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AUTHORS: Bülent SAHİN

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## New desmid records from Kaçkar Mountains National Park (Rize/Turkey)

Bülent ŞAHİN<sup>\*1</sup>

ORCID: 0000-0002-5477-9676

<sup>1</sup> Trabzon University, Department of Biology Education, Fatih Education Faculty, 61335 Söğütlü-Trabzon, Türkiye

### Abstract

The periphytic algal samples were taken from 14 lakes and one pond in the Kaçkar Mountains National Park in 2020. The samples were observed under light microscope for their morphometric characteristics based identification. At the end of the research, 78 taxa belonging to the Charophyta division were identified. 7 of them, which are *Closterium jenneri* var. *curvatissimum* (West & G.S.West) A.J.Brook & D.B.Williamson, *Cosmarium margaritifera* f. *regularis* (Nordstedt) West & G.S.West, *Euastrum ansatum* var. *concaum* Willi Krieger, *E. verrucosum* var. *coarctatum* Delponte, *E. verrucosum* var. *planctonicum* West & G.S.West, *Staurastrum capitulum* Brébisson and *S. sexcostatum* Brébisson ex Ralfs, were determined as new records for the desmid flora of Turkey. In this study, morphotaxonomy, ecology, and distribution of each species are discussed in detail and it has been also recorded the geographic distribution of desmid species in Turkey.

**Key words:** Kaçkar Mountains National Park, high mountain lakes, desmids, new records, Turkey

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## Kaçkar Dağları Milli Park'ından (Rize/Türkiye) yeni desmid kayıtları

### Özet

Perifitik alg örnekleri 2020 yılında Kaçkar Dağları Milli Parkı'nda bulunan 14 göl ve bir göletten alınmıştır. Örnekler, morfometrik özelliklere dayalı tanımlamaları için ışık mikroskopunda incelenmiştir. Araştırma sonucunda Charophyta bölümüne ait 78 takson tespit edilmiştir. Bunlardan 7 tanesi *Closterium jenneri* var. *curvatissimum* (West & G.S.West) A.J.Brook & D.B.Williamson, *Cosmarium margaritifera* f. *regularis* (Nordstedt) West & G.S.West, *Euastrum ansatum* var. *concaum* Willi Krieger, *E. verrucosum* var. *coarctatum* Delponte, *E. verrucosum* var. *planctonicum* West & G.S.West, *Staurastrum capitulum* Brébisson ve *S. sexcostatum* Brébisson ex Ralfs Türkiye desmid florası için yeni kayıt olarak belirlenmiştir. Bu çalışmada, her bir türün morfotaksonomisi, ekolojisi ve yayılışları ayrıntılı olarak ele alınmış ve desmid türlerinin Türkiye'deki coğrafi yayılışları kaydedilmiştir.

**Anahtar kelimeler:** Kaçkar Dağları Milli Parkı, yüksek dağ gölleri, desmidler, yeni kayıtlar, Türkiye

### 1. Introduction

High mountain lakes are different aquatic ecosystems. They have different light, nutrient, temperature and pressure conditions from other aquatic ecosystems [1]. These conditions occur a suitable environment for the development and settlement of unique algae (especially desmids) species. Algae are one of the important components of high mountain lake ecosystems. They form a particular spectrum of taxonomic groups, with rare and distinctive species, and are considered to be indicators of climatic changes. Bacillariophyta, Chlorophyta and Charophyta are among the important algal groups of these ecosystems [2].

\* Corresponding author / Haberleşmeden sorumlu yazar: Tel.: +905336338855; Fax.: +904622487344; E-mail: bulentsahin61@gmail.com

Desmids, which belong to the Zygnematophyceae class, are unicellular or pseudo-filamentous, cosmopolitan and k-strategist organisms. They are usually found in slightly acidic waters with low nutrient concentration and low conductivity. They are sensitive to changes in the aquatic ecosystems, and they are, therefore, used as bioindicators. For these reasons, recognizing desmids is important in terms understanding of their relationships with their environment [3].

