New desmid records from high mountain lakes in Artabel Lakes Nature Park, Gümüşhane, Turkey

Bülent ŞAHİN†*, Bülent AKAR‡

†Department of Biology Education, Fatih Education Faculty, Trabzon University, Trabzon, Turkey
‡Department of Food Engineering, Faculty of Engineering and Natural Sciences, Gümüşhane University, Gümüşhane, Turkey

Abstract: The algal flora of 17 lakes and 1 pond in the Artabel Lakes Nature Park were investigated during two summer seasons (2013 and 2016). In total, 26 desmid taxa were found and identified as new records for the desmid flora of Turkey based on their morphotaxonomic characteristics and ecological preferences. The taxa identified belong to the genera Actinotaenium (1), Closterium (1), Cosmarium (15), Micrasterias (1), Spondylosium (1), Stauroastrum (5), Teilingia (1), and Tetramorus (1). Morphotaxonomy, ecology, and distribution of each species were discussed in detail.

Key words: Desmids, new records, high mountain lakes, Artabel Lakes Nature Park, Turkey

1. Introduction

Desmid habitats are exclusively freshwater (Coesel and Meesters, 2007; Kouwets, 2008). Desmids usually prefer acidic or pH-circumneutral, nutrient-poor, and clear waters (Lenzenweger, 1996; Coesel and Meesters, 2007). It is well known that members of order Desmidiales exhibit great diversity in their external morphology and also have remarkably complex cell symmetry (Lee, 2015). That is why they attract the attention of researchers. To date, about 3250 different desmid species have been identified worldwide (Guiry and Guiry, 2019). Desmids are also considered excellent bioindicators in terms of the stability of ecosystems (Coesel, 1998). In recent years, eutrophication, acidification, desiccation, and cultivation have been identified as processes that could negatively affect desmid habitats (Lenzenweger, 1996; Šimek, 1997; Coesel et al., 1978; Štastný, 2009). Therefore, these processes have played a part in affecting the most endangered group of aquatic microorganisms (Coesel, 1998).

According to phylogenetic studies, Conjugatophyceae is one of the most important classes within the Charophyta and is associated with land plants (Gontcharov, 2008a). However, recent molecular phylogenetic studies have shown a disagreement between the traditional taxonomic structure of Conjugatophyceae and the pattern of phylogenetic relationships between the class members (Gontcharov, 2008a).

Desmids are an integral part of benthic habitats of high mountain lakes; in particular, those of the Northern Hemisphere (Medvedeva, 2001; Sterlyagova, 2008). In the period from 1998 to 2014, 43 new records of desmid species from high mountain lakes in the eastern Black Sea Region were identified and published (Şahin, 1998, 2000, 2002, 2007, 2008, 2009; Şahin and Akar, 2007; Akar and Şahin, 2014). Some of them [e.g., Actinotaenium cruciferum (De Bary) Teiling, A. cucurbita (Brébisson ex Ralfs) Teiling, Micrasterias americana Ehrenberg ex Ralfs, M. denticulata Brébisson ex Ralfs, M. rotata Ralfs, Netrium digitus (Brébisson ex Ralfs) Itzigsohn & Rothe, and Spondylosium planum (Wolle) West & G.S.West] were remarkable, because they were the first representatives of their genera in Turkey. These findings are considered unsurprising for this interesting and unexplored mountain region of Turkey. The high mountain lakes in this region contain many boreal and arctic–alpine desmid species, and in-depth survey studies on species composition and biogeographical distribution of the hidden desmid flora of these unique habitats are still an important prerequisite for expanding our scant knowledge.

Artabel Lakes Nature Park is one of the important nature parks in Turkey and contains 23 high mountain lakes. The first data published on the algal flora of this mountain nature habitat was presented by Atıcı (2018). In general, 96 algal species belonging to Bacillariophyta,
Charophyta, Cyanobacteria, Chlorophyta, Euglenophyta, Pyrrophyta, and Cryptophyta were identified. Among these, only 4 desmid species were recorded: Closterium attenuatum, Cosmarium formosulum, C. impressulum, and Staurastrum cyclocanthum.

The main goal of the present work was to describe 26 desmid taxa, considered herein, as new desmid records for the freshwater algal flora of Turkey. Morphology, ecology, and distribution of each taxon have also been discussed in detail.

2. Materials and methods

2.1. Study area

Gümüşhane Province, located in the eastern Black Sea Region of Turkey, is characterized by many protected areas rich in biodiversity of organisms. Artabel Lakes is a nature park situated in Gümüşhane Province and is the working area. Artabel Lakes Nature Park (40°21'36", 40°26'42"N and 39°0'24", 39°8'23"E) is located 50 km southwest of Gümüşhane and 28 km from Torul District. Its total surface area is about 5859 ha, and elevation ranges from 2697 to 3030 m a.s.l. (Doğa Koruma ve Milli Parklar Genel Müdürlüğü, 2013).

The main source values of Artabel Lakes Nature Park are its unique features; the glacial lakes and the richness of its flora and fauna (Doğa Koruma ve Milli Parklar Genel Müdürlüğü, 2013). The glacial lakes that provide the name for the area are of worldwide importance in terms of their hydrological and geomorphological features (Doğa Koruma ve Milli Parklar Genel Müdürlüğü, 2013). The area also includes endemic taxa listed in the International Nature Conservation Union (IUCN) and the Bern Convention Annex I, II, and III (Doğa Koruma ve Milli Parklar Genel Müdürlüğü, 2013). Artabel Lakes Nature Park consists of 3 subbasins belonging to 3 different stream systems (the Gümüştuğ, Artabel, and Kongel stream basins) (Doğa Koruma ve Milli Parklar Genel Müdürlüğü, 2013). The total area includes 23 lakes composed of Artabel Lakes (6), Acembol Lakes (3), Beş Lakes (5), Kara Lakes (6), and Yıldız Lakes (3). There is also a previously-unnamed lake (Isimsiz Lake: IL) and a small pond (Yıldız Lakes pond: YLP) (Figure 1) (Doğa Koruma ve Milli Parklar Genel Müdürlüğü, 2013).

