

NEW RECORDS FOR THE TURKISH FRESHWATER ALGAL FLORA IN TWENTY FIVE RIVER BASINS OF TURKEY, PART VI: CHAROPHYTA

Faruk MARAŞLIOĞLU^{1*}, Elif Neyran SOYLU², Nilsun DEMİR³, Abuzer ÇELEKLİ⁴, Haşim SÖMEK⁵, Burak ÖTERLER⁶, Tolga ÇETİN⁷, Yakup KARAASLAN⁷, Tuğba ONGUN SEVİNDİK⁸, Tolga COŞKUN³, Cüneyt Nadir SOLAK⁹, Bengü TEMİZEL²

¹ Hitit University, Faculty of Arts and Science, Department of Biology, Çorum, TURKEY

² Giresun University, Faculty of Arts and Science, Department of Biology, Giresun, TURKEY

³ Ankara University, Faculty of Agriculture, Department of Fisheries and Aquaculture, Dışkapı, Ankara, TURKEY

⁴ Gaziantep University, Faculty of Art and Science, Department of Biology, Gaziantep, TURKEY

⁵ İzmir Katip Çelebi University, Faculty of Fisheries, Department of Aquatic Sciences of Fisheries, İzmir, TURKEY

⁶ Trakya University, Balkan Campus, Faculty of Science, Department of Biology, Edirne, TURKEY

⁷ T.R. Ministry of Agriculture and Forestry, Directorate General of Water Management, Ankara, TURKEY

⁸ Sakarya University, Faculty of Arts and Science, Department of Biology, Adapazarı, TURKEY

⁹ Dumlupınar University, Faculty of Arts and Science, Department of Biology, Kütahya, TURKEY

Cite this article as:

Maraşlıoğlu F., Soylu E.N., Demir N., Çelekli A., Sömek H., Öterler B., Çetin T., Karaaslan Y., Ongun Sevindik T., Coşkun T., Solak C.N. & Temizel B. 2021. New records for the Turkish freshwater algal flora in twenty five river basins of Turkey, part vi: Charophyta. *Trakya Univ J Nat Sci*, 22(2): 111-129, DOI: 10.23902/trkjinat.875740

Received: 06 February 2021, Accepted: 13 April 2021, Online First: 11 May 2021, Published: 15 October 2021

Edited by:

Naime Arslan

*Corresponding Author:

Faruk Maraşlıoğlu
farukmaraslioglu@hitit.edu.tr

ORCID iDs of the authors:

FM. orcid.org/0000-0002-7784-9243
ENS. orcid.org/0000-0002-7583-3416
ND. orcid.org/0000-0002-3895-7655
AÇ. orcid.org/0000-0002-2448-4957
HS. orcid.org/0000-0003-4281-9738
BÖ. orcid.org/0000-0002-9064-1666
TÇ. orcid.org/0000-0002-7817-3222
YK. orcid.org/0000-0001-8993-4771
TOS. orcid.org/0000-0001-7682-0142
TC. orcid.org/0000-0001-5732-7424

Key words:

Phytoplankton
Desmidiaceae
Zygnematales
First record
Lake
River Basin

Abstract: Although planktonic algae are a basic component of freshwater ecosystems, studies on their diversity and species distribution are still not in satisfactory numbers. This study aims to contribute to Turkish freshwater algal flora particularly with the new records reported. A total of 158 Charophyta taxa were determined in the study conducted from 2017 to 2019 in 25 river basins of Turkey. In this study, while the highest Charophyta taxon was found in Sakarya and Batı Akdeniz basins with 50 and 42 taxa, respectively, Burdur basin was the only basin where we did not find the Charophyta species. The highest Charophyta diversity was observed in Girdev Lake (Batı Akdeniz basin) and Işık Dağı Karagöl Lake (Sakarya basin) among the lakes of Turkey's 25 river basins. Thirty-one of these Charophyta taxa represent new records for the freshwater algal flora of Turkey. Of these, 13 species are commonly distributed, while 18 species have rare distribution areas. Morphology, ecology, and distribution of each taxon were also discussed in details.

Özet: Planktonik algler tatlı su ekosistemlerinin temel bir bileşeni olmasına rağmen, onların çeşitliliği ve tür dağılımları konusundaki çalışmalar hala tatmin edici sayılarda değildir. Bu çalışma, özellikle raporlanan yeni kayıtlarla Türkiye tatlı su alg florasına katkıda bulunmayı amaçlamaktadır. 2017-2019 yılları arasında Türkiye'nin 25 nehir havzasında yapılan bu çalışmada toplam 158 Charophyta taksonu tespit edilmiştir. Bu çalışmada, en yüksek Charophyta taksonuna sırasıyla 50 ve 42 takson sayısı ile Sakarya ve Batı Akdeniz havzalarında rastlanırken, Charophyta türüne rastlamadığımız tek havza Burdur olmuştur. Türkiye'nin 25 akarsu havzasındaki göller arasında en fazla Charophyta çeşitliliği Girdev Gölü (Batı Akdeniz havzası) ve Işık Dağı Karagöl (Sakarya havzası)'de görülmüştür. Tespit edilen bu Charophyta taksonlarının 31'i Türkiye'deki tatlı su alg florası için yeni kayıt niteliğindedir. Bunlardan 13 tür yayılış alanı olarak yaygın iken, 18 tür nadir yayılış alanına sahiptir. Her bir taksonun morfolojisi, ekolojisi ve dağılımı da ayrıntılı olarak verilmiştir.

Introduction

In recent years, several projects funded by the Ministry of Agriculture and Forestry, Directorate General of Water Management (DGWM) and General Directorate of State Hydraulic Works (DSİ) have been implemented on biological quality components of aquatic ecosystems.

The present study is a part of the "Establishment of Reference Monitoring Network in Turkey" project which is funded by DGWM. In this project, 275 lakes in 25 river basins were studied, and a total of 1363 phytoplankton taxa of which 158 belong to Charophyta were determined.



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Among the determined species, new records were reported, in addition to already reported taxa, for Turkish flora. Most of the Charophyta taxa that were identified in our study belong to the order Desmidiiales, as seen in many studies.

The most Charophyta taxa identified in the lakes within 25 river basins belong to the order Desmidiiales, as seen in many previous similar studies (Shukla *et al.* 2008, Oliveira *et al.* 2010, Hansen *et al.* 2018). Desmids are exclusively found in freshwater habitats (Kouwets 2008) and usually prefer acidic or pH-circumneutral, nutrient-poor, and clear waters (Lenzenweger 1996). According to Şahin and Akar (2019), desmid flora is typical, with a predominance of cosmopolitan species, planktic-benthic forms, acidophilic and pH-indifferent species, and halophobic-to-salinity-indifferent species. It is well known that Desmidiiales members, which attracted the attention of scientists due to their forms, exhibit great diversity in their external morphology and show a remarkably complex cell symmetry (Lee 2015). 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, Şimek 1997, Coesel *et al.* 1978, Štastný 2009).

Turkish inland waters have quite rich algal diversity with 3690 taxa determined so far (Taşkın *et al.* 2019). However, the number of Charophyta members listed in algaebase (4906 taxa) are more than the total number of algal taxa in Turkey (Guiry & Guiry 2021). The number of Charophyta members identified in Turkish freshwaters is only 385 (Taşkın *et al.* 2019). However, 186 desmid species were detected only in four different localities on the Danish island Bornholm (Hansen *et al.* 2018). Thus, more studies are needed to contribute to completion of the list of algal flora of Turkey. A few checklists containing the algae determined in several studies on freshwater algal flora of Turkey were published by Gönüloğlu *et al.* (1996), Aysel (2005) and Şahin (2005) and new taxa records were given during

studies performed in the last couple of decades (Aysel *et al.* 1993, Öztürk *et al.* 1995a, 1995b, Şahin 1998, 2000, 2002, 2007, 2009, Apaydın-Yağcı & Turna 2002, Atıcı 2002, Şahin & Akar 2007, Baykal *et al.* 2009, Sevindik *et al.* 2010, 2011, 2015, 2017; Bekleyen *et al.* 2011, Özer *et al.* 2012, Akar & Şahin 2014, Yüce & Ertan 2014, Varol & Fucikova 2015, Varol & Şen 2016, Maraşlıoğlu & Soylu 2018, Şahin & Akar 2019, Şahin *et al.* 2020).

The studies mentioned above were conducted in different wetlands in Turkey and provided a great contribution to the determination of freshwater algal flora of Turkey and to the checklists published earlier. Reliable descriptive information was also given in these publications about the new records. The aim of the study is to determine the algal flora of Turkish freshwater in selected 25 river basins.

Materials and Methods

Study Area

Turkey has 25 river basins (Fig. 1, Table 1), and inland water bodies in these basins consisting of 200 natural lakes, 806 reservoirs and 1000 irrigation ponds. The general directorate of state hydraulic works of Turkey (DSİ) data show that the volume of annual average precipitation is estimated to be 501 billion m³ water, of which about 55% is lost by evapotranspiration, 31% flows into water bodies (158 billion m³) and 14% feeds aquifers (69 billion m³). The Fırat-Dicle Basin provides the largest single volume of available exploitable freshwater resources in Turkey, representing 28.5% of the total (DSİ 2014).

