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RESEARCH PAPER

New Diatom Records for Turkish Freshwater Algal Flora from Lakes Ladik (Samsun, Turkey) and Hazar (Elazığ, Turkey)

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Abstract

The majority of phycological studies in Turkey focus on seasonal changes of phytoplankton and phytobenthos in lentic and lotic systems, while very few studies related to counting diatoms in sediment cores obtained as a result of paleolimnological work have been published. In this paleolimlogical study, seventeen (14+3) new diatom records for freshwater algal flora of Turkey were determined on sediment core samples at five different locations collected in July 2006 from Lakes Ladik (Samsun) and Hazar (Elazığ). We recorded seventeen diatom taxa belonging to Naviculales (8), Cymbellales (2), Eunotiales (2), Bacillariales (2), Fragilariales (1), Tabellariales (1) and Aulacoseirales (1) orders from Lakes Ladik (Samsun) and Hazar (Elazığ). All of the reported taxa are new records for freshwater algal flora of Turkey. General information on the morphology and taxonomy of the species are briefly described in this paper, with their illustrations.

Keywords: Lake Ladik, Lake Hazar, sediment core, new record, diatom, Turkey.

Introduction

Ecologically and economically, aquatic ecosystems are important resources and, to this end, a framework for the management and protection of water resources in each main catchment basin across Europe was established in 2000, known as the European Water Framework Directive (Kelly, 2013). Diatoms are a very diverse group of algae (Mann, 1999; Wojtal, 2009) and good indicators in aquatic ecosystems. They occur in a wide variety of environments and show a broad range of tolerance along several gradients of abiotic factors (Blanco, Ector, Huck, Monnier, & Cauchie, 2008; Rimet, 2012)

Ertan and Morkoyunlu (1998) pointed out that Turkey has 906.118 ha of lakes, 18.000 ha of dam lakes and a 145.000-km long water network. Therefore, Turkey has a great potential of algal diversity in inland waters. Also, situated between large continents (Eurasia and Africa), Turkey comprises areas of very diverse geological, climatic and environmental conditions, so it should expect that the diversity of diatoms is high in this region (Solak, Kulikovskiy, Kaleli & Gönülol, 2016).

Historically, the first freshwater diatom study in Turkey was conducted by Ehrenberg (1844) based on the material collected from the Murat and Aras Rivers. Subsequently, Schröder (1895) collected samples from Anatolia (the Tarsus River in Mersin) and Brunthaler (1903) investigated diatoms from Lake Iznik. The above studies were followed by the study of Lake Van (the largest lake in Turkey) performed by Legler & Krasske (1940) and Gessner (1957). Contrary to the past, today's freshwater algal studies is progressing rapidly in Turkey. However, the total list of the algal flora of Turkey has not yet been completed. A few checklists including the results of the studies of freshwater algal flora of Turkey were published on different dates (Gönülol, Öztürk, & Öztürk, 1996; Aysel, 2005; Şahin, 2005). In addition to these check-lists, many studies on the new records of algae have been done for the last twenty-five years (Aysel, Dural, & Gezerler-Şipal, 1993; Öztürk, Gönülol, & Öztürk, 1995a, Öztürk, Gezerler-Şipal, Güner, Gönülol, & Aysel, 1995b; Şahin, 2000, 2002, 2007, 2009; Apaydın-Yağcı & Turna, 2002; Atıcı, 2002; Baykal *et al*., 2009; Ongun-Sevindik, Çelik, & Gönülol, 2010, 2011; Bekleyen, Gokot, & Varol, 2011; Özer *et al*., 2012; Akar & Şahin, 2014; Yüce & Ertan, 2014; Varol & Fucikova, 2015; Varol & Şen, 2016). These studies contribute largely to the determination of the freshwater algal flora of Turkey. Also, the reliable descriptive information was given about the new records in these publications.

One of the aims of the study is to learn about the past ecology of the lake and to determine the effect of the changes in the fault on this ecology based on the diatom records accumulated on the sediment cores. Another aim of this study which is also the purpose of this paper is to determine whether there is a new diatom record for the Turkish Freshwater Algal Flora. The present study constitutes the first phase of the studies to be prepared in line with these purposes. We think that this study will contribute to the diatom flora of Turkey.

Materials and Methods

Study Area

When selecting the sampling areas in accordance with the purpose of our study, it was taken into consideration that both lakes are located on the East Anatolian Fault (the Master Fault). Therefore, while one of our sampling areas was the Lake Ladik from the Middle Black Sea Region, the other was the Lake Hazar from the Eastern Anatolia Region.

Lake Ladik (40°50′N to 41°00′N, 35°40′E to 36°05′E) is located within the borders of the Ladik district of Samsun Province in the central Black Sea region of Turkey (Figure 1). The lake, approximately 5 km-long and 2 km-wide, has an elevation of 867 m and a depth of seasonally ranging between 2.5 and 6.0 m. Lake Ladik has a drainage area of 141.40 km^2 (SHW, 1997). In addition to Küpecik, Çakırgümüş and Talıcak inlet streams, the lake is fed by small streams coming from the Akdağ Mountain. Water level of the lake is controlled by the Tersakan stream that flows into Yeşilırmak River. Lake Ladik was classified as an eutrophic lake (Maraşlıoğlu, Soylu, & Gönülol, 2005) but it is under natural protected area due to its floating islands (Bulut, 2012). Prior to 1958 when a regulator was constructed at the Tersakan outlet, the natural size of the lake was much smaller (Figure 1). This regulator could only stabilized the water level of the lake. Following the improvement of the regulator in 1986, the water depth in the lake has increased significantly and has become its present state (SHW, 1997).

Lake Hazar, formed by faulting of the Eastern Anatolia Fault, is a tectonic lake located at 38°31′ N, 39°25′ E. Lake Hazar covers about 100 km^2 of the basin area with an NE-trending elongated-shape along the East Anatolian Fault. The Hazar Basin is a 25 km-long, 7 km-wide and 216 m-deep depression located on the central section of the East Anatolian Fault zone at a mean elevation of 1250 m and predominantly overlain by Lake Hazar. This basin has been described previously as a pull-apart basin because of its rhombic shape and an apparent fault step-over between the main fault traces situated at the southwestern and northeastern ends of the lake. According to bathymetrical measurement of the lake, various maximum depths ranging between 80 and 210 m (Figure 2). The bathymetry map shows two distinct areas: an irregular 216 m-deep sub-basin in the northeastern half of the lake and a much flatter and shallower sub-basin occupying its southwestern half. These two main sub-basins have been named the Deep and Flat basins to facilitate the description of the basin. Hazar Basin sediments are predominantly sourced from two main drainage systems discharging into the lake at its southwestern and northeastern ends (Hempton, Dunne, & Dewey, 1983). The northeastern drainage system comprises several streams with small drainage areas, whereas the southwestern system is mainly dominated by the Kürk River, which drains a large area and forms a significant alluvial fan at the southwestern coast of the lake (Figure 2). (Moreno *et al.*, 2011).

Sampling and Identification

Sediments were sampled in both Lakes Ladik and Hazar using a UWITEC gravity corer in July

Figure 1. Location of the sediment core labeled as "LA-001" core reference in Lake Ladik. The gray-shaded area is the approximate natural extend of the lake before it became a water reservoir in 1958.

2006. In Lake Hazar, 84 and 94 cm-long cores were collected from the southwestern edge of the lake at water depths of about 5 meter (HZ002 and HZ003, respectively). The other two cores in Hazar, 74 and 62 cm-long, were obtained at water depths of 20 and 57 meters (HZ005 and HZ006, respectively). In Lake Ladik, LA001 core recovered the top 62 cm of the sedimentary sequence at a water depth of 4 meter. The coordinates, lengths and taken depths of the cores are shown in Table 1. The cores remained refrigerated in dark and at 4-6 ˚C temperature before sub-sampling in the laboratory prior to analysis.

Diatom valves were separated from the organic matrix of the sediments using standard techniques defined by Batterbee (1986). Small samples of dry sediment (0.5-1 g) were digested in a solution of 50:50 concentrated sulfuric and nitric acid. Digestion was accelerated by placing the samples in a boiling water bath for 1 h. Digested slurries were rinsed several times in distilled water until neutral pH was reached. On a slide warmer, slurries were dried overnight on coverslips, and then mounted onto microscope slides using Naphrax, a permanent mounting medium.

Diatom valves were enumerated and identified under oil immersion (1000X magnification) using an Olympus BX41 microscope. For each slide, a minimum of 300 valves was counted along a transect. Species identifications were based primarily on the Krammer and Lange-Bertalot (1991a, 1991b, 1999a, 1999b). We checked checklist of Aysel (2005) and the database of Turkish algae (Gönülol, 2017), to determine new taxa for Turkish freshwater algal flora. The current accepted nomenclature has been checked with AlgaeBase (Guiry & Guiry, 2017) and the author names are given in abbreviated form according to Brummit and Powel (1992).