2.2. Sampling and laboratory studies

Sampling of the algal specimens was carried out during the summer seasons of 2013 (August 15th) and 2016 (August 13th). In the first period, samples were collected from Artabel and Beş Lakes, and in the second period algal samples were gathered from Acembol and Yıldız Lakes, Isimsiz Lake, and Yıldız Lakes pond. Kara Lakes could not be reached due to difficult transportation conditions. Forty-three benthic algae samples (epipelic, epilithic, and epiphytic) were sampled from the littoral regions of 17 lakes and 1 pond and then transported to the laboratory for further investigation. Epipelic algae were taken with a glass tube from the surface of the sediment. Epilithic samples were scraped from randomly chosen stones with the toothbrush and washed into plastic bottles. Epiphytic species were collected by squeezing out the moss [Hygrohypnum luridum (Hedw.) Jenn.] and filamentous green alga (Microspora sp.). All samples were preserved with 4% (v/v) formaldehyde in 100 mL plastic bottles. In the lab, temporary slides were prepared using the appropriate methods (Round, 1953; Sládečková, 1962) and identified under a light microscope (Leica DM 2500).

The desmid taxa were photographed using a Leica DFC 290 camera attached to the microscope. Dissolved oxygen, water temperature, pH, and conductivity of lake waters were measured in situ using Thermo Orion-4-Star pH and YSI-55 portable meters.

The following abbreviations are used in the text: length (L), breadth (B), and isthmus (I). All of the taxa were identified following West and West (1904, 1905, 1908, 1912, 1923), Rűzička (1977), Lind and Brook (1980), Huber-Pestalozzi (1982), Dillard (1990, 1991, 1993), Bourrelly and Couté (1991), Lenzenweger (1996, 1997, 1999), John et al. (2003), Brook and Williamson (2010), Stastný (2010), Coesel and Meesters (2007, 2013), Kim (2015), and Lee (2015). The desmid species were carefully checked using the freshwater algae and desmids checklist of Turkey (Aysel, 2005; Şahin, 2005) and the algae of Turkey database (Gönülol, 2018). The current status of nomenclature of all taxa identified has been checked in the Algaebase website (Guiry and Guiry, 2019). In order to describe dimensions of the desmid species, measurements were mostly performed one time due to the rarity of most of species. Only a few species were recorded in 2 or 3 lakes; therefore, we were able to determine their dimension ranges.

Frequency of desmids recorded in the lakes was classified according to the following scale: very rare (VR): 1%–20%, rare (R): 21%–40%, common (C): 41%–60%, frequent (F): 61%–80%, and very frequent (VF): 81%–100% (Kocataş, 1992).

3. Results and discussion

The results of physical and chemical analyses of the investigated waters are given in another paper (Şahin and Akar, 2019). In this study, 26 species and infraspecific desmid taxa were identified as new records for the desmid flora of Turkey. They belong to genera Actinotaenium (1), Closterium (1), Cosmarium (15), Microasterias (1), Spondylosium (1), Staurastrum (5), Teililinga (1), and Tetmemorus (1). Morphotaxonomic description, ecology, and distribution of each of these taxa are given below. Ecological preferences of each desmid species were also...
discussed based on hydrochemical data published in a previous study (Şahin and Akar, 2019).

**Phylum:** Charophyta  
**Class:** Conjugatophyceae (=Zygnematophyceae)  
**Order:** Desmidiales  
**Family:** Closteriaceae  
**Genus:** Closterium Nitzsch ex Ralfs  
**Closterium cf. cornu** Ehrenberg ex Ralfs (Figure 2A)

West and West (1904) p. 157, pl. 20, figs. 1–5; Růžička (1977) p. 104, pl. 8, figs. 1–7; Lind and Brook (1980) p. 30, fig. 26; Huber-Pestalozzi (1982) p. 72, pl. 4, figs. 17–21; Lenzenweger (1996) p. 36, pl. 2, fig. 17; John et al. (2003) p. 521, pl. 129, fig. H; Coesel and Meesters (2007) p. 41, pl. 8, figs. 20–21; Brook and Williamson (2010) p. 183, pl. 74, figs. 1–7, 14.

**Dimensions:** L: 192–200 µm, B: 12.75–13.60 µm.  
**Description:** Cells 15 times longer than breadth. Cells slender, slightly curved, gradually attenuating from the middle to the poles; outer margin slightly curved; inner margin slightly concave and straight in the median part; apices narrow, rounded–truncate; cell wall without girdle bands, smooth and colorless. Terminal vacuoles were not observed.

**Ecology and distribution:** This species was very rare (VR), found only in the epipelic samples of the lake YL3. Lake YL3 is located at an elevation of 2980 m a.s.l. and is characterized by a pH value of 7.01. This species belongs to desmids with a wide ecological valence, so it can occur in acidic (pH 5–6.5) to slightly alkaline (pH 8), oligotrophic, oligo-mesotrophic, dystrophic, tropic, and

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**Figure 1.** Map of Artabel Lakes Nature Park.
alpine (1400–2260 m a.s.l.) water bodies (Růžička, 1977; Huber-Pestalozzi, 1982; Lenzenweger, 1996; John et al., 2003; Coesel and Meesters, 2007).

Family: Desmidiaeae

Genus: Actinotaenium (Nägeli) Teiling

Actinotaenium curtum (Brébisson ex Ralfs) Teiling ex Růžička and Pouzar (Figure 2B)

Huber-Pestalozzi (1982) p. 141, pl. 17, fig. 7; Bourrelly and Coute (1991) p. 57, pl. 23, fig. 4; Dillard (1991) p. 15, pl. 2, fig. 13; Lenzenweger (1996) p. 115, pl. 17, fig. 1; John et al. (2003) p. 531, pl. 131, fig. O; Coesel and Meesters (2007) p. 60, pl. 31, figs. 11–12.

Dimensions: L: 32.98 µm, B: 15.81 µm.

Description: Cells broadly fusiform; sinus a shallow notch; lateral margins convex and narrowed towards the apices; apices broadly rounded.

Ecology and distribution: Very rare (VR) and found only in the epiphytic samples of the lake IL. Lake IL is located at an elevation of 2668 m a.s.l. and is characterized by a pH value of 6.78. This taxon is known for its wide ecological valence and occurs in acidic (pH 4.8–6) and alkaline (pH 8) habitats with Sphagnum and among other algae and mosses, in oligo–mesotrophic water bodies, and in arctic and alpine waters (the Alps, 2680 m a.s.l.; China, 3000 m a.s.l.; and the Himalayas, about 5000 m a.s.l.) (Huber-Pestalozzi, 1982; John et al., 2003; Coesel and Meesters, 2007).

Genus: Cosmarium Corda ex Ralfs

Cosmarium anceps P. Lundell (Figures 2C and 2D)

West and West (1908) p. 47, pl. 69, figs. 14–17; Dillard (1991) p. 44, pl. 15, fig. 9; Lenzenweger (1999) p. 74, pl. 51, fig. 26; John et al. 2003, p. 535, pl. 132, fig. T; Coesel and Meesters (2007) p. 105, pl. 59, fig. 19.