A total of 275 lakes, including reservoirs, were sampled during the study in 25 river basins. The number of studied lakes considering the river basins were given in Table 1. These lakes, located between the longitudes of 26° 19' and 43° 54' E and the latitudes of 35° 56' and 42° 00' N, are grouped in 22 lake typologies based on altitude (R), lake depth (D), lake size (A), and geology (J) (DGWM 2015a). The altitudes of the sampled lakes vary from sea level (Lake Gala) to 2757 m (Lake Çamlu).



Fig. 1. 25 River basins in Turkey.

Table 1. The number and names of sampled lakes in the 25 river basins.

No	Basin	The number of studied lakes	Name of lake
1	Akarçay	10	(1) Akşehir Lake, (2) Eber Lake, (3) Akdeğirmen Reservoir, (4) 26 Ağustos TP Lake, (5) Karamık Reeds, (6) Ağzıkara Pond, (7) Tınaztepe Pond, (8) Gezler Pond, (9) Şehit Uz. Çvş. Nurullah Oymak Pond, (10) Tazlar Satı Gelin Pond
2	Antalya	9	(11) Eğirdir Lake, (12) Kovada Lake, (13) Gölcük Lake, (14) Cemalalanı Lake, (15) Duruca Lake, (16) Eğri Lake, (17) Küllü Lake, (18) Titreyen Lake, (19) Düden Lake
3	Aras	3	(20) Aktaş Lake, (21) Çıldır Lake, (22) Aygır Lake
4	Asi	8	(23) Reyhanlı (Yenihisar) Lake, (24) Yayladağ Reservoir, (25) Tahtaköprü Reservoir, (26) Karagöl Lake, (27) Adsız Lake, (28) Yarseli Reservoir, (29) Üçpınar Pond, (30) Sapkanlı Pond
5	Batı Akdeniz	13	(31) Gölhisar Lake, (32) Girdev Lake, (33) Avlan Lake, (34) Dalaman Wetlands, (35) Denizcik Lake, (36) Kocagöl Lake, (37) Kusuru Lake, (38) Köycegiz Lake, (39) Küçükdalyan Lake, (40) Yeşilgöl Lake, (41) Yazır Lake, (42) Baranda Lake, (43) Pozan Lake
6	Batı Karadeniz	14	(44) Nazlı Lake, (45) Büyük Lake, (46) Derin Lake, (47) Parçayır Lake, (48) Abant Lake, (49) Dipsiz Lake, (50) Gölcük Lake, (51) Keçi Lake, (52) Yeniçağa Lake, (53) Kuyudüzü Lake, (54) Erze Lake, (55) Koca Lake, (56) Kuru Lake Natural Park, (57) Sazlı Lake
7	Burdur	6	(58) Acıgöl Lake, (59) Burdur Lake, (60) Karataş Lake, (61) Salda Lake, (62) Tefenni Pond, (63) Keçiborlu Güneykent Uzundere Pond
8	Büyük Menderes	13	(64) Işıklı Lake, (65) Bafa Lake, (66) Azap Lake, (67) Karakuyu Reeds, (68) Süleymanlı Lake, (69) İkizdere Reservoir, (70) Gerenlik Lake, (71) Gökgöl Lake, (72) Gökpınar Reservoir, (73) Karacasu Reservoir, (74) Karagöl Lake, (75) Saklı Lake, (76) Sülüklü Lake
9	Ceyhan	18	(77) Gölbaşı Lake, (78) Kartalkaya Reservoir, (79) Kara Lake, (80) B. Yapalak Pond, (81) Korkmaz Pond, (82) Zorkun Pond, (83) Merk Pond, (84) Yamaçoba Pond, (85) Kızılınış Pond, (86) Arıklıkış Pond, (87) Karacaören Pond, (88) Meletmez Pond, (89) Postkabasakal Pond, (90) Bağtepe Pond, (91) Zerdali Pond, (92) Kozan Aydın Pond, (93) Yumurtalık Zeytinbeli Pond, (94) Yumurtalık Ayvalık Pond
10	Çoruh	8	(95) Adsız Lake, (96) Boğa Lake, (97) Balık Lake, (98) Şavşat Karagöl Lake, (99) Çil Lake, (100) Borçka Karagöl Lake, (101) Tortum Lake, (102) Ürünlü Pond
11	Doğu Akdeniz	12	(103) Aygır Lake, (104) Uzun Lake, (105) Değirmendere Pond, (106) Cemilli Çevlik Pond, (107) Hacınuhlu Kelce Pond, (108) Akın Pond, (109) Kızılöz Pond, (110) Başyayla Pond, (111) Göktepe Pond, (112) Bağbaşı Reservoir, (113) Yassıbağ Pond, (114) Hadım-İnönü Pond
12	Doğu Karadeniz	7	(115) Gaga Lake, (116) Sera Lake, (117) Ulugöl Lake, (118) Uzungöl Lake, (119) Çamlu Lake, (120) Çakır Lake, (121) Limni Lake
13	Fırat-Dicle	17	(122) Kaz Lake, (123) Ahır Lake, (124) Haçlı Lake, (125) Korlu Lake, (126) Hazar Lake, (127) Karagöl Lake, (128) Yeşildere Pond, (129) Palandöken Pond, (130) Güroymak Reservoir, (131) Kalecik Reservoir, (132) Kapaçmaz Pond, (133) Dedeyolu Pond, (134) Güzelyurt Sulama Pond, (135) Hasancık Pond, (136) İncesu Pond, (137) Otlukbeli Lake, (138) Siverek Yeleken Pond
14	Gediz	6	(139) Gölcük Lake, (140) Demirköprü Reservoir, (141) Marmara Lake, (142) Gördes Reservoir, (143) Karagöl Lake, (144) Küçükler Reservoir
15	Kızılırmak	23	(145) Gölbel Lake, (146) Ulaş Lake-2, (147) Büyük Lota Lake, (148) Hafik Lake, (149) Küçük Lota Lake, (150) Tödürge Lake, (151) Arı Lake, (152) Aygır Lake, (153) Bakkal Lake, (154) Dipsiz Lake, (155) Elekci Lake, (156) Ulaş Lake-1, (157) Ulaş Lake-3, (158) Deniz Lake, (159) Yeşilgöl 1 Lake, (160) Bardakçılı Mevki Lake, (161) Yenidanişment Mevki Lake, (162) Palanga Lake, (163) Sugiyolan Mevki Lake, (164) Kayabaşı Lake, (165) Kuru Lake, (166) Sıraç Lake, (167) Kızılcım Lake
16	Konya	18	(168) Sarıot Lake, (169) Beyşehir Lake, (170) Tuz Lake, (171) Süleymanhacı Lake, (172) Gök (Kozanlı) Lake, (173) Meke Lake (Meke Maarı), (174) Gavur Lake, (175) Dipsiz Lake, (176) Acıgöl Lake 2, (177) Bakı Lake, (178) Uyuz Lake, (179) Acıgöl Lake 1, (180) Kayı Lake, (181) Düden Lake, (182) Kovalı Lake, (183) Köpek Lake, (184) Küçük Lake, (185) Sülüklü Lake

Table 1. Continued.

No	Basin	The number of studied lakes	Name of lake
17	Kuzey Ege	5	(186) Boz Lake, (187) Güzelhisar Reservoir, (188) Karagöl Lake, (189) Sevişler Reservoir, (190) Tepe Lake
18	Küçük Menderes	6	(191) Çatal Lake, (192) Tahtalı Reservoir, (193) Alaçatı Barajı, (194) Belevi Lake, (195) Gebekirse Lake, (196) Ürkmez Reservoir
19	Marmara	9	(197) Habibler Mevki Pond, (198) Great Dipsiz Lake, (199) İznik Lake, (200) Koca Lake, (201) Karamaden Lake, (202) Danamandıra Lake-1, (203) Danamandıra Lake-2, (204) Small Dipsiz Lake, (205) Sinekli Lake
20	Meriç-Ergene	5	(206) Gala Lake, (207) Sığircı Lake, (208) Pamuklu Lake, (209) Üsküp Sulama Pond, (210) Domuz Lake
21	Sakarya	23	(211) Taşkısığı Lake, (212) Akgöl 2 Lake, (213) Çubuk Lake, (214) Poyrazlar Lake, (215) Sapanca Lake, (216) Işık Dağı Karagöl Lake, (217) Çavuşcu Lake, (218) Mogan Lake, (219) Üçlerkayası Pond, (220) Çubuk Karagöl Lake, (221) Eymir Lake, (222) Akgöl 1 Lake, (223) Küçük Akgöl Lake, (224) Avdan Lake, (225) Kayuslu Lake, (226) Karamurat Lake, (227) Cüneyt Sönmez Pond, (228) Çılınlar Pond, (229) Yıldırım Evcı Pond, (230) Ovacık Lake, (231) Sülüklü Lake, (232) Çamkoru TP Pond, (233) Anagöl Lake
22	Seyhan	12	(234) Bahçelik Reservoir, (235) Tufanbeyli Demiroluk Pond, (236) Adsız Lake, (237) Pekmezli-Çatalçam Pond, (238) Tufanbeyli Doğanbeyli Pond, (239) Gümüşören Reservoir, (240) Şıhlı Pond, (241) Döleklı Pond, (242) Kılıçlı Pond, (243) Topacık Pond, (244) Hüsnıye Pond, (245) Çavuşlu Pond
23	Susurluk	9	(246) Manyas Lake, (247) Uluabat Lake, (248) Adsız-1 Lake, (249) Gölbaşı Lake, (250) Gölcük Lake, (251) İkızcetepeler Reservoir, (252) Karagöl Lake, (253) Kilimli Lake, (254) Nilüfer Reservoir
24	Van Gölü	7	(255) Akgöl Lake, (256) Erçek Lake, (257) Bostanıçı Pond, (258) Arın Lake, (259) Aygır Lake, (260) Van Lake, (261) Nazık Lake
25	Yeşılırmak	14	(262) Akgöl Lake, (263) Aşağıtepecık (Gölova) Lake, (264) Boraboy Göleti, (265) Büyük Lake, (266) Düden Lake, (267) Kaz Lake, (268) Ladık Lake, (269) Uyuz Lake, (270) Karacaören Mevki Lake, (271) Dipsız Lake 2, (272) Sarıççek Lake, (273) Yenıhayat Reservoir (274) Dipsız Lake 1, (275) Zınav Lake