Results and Discussion

A total of seventeen (14+3) diatoms: Naviculales (8), Cymbellales (2), Eunotiales (2), Bacillariales (2), Fragilariales (1), Tabellariales (1) from Bacillariophyceae classis and Aulacoseirales (1) from Coscinodiscophyceae classis were listed below.

Divisio: Bacillariophyta
Class: Bacillariophyceae
Order: Naviculales
Family: Brachysiraceae
Genus: *Brachysira* Kützing, 1836
Brachysira brebissonii Ross, 1986 (Figure 3, a)
Synonyms: *Navicula aponina* var. *brachysira* Kütz.
Navicula brachysira Brébisson ex Rabenhorst
Navicula serians var. *minima* Grunow
Navicula serians var. *minor* Grunow
Anomoeoneis brachysira (Brébisson ex Rabenhorst) Cleve
Schizonema brachysirum (Brébisson) Kuntze
Anomoeoneis serians f. *minor* Boyer
Anomoeoneis serians var. *brachysira* (Brébisson

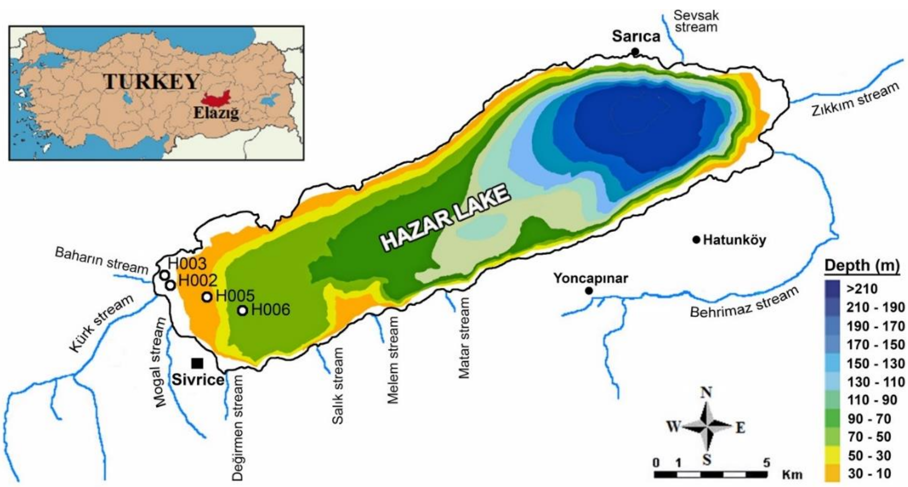

Figure 2. The bathymetry map and sediment core locations of Lake Hazar (H002, H003, H005, H006).

Table 1. The coordinates, lengths and taken depths of the cores in Lakes Hazar and Ladik

	Core reference	Coordinate (N.)	Coordinate (E.)	Depth (m)	Length (cm)
Hazar	HZ002	38˚27'59.64"	39˚18'09.73"	5	84
	HZ003	38˚28'13.72"	39˚18'00.15"	5	92
	HZ005	38˚27'41.31"	39˚18'39.64"	20	68
	HZ006	37˚27'26.73"	39˚19'11.18"	57	74
Ladik	LA001	40˚53'59.57"	36˚01'50.92"	4	62

ex Rabenhorst) Hustedt

Anomoeoneis serians var. *minor* (Grunow) F.W.Mills

Anomoeoneis brachysira var. *minima* (Grunow) A.Cleve

Description: Length range: 11-36 µm, width range: 4-8 µm, striae in 10 µm: 26-35. Valves are small, rhombic-lanceolate to elliptical-lanceolate with narrow rounded apices. Striae are weakly radiate from center to apex. The raphe is positioned within two ribs that lie on the external face of the valve (Hamilton, 2010).

Habitat Characteristics: This is a freshwater species and its general habitat is phytoplankton, benthic and fossil. *Brachysira brebissonii* is acidophilous, it has an affinity for environments with pH<7, with an optima of ~ 5.9 (Stevenson, Peterson, Kirschtel, King, & Tuchman, 1991). This taxon was widely distributed across North America in acidic waterbodies. In studies along the Altantic coastal plain this taxon was observed in ponds that were moderately acidic and oligotrophic to mesotrophic. Despite being widespread, it was usually found in low numbers. pH and TP optima (average weighted means, AWM) from four studies (Siver & Hamilton, 2011; Siver, Hamilton, Stachura-Suchoples, & Kociolek, 2005; Camburn & Charles, 2000; Gaiser & Johansen, 2000) range from 4.7-5.8 and 5.7-13.2 for pH and TP (µg/L) respectively. Also, *Brachysira brebissonii* is the most abundant taxa in dilute boreal and arctic lakes (Wolfe & Kling, 2001). We found this species at H005 and H006 stations of Lake Hazar in Elazığ (Turkey).

Distribution: *Europe* (Finland, Germany, Nederlands, Romania, Russia (Europe), Ireland, Spain, Baltic Sea, Britain, France, Italy, Macedonia, and Poland), *South-west Asia* (Iraq and Israel), *North America* (Northwest Territories, United States of America, Virginia, Alaska, Florida, Georgia, Great Lakes, New Jersey, Wyoming, NW USA and Tennessee), *South America* (Colombia and Brazil), *Asia* (Taiwan, China, Russia (Far East), and Nepal), *Atlantic Islands* (Iceland), *Pacific Islands* (Hawaiian islands), *Africa* (Ghana and Kenya), *Australia and New Zealand* (New Zealand, Tasmania, New South Wales, Northern Territory, Queensland, Western Australia, and Victoria) (Guiry & Guiry, 2017).

Brachysira styriaca (Grunow) R.Ross, 1986 (Figure 3, b)

Basionym: *Navicula styriaca* Grunow

Synonyms: *Navicula styriaca* Grunow

Frustulia styriaca (Grunow) De Toni

Brebissonia styriaca (Grunow) Kuntze

Anomoeoneis styriaca (Grunow) Hust.

Description: Length range: 16-37 µm, width range: 4.9-7.1 µm, striae in 10 µm: 26-30. Valves are lanceolate with rounded, unprotracted apices. Striae are radiate. (Bahls, 2014).

Habitat Characteristics: This is a freshwater species and is widely distributed and locally abundant in northern and alpine regions of the Northern Hemisphere (Lange-Bertalot & Moser, 1994). This species appears to favour waters with pH readings of <7 (Foged, 1974; Siver *et al.*, 2005). We found this species at H006 station of Lake Hazar in Elazığ (Turkey).

Distribution: *Europe* (Finland, Germany, Romania, Russia (Europe), Ireland, Spain, Baltic Sea, Britain, France, Italy, Macedonia, and Poland), *North America* (Northwest Territories, Alaska, Great Lakes, NW USA, United States of America), *Africa* (Sudan), *Asia* (Russia (Far East)), Atlantic Islands (Iceland), *Pacific Islands* (Hawaiian Islands), *Australia and New Zealand* (New South Wales, Queensland, Victoria, Australia, New Zealand, Tasmania) (Guiry & Guiry, 2017).

Brachysira cymbelliformis Metzeltin and Lange-Bert. 2007

Description: Valves strongly dorsiventral like in *Encyonema* or *Amphora*. Length 12.7-30 µm, breadth 4-7 µm. Raphe straight, filiform. Striae subparallel in central parts becoming progressively radiate towards the apices, 21-22 in 10 µm (Metzeltin & Lange-Bertalot, 2007).

Habitat Characteristics: This is a fossil species seemingly without extant populations. This is a freshwater species. We found this species at H002 in Lake Hazar stated as a lake with oligotrophic conditions by Koçer and Şen (2012). This species has been only found in Florida Peat of the United States by Lange-Bertalot up to now (Metzeltin & Lange-Bertalot, 2007).

Distribution: According to algaebase, there is no information about the bio-geography of this species.

Family: Naviculaceae

Genus: *Caloneis* Cleve, 1894

Caloneis silicula* var. *truncata (Kütz.) Meister, 1912 (Figure 3, c)

Basionym: *Navicula truncata* Kütz.

Synonym: *Caloneis ventricosa* (Ehrenb.) F.Meister var. *minuta* (Grunow) R.M.Patrick

Description: Length range: 25-31 µm, width range: 7-8 µm. Valves are linear and biconstricted, with apices rounded. The raphe is lateral and arched slightly. The striae are radiate to parallel. (Donkin, 2012).

Habitat Characteristics: This is a freshwater species. We found this taxon at H003 and H006 stations of Lake Hazar in Elazığ (Turkey).

Distribution: *Europe* (Netherlands and Romania) and *Asia* (China) (Guiry & Guiry, 2017).

Family: Naviculales incertae sedis

Genus: *Chamaepinnularia* Lange-Bert. and Krammer, 1996

Chamaepinnularia bremensis (Hust.) Lange-Bert., 1996 (Figure 3, d)

Basionym: *Navicula bremensis* Hust.