Dimensions: L: 28.47–30.54 µm, B: 15.47–16.40 µm, I: 9.75–9.96 µm.

Description: Cells longer than breadth; sinus slightly open and not deep; semicells truncate–pyramidal; sides very slightly concave; apex truncate; upper and lower angles rounded; cell wall is smooth.

Ecology and distribution: Very rare (VR) and found only in the epiphytic and epipelic samples of lakes YL1 and YL2. Lakes YL1 and YL2 are located at an elevation of 2980 m a.s.l. and are characterized by pH values of 6.85 and 6.89, respectively. According to Lenzenweger (1999), the ecological characteristics of this variety are like the type species. It is a well-adapted species that prefers oligotrophic and slightly eutrophic waters but also occurs in Sphagnum ponds and peat bogs and is found in the Alps up to 2500 m a.s.l.

C. botrytis var. gemmiferum (Brébisson) Nordstedt (Figures 2F and 2G)

West and West (1912) p. 5, pl. 97, figs. 4a–4b; Dillard (1991) p. 52, pl. 37, fig. 2; Lenzenweger (1999) p. 130, pl. 62, figs. 1–3.

Dimensions: L: 71.94–85.09 µm, B: 59.87–65.36 µm, I: 14.77–17.37 µm.

Description: Cells longer than breadth; sinus deep and linear; semicells ovate–pyramidal in shape; angles broadly rounded; lateral margins convex; cell wall uniformly granulated. It differs from the typical species in that the semicells have a central granulated protuberance surrounded by a smooth area of small extent. In the vertical view, there is a small inflation at the midregion on each side.

Ecology and distribution: This variety was very rare (VR) and found in the epipelic and epiphytic samples of lakes BL1 and BL2. Lakes BL1 and BL2 are located at an elevation of 2924 m a.s.l. and are characterized by pH values of 6.85 and 6.89, respectively. According to Lenzenweger (1999), the ecological characteristics of this variety are like the type species. It is a well-adapted species that prefers oligotrophic and slightly eutrophic waters but can also occur in Sphagnum ponds and peat bogs and is found in the Alps up to 2500 m a.s.l.

C. cucumis Corda ex Ralfs (Figure 2H)

West and West (1905) p. 152, pl. 59, figs. 18–20; Lind and Brook (1980) p. 58, fig. 83; Dillard (1991) p. 62, pl. 6, fig. 2; Lenzenweger (1999) p. 43, pl. 47, fig. 11; John et al. (2003) p. 538, pl. 132, fig. I.

Dimensions: L: 61.68 µm, B: 40.87 µm, I: 17.81 µm.

Description: According to Figure 2H, the shapes of the semicells exhibit differences. It is likely that this species was observed after cell division, and that this is why one of the semicells had not completed its development. Cell 1.5 times longer than breadth; cell moderately constricted; sinus narrowly linear; semicell semielliptic; angles round and apex convex. Cell wall finely and closely punctate.

Ecology and distribution: This species was recorded in the epiphytic habitat in lake YL2. It was very rare
Lake YL2 is located at an elevation of 2980 m a.s.l. and is characterized by a pH value of 6.89. According to Lenzenweger (1999) and John et al. (2003), this is a cosmopolitan taxon and widespread in slightly acidic conditions.

**Figure 2.** A. *Closterium cornu*; B. *Actinotaenium curtum*; C,D. *Cosmarium anceps*; E. *Cosmarium boitierense*; F,G. *Cosmarium botrytis* var. *genniferum* (front and apical views); and H. *Cosmarium cucumis*. Scale bar = 20 μm.
waters in the Alps up to 2000 m a.s.l. and in acidic (pH 4.8–6.8) pools.

*C. holmiense var. hibernicum* (West) Schmidle (Figure 3A)

Lenzenweger 1999, p. 78, pl. 51, fig. 33.

**Dimensions:** L: 55.32 µm, B: 33.42 µm, I: 16 µm.

**Description:** Cell longer than breadth; sinus narrow and linear; semicells trapezoidal with broadly rounded basal angles; lateral margins concave and weakly converging; apical angles rounded; apex broadly truncated and slightly convex. There are dense and scattered pores along the cell wall.

**Ecology and distribution:** This was a very rare (VR) element in the epiphytic samples of lake YL2. It was found in slightly acidic water (pH 6.89) located at an elevation of 2980 m a.s.l. According to Lenzenweger (1999), this variety is acidophilic.

*C. impressulum var. alpicola* Schmidle (Figure 3B)

Lenzenweger, 1999, p. 90, pl. 53, figs. 16–17.

**Dimensions:** L: 22.72–23.03 µm, B: 17–18.23 µm, I: 5.46–7.30 µm.

**Description:** Cell longer than breadth; sinus deep, linear, and closed; cell roughly square in shape, angles rounded; lateral undulations shallow and not very pronounced.

**Ecology and distribution:** It was found in the epilithic and epiphytic samples of lakes ACL1 and IL. It was very rare (VR). Lakes ACL1 and IL are located at average elevations of 2980 m a.s.l. and 2668 m a.s.l., respectively, and are characterized by pH values of 7.04 and 6.89, respectively. Lenzenweger (1999) reported that this variety occurs in the benthic zone of mountain lakes up to 2500 m a.s.l.

*C. norimbergense var. depressum* (West and G.S.West) Willi Krieger and Gerloff (Figure 3C)

West & West (1908) p. 53, pl. 69, figs. 28–29; Huber-Pestalozzi (1982) p. 227, pl. 24, figs. 7–8; Lenzenweger (1999), p. 80, pl. 52, fig. 19; Coesel & Meesters (2007) p. 127, pl. 67, figs. 16–17.

**Dimensions:** L: 11.62 µm, B: 9.63 µm, I: 4 µm.

**Description:** Cell about as long as breadth; sinus linear, deep, closed for the greater part; semicells rectangular shaped, sides concave, and angles rounded. Cell wall is smooth.

**Ecology and distribution:** It was found in the epipelagic and epiphytic samples of lakes ARL1 and ACL2. This variety was very rare (VR). Lakes ARL1 and ACL2 are located at average elevations of 2687 m a.s.l. and 2712 m a.s.l., respectively, and are characterized by pH values of 6.16 and 7.02, respectively. Lenzenweger (1999) p. 94, pl. 52, fig. 36.