Sampling and Identification

Phytoplankton was sampled annually from 2017 to 2019 in three seasons (spring, summer and autumn) at monitoring station(s) in each lake. The number of monitoring points (station) in the lakes varied according to the lake areas determined by the general directorate of water management. According to this, sampling point numbers were determined as 1 for lakes that have a surface area smaller than 50 ha, 2 for lakes that have a surface area between 50 and 500 ha and, 3 for lakes which have a surface area higher than 500 ha (DGWM 2015b). One of the selected stations was determined at the deepest point of the lake. No bathymetric study was carried out in the lakes, and the deepest point of the lake was determined through a depth meter. Three depths (surface, middle, and bottom) of the euphotic depth (Secchi disk depth \times 2.5) were sampled with a Ruttner water sampler (Hydro-Bios 2 L, 0.5 m long), then a subsample was taken from mixed water of the three depths. Plankton net with a pore diameter of 50 μ m was also used for sampling. Samples were fixed with Lugol's solution. Identification of the algal taxa was performed with compound and inverted microscopes according to the literature (Kolkwitz & Krieger 1971, Lind & Brook 1980, Huber-Pestalozzi

1982, Kadlubowska 1984, Lenzenweger 1996, 1997, 1999, 2003, Compère 2001, John *et al.* 2003, Coesel & Meesters 2007). Identified taxa were checked with the checklist of Aysel (2005), Taşkın *et al.* (2019), and the database of Turkish algae (Maraşlıoğlu & Gönüloğlu 2021). The currently accepted nomenclature and distribution of taxa were given according to Guiry & Guiry (2021). The author names were abbreviated according to Brummit & Powell (1992). Taxa were photographed with a camera attached to the microscopes. List of Charaophyta taxa, the basin and lakes they were obtained are given in Table 2. Species name, synonym, description, ecology, distributional data and obtained basin and lakes information are given only for new taxa in the result section.

Results

A total of 158 Charaophyta taxa, of which 31 are new records for the freshwater algal flora of Turkey were determined during the whole study (Table 2). Thirty-one taxa from Charaophyta were detected as new records for the freshwater algal flora of Turkey in this comprehensive study. 30 of the new records were found to be members of the order Desmidiaceales and 1 of the order Zygnematales. Morphotaxonomic description, ecology, and distribution of each of these taxa are given below.

Table 2. List of Charophyta taxa (Italic numbers show Basin names in Table 1, bold numbers show lake names in Table 1).

No	Taxa	Localities	
		Basin(s)	Lake(s)
1	<i>Actinotaenium wollei</i> (West & G.S.West) Teiling ex Ruzicka & Pouzar 1978*	23	246
2	<i>Closterium acerosum</i> Ehrenb. ex Ralfs 1848	2, 16, 18	12, 17, 182, 194
3	<i>Closterium aciculare</i> T.West 1860	16, 17, 18, 19, 23, 25	169, 177, 182, 185, 189, 186, 187, 193, 197, 199, 201, 202, 246, 249, 251, 274, 271
4	<i>Closterium acutum</i> Bréb. 1848	16, 17, 20, 21, 23, 25	174, 189, 208, 216, 251, 266, 275
5	<i>Closterium acutum</i> var. <i>linea</i> (Perty) West & G.S.West 1900	21	216
6	<i>Closterium acutum</i> var. <i>variabile</i> (Lemmerm.) Willi Krieg. 1935	1, 4, 5, 13, 21	8, 10, 28, 31, 42, 122, 124, 129, 211, 219
7	<i>Closterium diana</i> Ehrenb. ex Ralfs 1848	2, 5, 8, 11, 21, 25	17, 41, 64, 103, 216, 269, 271
8	<i>Closterium diana</i> var. <i>rectius</i> (Nordst.) De Toni 1977*	1	2
9	<i>Closterium ehrenbergii</i> Menegh. ex Ralfs 1848	18	194
10	<i>Closterium gracile</i> Bréb. ex Ralfs 1848	2, 10	12, 99
11	<i>Closterium idiosporum</i> West & G.S.West 1900	21	216
12	<i>Closterium jenneri</i> var. <i>cynthia</i> (De Not.) Petlovany 2015	21	216, 219
13	<i>Closterium kuetzingii</i> Bréb. 1856	15	162
14	<i>Closterium leibleinii</i> Kütz. ex Ralfs 1848	15	162
15	<i>Closterium limneticum</i> Lemmerm. 1899	13, 21	129, 131, 138, 232, 225
16	<i>Closterium littorale</i> Gay 1884	9, 14, 16, 19, 20, 23	78, 140, 141, 144, 185, 199, 208, 210, 206, 246
17	<i>Closterium lunula</i> Ehrenb. & Hemprich ex Ralfs 1848	9, 14, 17, 20, 23	84, 140, 189, 206, 208, 246, 251
18	<i>Closterium moniliferum</i> Ehrenb. ex Ralfs 1848	16, 22	174, 234
19	<i>Closterium navicula</i> (Bréb.) Lütkem. 1905	2, 10	12, 99
20	<i>Closterium parvulum</i> Nägeli 1849	8, 16	67, 174
21	<i>Closterium pronum</i> Bréb. 1856	5	40, 42
22	<i>Closterium pseudolunula</i> O.Borge 1909	1	2
23	<i>Closterium pygmaeum</i> Gutw. 1890*	21	224
24	<i>Closterium strigosum</i> Bréb. 1856	19	205
25	<i>Cosmarium abbreviatum</i> Racib. 1885	4, 21, 25	28, 216, 269
26	<i>Cosmarium asphaerosporum</i> Wittr. 1879	19	202
27	<i>Cosmarium berryense</i> Kouwets 1998	21	225
28	<i>Cosmarium bioculatum</i> Bréb. ex Ralfs 1848	4, 11, 14, 16, 17, 25	28, 104, 110, 140, 174, 189, 263
29	<i>Cosmarium bioculatum</i> var. <i>depressum</i> (Schaarschm.) Schmidle 1894	1, 21	10, 213, 219, 232
30	<i>Cosmarium bireme</i> G.S.West 1904	1, 13	6, 134
31	<i>Cosmarium blyttii</i> Wille 1880	24, 25	258, 272
32	<i>Cosmarium boeckii</i> Wille 1880	16	175
33	<i>Cosmarium botrytis</i> Menegh. ex Ralfs 1848	2, 14, 17, 19, 20, 23	17, 140, 141, 188, 202, 206, 251
34	<i>Cosmarium brebissonii</i> Menegh. ex Ralfs 1848*	5	32
35	<i>Cosmarium cataractarum</i> (Racib.) B.Eichler 1895	4	29
36	<i>Cosmarium clepsydra</i> Nordst. 1870	19, 20	199, 210
37	<i>Cosmarium contractum</i> O.Kirchner 1878	2, 5	12, 33
38	<i>Cosmarium contractum</i> var. <i>rotundatum</i> Borge 1925*	15	149
39	<i>Cosmarium contractum</i> var. <i>minutum</i> (Delponte) Coesel 1989	13	133
40	<i>Cosmarium crenatum</i> Ralfs ex Ralfs 1848	10	97

Table 2. Continued.