The complex community of microalgae, cyanobacteria, microinvertebrates and detritus, which are dependent on organic and inorganic environments, is called periphyton. These organisms are called epiphytic if they are found in the sediment, epilithic if they are attached to stony substrates, and epiphytic if they are attached to aquatic plants [4]. Especially, periphytic microalgae play key roles in the energy and matter cycles in the littoral zones [5]. Among the periphytic algal, the desmids form an important group in number of genera and species, and they use as indicators of water quality, especially in oligo- to mesotrophic softwater lakes [3].

The Eastern Black Sea Region is one of the important geographical regions of Turkey. The region, which has a rainy and temperate climate, has rich fauna and flora diversity. There are many glacial lakes in the mountains reaching an altitude of 4000 m (e.g. Kaçkar Mountain). Algological studies in the region started in 1990 and are actively continuing until present. During this time, a lot of data on freshwater algae, especially on desmids, were accumulated [6-8]. However, considering the size of the region, which is about 37.551 km<sup>2</sup>, and the abundance of rivers, lakes (especially high mountain lakes) and different types of water bodies, there are still a lot of areas not examined from the algological point of view.

In this study, the morphologies, ecologies and distributions of 7 desmid species, which are new records for the desmid flora of Turkey, are discussed.

## 1. Materials and methods

### 2.1. Study area

Kaçkar Mountains National Park is located in the Eastern Black Sea Region of Turkey, on the Eastern Black Sea Mountain range, within the borders of Çamlıhemşin district of Rize, Yusufeli district of Artvin province and İspir district of Erzurum province. Covering an area of 51,550 ha, the National Park lies between 40° 57' 49"- 40° 42' 10" northern latitudes and 41° 14' 45"- 40° 51' 27" east longitudes (Figure 1) [9, 10].

Kaçkar Mountains National Park includes mainly granitic and volcanic rocks ranging from the Late Cretaceous to Eocene in age. There are four major soil groups, which are high mountain-meadow soils, limeless brown forest soil, red yellow soils and gray brown soils, in the Park area. In the lower parts of the Kaçkar Mountains National Park, for example, around Ayder Plateau, the temperatures vary between 0 and 4 °C in winter months, while a rapid change is experienced in the spring and autumn months and rises above 18 °C in summer. On the other hand, above 3000 m, the temperatures drop down to -6 °C in winter, while in summer they vary between 6 and 9 °C. The aquatic ecosystem of Kaçkar Mountains National Park consists of stream and lake ecosystems. There are 100 glacier lakes in the park area. Kaçkar Mountains National Park, which has a rich biodiversity, is also home to many endemic species such as *Papaver lateritium*, *Barbarea trichopoda*, *Centaurea appendicigera*, *Alopecurus laguroides*, *Mertensiella caucasica*, *Bufo bufo*, *Darevskia derjugini* and *Vipera kaznokovi* [9].

### 2.2 Sampling and laboratory studies

The algal samples were taken from Kapılı Lakes (KPL)-1, 2, 3 on 19 July 2020, from Kavron Lake (KVL) on 28 August 2020 and from Adsız Pond (AP) on 10 September 2020. Epipellic algae were taken with a glass tube from the surface of the sediments. Epilithic and epiphytic samples were taken from stones and macrophyte plants (*Potamogeton* sp. and *Juncus* sp.) and washed into plastic bottles. 4% formaldehyde was used to preserve the samples [11, 12]. In the field, water temperature, dissolved oxygen, conductivity and pH were measured using Thermo Orion-4-Star pH and YSI-55 portable meters. In the lab, the light microscope (Leica DM 2500, Leica MC170 HD camera) was used to identify and photograph the species.