**Dimensions:** L: 28 µm, B: 20 µm, I: 6 µm.

**Description:** Cell longer than breadth; sinus deep, flat, and a large part closed; semicells pyramidal shaped. The undulation on the lateral sides evident. This makes it different from the nominate variety. Apical and basal angles broadly rounded; cell wall thick and coarsely scrobiculated.

**Ecology and distribution:** This variety was found in the epilithic and epiphytic samples of lakes ARL1 and ARL5. It was very rare (VR). Lakes ARL1 and ARL5 are located at average elevations of 2863 m a.s.l. and 2930 m a.s.l., respectively, and are characterized by pH values of 6.16 and 7.02, respectively. *Cosmarium paragranatoides var. dickii* was previously reported from waters at 1200 m a.s.l. with a pH value of 6.75 in Austria (Lenzenweger, 1999).

*C. pokornyanum* (Grunow) West and G.S.West (Figure 3D)

West and West (1905) p. 190, pl. 63, figs. 11–15; Dillard (1991) p. 131, pl. 10, fig. 14; Lenzenweger (1999) p. 95, pl. 52, fig. 27; Coesel and Meesters (2007) p. 131, pl. 66, figs. 15–17.

**Dimensions:** L: 21 µm, B: 14.51 µm, I: 5.29 µm.

**Description:** Cell distinctly longer than breadth; sinus linear, rather shallow, and narrowly open; semicells truncate–pyramidal from a base with parallel sides; basal angles rectangular; lower part of lateral sides slightly divergent and usually retuse; upper part of lateral sides longer, converging, and widely concave; apex truncate–retuse; upper angles rounded. Cell wall is smooth.

**Ecology and distribution:** We found this taxon in the epiphytic samples of a circumneutral habitat. It was very rare (VR). Lake YL3 is located at an elevation of 2980 m a.s.l. with a pH value of 6.8 in Austria (Lenzenweger, 1999; Coesel and Meesters, 2007).

*C. notabile var. subnotabile* (Wille) Coesel (Figure 3D)

Coesel and Meesters (2007) p. 127, pl. 68, fig. 19.

**Dimensions:** L: 32.37 µm, B: 24.21 µm, I: 14 µm.

**Description:** Cells longer than breadth; semicells subtrapeziform shaped; sinus fairly shallow, flat, and almost closed; lateral sides slightly convex; apex truncate. There are 6 crenate–undulate (including basal and apical angles) on the lateral sides. The apex has 4 crenate–undulate (including apical angles).

**Ecology and distribution:** *Cosmarium notabile var. subnotabile* was found in the epilithic samples of lake BL2. It was very rare (VR). Lake BL2 is located at an elevation of 2863 m a.s.l. and is characterized by a pH value of 6.75. According to Coesel and Meesters (2007), this variety is mesotrophic.

*C. paragranatoides var. dickii* Krieger and Gerloff (Figure 3E)

Lenzenweger (1999) p. 94, pl. 52, fig. 36.

**Dimensions:** L: 28 µm, B: 20 µm, I: 6 µm.

**Description:** Cell longer than breadth; sinus deep, flat, and a large part closed; semicells pyramidal shaped. The undulation on the lateral sides evident. This makes it different from the nominate variety. Apical and basal angles broadly rounded; cell wall thick and coarsely scrobiculated.

**Ecology and distribution:** This variety was found in the epilithic and epiphytic samples of lakes ACL1 and ARL5. It was very rare (VR). Lakes ARL1 and ARL5 are located at average elevations of 2687 m a.s.l. and 2930 m a.s.l., respectively, and are characterized by pH values of 6.16 and 7.02, respectively. *Cosmarium paragranatoides var. dickii* was previously reported from waters at 1200 m a.s.l. with a pH value of 6.8 in Austria (Lenzenweger, 1999).
m a.s.l. and is characterized by a pH value of 7.01. West and West (1905) noted that this species is principally found among mosses on wet limestone rocks in subalpine habitats. Lenzenweger (1999), on the other hand, stated that this species occurs in mountain lakes up to 2400 m a.s.l. According to Coesel and Meesters (2007), *Cosmarium pokornyanum* is mesotrophic.

*C. polygonum* var. *hexagonum* Grönl. (Figure 3G)

Lenzenweger (1999) p. 82, pl. 52, fig. 14.

**Dimensions:** L: 9.62 µm, B: 9.76 µm, I: 4.73 µm.

**Description:** Cell slightly wider than long; sinus deep, flat, and partly closed; semicells hexagonal and apex of the semicell slightly concave. There are granules on the cell wall of each of the basal angles of the semicells.

**Ecology and distribution:** It was found in the epiphytic samples of lake ARL1. It was very rare (VR). Lake ARL1 is located at an elevation of 2687 m a.s.l. and is characterized by a pH value of 6.19. This variety has only been reported by Lenzenweger from alpine lakes of the Central Alps (1999).

*C. pseudonitidulum* Nordstedt (Figure 3H)

West and West (1905) p. 195, pl. 63, fig. 26; Dillard (1991) p. 107, pl. 13, fig. 2; Lenzenweger (1999) p. 57, pl. 49, fig. 7; Coesel and Meesters (2007) p. 134, pl. 62, fig. 15.

**Dimensions:** L: 41.20 µm, B: 31.45 µm, I: 9.85 µm.

**Description:** Cell slightly longer than breadth; sinus deep, linear, and a large part closed; semicells trapeziform; lateral margins convex; basal and apex angles rounded. Cell wall is smooth.

**Ecology and distribution:** This species was found in the epiphytic samples of lake ARL1. It was very rare (VR). Lake ARL1 is located at an elevation of 2687 m a.s.l. and is characterized by a pH value of 6.19. Lenzenweger (1999) found it in a lake (pH 6.8–7) at an elevation of 1400 m in the Northern Alps of Austria. According to Coesel and Meesters (2007), this species is mesotrophic and occurs in slightly acidic and slightly alkaline waters.

*C. reniforme* var. *compressum* Nordstedt (Figure 3I)

West and West (1908) p. 158, pl. 79, figs. 3–4; Dillard (1991) p. 121, pl. 28, fig. 10; Lenzenweger (1999) p. 122, pl. 60, fig. 3; John et al. (2003) p. 546, pl. 134, fig. G; Coesel and Meesters (2007) p. 139, pl. 73, fig. 5.

**Dimensions:** L: 50.18 µm, B: 40.07 µm, I: 13.17 µm.

**Description:** Cell slightly longer than breadth; sinus deep, narrow, closed in the middle, but open widely to the outside and inside; semicells kidney-shaped and depressed. The median parts of the apex slightly truncate. Cell walls have granules which are rounded, disposed in obliquely decussating series.