No	Taxa	Localities	
		Basin(s)	Lake(s)
41	<i>Cosmarium cymatonotophorum</i> West 1892	21	213, 227, 228
42	<i>Cosmarium depressum</i> var. <i>planctonicum</i> Reverdin 1919	15, 21	149, 213
43	<i>Cosmarium difficile</i> Lütkem. 1892	4, 21	28, 216
44	<i>Cosmarium distentum</i> (West) Coesel & Meesters 2015*	5, 21	32, 214
45	<i>Cosmarium formosulum</i> Hoff 1888	2	12, 15
46	<i>Cosmarium galeritum</i> Nordst. 1870	15	148, 149, 158
47	<i>Cosmarium granatum</i> Bréb. ex Ralfs 1848	2, 16	11, 176, 177
48	<i>Cosmarium humile</i> Nordst. ex De Toni 1889	5, 10, 15, 19, 21, 25	32, 99, 159, 199, 216, 272
49	<i>Cosmarium humile</i> var. <i>substriatum</i> (Nordst.) Schmidle 1895*	5, 10	33, 99
50	<i>Cosmarium impressulum</i> Elfving 1881	5	32
51	<i>Cosmarium impressulum</i> var. <i>crenulatum</i> (Nägeli) Willi Krieg. & Gerloff 1965*	15	162
52	<i>Cosmarium laeve</i> Rabenh. 1868	2, 4, 5, 6, 11, 13, 15, 16, 20, 21	11, 16, 27, 32, 35, 48, 104, 105, 106, 107, 132, 133, 147, 149, 176, 185, 206, 224, 225
53	<i>Cosmarium mamilliferum</i> var. <i>madagascariense</i> West & G.S.West 1885*	13	126
54	<i>Cosmarium meneghinii</i> Bréb. ex Ralfs 1848	4, 5, 10, 21, 24	26, 32, 99, 216, 261
55	<i>Cosmarium moniliforme</i> Ralfs 1848	1, 8, 13, 21	5, 64, 132, 215, 219
56	<i>Cosmarium neodepressum</i> G.J.P.Ramos & C.W.N. Moura 2020	3, 5, 6, 15, 22	22, 32, 54, 55, 57
57	<i>Cosmarium norimbergense</i> var. <i>depressum</i> (West & G.S.West) Willi Krieg. & Gerloff 1969	5, 21	32, 227, 232
58	<i>Cosmarium nymnianum</i> Grunov 1868*	2	19
59	<i>Cosmarium obtusatum</i> (Schmidle) Schmidle 1898	5	32
60	<i>Cosmarium ornatum</i> Ralfs ex Ralfs 1848	9	86
61	<i>Cosmarium phaseolus</i> Bréb. ex Ralfs 1848	13, 21	132, 229
62	<i>Cosmarium phaseolus</i> var. <i>subbireme</i> Racib. 1889	21	216
63	<i>Cosmarium polygonatum</i> Halász 1940	5, 21	33, 214, 216, 219, 224
64	<i>Cosmarium pseudowembaerense</i> Kouwets 1998*	5, 13	33, 131
65	<i>Cosmarium punctulatum</i> Bréb. 1856	8, 12, 14, 20	64, 115, 140, 206
66	<i>Cosmarium pygmaeum</i> W.Archer 1864	5, 10, 16	32, 100, 175
67	<i>Cosmarium quinarium</i> Lundell 1871*	21	224
68	<i>Cosmarium regnellii</i> Wille 1884	5, 21	32, 216, 218, 219, 227, 228
69	<i>Cosmarium regnesi</i> Reinsch 1866	5, 21	32, 216
70	<i>Cosmarium reniforme</i> (Ralfs) W.Archer 1874	5, 25	32, 271, 275
71	<i>Cosmarium reniforme</i> var. <i>compressum</i> Nordst. 1887	8, 21	64, 216
72	<i>Cosmarium speciosum</i> Lundell 1871	2	15
73	<i>Cosmarium sphagnicola</i> West & G.S.West 1897*	5	32
74	<i>Cosmarium sportella</i> Bréb. ex Kütz. 1849	16	169
75	<i>Cosmarium subadoxum</i> Grönblad*	4, 13, 21	28, 29, 132, 135, 214,
76	<i>Cosmarium subcostatum</i> Nordst. 1876	2, 25	19, 269
77	<i>Cosmarium subcostatum</i> var. <i>minus</i> (West & G.S.West) Kurt Först. 1981	5	33
78	<i>Cosmarium subcrenatum</i> Hantzsch 1868	10, 17	99, 189
79	<i>Cosmarium subgranatum</i> (Nordst.) Lütkem. 1902*	21	224, 225

Table 2. Continued.

No	Taxa	Localities	
		Basin(s)	Lake(s)
80	<i>Cosmarium subprotumidum</i> Nordst. 1876	5	32
81	<i>Cosmarium subquadrans</i> West & G.S.West 1905*	4	28, 29
82	<i>Cosmarium subquadrans</i> var. <i>minus</i> Nordst. 1873*	21	215
83	<i>Cosmarium subtumidum</i> Nordst. 1878	5	35
84	<i>Cosmarium subtumidum</i> var. <i>minutum</i> (Willi Krieg.) Willi Krieg. & Gerloff 1965	5, 13	33, 133
85	<i>Cosmarium subundulatum</i> Wille 1880	15	148
86	<i>Cosmarium tenue</i> W.Archer 1868	13	132
87	<i>Cosmarium tetrachondrum</i> Lundell 1871*	5	32
88	<i>Cosmarium tinctum</i> Ralfs 1848	2, 4, 5, 13, 16, 21	12, 30, 37, 133, 136, 138, 176, 185
89	<i>Cosmarium venustum</i> (Bréb.) Archer 1861	16, 25	174, 271
90	<i>Cosmarium wembaerense</i> Schmidle 1898	1, 21	2, 218
91	<i>Cylindrocystis brebissonii</i> (Ralfs) De Bary 1858	2	19
92	<i>Desmidium aptogonum</i> Bréb. ex Kütz. 1849 *	8	67
93	<i>Elakatothrix gelatinosa</i> Wille 1898	1, 3, 5, 10, 12, 13, 16, 21, 25	3, 9, 22, 32, 35, 42, 95, 115, 117, 129, 131, 130, 134, 135, 175, 211, 214, 227, 231, 232, 213, 216, 225, 264, 265, 275, 274, 271, 273
94	<i>Euastrum lacustre</i> (Messik.) Coesel 1984*	15	148
95	<i>Gonatozygon brebissonii</i> De Bary 1858	2, 11	11, 104
96	<i>Gonatozygon monotaenium</i> De Bary 1856	5	35
97	<i>Groenbladia undulata</i> (Nordst.) Kurt Först.1973*	21	222
98	<i>Heimansia pusilla</i> (Hilse) Coesel 1993	1	6, 8
99	<i>Hormidiopsis crenulata</i> (Kütz.) Heering 1914	2	15
100	<i>Micrasterias furcata</i> C.Agardh ex Ralfs 1848*	21	216
101	<i>Micrasterias rotata</i> Ralfs 1848	10	99
102	<i>Mougeotia boodlei</i> (West & West) Collins 1912	2, 16	12, 13, 169, 174, 175, 176, 182
103	<i>Mougeotia capucina</i> C.Agardh 1824	17, 23	187, 249
104	<i>Mougeotia nummuloides</i> (Hassall) De Toni 1889	2	15
105	<i>Mougeotia parvula</i> Hassall 1843	2	11, 19
106	<i>Mougeotia quadrangulata</i> Hassall 1843	2, 16	11, 17, 175, 178, 182
107	<i>Mougeotia varians</i> (Wittr.) Czurda 1932	5	32
108	<i>Mougeotia viridis</i> (Kütz.) Wittr. 1872	14, 16,17, 19	142, 180, 189, 199
109	<i>Pleurotaenium trabecula</i> Nägeli 1849	2, 4	13, 26
110	<i>Roya closterioides</i> Coesel 2007	21	216
111	<i>Spirogyra aequinoctialis</i> West 1907	22	239
112	<i>Spirogyra cataeniformis</i> (Hassall) Kütz. 1849	2, 16	19, 176
113	<i>Spirogyra communis</i> (Hassall) Kütz. 1849	16	176
114	<i>Spirogyra dubia</i> Kütz. 1849	16	176
115	<i>Spirogyra decimina</i> var. <i>elongata</i> (Vaucher) Petlovany 2015*	2	11
116	<i>Spirogyra rivularis</i> (Hassall) Rabenh. 1868	2	19
117	<i>Spirogyra weberi</i> Kütz. 1843	2	11, 13, 15
118	<i>Spondylosium panduriforme</i> (Heimerl) Teiling 1957*	13	132
119	<i>Staurastrum alternans</i> Bréb. 1848	20, 23	206, 251

Table 2. Continued.