Description: Valves linear, broadest at the middle with apices rounded. Length 9-12 µm, breadth 2-3 µm. Raphe filiform, with dilated external proximal ends. Striae radiate, not punctate, 18-20/10 µm

(Lange-Bertalot & Metzeltin, 1996).

Habitat Characteristics: This is a freshwater/terrestrial species. We found this species at H002, H003 and H005 stations of Lake Hazar in Elazığ (Turkey).

Distribution: *Europe* (Britain, Germany and Netherlands), *North America* (United States of America and NW USA), *Asia* (Russia (Far East)), *Australia and New Zealand* (New Zealand, Northern Territory and Tasmania) (Guiry & Guiry, 2017).

Family: Naviculaceae

Genus: *Navicula* Bory, 1822

Navicula ammophila Grunow, 1882 (Figure 3, e)

Description: Length range: 27-31 µm, width range: 6.0-6.8 µm, striae in 10 µm: 14-16. Valves are lanceolate to linear-lanceolate with protracted apices. The central area is round. Striae are straight and slightly radiate around the center, becoming parallel, then convergent at the apices (Potapova, 2011).

Habitat Characteristics: This is a freshwater species. We found this species at H005 station of Lake Hazar in Elazığ (Turkey).

Distribution: *Europe* (Adriatic Sea, Baltic Sea, Germany and Netherlands), *North America* (Mexico, Mississippi and NW USA) and *Africa* (Ghana) (Guiry & Guiry, 2017).

Navicula minima Grunow, 1880 (Figure 3, f)

Synonyms: *Schizonema minimum* (Grunow) Kuntze
Navicula minutissima Grunow
Navicula atomoides Grunow
Navicula tantula Hust.

Description: Length range: 5-18 µm, width range: 2.0-4.5 µm (Krammer & Lange-Bertalot, 1999a). Valves linear to linear-elliptical with bluntly rounded apices. Striae fine, slightly radiate but shorter and more widely spaced at the centre, forming a butterfly-shaped to rectangular central area. Raphe fissures straight, slightly expanded at the centre.

Habitat Characteristics: This is a freshwater species and its general habitat is periphyton, epiphyte and fossil. *Navicula minima* mainly occurs at pH>7 (Alkaliphilous). Its saprobicity is α-meso/polysaprobous in Netherlands. This species is tolerant of moderate pollution and heavy organic pollution. According to TDI (UK), this species mainly occurs between 0.35 and 1.0 mg/l filtrable phosphate (Van Damm, Mertens, & Sinkeldam, 1994; Rott *et al.*, 1999; Kelly *et al.*, 2001). This species was also found by Montoya-Moreno, Sala, Vouilloud, Aguirre, and Plata (2013) in a lagoon. We found this species at H003 and H006 stations of Lake Hazar in Elazığ (Turkey).

Distribution: *Europe* (Baltic Sea, Black Sea, Britain, Czech Republic and/or Slovakia, Finland, Germany, Ireland, Italy, Russia (Europe), Romania, and Spain), *South-west Asia* (Iraq), *Atlantic Islands*, *North America*, *South America*, *Africa*, *Asia*, *Pacific Islands*, *Australia and New Zealand* (Guiry & Guiry, 2017).

Navicula caenosus J.R.Carter and Bailey-Watts, 1981

Description: Valves are 25 µm long and 7 µm broad with striae 3 in 10 µm (Hartley, Barber, Carter, & Sims, 1996).

Habitat Characteristics: This is a freshwater species. It is reported, a study in Scotland, to be found in lochs (Williams & Reid, 2002). We found this species at H005 station of Lake Hazar in Elazığ (Turkey).

Distribution: *Europe* (Britain) (Hartley, Ross, & Williams, 1986; Hartley *et al*., 1996; Whitton, John, Kelly, & Haworth, 2003).

Order: Cymbellales

Family: Cymbellaceae

Genus: *Cymbella* C.Agardh, 1830

Cymbella cymbiformis* var. *nonpunctata Fontell, 1917 (Figure 3, m)

Description: Length range: 25-87 µm, width range: 9-15 µm, dorsal striae in 10 µm: 10-15, ventral striae in 10 µm: 11-16 (Patrick & Reimer, 1975). Large forms found in a study exceeded the length range given above from his taxon (Johansen, Rushforth, Orbendorfer, Fungladda, & Grimes, 1983). The valve of these large forms is often curved transapically and swollen in the midregion.

Habitat Characteristics: This is a freshwater species. According to the our finding it is also a fossil species. We found this taxon at H003 and H006 stations of Lake Hazar in Elazığ (Turkey).

Distribution: *Europe* (Britain, Germany, Russia (Europe), Netherlands and Romania), *South-west Asia* (Iraq), *North America* (Indiana, Iowa, Michigan, Montana, and United States of America), *Asia* (China and Taiwan), *Australia and New Zealand* (Western Australia) (Guiry & Guiry, 2017).

Family: Gomphonemataceae

Genus: *Gomphonema* Ehrenb., 1832

Gomphonema anjae Lange-Bert. and Reichardt, 1991

Description: Valve is 18 µm long and 5 µm broad with striae 7 in 10 µm (Reichardt & Lange-Bertalot, 1991).

Habitat Characteristics: *Gomphnema anjae* is a phytoplanktonic species with freshwater habitat. This species was also found in a lagoon (Colombia) (Montoya-Moreno *et al.*, 2013) and in Animas river (USA), where heavy metals loading is present (Sgro, Poole, & Johansen, 2007). Otherwise, it is a fossil species found in some sediment core samples (Voigt, Grüger, Baier, & Meischner, 2008; Loakes, 2015). We found this species at H003 station of Lake Hazar in Elazığ (Turkey).

Distribution: *Europe* (Germany and Netherlands), *North America* (NW USA) and *South America* (Colombia) (Guiry & Guiry, 2017).

Order: Eunotiales

Family: Eunotiaceae

Genus: *Eunotia* Ehrenb., 1837

Eunotia soleirolii (Kütz.) Rabenhorst, 1864 (Figure 3, g)

Basionym: *Himantidium soleirolii* Kütz.

Synonyms: *Himantidium soleirolii* Kütz.
Eunotia pectinalis var. *soleirolii* (Kütz.)

H.F.Van Heurck

Description: Length range: 30-65 µm, width range: 3-4 µm, striae in 10 µm: 12-14. Valve linear-lunate in shape. It forms filaments in which the frustules contain internal septae (Ortiz-Lerín & Cambra, 2007).

Habitat Characteristics: *Eunotia soleirolii*, a periphytic algae living in freshwaters, is a fossil species. This species was also found by Montoya-Moreno *et al.* (2013) in a river and a lagoon. We found this species at H005 station of Lake Hazar in Elazığ (Turkey).

Distribution: *Europe* (Britain, Finland, Germany, Poland, Corsica, Netherlands and Romania), *North America* (New Hampshire, New Jersey, Northwest Territories, NW USA, Tennessee, United States of America), *South America* (Colombia), *Asia* (Russia (Far East) and Korea), *Pacific Islands* (Hawaiian Islands), *Australia and New Zealand* (New Zealand) (Guiry & Guiry, 2017).

Eunotia ambivalens Lange-Bert. and Tagliaventi, 2011 (Figure 3, h)

Synonym: *Eunotia bilunaris* var. *linearis* (Okuno) Lange-Bert. and Nörpel

Description: Length range: 44-205 µm, width range: 3.5-5.5 µm, striae in 10 µm: 9-12. Valves are very slender, elongated with parallel margins and slightly bent to almost straight. Transapical striae is dense and regular. Raphe is in the valve surface with a stroke-shaped appendage (Ortiz-Lerín & Cambra, 2007).

Habitat Characteristics: This is a freshwater species. We found this species at LA-001 station of eutrophic Lake Ladik in Samsun (Turkey).

Distribution: *Europe* (Germany and Netherlands) and *Asia* (Russia (Far East)) (Guiry & Guiry, 2017). According to some records, this species was also found in Bulgarian (Isheva & Ivanov, 2014) from Europe and in some states from North-South America (Bahls, 2009; Montoya-Moreno *et al.*, 2013).

Order: Bacillariales

Family: Bacillariaceae

Genus: *Nitzschia* Hassall, 1845

Nitzschia acula (Kütz.) Hantzsch, 1861 (Figure 3, ı)

Basionym: *Synedra acula* Kütz.

Synonyms: *Synedra acus* var. *acula* (Kütz.) Grunow
Nitzschia dissipata var. *acula* (Kütz.) Van Heurck

Description: Valves are 115-235 µm long, 2.8-3.6 µm broad, narrow, linear and needle like, striae 16-18 in 10 µm (Krammer & Lange-Bertalot, 1999b).