**Ecology and distribution:** *C. reniforme* var. *compressum* was found in the epiphytic samples of lake ACL3. It was very rare (VR). Lake ACL3 is located at an elevation of 2711 m a.s.l. and is characterized by a pH value of 7.52. This variety is one of the desmids with large ecological valance. It is rather common in slightly acidic and in slightly alkaline (pH 6–8.6) waters and in slightly brackish waters (West and West, 1908; Lenzenweger, 1999; John et al., 2003; Coesel and Meesters, 2007).

*C. simplicius* (West and G.S.West) Grönl. (Figure 3J)

West and West (1912) p. 41, pl. 102, figs. 20–21; Dillard (1991) p. 125, pl. 40, fig. 4; Lenzenweger (1999) p. 113, pl. 60, fig. 20; Coesel and Meesters (2007) p. 140, pl. 71, figs. 1–2.

**Dimensions:** L: 51.81 µm, B: 20.46 µm, I: 20.24 µm.

**Description:** Cell about 2 times longer than breadth; sinus very shallow and widely open; semicells oblong, base rectangular and apex strongly convex. Cell wall furnished with verrucae arranged in regular vertical and horizontal rows.

**Ecology and distribution:** It was found in the epiphytic samples of lake ARL1. It was very rare (VR). Lake ARL1 is located at an elevation of 2687 m a.s.l. and is characterized by a pH value of 6.19. According to Coesel and Meesters (2007), this species is mesotrophic.

*C. subspeciosum* var. *transiens* Messikomer (Figure 3K)

Lenzenweger (1999) p. 151, pl. 64, fig. 9.

**Dimensions:** L: 33.19–40.31 µm, B: 26.81–31.46 µm, I: 10.46–12.53 µm.

**Description:** Cell about 1.3 times as long as breadth; cells roughly elliptical; sinus moderately deep and linearly closed; semicells rounded–trapezoidal; basal angles broadly rounded; sides flat convex. There are 6 nongranulated waves (crenate) on each side. Apex truncate and flat convex. Cell wall with radially extending rows of outgoing side waves, paired on the outside, to the center of the cell to form simple wads.

**Ecology and distribution:** This variety was found in the epipelic, epilithic, and epiphytic samples of lakes ACL2, YL2, and YL3. It was very rare (VR). Lakes ACL2, YL2, and YL3 are located at average elevations of 2712 m a.s.l., 2980 m a.s.l., and 2980 m a.s.l., respectively, and are characterized by pH values of 7.09, 6.89, and 7.01, respectively. According to Lenzenweger (1999), *C. subspeciosum* var. *transiens* occurs in meadow swamps and ditches (pH 6.7).

**Genus:** *Micrasterias* C.Agardh Ex Ralfs

*Micrasterias truncata* Brébisson Ex Ralfs (Figure 4A)

West and West (1905) p. 82, pl. 42, 45, figs. 1–8, 5–6; Lind and Brook 1980, p. 42, fig. 55; Huber-Pestalozzi (1982) p. 395, pl. 50–52, figs. 4–6, 1–22, 1–19; Dillard (1993) p. 112, pl. 19, fig. 3; Lenzenweger (1996) p. 108, pl. 14, fig. 1; John et al. (2003) p. 561, pl. 136, fig. M; Coesel and Meesters (2007) p. 90, pl. 51, figs. 3–5.

**Dimensions:** L: 93.15–103 µm, B: 90.83–93.20 µm.
Figure 3. A. *Cosmarium holmiense* var. *hibernicum*, B. *Cosmarium impressulum* var. *alpicola*, C. *Cosmarium norimbergense* var. *depressum*, D. *Cosmarium notabile* var. *subnotabile*, E. *Cosmarium paragranatoides* var. *dickii*, F. *Cosmarium pokornyanum*, G. *Cosmarium polygonum* var. *hexagonum*, H. *Cosmarium pseudonitidulum*, I. *Cosmarium reniforme* var. *compressum*, J. *Cosmarium simplicius*, and K. *Cosmarium subspeciosum* var. *transiens*. Scale bar = 20 μm.
Description: Cell elliptical with widely truncate poles; sinus linear and open towards the outside; semicells 5-lobed. The incisions between the two lateral lobes are slightly open and not so deep. Lateral lobes bilobulate with each lobule emarginated. Polar lobe very widely cuneate. Apex convex and slightly retuse in the middle. Cell wall is punctate.

Ecology and distribution: This species was found in the epiphytic samples of lake YL1. It was very rare (VR). Lake YL1 is located at an elevation of 2980 m a.s.l. and is characterized by a pH value of 6.89. This taxon belongs to desmids with a wide ecological valence and can be observed in acidic, slightly acidic, circumneutral and slightly alkaline, oligo-mesoeutrophic, dystrophic, and mesotrophic water bodies (West and West, 1905; Huber-Pestalozzi, 1982; Lenzenweger, 1996; John et al., 2003; Coesel and Meesters, 2007).

Genus: Spondylosium Brébisson Ex Kützing
Spondylosium papillosum West and G.S. West (Figure 4B)

West and West (1923) p. 223, pl. 161, figs. 6–7; Lind and Brook (1980) p. 112, fig. 165;
Lenzenweger (1997) p. 143, pl. 43, fig. 15.
Dimensions: L: 7.5 µm, B: 7.5 µm, I: 5 µm.
Description: Cell very small; cell as long as breadth; the constriction moderately deep; sinus obtuse and open; semicells elliptical with truncate apices. There are 3 very minute granules on the lateral sides. Cells united by apices to form twisted filaments.

Ecology and distribution: Spondylosium papillosum was found in the epiphytic samples of lake ARL1. It was very rare (VR). Lake ARL1 is located at an elevation of 2687 m a.s.l. and is characterized by a pH value of 6.89. It occurs in peat waters (Lenzenweger, 1997).

Genus: Staurastrum Meyen ex Ralfs
Staurastrum dilatatum Ehrenberg ex Ralfs (Figures 4C and 4D)

West and West (1912) p. 172, pl. 126, figs. 10–15; Lind and Brook (1980) p. 82, fig. 127; Dillard (1991) p. 65, pl. 4, fig. 3; Lenzenweger (1997) p. 85, pl. 26, figs. 1–2; John et al. (2003) p. 569, pl. 138, fig. E; Coesel and Meesters (2007) p. 181, pl. 92, figs. 15–17; Coesel and Meesters (2013) p. 91, pl. 53, figs. 9–15; Kim (2015) p. 48, figs. 53A–53G.