The species were identified following West and West [13-17], Ruzicka [18], Lind and Brook [19], Förster [20], Croasdale et al. [21, 22], Dillard [23, 24], Lenzenweger [25, 26], John et al. [27], Brook and Williamson [28], Coesel and Meesters [29, 30]. The control of the species and the current status of nomenclature were made by using the relevant sources [6-7, 31-33].

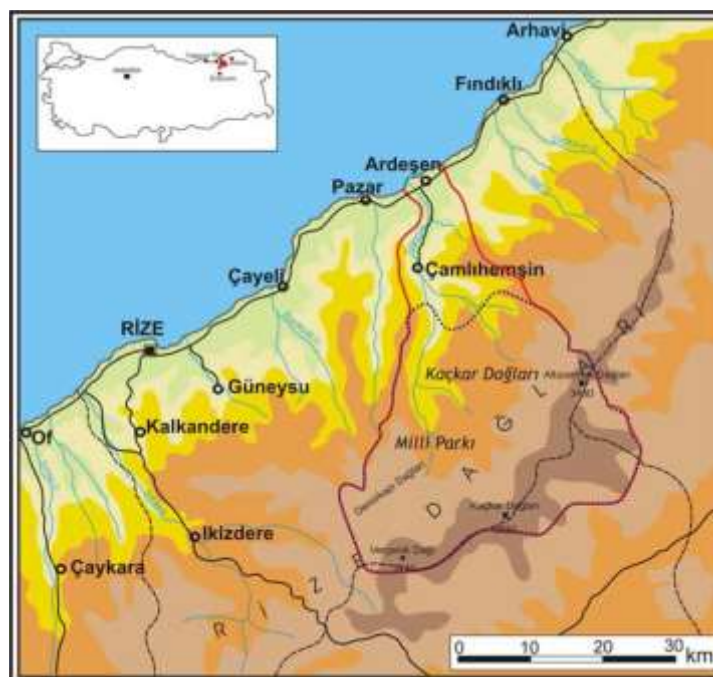


Figure 1. Location of the Kaçkar Mountains National Park [10].

## 2. Results

### 3.1. Physical and chemical analyses

The results of the physical and chemical analysis of the studied waters are given in Table 1.

Table 1. The some physical and chemical characteristics of the studied waters.

Lakes Parameters	Kapılı Lakes-1	Kapılı Lakes-2	Kapılı Lakes-3	Kavron Lake
Geographic coordinates	40°42'56".59 N 40°54'51".71 E	40°43'08".70 N 40°54'55".30 E	40°42'34".73 N 40°54'49".02 E	40°52'24".39 N 41°09'45".73 E
Altitude (m a.s.l.)	2980	2973	3074	2911
Area (m <sup>2</sup> )	70.529	14.879	35.738	9.007
Temperature (°C)	14.2	14.0	14.5	14.7
Dissolved oxygen (mg/L)	8.03	8.33	8.14	8.55
pH	6.30	6.30	6.55	7.18
Conductivity (µS/cm)	23.4	23.2	27.1	19.9

### 3.2. Taxonomic account

7 out of 78 Charophyta members identified as a result of the research were identified as new records for the desmid flora of Turkey. They belong to 4 genera, i.e., *Closterium* (1), *Cosmarium* (1), *Euastrum* (3) and *Staurostrum* (2). The morphotaxonomy, ecology, and distribution of each species are given below. The following abbreviations were used: Length: L, Breadth: B, Breadth of isthmus: I.

**Phylum: Charophyta**

**Phylum: Charophyta**

**Class: Zygnematophyceae**

**Subclass: Zygnematophycidae**

**Order: Desmidiales**

**Family: Closteriaceae**

**Genus: *Closterium***

***Closterium jenneri* var. *curvatissimum* (West & G.S.West) A.J.Brook & D.B.Williamson (Figure 2a)**

West & West, 1904, p.114, pl. 11, fig. 4.

Ruzicka, 1977, p. 235, pl. 28, figs 23, 24.

Lenzenweger, 1996, p.37, pl. 5, fig. 14.