No	Taxa	Localities	
		Basin(s)	Lake(s)
120	<i>Staurastrum anatinum</i> Cooke & Wills 1881	8	73
121	<i>Staurastrum avicula</i> var. <i>lunatum</i> (Ralfs) Coesel & Meesters 2013	5	32
122	<i>Staurastrum bieneanum</i> Rabenh. 1862	5, 21	32, 224
123	<i>Staurastrum bioculatum</i> W.R.Taylor 1935	11	110
124	<i>Staurastrum chaetoceras</i> (Schröd.) G.M.Sm. 1924	9, 13, 14, 17, 18, 19, 20, 23	82, 129, 137, 130, 139, 190, 187, 193, 199, 209, 247
125	<i>Staurastrum cingulum</i> (West & G.S.West) G.M.Sm. 1922	2, 3, 5, 10, 13, 15, 16, 22, 24	12, 15, 17, 22, 24, 42, 101, 125, 129, 131, 138, 145, 169, 175, 177, 182, 185, 245, 261
126	<i>Staurastrum cingulum</i> var. <i>obesum</i> G.M.Sm. 1922	15	145, 152
127	<i>Staurastrum crenulatum</i> (Nägeli) Delponte 1877	2, 5, 8, 15	17, 35, 64, 151
128	<i>Staurastrum denticulatum</i> (Nägeli) W.Archer 1861	10	99
129	<i>Staurastrum furcigerum</i> (Bréb.) W.Archer 1861	5, 21	32, 216, 224
130	<i>Staurastrum gracile</i> Ralfs ex Ralfs 1848	8, 14, 15, 16, 17, 19, 20, 23	69, 140, 141, 148, 169, 186, 187, 189, 199, 202, 203, 209, 210, 251
131	<i>Staurastrum hexacerum</i> Witt. 1872	5	32, 33
132	<i>Staurastrum lapponicum</i> (Schmidle) Grönblad 1926	21	218
133	<i>Staurastrum manfeldtii</i> Delponte 1878	5	32
134	<i>Staurastrum margaritaceum</i> Menegh. ex Ralfs 1848	16	174
135	<i>Staurastrum muticum</i> Bréb. ex Ralfs 1848	10, 11	99, 104
136	<i>Staurastrum muticum</i> f. <i>minus</i> Rabenh. 1868*	13	133
137	<i>Staurastrum paradoxum</i> Meyen ex Ralfs 1848	19, 20, 23	201, 209, 254
138	<i>Staurastrum pilosum</i> Bréb. 1856	23	251
139	<i>Staurastrum pingue</i> Teiling 1942	9, 13, 14, 21, 23	77, 127, 140, 219, 251
140	<i>Staurastrum pingue</i> var. <i>planctonicum</i> (Teiling) Coesel & Meesters 2013*	13, 21	129, 137, 215, 219
141	<i>Staurastrum punctulatum</i> Bréb. 1848	12, 25	120, 271
142	<i>Staurastrum striatum</i> (West & G.S.West) Ruzicka 1957*	5	33
143	<i>Staurastrum teliferum</i> Ralfs 1848*	10	99
144	<i>Staurastrum tetracerum</i> Ralfs ex Ralfs 1848	4, 5, 6, 10, 12, 13, 16, 21	24, 29, 32, 35, 46, 99, 115, 122, 124, 129, 131, 134, 137, 174, 175, 214, 216, 225
145	<i>Staurastrum trilobulatum</i> Dürschm.*	25	269
146	<i>Staurastrum vestitum</i> Ralfs 1848	5	32
147	<i>Stauroidesmus convergens</i> (Ehrenb. ex Ralfs) S.Lill. 1950	21	216
148	<i>Stauroidesmus dejectus</i> (Bréb.) Teiling 1954	20	209
149	<i>Stauroidesmus dickiei</i> (Ralfs) S.Lill. 1950	10, 21	99, 216
150	<i>Stauroidesmus extensus</i> (O.F.Andersson) Teiling 1948	21	227
151	<i>Stauroidesmus glaber</i> (Ralfs) Teiling 1948	5, 21	32, 216, 227
152	<i>Stauroidesmus lobatus</i> (Børgesen) Bourr. 1966	21	216
153	<i>Stauroidesmus triangularis</i> var. <i>brevispina</i> (V.Allorge & P.Allorge) Coesel & Meesters 2013*	21	216
154	<i>Teilingia excavata</i> (Ralfs ex Ralfs) Bourr. 1964	21	227
155	<i>Teilingia granulata</i> (J.Roy & Bisset) Bourr. 1964	10, 21	99, 216
156	<i>Teilingia quadrispinata</i> f. <i>evoluta</i> (A.M.Scott & Grönblad) Pal.-Mordv. 1982*	5	32
157	<i>Xanthidium antilopaeum</i> Kütz. 1849	10	99
158	<i>Zygnema pectinatum</i> (Vaucher) Agardh 1816	16	174, 180

* new record for Turkish freshwaters.

Phylum CHAROPHYTA
 Classis Zygnematophyceae
 Order Desmidiaceae
 Family Desmidiaceae

Genus *Actinotaenium* (Nägeli) Teiling

Actinotaenium wollei (West & G.S. West) Teiling 1978
 (Fig. 2a)

Synonym: *Cosmarium globosum* var. *wollei* West & G.S. West 1896

Description: Cells 27.5-47.4 µm long, 20.6-36.7 µm wide, isthmus 19.9-35.2 µm. Cells 1.3-1.5 times longer than broad; cells elliptic to nearly circular, semi cells semi circular; wall finely punctate; chloroplast stellate with a central pyrenoid. The mid-region of the cell is slightly narrowed.

Ecology: This is a freshwater species.

Distribution: *Europe:* Austria, Britain, France, Italy, Netherlands, Spain, Ukraine; *North America:* Arkansas, Québec; *Caribbean Islands:* Cuba; *South America:* Brasil; *South-west Asia:* Bangladesh; *South-east Asia:* Thailand; *Asia:* Russia, Russia (Far East); *Australia and New Zealand:* New Zealand.

Occurrence: It was determined in Susurluk basin (Manyas Lake).

Genus *Cosmarium* Corda

Cosmarium brebissonii Menegh. 1848 (Fig. 2b)

Synonym: -

Description: Cells 45-79 µm wide, 88-110 µm long. Semi cells are about trapeziform with very broadly rounded angles, walls covered with closely and evenly spaced conical granules.

Ecology: This is a freshwater species and characteristic of acidic, oligo-mesotrophic bog sites.

Distribution: *Europe:* Austria, Britain, Czech Republic, France, Georgia, Germany, Hungary, Ireland, Italy, Latvia, Netherlands, Portugal, Russia (Europe), Serbia, Spain, Ukraine; *South America:* Argentina, Brazil; *Asia:* China, Russia; *Australia and New Zealand:* Queensland.

Occurrence: It was determined in Batı Akdeniz basin (Girdev Lake).

Cosmarium contractum var. *rotundatum* Borge 1925
 (Fig. 2c)

Synonym: -

Description: Cells 1.5-1.8 times longer than broad, small and globose, 31-52 µm long and 21-33 µm wide; semi cells are globose to subcircular that are connected by an isthmus, lateral margins of the semi cells are convex with smooth and rounded apical margin; isthmus is 3.5-5.5 µm in length. Differs from the nominal variety in that semi cells are virtually circular in outline.

Ecology: This is a freshwater species.

Distribution: *Europe:* Austria, Britain, Czech Republic, Georgia, Germany, Netherlands; *North America:* Arkansas; *South America:* Brazil; *South-east Asia:* Philippines; *Asia:* China; *Australia and New Zealand:* Northern Territory.

Occurrence: It was determined in Kızılırmak basin (Küçük Lota Lake).

Cosmarium distentum (West) Coesel & Meesters 2015
 (Fig. 2d)

Synonym: *Cosmarium laeve* var. *distentum* G.S. West

Description: Cells 14-18 µm long, 11-15 µm wide, isthmus 3-4 µm. Cell length to breadth ratio is lower from the described diagnosis of *Cosmarium laeve* Rabenh. Semi cells widely ovate from the broad base, apex rounded or slightly truncate, a prominent tubercle in the center of the semi cell. The cell wall is finely punctate.

Ecology: This is a freshwater species.

Distribution: *Europe:* Netherlands.

Occurrence: It was determined in Batı Akdeniz (Girdev Lake) and Sakarya basins (Poyrazlar Lake).

Cosmarium humile var. *substriatum* (Nordst.) Schmidle 1895 (Fig. 2e)

Synonym: -

Description: Cells 17-28 µm long, 16-26 µm wide. The cell wall is sculptured by both incurvations and granules. Differs from the nominate variety by larger cell dimensions and in that the granules are arranged in two intramarginal series.

Ecology: This is a freshwater species and rather common species in various kinds of circumneutral, meso-eutrophic water bodies.

Distribution: *Europe:* Britain, Germany, Ireland, Italy, Latvia, Netherlands, Serbia, Slovenia, Ukraine; *North America:* Québec; *South America:* Argentina; *South-west Asia:* India; *Asia:* Russia, Tajikistan.

Occurrence: It was determined in Batı Akdeniz basin (Avlan Lake).

Cosmarium impressulum var. *crenulatum* (Nägeli) Willi Krieg. & Gerloff 1965 (Fig. 2f)

Synonym: *Cosmarium crenulatum* Nägeli

Description: Cells 29-33µm long, 20-24 µm wide. Cells longer than broad, in rough outline oval with regularly undulate margin. Half-cells transverse hexagonal. In the apical view elliptical, in the lateral view broadly oval. Cell wall smooth.

Ecology: This is a freshwater species and prefers mesotrophic water.

Distribution: *Europe:* Austria, Britain, Netherlands, Serbia; *South America:* Argentina; *South-west Asia:* India; *South-east Asia:* Thailand.

Occurrence: It was determined in Kızılırmak basin (Palanga Lake).

Cosmarium mamilliferum var. *madagascariense* West & G.S. West 1895 (Fig. 2g)

Synonym: -

Description: Cells 32-43 µm long, 25-36 µm wide, isthmus 7 µm, elliptical apical view, the wall is strongly scrobiculate.

Ecology: No habitat entry has yet been made for this entity.

Distribution: *Africa:* Zimbabwe.

Occurrence: It was determined in Fırat-Dicle basin (Hazar Lake).