Dimensions: L: 30.57–33.66 µm, B: 29.98–30.57 µm.
Description: Cell little longer than breadth; cell deeply constricted; sinus widely open; semicell elliptic–fusiform; dorsal margins convex; lateral margins inflated in the middle. Cell wall finely and densely granulates. Granules are arranged in concentric rings around the angles. Semicells apical, view 4-angular. Lateral sides concave, angles broadly round.

Ecology and distribution: Staurastrum dilatatum was found in the epipelic and epiphytic samples of lakes YL1 and IL. It was very rare (VR). Lakes YL1 and IL are located at average elevations of 2980 m a.s.l. and 2670 m a.s.l., respectively, and are characterized by pH values of 6.85 and 6.78, respectively. According to the literature (John et al., 2003; Coesel and Meesters, 2013), this species is cosmopolitan and occurs in acidic and oligo–mesotrophic water bodies.

S. dybowskii Woloszynska (Figure 4E)
Coesel and Meesters (2007) p. 182, pl. 105, fig. 1. Coesel and Meesters (2013) p. 93, pl. 72, figs. 12–15.
Dimensions: B: 43.45 µm.
Description: This species is identified according to apical view. Semicells in apical view 3-radiate; sides concave. Angles produced into rather long processes. The inner series of granules on the semicell body were arranged in pairs or threesomes (actually, emarginate verrucae).

Ecology and distribution: Staurastrum dybowskii was found in the epipelic samples of lake ARL4. It was very rare (VR). Lake ARL4 is located at an elevation of 2890 m a.s.l. and is characterized by a pH value of 6.73. According to Coesel and Meesters (2013), this species occurs in plankton of oligo–mesotrophic and slightly acidic water bodies.

S. glaronense Messikommer (Figure 4F)
Coesel and Meesters (2013) p. 100, pl. 74, figs. 1–2.
Dimensions: B: 30.88–33.66 µm.
Description: This species was identified based on morphotaxonomic features only available in the apical view. Semicells in apical view 5-radiate the short, thick-set processes rounded–truncate at their apex. Semicell body with a cluster of granules near the base of each process.

Ecology and distribution: This species was found in the epiphytic samples of lake ARL1. It was very rare (VR). Lake ARL1 is located at an elevation of 2687 m a.s.l. and is characterized by a pH value of 6.19. It occurs in oligo–mesotrophic water bodies (Coesel and Meesters, 2013). According to Coesel and Meesters (2013), this species is only known from a site in the Swiss Alps.

S. lapponicum (Schmidle) Grönnblad (Figures 5A and 5B)
Dillard (1991) p. 86, pl. 3, fig. 15; Lenzenweger (1997) p. 100, pl. 25, fig. 7; Coesel and Meesters (2007) p. 188, pl. 92, figs. 6–8; Coesel and Meesters (2013) p. 112, pl. 53, figs. 5–8; Kim (2015) p. 65, figs. 75A–75H.

Dimensions: L: 28.09–30.87 µm, B: 26.93–35.94 µm, I: 9.38 µm.
Description: Cells about as long as breadth; cell deeply constricted; sinus widely open; semicells ellipsoid to subrhomboid in outline; apex and ventral margins convex; lateral angles rounded; in vertical view semicell is triangular; margins broadly concave; angles broadly rounded; cell wall beset with fine granules. The granules are arranged in concentric series around the angles.
Ecology and distribution: This species was found in the epipelic and epiphytic samples of lakes ACL3, IL, and YLP. It was very rare (VR). Lakes ACL3, IL, and YLP are located at average elevations of 2711 m a.s.l., 2670 m a.s.l.,...
and 2980 m a.s.l., respectively, and are characterized by pH values of 7.52, 6.78, and 7.20, respectively. According to the literature (Lenzenweger, 1997; Coesel and Meesters 2013; Kim, 2015), this species prefers slightly acidic (pH 6.7–6.9) and mesotrophic water bodies.

**S. punctulatum var. pygmaeum** (Brébisson ex Ralfs) West and G.S.West (Figure 5C)

West and West (1912) p. 184, pl. 128, figs. 1–3; Dillard (1991) p. 117, pl. 4, fig. 2; Lenzenweger (1997) p. 122, pl. 25, fig. 3; John et al. (2003) p. 574, pl. 138, fig. H.

**Dimensions:** B: 29.29 µm.

**Description:** This species was only identified according to its morphotaxonomic diagnostic features as seen in the vertical view. Semicells 3-radiate, sides slightly concave. Granules minute but acute.

**Ecology and distribution:** It was found in the epiphytic samples of lake YL3. This variety was very rare (VR). Lake YL3 is located at an elevation of 2980 m a.s.l. and is characterized by a pH value of 7.1. *S. punctulatum* var. *pygmaeum* occurs in small waters (pH 6.5) (Lenzenweger, 1997).

**Genus: Teilingia Bourrelly**

*Teilingia excavata* var. *subquadrata* (West and G.S.West ex N. Carter) Stein (Figure 5D)

Dillard (1993) p. 119, pl. 34, fig. 3; Lenzenweger, 1997, p. 147, pl. 43, fig. 25.

**Dimensions:** L: 8.73–9.30 µm, B: 9.70–10.03 µm.

**Description:** Cells relatively wider and more deeply constricted; sinus narrow; semicells oblong; upper angles more widely rounded than the lower.

**Ecology and distribution:** This variety was found in the epipelagic and epiphytic samples of lakes ARL1 and BL4. It was very rare (VR). Lakes ARL1 and BL4 are located at average elevations of 2687 m a.s.l. and 2924 m a.s.l., respectively, and are characterized by pH values of 6.19 and 7.04, respectively. The ecological characteristics of this variety are similar to the type species (*Teilingia excavata*), which is common in acidic *Sphagnum* marshes (pH 5–5.8) and in peatlands (2300 m a.s.l., the Alps) (Lenzenweger, 1997).

**Genus: Tetmemorus Ralfs ex Rafls**

*Tetmemorus laevis* Ralfs ex Rafls (Figures 5E and 5F)

West and West (1904) p. 222, pl. 32, figs. 11–16; Huber-Pestalozzi (1982) p. 301, pl. 39, figs. 1–4; Dillard (1990) p. 144, pl. 51, fig. 3; Lenzenweger (1996) p. 63, pl. 8, fig. 13; John et al. (2003) p. 583, pl. 144, fig. H; Coesel and Meesters (2007) p. 70, pl. 39, figs. 1–2.