Habitat Characteristics: This is a freshwater species, benthic. The species was also found by some researchers in the lake where the pH is low (Camburn & Charles, 2000), but we found this species at H003 station of Lake Hazar stated as an alkaline lake by Koçer and Şen (2012), in Elazığ (Turkey). The optimal TP consumption per year is 63.2 µg/L (Bennion, 1994). Tychoplanktonic; Usually found in freshwater and brackish water environment. *Nitzschia acula* markedly prefers less oxygeneted waters but higher nutrient concentrations and is dominant in lentic waters of irrigations channels and marshes. (Pardal, Marques, & Graça, 2002).

Distribution: *Europe* (Baltic Sea, Britain, Germany, Ireland, Macedonia, and Spain), *South-west Asia* (Iran), *North America* (Alaska, Great Lakes, NW USA, Québec, Mexico and United States of America), *Asia* (Mongolia and Taiwan), *Australia and New Zealand* (Queensland and Tasmania) (Guiry & Guiry, 2017).

Nitzschia siliqua Archibald (Figure 3, i)

Synonym: *Nitzschia pseudocarinata* Cholnoky 1970

Description: Valves linear, with margins parallel, tapering quickly to narrow apices with knob-like ends. Length 19-21 µm, breadth 3-4 µm. Keel narrow, and keel puncta indistinct, numbering about the same as the striae, 20-22 in 10 µm (Krammer & Lange-Bertalot, 1988).

Habitat Characteristics: *Nitzschia siliqua* is a rare species. So, habitat information of this species is not available on record. But we found this species at H005 in oligotrophic Lake Hazar in Elazığ (Turkey).

Distribution: *Europe* (Netherlands), *North America* (NW USA and United States of America), *Australia and New Zealand* (Queensland) (Guiry & Guiry, 2017).

Order: Tabellariales

Family: Tabellariaceae

Genus: *Tabellaria* Ehrenb. ex Kütz., 1844

Tabellaria quadriseptata B.M.Knudson, 1952 (Figure 3, j)

Description: Length range: 23-130 µm, width range: 6-9 µm. Valve is linear between inflated area and poles. Septa are few (usually 4) (Krammer & Lange-Bertalot, 1991b).

Habitat Characteristics: *Tabellaria quadriseptata* a freshwater species. This species is mainly occurs at pH<5.5 (Acidobiontic). Saprobicity is oligosaprobous (i.e. oxygen saturation (%)>85, BOD_5<2) in Netherlands. This species is very sensitive to pollution. According to TDI (UK), *T. quadriseptata* occurs optimum between 0.01 and 0.035 mg/l filtrable phosphate and prefers low nutrient concentrations (Van Damm *et al*., 1994; Rott *et al*., 1999; Kelly *et al*., 2001). We found this species at LA-001 station of eutrophic Lake Ladik in Samsun (Turkey).

Distribution: *Europe* (Belgium, Britain, Germany, and Netherlands), *South-west Asia* (Iraq) and *North America* (Alaska, California, Great Lakes, Minnesota, New Jersey, NW USA, Québec, and United States of America) (Guiry & Guiry, 2017).

Order: Fragilariales

Family: Fragilariaceae

Genus: *Staurosira* Ehrenb., 1843

Staurosira construens* var. *exigua (W.Sm.) H.Kobayasi, 2002 (Figure 3, k)

Basionym: *Triceratium exiguum* W.Sm.

Synonyms: *Triceratium exiguum* W.Sm.
Fragilaria exigua (W.Sm.) Lemmermann
Fragilaria construens var. *exigua* (W.Sm.) Schulz

Description: Length: 9 µm, width: 3 µm, depth: 3 µm

(Krammer & Lange-Bertalot, 1991a).

Habitat Characteristics: This is a freshwater species. We found this taxon at H005 station of Lake Hazar in Elazığ (Turkey).

Distribution: *Europe* (Britain, Ireland, and Netherlands), *North America* (United States of America), *Australia and New Zealand* (New Zealand) (Guiry & Guiry, 2017).

Class: Coscinodiscophyceae

Order: Aulacoseirales

Family: Aulacoseiraceae

Genus: *Aulacoseira* Thwaites, 1848

Aulacoseira alpigena (Grunow) Krammer, 1991 (Figure 3, l)

Basionym: *Melosira distans* var. *alpigena* Grunow

Synonyms: *Melosira distans* var. *alpigena* Grunow

Melosira italica var. *alpigena* (Grunow) A.Cleve

Aulacoseira distans var. *alpigena* (Grunow) Simonsen

Aulacoseira lirata var. *alpigena* (Grunow) E.Y.Haworth

Description: Frustules are cylindrical and 4-15 µm in diameter, with a mantle height of 4-7 µm. The valve face is unornamented except for one row of marginal areolae. Spines are located at the end of each pervalvar costa. (Potapova, 2009).

Habitat Characteristics: This is a freshwater phytoplanktonic species. We found this species at H003 station of Lake Hazar in Elazığ (Turkey).

Distribution: *Europe* (Ireland, Netherlands, Spain, Sweden, Britain, Russia (Europe), Baltic Sea, Germany, Ireland, and Romania), *South-west Asia* (Bangladesh and Israel), *Atlantic Islands* (Iceland), *North America* (Alaska, Aleutian Islands, Great Lakes, Northwest Territories, NW USA, Tennessee and United States of America), *South America* (Brazil, Colombia), *Asia* (Mongolia, Korea, Russia (Far East), and Mongolia), *Africa* (Ghana), *Australia and New Zealand* (New Zealand) (Guiry & Guiry, 2017).

The number of diatoms have been estimated to include approximately 10^5 species in over 1,000 genera (Mann, 1999; Fourtanier and Kociolek, 1999, 2003). However, Ichimura (1996) has suggested that the total number of diatom species worldwide is probably not less than 2×10^5. Diatoms would thus be confirmed as the most species-rich group algae. In total, more than 800 diatom taxa have been found in Turkish lentic and lotic systems to date. The diversity of diatoms in Turkey are relatively low compared to the total number worldwide. The number of diatoms in Turkey are also low compared to other countries, such as Korea (1,000 diatom species) (Park, Lee, Kang, & Lee, 2014). Some genera such as *Navicula*, *Nitzschia*, *Cymbella*, *Surirella*, and *Cyclotella* have the high species diversity in Turkey. Morover, many of these diatoms frequently reported from water bodies in Turkey are taxa well known in European and Asiatic areas because of seeing commonly there, too (Solak & Wojtal, 2012). To date, the taxa listed in the results of Ladik and Hazar sediment cores have not been recorded in Turkey (Gönülol *et al.*, 1996; Aysel, 2005; Solak, Ector, Wojtal, Ács, & Morales, 2012; Solak *et al.*, 2016; Ongun-Sevindik *et al.*, 2011).

The trophic structures of the both lakes differ from each other. While Lake Ladik is nutrient-rich eutrophic lake (Maraşlıoğlu *et al.*, 2005), Lake Hazar has oligotrophic characters (Koçer & Şen, 2012). So, it is quite normal that the species composition derived from ecological difference of the two lakes is different. Also, when we compare the two lakes in terms of age, it is seen that Lake Hazar is an older lake. Anyway, Moreno *et al*. (2011) stated in a study that Lake Hazar level was ~80 m lower at the start of the Holocene than in 2007 and may have reached its present height only during the last two centuries. This information also confirms that the Lake Hazar is a rather old lake due to being avaliable since the Holocene period. Therefore, it was not too surprising for us that the most of the new diatom records were found in Lake Hazar. While 14+1 new diatom taxa were found in Hazar sediment, 2 new diatom taxa were found in Ladik sediment

According to the algaebase records (Guiry & Guiry, 2017), Bacillariophyceae class constitutes about 80% of Bacillariophyta division and Naviculales order with 4996 species forms the extensive group in the this class. With 1824 species, order Cymbellales forms the second largest group in this class after order Naviculales. This supports the results of which we have found in our study. Among the new diatom records, the Naviculales order from Bacillariophyceae contains the highest (8) records.

Navicula cells are extremely common (in freshwater or marine, epipelic); hardly a sample can be taken of epipelon without encountering this genus (Round *et al.*, 1990). The prevalence of *Navicula caenosus* species is not very broad. So, according to the records, the species was previously detected in Houlma Water, Shetland (Williams & Reid, 2002).

