µm (15-40 µm) in width, 13-14 (12-18) striae 10 µm, 13 (12-18) puncta 10 µm (Krammer & Lange-Bertalot, 1999a, Figure 104: 1-4; 105: 1).

Pinnularia Ehrenberg 1843

P. divergens W.Smith 1853

Valves 84-137 µm (50-160 µm) in length and 17-28 µm (13-30 µm) in width, 9-10 (8-12) striae 10 µm (Krammer & Lange-Bertalot, 1999a, Figure 179: 3-8).

P. gibba Ehrenberg 1841

Valves 63-98 µm (50-140 µm) in length and 8-11 µm (7-13 µm) in width, 9-11 (9-12) striae 10 µm (Krammer & Lange-Bertalot, 1999a, Figure 99: 1-7).

P. interrupta W.Smith 1853, (Figure 6. a)

Valves 37-52 µm (26-80 µm) in length and 10-12 µm (6.7-16 µm) in width, 11 (9-15) striae 10 µm (Krammer & Lange-Bertalot, 1999a, Figure 99: 1-7).

P. maior (Kützing) Rabenhorst 1853, (Figure 6. b)

Valves 146-249 µm (140-340 µm) in length and 28-36 µm (25-42 µm) in width, 5-6 (5-7) striae 10 µm (Krammer & Lange-Bertalot, 1999a, Figure 196: 1-4; 7: 3-4; 13: 7).

P. microstauron (Ehrenberg) Cleve 1891

Valves 42 µm (20-90 µm) in length and 10 µm (7-11 µm) in width, 10-12 (10-13) striae 10 µm (Krammer & Lange-Bertalot, 1999a, Figure 191. 7-9).

P. nobilis (Ehrenberg) Ehrenberg 1843

Valves 227-279 µm (200-350 µm) in length and 37-43 µm (34-50 µm) in width, 4-5 (4-6) striae 10 µm (Krammer & Lange-Bertalot, 1999a, Figure 198. 2, 3).

P. streptoraphe Cleve 1891

Valves 91-119 µm (85-260 µm) in length and 17-21 µm (15-35 µm) in width, 5 (5-7) striae 10 µm (Krammer & Lange-Bertalot, 1999a, Figure 191. 1-3).

P. viridis (Nitzsch) Ehrenberg 1843

Valves 69-146 µm (50-170 µm) in length and 12-23 µm (10-30 µm) in width, 7-9 (6-12) striae 10 µm (Krammer & Lange-Bertalot, 1999a, Figure 194: 1-4; 195: 1-6; 2: 4-6).

Rhoicophenia Grunow 1860

R. abbreviata (C.Agardh) Lange-Bertalot 1980b

Valves 22.5 µm (10-75 µm) in length and 7.6 µm (3-8 µm) in width, 16 (15-20) striae 10 µm (Krammer & Lange-Bertalot, 1999a, Figure 91: 20-28).

Stauroneis Ehrenberg 1843

S. anceps Ehrenberg 1843.

Valves 38-98 µm (20-130 µm) in length and 8-16 µm (6-18 µm) in width, 22-24 (20-33) striae 10 µm (Krammer & Lange-Bertalot, 1999a, Figure 87: 3-9; 88: 1-4).

S. phoenicenteron Ehrenberg 1843, (Figure 6. c, d)

Valves 194-237 µm (70-360 µm) in length and 39-51 µm (16-53 µm) in width, 12 (12-20) mid-dorsal striae 10 µm (Krammer & Lange-Bertalot, 1999a, Figure 6: 7-8; 8: 3; 15: 2; 18:1-3).

S. producta Grunow 1880

Valves 32-37 µm (30-50 µm) in length and 8-9 µm (8-11 µm) in width, 23-24 (22-28) mid-dorsal striae 10 µm (Krammer & Lange-Bertalot, 1999a, Figure 89: 1-7).

Bacillariaceae Ehrenberg 1840

Hantzschia Grunow 1877

H. amphioxys (Ehrenberg) Grunow 1880

Valves 49-76 µm (20-300 µm) in length and 7-21 µm (5-25 µm) in width, 11-15 (11-28) striae 10 µm, 8-9 (4-11) fibula 10 µm (Krammer & Lange-Bertalot, 1999b, Figure 88: 1-7).