Cosmarium nymannianum Grunov 1866 (Fig. 2h)

Synonym: -

Description: Cells 30-54 µm long and 29-42 µm wide; isthmus 12-13 µm wide; subhexagonal, elongate, sinus narrow, linear, semi cells are trapeziform in outline with concave lateral sides and apex, truncate-pyramidal with rounded basal and upper angles.

Ecology: This is a freshwater species.

Distribution: *Europe:* Austria, Britain, France, Germany, Ireland, Italy, Latvia, Spain, Ukraine; *North America:* Florida, Newfoundland, Québec; *South America:* Brazil; *South-west Asia:* India, Pakistan; *Asia:* Japan, Russia.

Occurrence: It was determined in Antalya basin (Düden Lake).

Cosmarium pseudowembaerense Kouwets 1998 (Fig. 2i)

Synonym: -

Description: Cells 12-18 µm long, 10-17 µm wide. Cells about as long as broad or a little longer, with a deep, linear sinus, closed for the greater part. Semi cells about hexagonal with broadly rounded angles and straight to slightly concave lateral sides, oval-elliptic in apical view. Apex is distinctly concave. Cell wall is smooth.

Ecology: This is a freshwater species.

Distribution: *Europe:* Czech Republic, France, Germany, Netherlands; *South America:* Brazil.

Occurrence: It was determined in Batı Akdeniz (Avlan Lake) and Fırat-Dicle basins (Kalecik Reservoir).

Cosmarium quinarium Lundell 1871 (Fig. 2j)

Synonym: -

Description: Cells 30-39 µm wide, 36-48 µm long, sinus deep, narrow, linear. Trapeziform semi cells with broadly rounded angles and slightly convex sides being marked with distant granules.

Ecology: This is a freshwater species.

Distribution: *Europe:* Austria, Britain, France, Germany, Ireland, Latvia, Netherlands, Scandinavia, Slovakia, Sweden, Ukraine; *North America:* Florida, Québec; *South America:* Brazil; *South-west Asia:* Bangladesh, India, Pakistan; *South-east Asia:* Thailand; *Asia:* Japan, Russia, Russia (Far East), Taiwan.

Occurrence: It was determined in Sakarya basin (Avdan Lake).

Cosmarium sphagnicola West & West 1897 (Fig. 2k)

Synonym: -

Description: Cells 9-13 µm long, 10-14 µm wide. Cells very small, roughly as long as they are wide. Half-cells elongated hexagonal with rounded corners and abroad, flat or slightly concave apex. Apical views elliptical, half-cells in a lateral view broadly oval or almost circular.

Ecology: This is a freshwater species.

Distribution: *Europe:* Austria, Britain, Czech Republic, France, Germany, Hungary, Ireland, Italy, Latvia, Netherlands, Portugal, Romania, Scandinavia, Spain, Ukraine; *North America:* Québec; *South America:* Brazil; *Asia:* Russia, Russia (Far East); *Australia and New Zealand:* New Zealand.

Occurrence: It has been detected in the Batı Akdeniz basin (Girdev Lake).

Cosmarium subadoxum Grönblad 2007 (Fig. 2l)

Synonym: -

Description: Cell 8-11 µm long, 8-11 µm wide. Cells about as long as broad with a deep, linear sinus, closed for the greater part. Semi cells in outline rectangular with convex lateral sides. Semi cells in apical view elliptic with a small, median tubercle on either side.

Ecology: This is a freshwater species.

Distribution: *Europe:* Czech Republic, France, Netherlands; *South America:* Brazil.

Occurrence: It was determined in Sakarya (Poyrazlar Lake), Fırat-Dicle (Kapaçmaz Pond, Hasancık Pond), and Asi basins (Yarseli Reservoir, Üçpınar Pond).

Cosmarium subgranatum (Nordst.) Lütkem. 1902 (Fig. 2m)

Synonym: -

Description: Cells 20-34 µm long, 15-25 µm wide. Cells longer than broad with a deep, linear sinus, closed for the greater part. Semi cells in rough outline pyramidal with lateral sides and undulations of the margin are pretty

irregular. Apical view ellipsoid with median inflation. Cell wall smooth.

Ecology: This is a freshwater species and common in meso-eutrophic water bodies, both acidic and alkaline.

Distribution: *Arctic:* Ellesmere Island; *Europe:* Britain, Czech Republic, France, Georgia, Germany, Hungary, Ireland, Italy, Netherlands, Romania, Serbia, Slovakia, Slovenia, Ukraine; *North America:* Northwest Territories, Québec; *Caribbean Islands:* Cuba; *South America:* Brazil; *Middle East:* Iraq; *Asia:* Myanmar; *Asia:* China, Russia (Far East), Taiwan, Tajikistan; *Australia and New Zealand:* New Zealand; *Pacific Islands:* Hawaiian Islands.

Occurrence: It was determined in Sakarya basin (Avdan Lake).

Cosmarium subquadrans West & West 1905 (Fig. 2n)

Synonym: -

Description: Cells small, 11-12.5 µm long, 12-15 µm wide, isthmus 3.5-4 µm wide, semi cells in front view transversely oblong, apex broad, truncate or slightly convex, semi cells in lateral view subcircular; vertical view fusiform-elliptic; cell wall smooth.

Ecology: This is a freshwater species.

Distribution: *Europe:* Austria, Britain, Czech Republic, Germany, Ireland, Italy, Netherlands, Ukraine; *Asia:* China, Japan, Russia, Tajikistan.

Occurrence: It was determined in Asi basin (Yarseli Reservoir, Üçpınar Pond).

Cosmarium subquadrans var. *minus* Symoens 1873 (Fig. 2o)

Synonym: -

Description: Cells 12-13 µm long, 16-18 µm wide. Cells broader than long, in outline oval with a deep, linear sinus, closed for the greater part. Semi cells entire with broadly rounded angles, in apical view fusiform to rhomboid. Cell wall smooth.

Ecology: This is a freshwater species.

Distribution: *Europe:* Czech Republic, Germany, Ireland, Netherlands.

Occurrence: It was determined in Sakarya basin (Sapanca Lake).

Cosmarium tetrachondrum Lundell 1871 (Fig. 2p)

Synonym: -

Description: Cell 20-23 µm long, 23-27 µm wide. Cells broader than long with a deep, linear sinus, closed for the greater part. Semi cells in outline low-trapeziform with broadly rounded angles. Apical view ellipsoid.

Ecology: This is a freshwater species.

Distribution: *Europe:* Britain, Czech Republic, France, Germany, Ireland, Latvia, Netherlands, Ukraine. *Asia:* Japan, Russia.

Occurrence: It was determined in Batı Akdeniz basin (Girdev Lake).

Genus *Desmidium* C. Agardh

Desmidium aptogonum Bréb. 1849 (Fig. 3a)

Synonym: -

Description: Cells 21-31 µm wide, 13-19 µm long, moderately constricted with an acute, open sinus; isthmus 15-24.5 µm wide; semi cells transversely oblong, lateral margins are slightly concave then converging to the apex.

Ecology: This is a freshwater species.

Distribution: *Europe:* Britain, Czech Republic, Finland, France, Georgia, Germany, Ireland, Italy, Netherlands, Portugal, Scandinavia, Slovenia, Spain, Sweden, Ukraine; *North America:* Florida, Maryland, New York, Québec, Wisconsin; *Caribbean Islands:* Cuba; *South America:* Brazil, Uruguay; *Middle East:* Iraq; *South-west Asia:* Bangladesh; India, Pakistan; *South-east Asia:* Myanmar, Thailand; *Asia:* China, Japan, Russia (Far East), Tajikistan; *Australia and New Zealand:* New South Wales, New Zealand, Northern Territory, Queensland, Victoria; *Pacific Islands:* Hawaiian Islands.

Occurrence: It was determined in Büyük Menderes basin (Karakuyu Reeds).

Genus *Euastrum* Ehrenb.

Euastrum lacustre (Messik.) Coesel 1984 (Fig. 3b)

Synonym: -

Description: Cells 28-48 µm long, 26-46 µm wide, isthmus 9-10 µm wide. Cells medium-sized, sinus narrow linear with dilated apex, semi cells nearly quadrangular, cell wall smooth.

Ecology: This is a freshwater species.

Distribution: *Europe:* Britain, France, Netherlands.

Occurrence: It was determined in Kızılırmak basin (Hafik Lake).

Genus *Groenbladia* Teiling

Groenbladia undulata (Nordst.) Kurt Först. 1973 (Fig. 3c)

Synonym: *Hyalotheca undulata* Nordst.

Description: Cells 10-17.5 µm long, 6-9 µm wide, more or less dumbbell-shaped, shallow median indentation; isthmus 4.5-7.5 µm wide, filaments sometimes in a mucilage sheath.

Ecology: This is a freshwater species.

Distribution: *Europe:* Austria, Britain, France, Germany, Ireland, Scandinavia, Spain; *North America:* Arkansas, Maine, Québec; *Caribbean Islands:* Cuba;

South America: Brazil; *South-west Asia:* Bangladesh; *Australia and New Zealand:* Northern Territory.

Occurrence: It was determined in Sakarya basin (Akgöl 1 Lake).