Brachysira cells are especially common in oligotrophic lakes and bogs (Round *et al.*, 1990). Freshwater or marine (1 species) to hypersaline; epipelic. Lange-Bertalot & Moser (1994) report that *B. styriaca* is widely distributed and locally abundant in northern and alpine regions of the Northern Hemisphere and that it is a good indicator of oligotrophic and oligosaprobic waters. We found in line with three new diatom records of the *Brachysira* genus including *B. styriaca* in oligotrophic Lake Hazar. *Brachysira* is a remarkable genus. Although *B. aponica* species was found in marine samples from all world, the other species from *Brachysira* genus were equally widely dispersed but only in freshwater. Some species are abundant in acidic (low conductivity) freshwaters and others are reported from more alkaline sites (Round *et al.*, 1990). Wolfe and Kling (2001) stated that *Brachysira brebissonii* to be cosmopolitan and acidophilous. pH and TP optima (average weighted means, AWM) from four studies (Siver & Hamilton, 2011; Siver *et al.*, 2005; Camburn & Charles, 2000; Gaiser & Johansen, 2000) range from 4.7-5.8 to 5.7-13.2 for pH and TP (µg/L) respectively. But we found this species in Lake Hazar expressed as an alkaline soda lake by Koçer and Şen (2012) due to having the mean pH value of 9.1. Similarly, Kilroy (2007) found that *B. brebissonii* species was abundant in New Zealand subalpine mire pools with alkaline character. This result confirms our findings. *Brachysira brebissonii* is highly polymorphic with respect to valve shape. Wolfe and Kling (2001), in a survey on some *Brachysira* species, noted that *B. brebissonii* has the co-occurrence of lanceolate, elliptical, and more rostrate forms in valve outline. They suggested that the slightly rostrate forms of the species which other authors had applied the subspecific designations of var. or fo. *thermalis*, not be considered distinct from *B. brebissonii*. Otherwise, *B. arctoborealis* is proposed for the rhombic forms that commonly co-occur with *B. brebissonii* and *B. microcephala*. *B. arctoborealis* is distinct from *B. brebissonii* with respect to both valve morphometry and copula structure, and, as an indicator of low pH environments, should be identified as distinct from *B. brebissonii* in ecological and paleolimnological studies.

Nitzschia cells are found from freshwater to marine; usually epipelic or planktonic. *N. acula* was found by Camburn and Charles (2000) at diatom flora of low-alkalinity lakes in Northeastern United States. However, this species was found in some lake sediments from Lakes Nicholls (Cameron, Tyler, Rose, Hutchinson, & Appleby, 1993) and Hazar with high alkalinity property. According to Pardal *et al*. (2002), *N. acula* prefers less oxygeneted waters with higher nutrient concentrations, such as *Cyclotella meneghiana*, *Melosira varians*, *Navicula phyllepta* taxa and is dominant in lentic waters of irrigations channels and marshes. However, we found this species in oligotrophic Lake Hazar, which was stated by Koçer and Şen (2012) that it has higher oxygeneted waters and less nutrient concentrations.

Eunotia is a large genus that comprises around 200 species (VanLandingham, 1968). In this genus although numerous species are restricted to tropical areas, due to their environmental water preferences: low pH and conductivity, the genus has a world-wide distribution (Metzeltin & Lange-Bertalot, 1998; Sala *et al.*, 2002; Díaz-Castro *et al.*, 2003). The occasional cells found in marine fossil deposits dating back to the Eocene are surprising (Round *et al.*, 1990). *Eunotia* is essentially a freshwater diatom genus frequently associated with acidic waters (Slàdecek, 1986; Alles *et al*., 1991; Cameron, 1995; Pierre, 1996) and epiphyton and metaphyton of oligotrophic or dystrophic situations (Patrick & Reimer, 1966; Lange-Bertalot & Metzeltin, 1996). While only one of two new *Eunotia* records was found in oligotrophic Lake Hazar, the other *Eunotia* record (*E. ambivalens*) was found in Lake Ladik, which has an eutrophic environment. Montaya-Moreno *et al.* (2013) stated that habitat of *Eunotia soleirolii* species is periphyton and fossil. This result confirms our findings that we found this species in sediment core of Lake Hazar. According to Patrick and Reimer (1966), *E. soleirolii* occurs predominantly in periodic water-bodies as well as under alkaline or acidic conditions, high or low electrolyte content. Also, Van Damm *et al.* (1994) stated that this species is circumneutral, mainly occurring at pH values about 7. Patrick and Reimer's result was confirmed by our findings that we found this species in sediment cores of alkaline Lake Hazar. *E. ambivalens* (syn: *E. bilunaris var. linearis*) is acidophilus, mainly occurring at pH<7 (Van Damm *et al*., 1994). However, we found this species in Lake Ladik which was stated as an alkaline lake by Maraşlıoğlu *et al.* (2005) due to pH values ranging between 8.0 and 9.0.

Brachysira brebissonii, *B. cymbelliformis*, *Navicula minima*, *Eunotia soleirolii*, *Gomphonema anjae*, and *Cymbella cymbiformis* var. *nonpunctata*, all were found in core sediments of Lake Hazar, are also fossil taxa. *Gomphonema anjae* species from these taxa is found in the phytoplankton of Germany (Ludwig & Schnittler 1996; Täuscher, 2014), Netherlands (Veen, Hof, Kouwets, & Berkhout, 2015) and North-South America Lakes (Bahls, 2009; Montoya-Moreno *et al.*, 2013), and in the phytobenthos of the Lednice Ponds characterized as highly eutrophic because of rich in organic matter, with high calcium and salt contents (Kopp *et al*., 2012). Also, this species was recorded as a new taxon for Bulgarian algal flora in a study in Boyanska River (Isheva & Ivanov, 2014). Otherwise, in some studies it was found in sediment cores (Voigt *et al.*, 2008; Loakes, 2015). Ludwig and Schnittler (1996) reported that this taxon is also in red list category (endangered species) for Germany. According to the some Turkish records (Pala, 2007; Sıvacı, Barinova, Solak, & Çobanoğlu, 2013), only three of the six fossil taxa are new diatom records for freshwater algal flora of Turkey. In the some studies, it is stated that *C. cymbiformis* var. *nonpunctata* (Figure 3, m) was previously found by Şahin (1998), Sıvacı and Pabuçcu (2007), Baytut and Gönülol (2016). However, none of the previous studies are on sediment cores and in none of them has been found in fossil records. Two of the three studies were made on periphyton and the other one was on phytoplankton. According to algaebase data (Guiry & Guiry, 2017), however, it is a fossil taxon seemingly without extant populations. Besides, most studies in other countries (e.g. Laird Fritz, & Cumming, 1998; Ognjanova-Rumenova, 2001; Tingstad *et al.*, 2011; White, 2012), *C. cymbiformis* var. *nonpunctata* was found in the core sediments. Therefore, the other records found on *C. cymbiformis* var. *nonpunctata* from Turkey should be *C. cymbiformis* or *C. cymbiformis* var. *longa.*

Because these *Cymbella* taxa resemble each other and both species (*C. cymbiformis*, C. *cymbiformis* var. *longa*) were previously recorded by Aysel (2005). So, our opinion is that *C. cymbiformis* var. *nonpunctata* taxon is the first record for the Turkey's recent diatom flora.

Algal flora studies require rigorous and long-term effort. Long-term monitoring and measuring of new records can prevent mistakes in the identification of species (Ongun Sevindik *et al*., 2010). Besides, when a species is identified the habitat and ecology informations of the species should also be considered in addition to the morphological characteristic information of the species. Furthermore, for accuracy, experts need constantly updated databases.

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References

Akar, B., & Şahin, B. (2014). New desmid records of Karagöl Lake in Karagöl-Sahara National Park (Şavşat-Artvin/Turkey). *Turkish Journal of Fisheries and Aquatic Sciences*, 14(1), 269-274. http://dx.doi.org/10.4194/1303-2712-v14_1_29

Alles, E., Nörpel-Schempp, M., & Lange-Bertalot, H. (1991). Zur Systematik und ökologie charakteristischer *Eunotia*-Arten (Bacillariophyceae) in elektrolytarmen Bachoberlaufen. *Nova Hedwigia*, 53, 171-213.

Apaydın-Yağcı, M., & Turna, İ.İ. (2002). A new record for the algal flora of Turkey: Chaetomorpha crassa (C.ag.) kütz. (Cladophoraceae, Chlorophyceae). *Turkish Journal of Botany*, 26, 171-174. Retrieved from http://dergipark.gov.tr/tbtkbotany/issue/ 11839/ 141429

Atıcı, T. (2002). Nineteen new records from Sarıyar Dam Reservoir phytoplankton for Turkish Freshwater algae. *Turkish Journal of Botany*, 26, 485-490. Retrieved from http://ijaedu.ocerintjournals.org/tbtkbotany/issue/11836/141403

Aysel, V. (2005). Check-List of the Freshwater Algae of Turkey. *Journal of the Black Sea/Mediterranean Environment*, 11(1), 1-124.

Aysel, V., Dural, B., & Gezerler-Şipal, U. (1993). Two new records of Cyanophyceae for the Algal Flora of Turkey. *Turkish Journal of Botany*, 17, 263-266.

Bahls, L. (2009). A checklist of diatoms from inland waters of the Northwestern United States. *Proceedings of the Academy of Natural Sciences of Philadelphia*, 158(1), 1-35. http://dx.doi.org/10.1635/053.158.0101

Bahls, L. (2014). *Brachysira styriaca*. In Diatoms of the United States. Retrieved from http://westerndiatoms.colorado.edu/taxa/species/brachysira_styriaca

Batterbee, W. (1986). Diatom analysis. In B.E. Berglund (Ed.), *Handbook of Holocene Palaeoecology* (pp. 527-570). Wiley, Chichester, UK, The Blackburn Press, 869 pp.