Nitzschia Hassall 1845

N. linearis W.Smith 1853

Valves 78-132 µm (34-228 µm) in length and 4-6 µm (2.5-7.5 µm) in width, 28-30 (28-41) striae 10 µm, 10-11 (8-17) fibula 10 µm (Krammer & Lange-Bertalot, 1999a, Figure 55: 1-10).

N. lorenziana Grunow 1880

Valves 78-149 µm (37-190 µm) in length and 4-6 µm (3-7 µm) in width, 14-15 (13-19) striae 10 µm, 7 (6-10) fibula 10 µm (Krammer & Lange-Bertalot, 1999a, Figure 86: 6-10).

N. palea (Kützing) Smith 1856

Valves 21-47 µm (15-70 µm) in length and 3-4 µm (2.5-5 µm) in width, 27-29 (28-40) striae 10 µm (Krammer & Lange-Bertalot, 1999b, Figure 59: 1-24; 60: 1-7).

N. sigma (Kützing) W.Smith 1853

Valves 57-209 µm (35-1000 µm) in length and 8-23 µm (4-26 µm) in width, 16-18 (15-38) striae 10 µm, 4-6 (3-12) fibula 10 µm (Krammer & Lange-Bertalot, 1999b, Figure 23: 1-9).

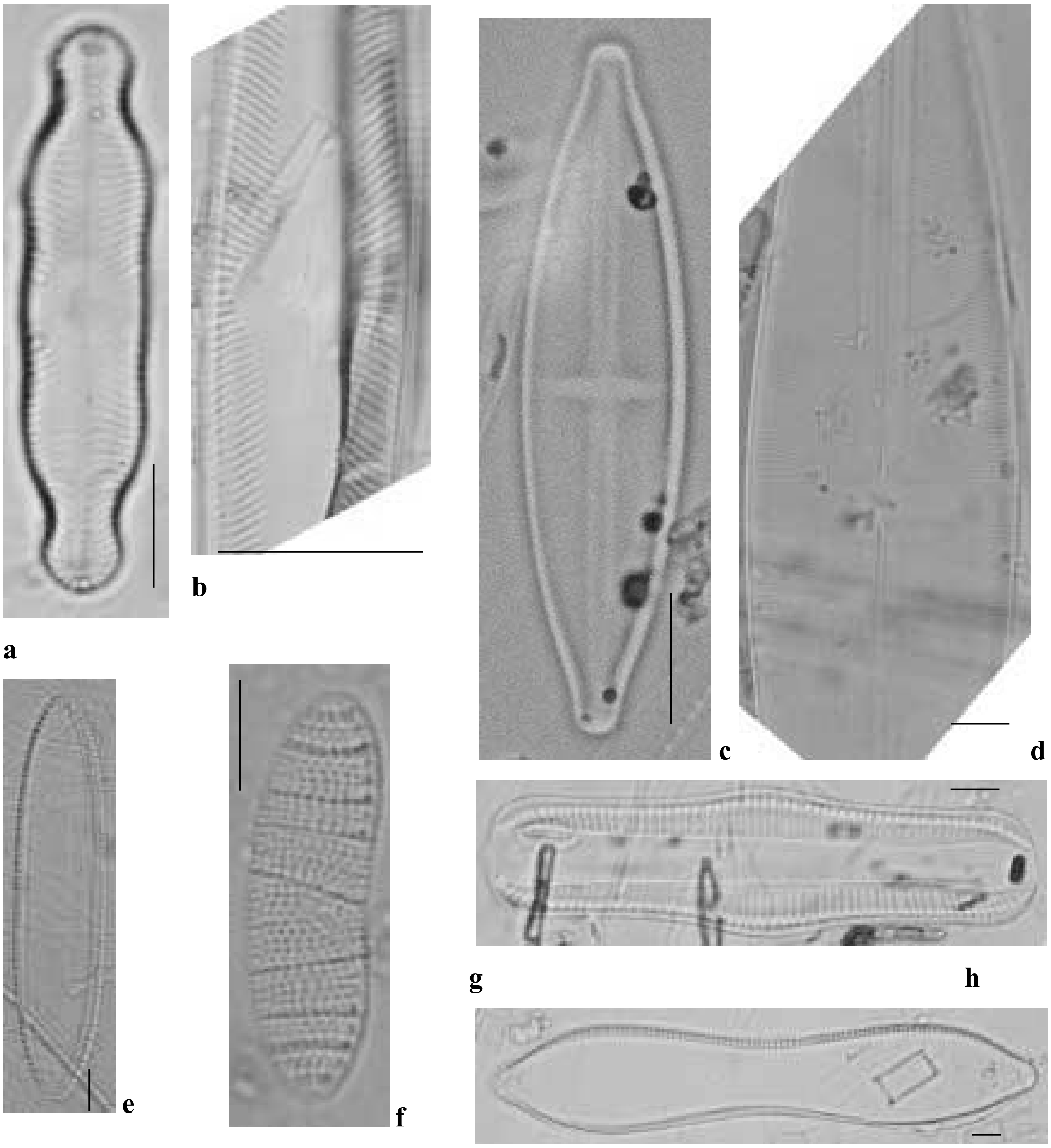

Figure 6. a) *Pinnularia interrupta*, b) *P. maior*, c, d) *Stauroneis phoenicenteron*, e) *Nitzschia tryblionella*, f) *Epithemia adnata*, g) *Rhopalodia gibba*, h) *Cymatopleura solea* (Scale 10 µm).

N. sigmoidea (Nitzsch) W.Smith 1853

Valves 215-248 μm (90-500 μm) in length and 10-13 μm (8-15 μm) in width, 23 (21-27) striae 10 μm, 5 (5-7) fibula 10 μm (Krammer & Lange-Bertalot, 1999b, Figure 4: 1, 2; 5: 1-5).

N. tryblionella Hantzsch 1860, (Figure 6. e)

Valves 88-109 μm (50-180 μm) in length and 19-27 μm (16-35 μm) in width, 32-33 (30-35) striae 10 μm, 7 (5-9) fibula 10 μm (Krammer & Lange-Bertalot, 1999a, Figure 27: 1-4).

N. vermicularis (Kützing) Hantzsch 1860

Valves 87-186 μm (75-250 μm) in length and 4-6.5 μm (3.5-7 μm) in width, 29-32 (30-40) striae 10 μm (Krammer & Lange-Bertalot, 1999b, Figure 4: 4, 5; 7: 1-7; 8: 1, 2).