Genus *Micrasterias* Agardh

Micrasterias furcata Agardh 1848 (Fig. 3d)

Synonym: -

Description: Cells 150 µm long, 130 µm wide, isthmus 17-20 µm wide, cells are elliptical in outline with narrowly opened deep sinus. Semi cells with well-developed lateral lobes. The cell wall is smooth.

Ecology: This is a freshwater species.

Distribution: *Europe:* Austria, Britain, Czech Republic, France, Germany, Ireland, Italy, Netherlands, Romania, Spain, Ukraine; *North America:* Arkansas, Maine, Québec, Wisconsin; *Caribbean Islands:* Cuba; *South America:* Brazil, Uruguay; *Middle East:* Iraq; *Asia:* Russia (Far East); *Australia and New Zealand:* Victoria.

Occurrence: It was determined in Sakarya basin (Işık Dağı Karagöl Lake).

Genus *Spondylosium* Bréb.

Spondylosium panduriforme (Heimerl) Teiling 1957 (Fig. 3e)

Synonym: *Cosmarium moniliforme* var. *panduriforme* (Heimerl) Schmidle

Description: Cells 36-42 µm long, 21-22 µm broad, isthmus 13.2-14 µm. Semi cells circular; apex broadly rounded; cell wall finely punctate. This species is characterized by a copious mucilaginous envelope, enclosing the complete cell body.

Ecology: This is a freshwater species.

Distribution: *Europe:* France, Germany, Ireland, Italy, Netherlands, Ukraine; *South America:* Argentina, Brazil, Uruguay; *South-west Asia:* Bangladesh; *Asia:* Russia (Far East); *Australia and New Zealand:* New South Wales, New Zealand.

Occurrence: It was determined in the Fırat-Dicle basin (Kapaçmaz Pond).

Genus *Staurastrum* Meyen

Staurastrum pingue var. *planctonicum* (Teiling) Coesel & Meersters 2013 (Fig. 3f)

Synonym: *Staurastrum planctonicum* Teiling

Description: Cells 3 radiate, 70-95 µm wide, 57-65 µm long with processes, isthmus 9-13 µm wide; lower part of semi cells elongate, cup-shaped flaring upwards into long, slightly divergent, curved processes, walls smooth.

Ecology: This is a freshwater species.

Distribution: *Europe:* Bulgaria; *Africa:* Democratic Republic of Congo.

Occurrence: It was determined in Sakarya (Sapanca Lake, Üçlerkayası Pond) and Fırat-Dicle basins (Palandöken Pond, Otlukbeli Pond).

Staurastrum muticum f. *minus* Rabenh. 1868 (Fig. 3g)

Synonym: -

Description: Cells 21-22 µm long, 19-21 µm wide, isthmus 7-8 µm. Cells medium-sized, very slightly longer than broad, semi cells narrowly elliptic oval, in vertical view cells triangular, narrowly rounded at the angles, cell wall finely and densely punctate.

Ecology: This is a freshwater species.

Distribution: *Europe:* Ireland, Netherlands; *North America:* Québec; *South America:* Argentina; *South-west Asia:* India; *Australia and New Zealand:* Northern Territory.

Occurrence: It was determined in Fırat-Dicle basin (Dedeyolu Pond).

Staurastrum striatum (West & West) Ruzicka 1957 (Fig. 3h)

Synonym: -

Description: Cells 25-35 µm long, 24-36 µm wide. Cells about as long as broad, deeply constricted. Sinus is widely open, acute-angled. Semi cells (sub) rhomboid with rounded, or rounded-truncate lateral angles. Semi cells in apical view 3-angular with slightly concave sides and rounded, or rounded-truncate angles.

Ecology: This is a freshwater species.

Distribution: *Europe:* Czech Republic, France, Germany, Netherlands, Romania, Serbia; *Australia and New Zealand:* New South Wales.

Occurrence: It was determined in Batı Akdeniz basin (Avlan Lake).

Staurastrum teliferum Ralfs 1848 (Fig. 3i)

Synonym: -

Description: Cells 3-radiate, 40-64 µm wide, 32-56 µm long excluding spines, deeply constricted with an open sinus, isthmus 8-10 µm wide; semi cells elliptical with broadly rounded angles.

Ecology: This is a freshwater species.

Distribution: *Europe:* Andorra, Austria, Baltic Sea, Britain, Czech Republic, France, Georgia, Germany, Hungary, Ireland, Italy, Latvia, Netherlands, Portugal, Romania, Scandinavia, Serbia, Slovakia, Slovenia, Spain, Ukraine; *North America:* Northwest Territories, Québec; *South America:* Brazil, Uruguay; *Africa:* Zaire; *Middle East:* Iraq; *South-west Asia:* India; *Asia:* China, Japan, Taiwan.

Occurrence: It was determined in Çoruh basin (Çil Lake).

Staurastrum trilobulatum Dürschm. (Fig. 3j)

Synonym: -

Description: Cells 1.1-1.4 times longer than wide, 13-26 µm wide, 18-31 µm long, isthmus 5-8 µm; median constriction deep, sinus closed; semi cells subtrapezoidal and 3-lobed, with truncate basal lobes and apex, rectangular basal angles and apical slightly rounded; semi cells elliptic in apical and lateral view, cell wall smooth or finely punctate.

Ecology: This is a freshwater species.

Distribution: No record was found regarding the distribution range of this taxon.

Occurrence: It was determined in Yeşilirmak basin (Uyuz Lake).

Genus *Staurodesmus* Teiling

Staurodesmus triangularis var. *brevispina* (Allorge & Allorge) Coesel & Meesters 2013 (Fig. 3k)

Synonym: -

Description: Cells mostly biradiate, rarely triradiate, 19-25 µm long, 19-25 µm wide (excluding spines). Isthmus short, 5-7 µm wide. This species is characterized by biradiate cells, relatively short spines, and 'elevated' apices. Spines shorter than 2/3 breadth of the semi cell body. Lateral sides of semi cell body straight to slightly convex.

Ecology: This is a freshwater species.

Distribution: No record was found regarding the distribution range of this taxon.

Occurrence: It was determined in Sakarya basin (Işık Dağı Karagöl Lake).

Genus *Teilingia* Bourr.

Species: *Teilingia quadrispinata* f. *evoluta* (A.M.Scott & Grönblad) Pal.-Mordv. (Fig. 3m)

Synonym: *Sphaeroszoma quadrispinatum* f. *evolutum* A.M.Scott & Grönblad

Description: Cells 7.5-10.7 µm long, 8.7-11.5 µm wide, isthmus 4.1-5.7 µm.

Ecology: This is a freshwater species.

Distribution: *North America:* Florida, *Asia:* Russia.

Occurrence: It was determined in Batı Akdeniz basin (Girdev Lake).

Family Closteriaceae

Genus *Closterium* Nitzsch

Closterium diana var. *rectius* (Norst.) De Toni 1977 (Fig. 3n)

Synonym: -

Description: Cells 150-380 µm long, 8-16 µm wide. Cells approximately 8-15 times as long as wide, evenly slightly to strongly curved, cell wall always smooth, without girdles.

Ecology: This is a freshwater species.

Distribution: *Europe:* Czech Republic, Germany, Netherlands.

Occurrence: It was determined in Akarçay basin (Eber Lake).

Closterium pygmaeum Gutw. 1890 (Fig. 3o)

Synonym: -

Description: Cells 57 µm long and 5.3 µm wide, slightly curved, gradually attenuated toward the apex which is rounded; cell wall smooth, cells contain two pyrenoids in half part of the cell.

Ecology: This is a freshwater species.

Distribution: *Europe:* Austria, Britain, France, Germany, Netherlands, Scandinavia, Spain, Ukraine; *South America:* Brazil; *Australia and New Zealand:* New South Wales, Tasmania.

Occurrence: It was determined in Sakarya basin (Avdan Lake).

Order Zygnematales

Family Zygnemataceae

Genus *Spirogyra* Link

Spirogyra decimina var. *elongata* (Vaucher) Petlovany 2015 (Fig. 3l)

Synonym: *Spirogyra elongata* (Vaucher) Dumortier

Description: Cells 45-280 µm long, 26-38 µm wide, chloroplast single, making 2-5 turns of cell; conjugation ladder-like and lateral, conjugation scalariform; median wall smooth, thick with a wavy suture line.

Ecology: This is a freshwater species.

Distribution: *Europe:* Britain, Georgia, Germany, Ireland; Latvia, Netherlands, Romania, Russia (Europe), Slovakia, Slovenia, Spain; *North America:* California, Laurentian Great Lakes, Québec; *South America:* Argentina, Brazil; *Middle East:* Iraq, Turkey; *South-west Asia:* India, *Asia:* China, Japan, Tajikistan; *Australia and New Zealand:* New South Wales, New Zealand, Queensland, South Australia.

Occurrence: It was determined in Antalya basin (Eğirdir Lake).

Discussion

A total of 158 taxa from Charophyta were determined in the study conducted from 2017 to 2019 in 25 river basins of Turkey. Of these 31 taxa represent new records for the freshwater algal flora of Turkey. They belong to genera *Cosmarium* (15), *Staurastrum* (5), *Closterium* (2), *Actinotaenium* (1), *Desmidium* (1), *Eastrum* (1),

Groenbladia (1), *Micrasterias* (1), *Spirogyra* (1), *Spondylosium* (1), *Staurodesmus* (1), and *Teilingia* (1).