Baykal, T., Akbulut, A., Açıkgöz, İ., Udoh, A.U., Yıldız, K., & Şen, B. (2009). New records for the freshwater algae of Turkey, *Turkish Journal of Botany*, 33, 141-152. http://doi.org/10.3906/bot-0705-10.

Baytut, Ö., & Gönülol, A. (2016). Phytoplankton distribution and variation along a freshwater-marine transition zone (Kızılırmak River) in the Black Sea. *Oceanological and Hydrobiological Studies*, 45(4), 453-465. http://dx.doi.org/10.1515/ohs-2016-0039

Bekleyen, A., Gokot, B., & Varol, M. (2011). Thirty-four new records and the diversity of the Rotifera in the Turkish part of the Tigris River watershed, with remarks on biogeographically interesting taxa. *Sci Res Essays*, 6(30), 6270-6284. http://dx.doi.org/ 10.5897/ SRE11.355

Bennion, H. (1994). A diatom-phosphorus transfer function for shallow, eutrophic ponds in southeast England. *Hydrobiologia*, 275, 391-410. http://dx.doi.org/10.1007/BF00026729

Blanco, S., Ector, L., Huck, V., Monnier, O., & Cauchie, H.M., (2008). Diatom assemblages and water quality assessment in the Duero Basin (NW Spain). *Belgian Journal of Botany*, 141(1), 39-50. http://dx.doi.org/10.2307/20794650

Brummitt, R.K., & Powell, C.E. (1992). Authors of plant names. A list of authors of scientific names of plants, with recommended standart forms of their names, including abbreviations, London, England, Kew Royal Botanic Gardens, 4: 732 pp.

Brunthaler, J. (1903). Phytoplankton aus Kleinasien Sitzungsber. Kaiserl. Akad. Wiss. *Math.-Naturwiss. Cl*., 112(1), 289-293.

Bulut, İ. (2012). Floating islands of Turkey. Erzurum, Turkey, Megaofset Press.

Camburn, K.E., & Charles, J.C. (2000). Diatoms of low-alkalinity lakes in the northeastern United States. Philadelphia, Pennsylvania, U.S.A., Academy of Natural Sciences of Philadelphia, Scientific Publications, 18: 152 pp.

Cameron, N.G. (1995). The representation of diatom communities by fossil assemblages in a small acid lake. *Journal of Paleolimnology*, 14, 185-223. http://dx.doi.org/10.1007/ BF00735481

Cameron, N.G., Tyler, P.A., Rose, N.L., Hutchinson, S., & Appleby, P.G. (1993). The Recent Paleolimnology of Lake Nicholls, Mount Field National-Park, Tasmania. *Hydrobiologia*, 269, 361-370.

Díaz-Castro, J.G., Souza-Mosimann De, R.M., Laudares-Silva, R., & Forsberg, B.R. (2003). Composition of the periphytic diatom community of the Jaú river, Amazonas, Brazil. *Acta Amazonica*, 33(4),583-606. http://dx.doi.org/10.1590/S0044-59672003000400005

Donkin, S.A. (2012). The Natural History of the British Diatomaceae. General Books LLC, US, 22 pp.

Ehrenberg, C.G. (1844). Untersuchungen über die kleinsten Lebensformen im Quellenlande des Euphrats und Araxes, so wie über eine an neuen Formen sehr reiche, marine Tripelbildung von den Bermuda-Inseln. *Bericht über die zur Bekanntmachung geeigneten Verhandlungen der Königlich Preussischen Akademie der Wissenschaften zu Berlin*, 1844, 253-275.

Ertan, Ö.O., & Morkoyunlu, A. (1998). The algae flora of Aksu Stream (Isparta-Turkey). *Turkish Journal of Botany*, 22, 239-255. Retrieved from http://dergipark.gov.tr/

tbtkbotany/issue/11862/141606
Foged, N. (1974). Freshwater diatoms in Iceland. Bibliotheca Phycologica, Germany, J.Cramer Press, 15: 118pp.
Fourtanier, E., & Kociolek, J.P. (1999). Catalogue of the diatom genera. *Diatom Research*, 14, 1-190. https://doi.org/10.1080/0269249X.1999.9705462
Fourtanier, E., & Kociolek, J.P. (2003). Addendum to "Catalogue of the Diatom Genera". *Diatom Research*, 18, 245-258. http://dx.doi.org/10.1080/0269249X.2003.9705590
Gaiser, E.E., & Johansen, J.R. (2000). Freshwater diatoms from Carolina bays and other isolated wetlands on the Atlantic coastal plain of South Carolina, U.S.A., with descriptions of seven taxa new to science. *Diatom Research*, 15(1): 75-130. http:// dx.doi.org/10.1080/0269249X.2000.9705487
Gessner, F. (1957). Van Gölü. Zur Limnologie des großen Soda-Sees in Ostanatolien. *Archiv für Hydrobiologie,* 53, 1-22.
Gönülol, A. (2017). Turkish algae electronic publication, Samsun, Turkey. Retrieved from http://turkiyealgleri.omu.edu.tr
Gönülol, A., Öztürk, M., & Öztürk, M. (1996). A check-list of the freshwater algae of Turkey. *Ondokuz Mayıs University Journal of Science*, 7(1), 8-46.
Guiry, M.D., & Guiry, G.M. (2017). AlgaeBase, World-wide electronic publication. Galway: National University of Ireland, Retrieved from http://www.algaebase.org.
Hamilton, P. (2010). *Brachysira brebissonii*, In Diatoms of the United States. Retrieved from http://westerndiatoms.colorado.edu/taxa/species/brachysira_brebissonii
Hartley, B., Barber, H.G., Carter, J.R., & Sims, P.A. (1996). An atlas of British diatoms. Bristol, UK, Biopress Ltd. 601 pp.
Hartley, B., Ross, R., & Williams, D.M. (1986). A check-list of the freshwater, brackish and marine diatoms of the British Isles and adjoining coastal waters. *Journal of the Marine Biological Association of the United Kingdom*, 66(3), 531-610. https://doi.org/ 10.1017/S0025315400042235
Hempton, M.R., Dunne, L.A., & Dewey, J.F. (1983). Sedimentation in an active strike-slip basin, south-eastern Turkey. *Journal of Geology*, 91, 401-412.
Ichimura, T. (1996). Genome rearrangement and speciation in freshwater algae. *Hydrobiologia*, 336, 1-17. http://dx. doi.org/10.1007/978-94-017-0908-8_1
Isheva T., & Ivanov, P. (2014). Diatom diversity of springs and spring-fed streams in Vitosha Nature Park, Bulgaria. Sofia, Bulgaria, Annual of Sofia University, Faculty of Biology, Book 2, Vol. 99, 154 pp.
Johansen, J.R., Rushforth, S.R., Orbendorfer, R., Fungladda, N., & Grimes, J.A. (1983). The Algal Flora of Selected Wet Walls in Zion National Park, Utah, USA. *Nova Hedwigia*, 38, 765-808.
Kelly, M.G., Adams, C., Graves, A. C., Jamieson, J., Krokowski, J., Lycett, E.,….Wilkins, C. (2001). The Trophic Diatom Index: A user's manual. E2/TR2. Almondsbury, Bristol, UK, 135 pp.
Kelly, M. (2013). Data rich, information poor? Phytobenthos assessment and the Water Framework Directive. *European Journal of Phycology*, 48(4), 437-450. http://dx. doi.org/10.1080/09670262.2013.852694
Kilroy, C. (2007). *Diatom communities in New Zealand subalpine mire pools: distribution, ecology and taxonomy of endemic and cosmopolitan taxa* (PhD thesis). School of Biological Sciences, University of Canterbury, New Zealand.
Koçer, M.A.T., & Şen, B. (2012). The seasonal succession of diatoms in phytoplankton of a soda lake (Lake Hazar, Turkey). *Turkish Journal of Botany*, 36, 738-746. http://doi.org/10.3906/bot-1106-9
Kopp, R., Skácelová O., Heteša, J., Marvan, P., Bešta, T., Zapomìlová, E., Straková, L., & Bohunická, M. (2012). A hundred years of phycological research in the Lednice Pond – the impact of environmental conditions on the development of cyanobacteria and algae. *Acta Musei Moraviae, Scientiae biologicae (Brno)*, 97(1), 3–87.
Krammer, K., & Lange-Bertalot, H. (1988). Süßwasserflora von Mitteleuropa. Band 2 (Bacillariophyceae) Teil 2 (Bacillariaceae, Epithemiaceae, Surirellaceae). Stuttgart, Germany, Gustav Fischer Verlag, 596 pp.
Krammer, K., & Lange-Bertalot, H. (1991a). Sübwasserflora von Mitteleuropa. Bacillariophyceae, 3. Teil. Centrales, Fragillariaceae, Eunoticeae. Stuttgart, Germany, Gustav Fischer Verlag, 576 pp.
Krammer, K., & Lange-Bertalot, H. (1991b). Sübwasserflora von Mitteleuropa. Bacillariophyceae, 4. Teil. Achnanthaceae, Kritische Erganzungen zu Navicula (Lineolate) und Gomphonema Gesamtliterat. Stuttgart, Germany, Gustav Fischer Verlag, 437 pp.
Krammer, K., & Lange-Bertalot, H. (1999a). Sübwasserflora von Mitteleuropa. Bacillariophyceae, 1. Teil. Naviculaceae. Berlin, Germany, Spectrum Acad. Verlag, 876 pp.
Krammer, K., & Lange-Bertalot, H. (1999b). Sübwasserflora von Mitteleuropa. Bacillariophyceae, 2. Teil. Bacillariaceae, Epithemiaceae, Surirellaceae. Berlin, Germany, Spectrum Acad. Verlag, 610 pp.
Laird, K.L., Fritz, S.C., & Cumming B.F. (1998). A diatom-based reconstruction of drought intensity, duration, and frequency from Moon Lake, North Dakota: A sub-decadal record of the last 2,300 years. *Journal of Paleolimnology*, 19, 161-179.
Lange-Bertalot, H., & Metzeltin, D. (1996). Indicators of Oligotrophy: 800 taxa representative of three ecologically distinct lake types. Carbonate buffered-Oligodystrophic-Weakly buffered soft water. Königstein, Germany, Koeltz Scientific Books, Iconographia Diatomologica, 2: 390 pp.
Lange-Bertalot, H., & Moser, G. (1994). *Brachysira*. Monographie der Gattung. Berlin, Stuttgart, Germany, Biblioteca Diatomologica, J. Cramer, 29: 212 pp.
Legler, F., & Krasske, G. (1940). Diatomeen aus dem Vansee (Armenien). Beiträge zur Ökologie der Brackwasserdiatomeen. *Beihefte zum Botanischen Centralblatt*, 60, 335-346.
Loakes, K. (2015). *Late Quaternary palaeolimnology and environmental change in the South Wollo Highlands, Ethiopia*. (PhD Thesis). Loughborough University, Institutional Repository, London, England.
Ludwig, G., & Schnittler, M. (1996). Rote Liste gefährdeter Pflanzen Deutschlands. *Schriftenreihe für Vegetationskunde*, 28, 1-744.
Mann, D.G. (1999). The species concept in diatoms. *Phycologia*, 38(6), 437-495. http://dx.doi.org/10.2216/i0031-8884-38-6-437.1
Maraşlıoğlu, F., Soylu, E.N., & Gönülol, A. (2005). Seasonal variation of the phytoplankton of Lake Ladik, Samsun, Turkey. *Journal of Freshwater*