Epithemiaceae Karsten 1928

Epithemia Brebisson 1844

E. adnata (Kützing) Brebisson 1838, (Figure 6. f).

Valves 57-127 μm (15-150 μm) in length and 7.5-13 μm (7-14 μm) in width, 9-11 (11-14) striae 10 μm, 48 (20-80) fibula 100 μm (Krammer & Lange-Bertalot, 1999b, Figure 107: 1-11; 108: 1-3).

E. argus (Ehrenberg) Kützing 1844.

Valves 27-39 μm (20-130 μm) in length and 6-9 μm (4-18 μm) in width, 9-11 (8-14) striae 10 μm (Krammer & Lange-Bertalot, 1999b, Figure 102: 1-9; 103: 1-5).

E. sorex Kützing 1844.

Valves 27.5-31 μm (8-70 μm) in length and 7.5-16 μm (6.5-16 μm) in width, 11 (10-15) striae 10 μm (Krammer & Lange-Bertalot, 1999b, Figure 106. 1-14).

Rhopalodia O.Müller 1895

R. gibba O.Müller 1895, (Figure 6. g).

Valves 92.5-245 μm (22-300 μm) in length and 25 μm (18-30 μm) in width, 54 (50-80) fibula 100 μm, 3 (2-4) alveolus 10 μm, and 12 (12-17) inter fibula 10 μm (Krammer & Lange-Bertalot, 1999b, Figure 110: 1; 111: 1-13; 111A: 1-7).

Surirellaceae Kützing 1844

Campylodiscus Ehrenberg 1840

C. hibernicus Ehrenberg 1845

Valves 55-57 μm (25-150 μm) in diameter, 12 (10-20) fibula 100 μm (Krammer & Lange-Bertalot, 1999b, Figure 175: 5; 179: 1-4; 180: 1-7; 181: 1-3).

C. noricus Ehrenberg 1840

Valves 62-113 μm (60-150 μm) in diameter, 23-25 (20-30) fibula 100 μm (Krammer & Lange-Bertalot, 1999b, Figure 182: 1-5).

Cymatopleura W.Smith 1851

C. elliptica W.Smith 1851

Valves 82.5-97 μm (60-280 μm) in length and 42.5-47.5 μm (30-90 μm) in width, 4 (2.5-6) fibula 10 μm, 15-17 (15-20) striae 10 μm (Krammer & Lange-Bertalot, 1999b, Figure 119: 1-4; 120: 1-6; 121: 1-3; 122: 3).