Brook & Williamson, 2010, p. 314, pl. 149, fig. 1.

**Homotypic synonym:** *Closterium cynthia* var. *curvatissimum* West & G.S.West 1903

**Dimensions:** L: 95.24 µm, B: 13.91 µm.

**Description:** Cells 6.8 times longer than wide, strongly curved, gradually narrowed to the apices. Apices broadly rounded. Cell wall finely striate and yellow-brown in colour. This variety differ markedly from the nominal variety in that the ends curve inwards.

**Ecology:** This is a very rare variety, so that there were no found knowledges about the ecological properties of this variety in the literature [18]. Unfortunately, we could not take the water sample from the Adsız Pond. It was found in the epiphytic samples (*Potamogeton* sp.) of the Adsız Pond (Table 1).

**Distribution:** (as *Closterium cynthia* var. *curvatissimum* West & G.S.West) *Europe:* Austria, Britain, Europe, Netherlands, *Australia and New Zealand:* New South, (as *Closterium jenneri* var. *curvatissimum* (West & G.S.West) A.J.Brook & D.B.Williamson) *Europe:* Britain, Ukraine [33].

**Family:** Desmidiaceae

**Genus:** *Cosmarium*

***Cosmarium margaritifera* f. *regularis* (Nordstedt) West & G.S.West (Figure 2b)**

West & West, 1908, p. 203, pl. 83, fig. 12.

Croasdale & Flint, 1988, p. 74, pl. 45, figs. 13-15, pl. 46, figs 1-3.

**Homotypic synonym:** *Cosmarium confusum* var. *regularis* Nordstedt 1887

**Dimensions:** L: 41.22 µm, B: 37.53 µm, I: 13.54 µm.

**Description:** Cells slightly longer than broad and very deeply constricted. Sinus deep and narrow. Semicells broadly pyramide-truncate. Basal and upper angles rounded. Sides slightly convex. Apex wide and straight. There are small granules on the apex.

**Ecology:** Croasdale and Flint [21] states that this form occurs in acidic lakes and pools. In this study, it was found in the epipellic samples of the Adsız Pond (Table 1).

**Distribution:** (as *Cosmarium confusum* var. *regularis* Nordstedt) *Europe:* France, *Australia and New Zealand:* New Zealand, (as *Cosmarium margaritifera* f. *regularis* (Nordstedt) West & G.S.West) *Europe:* Germany, *North America:* Québec, *Asia:* Russia (Far East), *Australia and New Zealand:* New Zealand, Northern Territory [33].

**Genus:** *Euastrum*

***Euastrum ansatum* var. *concauum* Willi Krieger (Figure 2c)**

Lenzenweger, 1996, p.74, pl. 9, fig. 5.

**Synonym:** No.

**Dimensions:** L: 100.48-100.78 µm, B: 50.81-51.14 I: 10.35-10.99 µm.

**Description:** Cells 2 times longer than wide with trapezoidal semicell. Sinus deeply constricted and linear. Basal lobes and apices broadly rounded, the indentation between the basal and parietal lobe is very pronounced. Apex rounded-truncate with a narrow deep incision. Cell wall punctate.

**Ecology:** This variety found occasionally in moderately acidic moors in the Alps [25]. In this study, it was identified in the epipellic and epilithic samples of the Kapılı Lakes-1, Kapılı Lakes -2 and Kavrön Lake (Table 1).

**Distribution:** (as *Euastrum ansatum* var. *concauum* Willi Krieger) *Europe:* Austria, Germany, *South America:* Brazil, *Australia and New Zealand:* Northern Territory [33].

***E. verrucosum* var. *coarctatum* Delponte (Figure 2d)**

West & West, 1905, p. 66, pl. 40, fig. 4.

Förster, 1982, p. 347, pl. 47, fig. 4.

Dillard, 1993, p. 74, pl. 8, fig. 21.

Lenzenweger, 1996, p.92, pl. 12, figs 7, 8.