**Dimensions:** L: 72.00–89.02 µm, B: 20.06–24.87 µm.

**Description:** Cells longer than breadth, with a slight median constriction; cells in front view from the midregion toward the ends moderately tapering, with convex to concave lateral sides; semicells very gradually attenuated to the apices; apex fairly broad and rounded, with a deep median incision; in side view strongly attenuated; cell wall minutely punctate and colorless.

**Ecology and distribution:** This species was found in the epiphytic samples of lakes YL2 and YL3. It was very rare (VR). Lakes YL2 and YL3 are located at an elevation of 2980 m a.s.l. and are characterized by pH values of 6.89 and 7.01, respectively. *Tetmemorus laevis* has relatively wide ecological tolerance and worldwide distribution. It is associated with acidic, slightly acidic, slightly alkaline (pH 3.8–8), oligotrophic, oligo–mesotrophic, alpine (2150–3600 m a.s.l.), and tropic habitats (West and West, 1904; Huber-Pestalozzi, 1982; Lenzenweger, 1996; John et al., 2003; Coesel and Meesters, 2007).

In total, 26 desmid species were described herein as new records for the freshwater algal flora of Turkey. Qualitatively, *Cosmarium* was the most dominant and diverse genus with 15 species (57.69%), followed by the subdominant *Staurastrum* (5 species; 19.23%); whereas the other genera were only represented by 1 species (3.84%). The dominance of the genus *Cosmarium* in these mountain nature park habitats is highly congruent with previous studies on similar ecosystems in the Northern Hemisphere (Medvedeva, 2001; Sterlyagova, 2008; Šovran et al., 2013; Briškaite et al., 2016). *Cosmarium* is the genus that typifies desmids (Lee, 2015). According to recent phylogenetic data, Gontcharov and Melkonian (2008b) showed that *Cosmarium* is polyphyletic in origin, and its species are distributed within 11 well-supported clades.

Variation in the dimensions of some identified taxa have been observed, and this phenomenon can be explained as a type of ecomorphological adaptation to the habitats studied. For instance, *Closterium cf. cornu* has a cell width of 12.75–13.60 µm, while West and West (1904) and John et al. (2003) stated that cell width ranges 6.5–8.8 µm and 5–10 µm, respectively. However, it is still compatible with data available in Lind and Brook (1980) (16–36 µm). In addition, *Actinotaenium curtum* in the current study is narrower in width than findings published in the literature, i.e. 15.81 µm vs. 18–25 µm in Lenzenweger (1996) and Coesel and Meesters (2007) and 18–32 µm in John et al. (2003). Nevertheless, Dillard (1991) pointed out that the cell width of *A. curtum* ranges 15–24 µm. The dimensions of *Cosmarium holmiense* var. *hibernicum* (L: 55.32 µm, B: 33.42 µm, I: 16 µm), *C. impressulum* var. *alpica* (L: 22.72–23.03 µm, B: 17–18.23 µm, I: 5.46–7.30 µm), and *C. polygonum* var. *hexagonum* (L: 9.62 µm, B: 9.76 µm, I: 4.73 µm) are similarly incompatible with the literature (Lenzenweger, 1999).

To date, *Cosmarium polygonum* var. *hexagonum* and *Staurastrum glaronense* have only been reported by Lenzenweger (1999) and Coesel and Meesters (2013) from the Central Alps and Swiss Alps. There is no information regarding distribution of these species in the Algaebase.
(Guiry and Guiry, 2019). Therefore, our results will be the second published for these interesting species.

On the basis of the hydrochemical data, the lakes and the pond in Artabel Lakes Nature Park are characterized
by relatively acidic to circumneutral waters. Furthermore, our results show that desmids are not merely one of the main freshwater microalgae groups that occur in high-mountain lakes biotopes in Turkey; they also inhabit microhabitats with oligotrophic conditions characterized by relatively acidic to weakly alkaline waters with low conductivity (Saber et al., 2018). Geographical and ecological analyses also showed that the desmid flora is typical, with a predominance of cosmopolitan species, planktic–benthic forms, acidophilic and pH-indifferent species, and halophobic-to-salinity–indifferent species.

In conclusion, the investigated lakes can be classified as relatively pristine habitats in good ecological condition based on their hydrochemical and desmid biodiversity characteristics.

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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: 269-274. doi: 10.4194/1303-2712-v14-1-9
Atıcı T (2018). Use of cluster analysis and similarity of algae in Eastern Black Sea Region Glacier Lakes (Turkey), Key area: Artabel Lakes Natural Park. Gazi University Journal of Science 31: 25-40.
Aysel V (2005). Check-list of the freshwater algae of Turkey. Journal of the Black Sea/Mediterranean Environment 11: 1-124.
Bourrelly P, Couté A (1991). Desmidiées de Madagascar (Chlorophyta, Zygophyceae). 1st ed. Stuttgart, Germany: J Cramer (in French).
Briškaite R, Patova E, Juzenas S (2016). Desmid flora in the lakes of the Khrebtovyı Nature Reserve in the Polar Ural (Russia). Botanica Lithuanica 22: 113-122.
Brook AJ, Williamson DB (2010). A Monograph on Some British Desmids. 1st ed. London, UK: The Ray Society.
Coesel PFM, Kwakkestein R, Verschoor A (1978). Oligotrophication and eutrophication tendencies in some Dutch moorland pools, as reflected in their desmid flora. Hydrobiologia 61: 21-31.
Coesel PFM (1998). Sieralgen en Natuurwaarden. 1st ed. Utrecht, the Netherlands: KNNV Publishing (in Dutch).
Coesel PFM, Meesters KJ (2007). Desmids of the Lowlands: Mesotaeniaceae and Desmidiaceae of the European Lowlands. 1st ed. Zeist, the Netherlands: KNNV Publishing.
Coesel PFM, Meesters KJ (2013). European Flora of the Desmid Genera Stauroastrum and Staurodesmus. 1st ed. Zeist, the Netherlands: KNNV Publishing.
Doğa Koruma ve Milli Parklar Genel Müdürlüğü (2013). Artabel Gölleri Tabiat Parkı Uzun Devreli Gelişme Planı Analitik Etüt ve Sentez Raporu. Ankara, Turkey: Doğa Koruma ve Milli Parklar Genel Müdürlüğünü (in Turkish).
Dillard GE (1991). Freshwater Algae of the Southeastern United States, Chlorophyceae: Zygmematales: Desmidiaeae. Part 4 (Section 2). 1st ed. Stuttgart, Germany: J Cramer.
Dillard GE (1993). Freshwater Algae of the Southeastern United States, Chlorophyceae: Zygmematales: Desmidiaeae. Part 6 (Section 4). 1st ed. Stuttgart, Germany: J Cramer.
Gontcharov AA (2008a). Phylogeny and classification of Zygmematophyceae (Streptophyta): current state of affairs. Fottea 8: 87-104.
Gontcharov AA, Melkonian M (2008b). In search of monophyletic taxa in the family Desmideaeae (Zygmematophyceae, Viridiplantae): the genus Cosmarium. American Journal of Botany 95: 1079-1095. doi: 10.3732/ajb.0800046
Gönülol A (2018). Turkish Algae Electronic Publication. Samsun, Turkey: Samsun Ondokuz Mayıs University. Available online at http://turkiyealgleri.omu.edu.tr
Guiry MD, Guiry GM (2019). AlgaeBase. Worldwide Electronic Publication. Galway, Ireland: National University of Ireland. Available online at http://www.algaebase.org
Huber-Pestalozzi G (1982). Das Phytoplankton des Süßwassers Systematik und Biologie. 8. Teil, 1. Halte. 1st ed. Stuttgart, Germany: E. Schweizerbartische Verlagsbuchhandlung (Nägele u. Obermiller) (in German).
John DM, Whitton BA, Brook AJ (2003). The Freshwater Algal Flora of the British Isles: An Identification Guide of Freshwater and Terrestrial Algae. 1st ed. Cambridge, UK: Cambridge University Press.
Kim HS (2015). Algal Flora of Korea. Volume 6, Number 6 Charophyta: Conjugatophyceae (Desmids III): Desmidiaeae: Desmidiaeae: Staurodesmus and Stauroastrum I, Freshwater Green Algae. 1st ed. Seoul, Incheon, Korea: National Institute of Biological Resources, Ministry of the Environment.
Kocataş A (1992). Ekoloji (Çevre Biyolojisi). 1st ed. İzmir, Turkey: Ege Üniversitesi Matbaası (in Turkish).
Kouwets FAC (1998). Southern elements in the desmid flora of France. Biologia 53: 445-455.
Kouwets F (2008). The species concept in desmids: the problem of variability, infraspecific taxa and the monothetic species definition. Biologia 63: 881-887.