C. solea W.Smith 1851, (Figure 6. h).

Valves 76-118 μm (30-300 μm) in length and 22.5-31 μm (10-45 μm) in width, 6 (6-9) fibula 10 μm, 26-28 (25-32) striae 10 μm (Krammer & Lange-Bertalot, 1999b, Figure 116:1- 4; 117: 1-5; 118: 1-8; 122: 4).

C. solea Smith var. **apiculata** Ralfs 1861

Valves 67-75 μm in length and 16-17 μm in width, 5-6 fibula 10 μm, 23-27 (25-32) striae 10 μm (Krammer & Lange-Bertalot, 1999b, Figure 118: 2, 4-8).

Stenopterobia Brebisson 1878

S. curvula (W.Smith) Krammer 1987.

Valves 110 μm (70-280 μm) in length and 6.5-7 μm (6-9 μm) in width, 34 (30-60) fibula 100 μm, 22 (22-24) striae 10 μm (Krammer & Lange-Bertalot, 1999b, Figure 170: 1, 2; 171: 5-9; 172: 1-3).

Surirella Turpin 1828

S. angusta Kützing 1844.

Valves 21-41 μm (18-70 μm) in length and 7-13 μm (6-15 μm) in width, 1:3-1:4 (1:3-1:5) length:width ratio, 21-24 (20-28) striae 10 μm, (Krammer & Lange-Bertalot, 1999b, Figure 133: 6-13; 134: 1, 6-10).

S. biseriata Brebisson 1836.

Valves 87-327 μm (80-400 μm) in length and 33-79 μm (30-90 μm) in width, 14 (10-20) striae 10 μm (Krammer & Lange-Bertalot, 1999b, Figure 141: 1-3; 142: 1-5; 143: 1-9; 144: 1-3; 145: 1).

S. brebissonii Krammer and Lange-Bertalot 1987.

Valves 29-43 μm (8-70 μm) in length and 16-23 μm (8-30 μm) in width, 1.8:1-1.9:1 (1:1-2.4:1) length:width ratio, 17-18 (16-20) striae 10 μm, 37 (35-70) fibula 10 μm (Krammer & Lange-Bertalot, 1999b, Figure 123: 4, 5; 126: 2-11; 127: 1-13).

S. elegans Ehrenberg 1843.

Valves 187-315 µm (110-400 µm) in length and 59-74 µm (35-90 µm) in width, 16-17 (12-21) canal 100 µm (Krammer & Lange-Bertalot, 1999b, Figure 160: 5; 161: 1, 2; 162: 1-7; 163: 1-4).

S. minuta Brebisson 1849.

Valves 13-21 µm (9-47 µm) in length and 9-10 µm (9-11 µm) in width, 22-23 (21-29) striae 10 µm, 64-68 (60-80) fibula 100 µm (Krammer & Lange-Bertalot, 1999b, Figure 127: 14; 134: 2, 11, 12; 135: 1-14).

S. ovalis Brebisson 1838.

Valves 27-53 µm (16-120 µm) in length and 15-36 µm (12-45 µm) in width, 1:1.5-1:3 (1:3-1:1) length:width ratio, 17 (16-19) striae 10 µm (Krammer & Lange-Bertalot, 1999b, Figure 125: 1-7; 126: 1).

S. robusta Ehrenberg 1841.

Valves 178-359 µm (150-400 µm) in length and 67-114 µm (50-150 µm) in width, 7-8 (7-12) canal 100 µm (Krammer & Lange-Bertalot, 1999b, Figure 156: 1-5; 157: 1-4).

S. subsalsa Smith 1853.

Valves 17-24 µm (15-48 µm) in length and 9-11 µm (8-16 µm) in width, 10-11 (10-13) striae 10 µm (Krammer & Lange-Bertalot, 1999b, Figure 128: 1-10).

Discussion

During the present study, a total of 119 diatom taxa were identified from Lake Gölköy. Ten taxa in 4 genera of Centrales, and 109 taxa with 29 genera in the order Pennales were described. The diatom composition of the lake was especially dominated by *Naviculaceae* at about 48.7% abundance, including 58 taxa in 13 genera. This family is followed by Fragilariaceae at 16.8% abundance with 20 taxa in 5 genera.