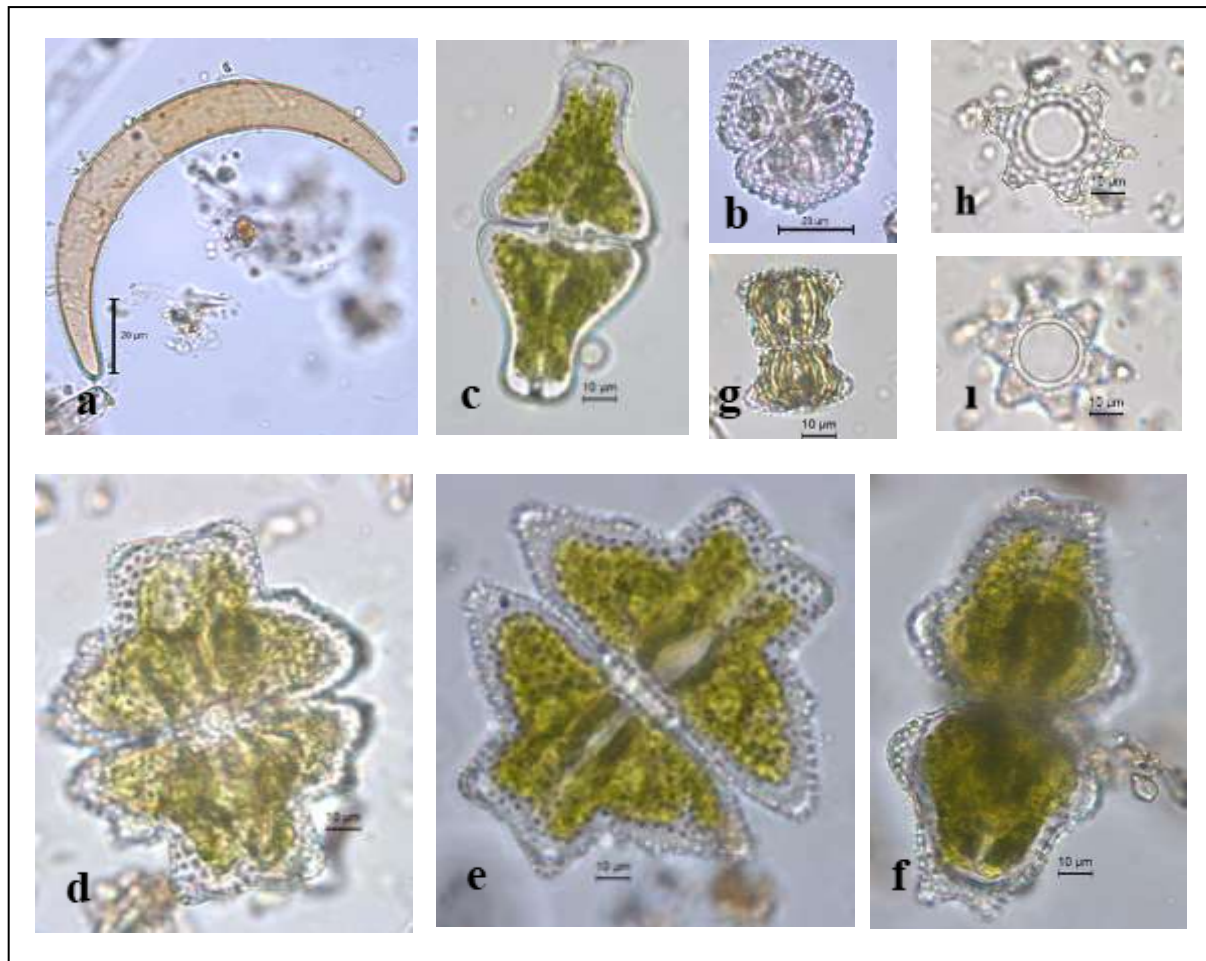
**Synonym:** No.