Ecology, 20(3), 549-554. http://doi.org/10.1080/02705060.2005.9664770

Metzeltin, D., & Lange-Bertalot, H. (1998). Tropical diatoms of South America I: About 700 predominantly rarely known or new taxa representative of the neotropical flora. Germany, Koeltz Scientific Books, Iconographia Diatomologica, 5: 695 pp.

Metzeltin, D., & Lange-Bertalot, H. (2007) . Tropical diatoms of South America II: Special remarks on biogeographic disjunction / Diversity-Taxonomy-Biogeography. Ruggell, Liechtenstein, Iconographia Diatomologica, A.R.G. Gantner Press, 18: 877 pp.

Montoya-Moreno Y., Sala S., Vouilloud A., Aguirre N., & Plata Y. (2013). Lista de las diatomeas de ambientes continentales de Colombia. *Biota Colombiana*, 14(2), 13-78. http://doi.org/10.15472/rddjgp UTF-8 txt

Moreno, D.G., Hubert-Ferrari, A., Moernaut, J., Fraser, J.G., Boes, X., Daele, M.V., … Batistw, M.D. (2011). Structure and recent evolution of the Hazar Basin: a strike-slip basin on the East Anatolian Fault, EasternTurkey. *Basin Research*, 23, 191-207. http://dx.doi.org/10.1111/j.1365-2117.2010.00476.x

Ognjanova-Rumenova, N. (2001). Diatom analysis of Upper Quaternary lake sediments from Dalgoto ezero in Northern Pirin Mountains: I. Taxonomical remarks. *Phytologia Balcanica*, 7(2), 181-194.

Ongun-Sevindik, T., Çelik, K., & Gönülol, A. (2010). Twenty-four New Records from Çaygören Reservoir Phytoplankton for Turkish Freshwater Algae. *Turkish Journal of Botany*, 31(4), 249-259. http://doi.org/10.3906/bot-0906-56.

Ongun-Sevindik, T., Çelik, K., & Gönülol, A. (2011). Twenty New Records for Turkish Freshwater Algal Flora from Çaygören and Ikizcetepeler Reservoirs (Balıkesir, Turkey). *Turkish Journal of Fisheries and Aquatic Sciences*, 11, 399-406. http://doi.org/ 10.4194/1303-2712-v11_3_09

Ortiz-Lerín, R., & Cambra, J. (2007). Distribution and taxonomic notes of *Eunotia* Ehrenberg 1837 (Bacillariophyceae) in rivers and streams of Northern Spain. *Limnetica*, 26 (2), 415-434.

Özer, T.B., Erkaya, İ.A., Udoh, A.U., Akbulut, A., Yıldız, K., & Şen, B. (2012). New records for the freshwater algae of Turkey (Tigris Basin). *Turkish Journal of Botany*, 36(6), 747-760. http://dx.doi.org/10.3906/bot-1108-16

Öztürk, M., Gönülol, A., & Öztürk, M. (1995a). Türkiye alg florası için yeni bir kayıt: Pleurotaenium trabecular (Ehr.) ex Nägeli (Desmidiaceae), *Ondokuz Mayıs University Journal of Science*, 6(1), 212-218.

Öztürk, M., Gezerler-Şipal, U., Güner, H., Gönülol, A., & Aysel, V. (1995b). *Closterium kuetzingii* Bréb. var. *kuetzingii* (Conjugatophyceae, Desmidiales), A new record for the algal flora of Turkey. *Ege Journal of Fisheries and Aquatic Sciences*, 12(1-2), 145-149.

Pala, G. (2007). Planktonic algae and seasonal changes in the Gülüşkür section of Keban Dam Lake, II-Bacillariophyta. *Fırat University Journal of Science and Engineering*, 19(1), 23-32.

Pardal, M.A., Marques, J.C., & Graça, M.A. (2002). Aquatic ecology of the Mondego River basin global importance of local experience. London, UK, Editeur, 576 pp.

Park, J.S., Lee, S.D., Kang, S.E., & Lee, J.H. (2014). New records of the marine pennate diatoms in Korea. *Journal of Ecology and Environment*, 37(4), 231-244. http://dx.doi.org/10.5141/ecoenv.2014.028

Patrick, R., & Reimer, C.W. (1966). The diatoms of the United States I. Monographs of the Academy of Natural Sciences of Philadelphia. Pennsylvania, US, Sutterhouse, Litiz, Monograph No. 13, 688 pp.

Patrick, R., & Reimer, C.W. (1975). The diatoms of the United States, exclusive of Alaska and Hawaii, Volume 2, Part 1-Entomoneidaceae, Cymbellaceae, Gomphonemaceae, Epithemaceae. Academy of Natural Sciences of Philadelphia, Pennsylvania,US, Sutterhouse, Litiz, Monograph No. 13, 213 pp.

Pierre, J.F. (1996). Algal Community and Acidity of Small Streams in the Vosges Mountains. *Bulletin Des Académie Et Société Lorraines Des Sciences*, 35, 139-156.

Potapova, M. (2009). *Aulacoseira alpigena*, In Diatoms of the United States. Retrieved from http://westerndiatoms.colorado.edu/taxa/species/Aula coseira_alpigena

Potapova, M. (2011). *Navicula subrostellata*, In Diatoms of the United States. Retrieved from http://westerndiatoms.colorado.edu/taxa/species/navic ula_subrostellata

Reichardt, E., & Lange-Bertalot, H. (1991). Taxonomische Revision des Artencomplexes um *Gomphonema angustum–G. dichotomum–G. intricatum–G. vibrio* und ahnliche Taxa (Bacillariophyceae). *Nova Hedwigia*, 53(3-4): 519-544.