Some genera showed high species richness with 16, 14, 9, and 8 taxa for *Cymbella, Fragilaria, Navicula*, and *Pinnularia*, respectively. The diatom composition of Lake Gölköy showed similarity to that of Lake Abant (Bolu), a natural lake of similar size (Çelekli & Külköylüoğlu, 2006). Although there are structural and geographical differences between these lakes, such similarity may depend on the indirect connection between them. This is because the water released from Lake Abant flows to Yumrukaya Reedbeds, and then it is transferred to Lake Gölköy by concrete canals for agricultural purposes. This may eventually bring many diatoms from Lake Abant to Lake Gölköy.

An average of 45 taxa occurred per month during our study. The numbers of species increased in some months (e.g., November (68 taxa), December (62 taxa)) in 2003 to September (55 taxa) and October (58 taxa) 2004. The lowest number of species was detected in June 2003, with 21 taxa.

Most of the members of Bacillariophyceae collected from Lake Gölköy have a wide distribution as reported in Lake Abant and in a karstic Akkaya spring (Çelekli & Külköylüoğlu, 2006), and in different parts of Turkey (Gönülol et al., 1996). For example, during our study, some species were found in almost every month at each station (e.g., *Asterionella formosa*, *Aulacoseria granulata*, *Cyclotella praetermis*, *Cymbella cistula*, *Fragialaria bicep*, *F. crotonensis*, *F. dilata*, *Navicula radios, N. trivialis* and *Nitzschia sigmoidae*) were already reported commonly from different water bodies in Turkey (Gönülol et al., 1996). One of the critical similarities among the previous reports and the results of the present study is that most of the diatoms described are known to prefer nutrient-rich environments (Patrick & Reimer, 1966, 1975; Round, 1981). This may suggest changes in the water quality of Lake Gölköy where 2 creeks (Abant and Mudurnu creeks) apparently carry nutrient-enriched water from chicken farms, industries, and domestic sources. Such effects of point and non-point sources were already stated to affect the occurrence of other taxonomic groups. For example, Külköylüoğlu (2005) reported that among 17 ostracod taxa reported from the lake almost all were cosmopolitan, and the 4 most frequently occurring species comprised about 70% of the total abundance. Such an increase in the numbers of cosmopolitan species and a decrease in specialist species are called pseudorichness (Külköylüoğlu, 2004).

Külköylüoğlu (2005) stated that Lake Gölköy is mesotrophic. The 2 most common diatoms (*A. formosa* and *A. granulata*) in Lake Gölköy during autumn and spring have been reported as dominant species in mesotrophic lakes and eutrophic lakes (Round, 1981). Indeed, in productive lakes, *Aulacoseria* can be an abundant species in winter, and following *Asterionella* can reach a high level during spring (Hutchinson, 1967). Similarly, *A. granulata* was the co-dominant diatom, especially in autumn and winter, and *A. formosa* was very common in spring in our study.

Cymbella has the greatest diversity, including 16 species. Most of them have wide distribution throughout Turkey (Gönülol et al., 1996; Akbulut, 2003). Second, Fragilaria consisted of 14 taxa; some of them, such as *F. biceps, F. capucina*, *F. crotonensis* and *F. dilata*, were commonly distributed at almost every sampling station during the study period. Many species of this genus were commonly found in different habitats in Turkey (Gönülol et al., 1996). They prefer nutrient-rich environments, and so can be found especially in meso-eutrophic water bodies (Hutchinson, 1967; Wetzel, 1975; Round, 1981).

Nitzschia included 7 species; 2 of them, *N. sigmoidae* and *N. vermicularis*, were common in almost every month at each station. Round (1981) reported that in temperate lakes *Nitzschia* can be dominant in the plankton when the water is rich in organic nutrients. Similarly, as mentioned above, major sources of polluted water, Abant and Mudurnu creeks entering Lake Gölköy, might explain the common occurrence of these species.

Some species such as *Didymosphaenia geminata* and *Cymatopleura solea* var. *apiculata* were rarely found in this lake. Krammer & Lange-Bertalot (1999a) stated that *D. geminata* was generally found in oligotrophic water. Neither species is commonly distributed in Turkey (Gönülol et al., 1996).

Overall, the results of this taxonomic study showed that the diatom composition of Lake Gölköy supports the idea of pseudorichness due to increasing numbers of cosmopolitan species found. One of the possible reasons for such an effect is changes in the physico-chemical structure of the lake water. When the lake is considered a potential drinking water reservoir for Bolu in future, such changes will be critical.

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