**Dimensions:** L: 109.84 µm, B: 94.75 µm, I: 26.53 µm.

**Description:** Cells only a little longer than wide. Sinus linear, closed, and open at the end. All lobes very short, polar lobe prominent, exserted, apex only slightly retuse, lateral lobes scarcely bilobulate, widely retuse. Basal lobes slightly raised and tightly rounded at the ends, indentation between the basal and the small lateral lobes flat.

**Ecology:** This variety prefers temperate climate and is absent in the tropics. Mainly, it residing in the littoral areas of lakes, which have pH 7 value [20]. It was found in the epipellic samples of the Kapılı Lakes-1 (Table 1).

**Distribution:** (as *Euastrum verrucosum* var. *coarctatum* Delponte) *Europe:* Austria, Britain, France, Ireland, Italy, Latvia, Ukraine, *North America:* New Jersey, Québec, *Asia:* China, Russia [33].



**Figure 2.** a. *Closterium jenneri* var. *curvatissimum*, b. *Cosmarium margaritifera* f. *regularis*, c. *Euastrum ansatum* var. *concavum*, d. *E. verrucosum* var. *coarctatum*, e, f. *E. verrucosum* var. *planctonicum* (e. General view, f. Apical view), g. *Staurastrum capitulum*, h, i. *S. sexcostatum*. Scale bar: 10, 20 µm.

***E. verrucosum* var. *planctonicum* West & G.S.West (Figures 2e, f)**

West & West, 1905, p. 67, pl. 40, fig. 7.

Förster, 1982, p. 347, pl. 48, fig. 3.

Dillard, 1993, p. 74, pl. 9, fig. 3.

John et al., 2003, p. 556, pl. 136, fig. L.

**Synonym:** No.

**Dimensions:** L: 113.07 µm, B: 122.15 µm, I: 24.48 µm.

**Description:** The width of the cell is longer than its length. Sinus deep, linear and widely open for the greater part. This variety has a significantly flatter basal part. The apical part appears more distinct due to its diverging sides. Lateral lobes entire and obtusely conical.

**Ecology:** It was described from epipelagic samples in the Kapılı Lakes-2 and Kapılı Lakes-3 (Table 1).

**Distribution:** (as *Euastrum verrucosum* var. *planctonicum* West&G.S.West) Europe: Britain [33].

**Genus:** *Staurastrum*

***Staurastrum capitulum* Brébisson (Figure 2g)**

West & West, 1912, p. 124, pl. 118, figs. 7, 10.

Dillard, 1991, p. 50, pl. 3, fig. 9.

Croasdale et al., 1994, p. 88, pl. 80, fig. 1.

Lenzenweger, 1997, p. 79, pl. 42, fig. 9.

Coesel & Meesters, 2013, p. 80, pl. 58, figs. 8-10.

**Homotypic synonym:** *Cylindriastrum capitulum* (Brébisson) Palamar-Mordvintseva 1982

**Heterotypic synonyms:** *Staurastrum amoenum* Hilse 1866, *Staurastrum capitulum* var. *amoenum* (Hilse) Rabenhorst 1868, *Staurastrum capitulum* var. *dimidio-minus* Grönblad 1964

**Dimensions:** L: 43.53 µm, B: 24.42 µm, I: 14.99 µm.

**Description:** Cells 1.7 times longer than wide and slightly constricted. Sinus a small acute-angled notch. Semicells campanulate in outline. Lateral margins concave, apex slightly retuse. Angles broadly rounded. There are acute granules, which arranged in concentric series near the angles, at the cell wall in the apical region.

**Ecology:** This species found in benthic of acidic to neutral, oligo-mesotrophic water bodies, also in fens and alpine ponds up to an altitude of 2500 m [26, 30]. It was found in the epipellic samples of the Kapılı Lakes-1 (Table 1).