Rimet, F. (2012). Recent views on river pollution and diatoms. *Hydrobiologia*, 683, 1-24. http://dx.doi.org/10.1007/s10750-011-0949-0

Rott, E., Pipp, E., Pfister, P., Van Dam, H., Ortler, K., Binder, N., & Pall, K. (1999). Indikationslisten für Aufwuchsalgen in österreichischen Fliessgewässern. Teil 2: Trophieindikation (sowie geochemische Präferenzen, taxonomische und toxikologische Anmerkungen). Wasserwirtschaftskataster, Bundesministerium f. Land-u. Forstwirtschaft, Wien, Austria, 248 pp.

Round, F., Crawford, R., & Mann, D. (1990). The diatoms. Bristol, England, Cambridge University Press, 747 pp.

Sala, S.E., Duque, S.R., Núñez-Avellaneda M., & Lamaro, A.A. (2002). Diatoms from the Colombian Amazon: Some species of the genus *Eunotia* (Bacillariophyceae). *Acta Amazonica*, 32(4), 589-603. http://dx.doi.org/10.1590/1809-43922002324603.

Schröder, B. (1895). Kleinasiatische Algen. *La Nuova Notarisia: Rassegna Consacrata Allo Studio Delle Alghe*, 6, 99-106.

Sgro G.V., Poole J.B., & Johansen, J.R. (2007). Diatom species composition and ecology of the Animas River Watershed, Colorado, USA. *Western North American Naturalist*, 67(4), 510-519. http://dx.doi.org/10.3398/1527-0904(2007)67[510:DSCAEO]2.0.CO;2

SHW, (1997). General Directorate of State Hydraulic Works report. Ladik project: The irrigation planning report of İbi and Havza plains. Samsun, Turkey, VIII. Regional Directorate of State Hydraulic Works, Planning Department, 135 pp.

Sıvacı, E.R., & Pabuçcu, K. (2007). Epipelic and Epilithic Diatoms of the Balıklı Spa in Central Anatolia Turkey. *Journal of Freshwater Ecology*, 22(1), 145-146. http://dx.doi.org/10.1080/02705060.2007.9664154

Sıvacı, R.E., Barinova, S., Solak, C.N., & Çobanoğlu, K. (2013). Ecological assesment of great Lota Lake

(Turkey) on the base of diatom communities. *African Journal of Biotechnology*, 12(5), 453-464.

Siver, P.A., & Hamilton, P.B. (2011). Diatoms of North America: The freshwater flora of waterbodies of the Atlantic Coastal Plain. Ruggell, Liechtenstein, Iconographia Diatomologica, A.R.G. Gantner Press, 22: 916 pp.

Siver, P.A., Hamilton, P.B., Stachura-Suchoples, K., & Kociolek, J.P. (2005). Diatoms of North America: The freshwater flora of Cape Cod. Ruggell, Liechtenstein, Iconographia Diatomologica, A.R.G. Gantner Press, 14: 463 pp.

Slàdecek, V. (1986). Diatoms as indicators of organic pollution. *Acta Hydrochimica et Hydrobiologica*, 14, 555-566. http://doi.org/10.1002/aheh.19860140519

Solak, C.N., & Wojtal, A.Z. (2012). Diatoms in springs and streams of Türkmen Mountain (Sakarya river basin) common in Turkish inland waters. *Polish Botanical Journal*, 57(2), 375-425.

Solak, C.N., Kulikovskiy, M., Kaleli, A., & Gönülol, A. (2016). Rare and new records for diatoms of Turkey from Kütahya running waters. *Oceanological and Hydrobiological Studies*, 45(4), 564-587. http://doi.org/10.1515/ohs-2016-0047

Solak, C.N., Ector, L., Wojtal, A.Z., Ács, É., & Morales, E. (2012). A review of investigations on diatoms (Bacillariophyta) in Turkish inland waters. *Nova Hedwigia, Beiheft*, 141: 431-462. http://doi.org/1438-9134/2012/0141-0431.

Stevenson, R. J., Peterson, C.G., Kirschtel, D.B., King, C.C., & Tuchman, N.C. (1991) Density-dependent growth, ecological strategies, and effects of nutrients and shading on benthic diatom succession in streams. *Journal of Phycology*, 27, 59–69. http://doi.org/10.1111/j.0022-3646.1991.00059.x

Şahin, B. (1998). A study on the benthic algae of Uzungöl (Trabzon). *Turkish Journal of Botany*, 22, 171-189. Retrieved from http://ijaedu.ocerintjournals.org/tbtkbotany/issue/11863/141616

Şahin, B. (2000). Some new desmids records for freshwater algal flora of Turkey. *Flora Mediterranea*, 10, 223-226.

Şahin, B. (2002). Contribution to the desmid flora of Turkey. *Algological Studies*, 107, 39-48. http://doi.org/10.3906/bot-0809-15

Şahin, B. (2005). A preliminary checklist of desmids of Turkey. *Cryptogamie, Algologie*, 26(4), 399-415.

Şahin, B. (2007). Two new records for he freshwater algae of Turkey. *Turkish Journal of Botany*, 31, 153-156. http://doi.org/31-2-8-0605-14

Şahin, B. (2009). Contribution to the desmid flora of Turkey. *Turkish Journal of Botany*, 33, 457-460. http://doi.org/10.3906/bot-0809-15

Täuscher, L. (2014). Checkliste der Algen (Cyanobacteria et Phycophyta). In D. Frank & V. Neumann (Eds.), *Bestandssituation der Pflanzen und Tiere Sachsen-Anhalts*. Stuttgart (Hohenheim), Germany, Eugen Ulmer-Verlag, 469 pp.

Tingstad, A.H., Moser, K.A., MacDonald, G.M., & Munroe, J.S. (2011). A~13,000-year paleolimnological record from the Uinta Mountains, Utah, inferred from diatoms and loss-on-ignition analysis. *Quaternary International*, 235(1), 48-56. http://dx.doi.org/10.1016/j.quaint.2010.11.023

Van Damm, H., Mertens, A., & Sinkeldam, J. (1994). A coded checklist and ecological indicator values of freshwater diatoms from the Netherlands. *Netherlands Journal of Aquatic Ecology*, 28, 117-133. http://dx.doi.org/10.1007/BF02334251

VanLandingham, S.L. (1968). Catalogue of the fossil and recent genera and species of Diatoms and their synonyms. Verlag Von J.Cramer, Lehre, 4654 pp.

Varol, M., & Fucikova, K. (2015). Four New Records for the Freshwater Algae of Turkey. *Journal of Limnology and Freshwater Fisheries Research*, 1(2), 83-88. http://dx.doi.org/ 10.17216/ LimnoFish-5000119624

Varol, M., & Şen, B. (2016). New Records of Euglenophyceae for Turkish Freshwater Algae. *Turkish Journal of Fisheries and Aquatic Sciences*, 16, 219-225. http://dx.doi.org/ 10.4194/1303-2712-v16_2_01

Veen, A., Hof, C.H.J., Kouwets, F.A.C., & Berkhout, T. (2015). Rijkswaterstaat Waterdienst, Informatiehuis Water [Taxa Watermanagement the Netherlands (TWN)] http://ipt.nlbif.nl/ipt/resource?r=checklist-twn. Consulted March 2017. pp. on line. The Netherlands: Laboratory for Hydrobiological Analysis, Rijkswaterstaat.

Voigt, R., Grüger, E., Baier, J., & Meischner, D. (2008). Seasonal variability of Holocene climate: a palaeolimnological study on varved sediments in Lake Jues (Harz Mountains, Germany). *Journal of Paleolimnology*, 40(4), 1021-1052. http://doi.org/10.1007/ s10933-008-9213-7

White, C.A. (2012). *Sedimentary diatoms as indicators of water quality and ecosystem change in lakes of Riding Mountain National Park of Canada* (M.Sc. Thesis). University of British Columbia, Kelowna, Canada.

Whitton, B.A., John, D.M., Kelly, M.G., & Haworth, E.Y. (2003). A coded list of freshwater algae of the British Isles. World-wide web electronic publication. Retrieved from http://www.nhm.ac.uk/our-science/data/ukspecies/checklists/NHMSYS0000591449/ index.html

Williams, D.M., & Reid, G. (2002). The diatom type slides and bibliography of John Carter (1908-1993). *Bulletins of the Natural History Museum: Botany Series*, 32(2), 137-151. https://doi.org/ 10.1017/S0968044602000063

Wojtal, A.Z. (2009). Diatom flora of the Kobylanka stream near Kraków (Wyżyna Krakowsko-Czestochowska Upland, S Poland). *Polish Botanical Journal*, 54(2), 129-330.

Wolfe, A.P., & Kling, H.J. (2001). A consideration of some North American soft-water Brachysira taxa and description of *B. arctoborealis* sp. nov. In R. Jahn, J.P. Kociolek, A. Witkowski, and P. Compère (Eds), *Studies on Diatoms* (pp. 243-264). Koenigstein, Germany, Lange-Bertalot-Festschrift: Koeltz.

Yüce, A.M., & Ertan, Ö.O. (2014). A new record for the freshwater algae of Turkey. *Scientific Research Journal*, 2(4), 21-22.