Lee OM (2015). Additions to the six taxa of the genus Cosmarium (Desmidiaceae, Charophyta) in Korea. Journal of Ecology and Environment 38: 629-636.

Lenzenweger, R. (1996). Desmidiaceenflora von Österreich. Teil 1. 1st ed. Berlin-Stuttgart, Germany: J. Cramer (in German).

Lenzenweger R (1997). Desmidiaceenflora von Österreich. Teil 2. 1st ed. Berlin-Stuttgart, Germany: J. Cramer (in German).

Lenzenweger R (1999) Desmidiaceenflora von Österreich. Teil 3. 1st ed. Berlin-Stuttgart, Germany: J. Cramer (in German).

Lind EM, Brook AJ (1980). Desmids of the English Lake District. 1st ed. Ambleside, UK: Freshwater Biological Association Scientific Publication.

Medvedeva LA (2001). Biodiversity of aquatic algal communities in the Sikhote-Alin biosphere reserve (Russia). Cryptogamie, Algologie 22: 65-100.

Round FE (1953). An investigation of two benthic algal communities in Malham Tarn, Yorkshire. Journal of Ecology 41: 174-197.

Růžička J (1977). Die Desmidiaceen Mitteleuropa. Band 1. 1st ed. Stuttgart, Germany: Schweizerbartische Verlagsbuchhandlung (in German).

Saber AA, Kouwets FAC, Haworth EY, Cantonati M (2018). A new Euastrum species (Conjugatophyceae, Streptophyta) from the Western Desert of Egypt. Cryptogamie, Algologie 39(2): 215-226. doi: 10.7872/crya.v39.iss2

Šimek O (1997). Changes in desmid flora of the nature reserve Režabinec in South Bohemia after 30 years of intense environmental agriculture. Algological Studies 87: 59-85.

Sládečková A (1962). Limnological investigation methods for the periphyton ("Aufwuchs") community. Botanical Review 28: 286-350.

Šovran S, Jovanovic V, Krizmanic J, Cvijan M (2013). Desmid flora from four bogs in Serbia. Archives of Biological Sciences 65: 721-732. doi: 10.2298/ABS1302721S

Štastný J (2009). The desmids of the Swamp Nature Reserve (North Bohemia, Czech Republic) and a small neighbouring bog: species composition and ecological condition of both sites. Fottea 9: 135-148.

Štastný J (2010). Desmids (Conjugatophyceae, Viridiplantae) from the Czech Republic; new and rare taxa, distribution, ecology. Fottea 10: 1-74.

Sterlyagova IN (2008). Desmids in mountain lakes of the subpolar Urals. Biologia 63: 915-920. doi: 10.2478/s11756-008-0142-8

Şahin B (1998). Some new records of desmids from Turkey. Pakistan Journal of Botany 30: 7-13.

Şahin B (2000). Some new desmids records for the 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.

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

Şahin B (2007). Two new records for the freshwater algae of Turkey. Turkish Journal of Botany 33: 153-156.

Şahin B (2008). Species composition and diversity of epipelic algae in Limni Lake (Gümüşhane/Turkey). Acta Botanica Hungarica 50: 397-405. doi: 10.1556/ABot.50.2008.3-4.16

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

Şahin B, Akar B (2007). The desmid flora of some high mountain lakes of the Turkish Eastern Black Sea Region. Pakistan Journal of Botany 39: 1817-1832.

Şahin B, Akar B (2019). New records from Artabel Lakes Nature Park (Gümüşhane/Turkey) to the freshwater algal flora of Turkey. Turkish Journal of Botany 43: 135-142. doi: 10.3906/bot-1805-8

West W, West GS (1904). A Monograph of the British Desmidiaceae. Volume I. 1st ed. London, UK: Printed for the Ray Society.

West W, West GS (1905). A Monograph of the British Desmidiaceae. Volume II. 1st ed. London, UK: Printed for the Ray Society.

West W, West GS (1908). A Monograph of the British Desmidiaceae. Volume III. 1st ed. London, UK: Printed for the Ray Society.

West W, West GS (1912). A Monograph of the British Desmidiaceae. Volume IV. 1st ed. London, UK: Printed for the Ray Society.

West W, West GS (1923). A Monograph of the British Desmidiaceae. Volume V. 1st ed. London, UK: Printed for the Ray Society.