**Distribution:** (as *Staurastrum capitulum* Brébisson) *Europe:* Austria, Britain, Bulgaria, Czech Republic, France, Germany, Hungary, Ireland, Italy, Latvia, Romania, Serbia, Slovakia, Spain, *North America:* Florida, North Carolina, Northwest Territories, Tennessee, *Asia:* Japan, (as *Staurastrum amoenum* Hilse) *Europe:* France, Ireland, (as *Cylindriastrum capitulum* (Brébisson) Palamar-Mordvintseva) *Asia:* Russia [33].

***S. sexcostatum* Brébisson ex Ralfs (Figures 2h, i)**

West & West, 1923, p. 147, pl. 150, fig. 14.

Lind & Brook, 1980, p. 100, fig. 152.

Dillard, 1991, p. 125, pl. 5, fig. 2.

Lenzenweger, 1997, p. 127, pl. 31, fig. 16.

Coesel & Meesters, 2007, p. 198, pl. 110, figs. 4-7.

Coesel & Meesters, 2013, p. 148, pl. 75, figs. 12-16.

**Heterotypic synonym:** *Staurastrum sexcostatum* subsp. *productum* West 1892

**Dimensions:** B: 39.64 µm.

**Description:** In the vertical view semicells 6-radiate and star-shaped. The arms short, truncate, and has small spines ends. The margins concave and tipped with tiny granules. Apex with curved series of intramarginal granules following the outline of the semicell.

**Ecology:** It occurs in the swampy areas (pH 6.5-6.7) of the Central Alps (over 2000 m high), and also in benthic shallow, ephemeral, oligo-mesotrophic pools [26, 30]. It was found in the epipellic samples of the Kapılı Lakes-3 (Table 1).

**Distribution:** (as *Staurastrum sexcostatum* Brébisson ex Ralfs) *Europe:* Austria, Britain, Czech Republic, Europe, France, Germany, Hungary, Ireland, Italy, Latvia, Netherlands, Portugal, Romania, Russia (Europe), Serbia, Slovakia, Slovenia, Spain, Ukraine, *Africa:* Nigeria, *Asia:* Russia, Russia (Far East), (as *Staurastrum sexcostatum* subsp. *productum* West) *Europe:* Spain, *South America:* Argentina [33].

### 3. Conclusions and discussion

At the end of the research, 78 species belonging to Charophyta were determined from 15 lakes. As in other studies in the region, the members of the family Desmidiaceae were dominant in this study [6, 7]. They comprised 67.94% of all recorded species.

Floristic studies on freshwater microalgae are of great importance as they provide basic scientific data needed for the formation of biodiversity models of these organisms and the application of biomonitoring networks. In addition, the biogeographical data of these microalgae are also important [34]. The appearance of 7 new record desmid species within this geographical area reveals one of the aspects of the biogeographic particularities of the high mountain lakes. From a floristic point of view, the present work confirms the presence of a noticeable algal species richness in the Eastern Blacksea region.

*Closterium jenneri* var. *curvatissimum*, *Cosmarium margaritifera* f. *regularis*, *Euastrum ansatum* var. *concavum*, *E. verrucosum* var. *coarctatum*, *Staurastrum capitulum* and *S. sexcostatum* are widely distributed in different parts of the world, while *Euastrum verrucosum* var. *planctonicum* is only reported from Britain, up till now [33]. This result is important in terms of indicating a second geographical distribution area of the species. Thus, this study offers an important contribution to characterize desmids of Turkey.

The literature states that the identified species prefer acidic, slightly acidic and neutral waters [18, 20-22, 25-27, 29, 30]. According to the results of the physico-chemical analyses, the lake waters have slightly acidic and neutral pH properties (Table 1). This data support the above-mentioned statements.

In conclusion, the data (78 desmid species) obtained from this study revealed the first clues to the existence of a rich desmid flora in the lakes of the Kaçkar Mountains National Park. In order to completely evaluate the desmid flora of the park, it is necessary to investigate other lakes as well. At the same time, we think that these studies will also increase the number of new recorded desmid species..

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