Although some of the Charophyta taxa (*Elakatothrix gelatinosa*, *Staurastrum tetracerum*, *Cosmarium laeve*, *Staurastrum cingulum*, *Closterium aciculare*, *Staurastrum gracile*, *Cosmarium neodepressum*, *Staurastrum chaetoceras*, *Closterium acutum* var. *variable*, *Closterium littorale*) found to have a wide distribution in 25 river basins of Turkey, most of the charophyta taxa (115 taxa) found to have rare distribution and were only observed in 1 or 2 lakes in 25 river basins. Besides, all of 31 new records have a rare distribution range except *Cosmarium subadoxum* and *Staurastrum pingue* var. *Planctonicum*. *Elakatothrix gelatinosa* has the highest distribution rate with its occurrence in 29 lakes, among the member of Charophyta.

There is no direct correlation between the number of lakes sampled in the basins and the number of species found. Despite sampling 23 lakes in Kızılırmak basin, only 15 Charophyta taxa were found in Kızılırmak basin, and only 6 Charophyta taxa were found in Ceyhan basin despite 18 sampling lakes. However, 42 Charophyta taxa were found in Batı Akdeniz where only 13 lakes were studied and 27 Charophyta taxa were found in Antalya basin where only 9 lakes were studied.

Basin-based distributions of Charophyta members identified in this study were as below: 50 taxa in Sakarya, 42 in Batı Akdeniz, 27 in Antalya, 26 in Konya, 21 in Fırat-Dicle, 17 in Çoruh, 15 in Kızılırmak, 13 in Yeşilirmak, Susurluk, Asi, 12 in Meriç Ergene, 10 in Kuzey Ege, 9 in Gediz, Akarçay, Büyük Menderes, 6 in Ceyhan, Doğu Akdeniz, 4 in Seyhan, Küçük Menderes, and 3 in Batı Karadeniz, Doğu Karadeniz, Marmara, Van Gölü, Aras basins. The Burdur basin is the only basin that no Charophyta species were found. The reason for this is that high salinity in Acı Lake, high pH in Salda Lake and higher eutrophic features in Burdur and Karataş Lakes. Thus, Desmids, which are sensitive species, were not found in the lakes of Burdur basin. The highest Charophyta diversity was observed in Girdev Lake (Batı Akdeniz basin) and Işık Dağı Karagöl Lake (Sakarya basin) among the lakes of Turkey's 25 river basins in this

study. The moderate ecological status in both lakes proves that desmids are mostly appear in uncontaminated waters.

Charophytes are commonly found in freshwater habitats such as ponds and streams, and few species are found in brackish waters (Adl et al. 2005). Most of the species are known from the temperate zone, but they also tolerate polar conditions (Gałka 2007, Boszke & Bociąg 2008). Desmiales, as an important ordo in Charophyta, are mostly planktonic organisms that very sensitive to environmental changes, and eutrophic conditions do not contain ideal growth conditions for these group members (Davis 1955, Edmondson 1959, Gayathri et al. 2011). They occur typically in clean standing waters such as lakes, ponds or shallow pools. The highest diversity is found in mesotrophic, slightly acidic to slightly alkaline water bodies like fen hollows or moorland pools where desmids are among the dominant groups of the phytobenthos, both in terms of species richness and biomass (Coesel & Meesters 2007). Desmids are not merely one of the main freshwater microalgae groups that occur in high mountain lakes biotopes in Turkey, but they also inhabit microhabitats with oligotrophic conditions characterized by relatively acidic to weakly alkaline waters with low conductivity (Şahin & Akar 2019). In this study, only the *Spirogyra decimina* var. *elongata* was identified from the Zygnematales order. *Spirogyra* species were found in freshwater habitats under moderately eutrophic or mesotrophic conditions (Novis 2004, Stancheva et al. 2013, Sherwood et al. 2018). They mostly occur in benthos (Volkova et al. 2018) but they can also be found in plankton (Kravtsova et al. 2020).

In conclusion, 31 new records were added to the freshwater algal flora of Turkey within this study. 13 of these newly recorded taxa belong to the Charophyta group, which are widely distributed in different parts of the world and 18 taxa are rarely distributed. When the current new records of this study were added to the previous Turkish algae list of Taşkın et al. (2019) and the database of Turkish algae (Maraşlıoğlu & Gönülol 2021) which is formed by screening a large number of studies on Turkish algae, it can be concluded that there is nearly around 450 Charophyta species in Turkish freshwaters.

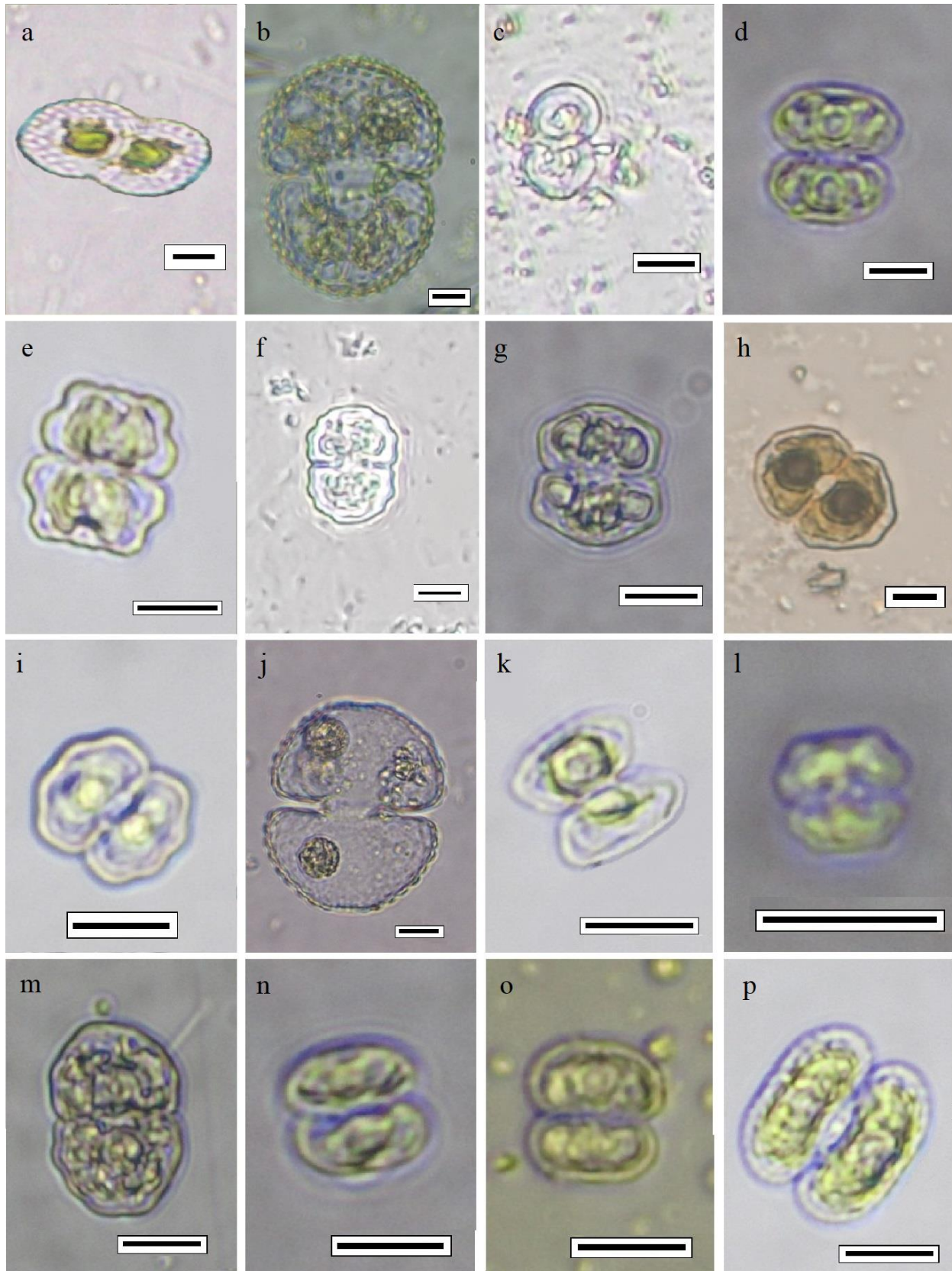


Fig. 2. Microscopic view of determined Desmidiaceae species; **a)** *Actinotaenium wollei*, **b)** *Cosmarium brebissonii*, **c)** *Cosmarium contractum* var. *rotundatum*, **d)** *Cosmarium distentum*, **e)** *Cosmarium humile* var. *substriatum*, **f)** *Cosmarium impressulum* var. *crenulatum*, **g)** *Cosmarium mamilliferum* var. *madagascariense*, **h)** *Cosmarium nymannianum*, **i)** *Cosmarium pseudowembaerense*, **j)** *Cosmarium quinarium*, **k)** *Cosmarium sphagnicola*, **l)** *Cosmarium subadoxum*, **m)** *Cosmarium subgranatum*, **n)** *Cosmarium subquadrans*, **o)** *Cosmarium subquadrans* var. *minus*, **p)** *Cosmarium tetrachondrum*. Scales 10 μ m.

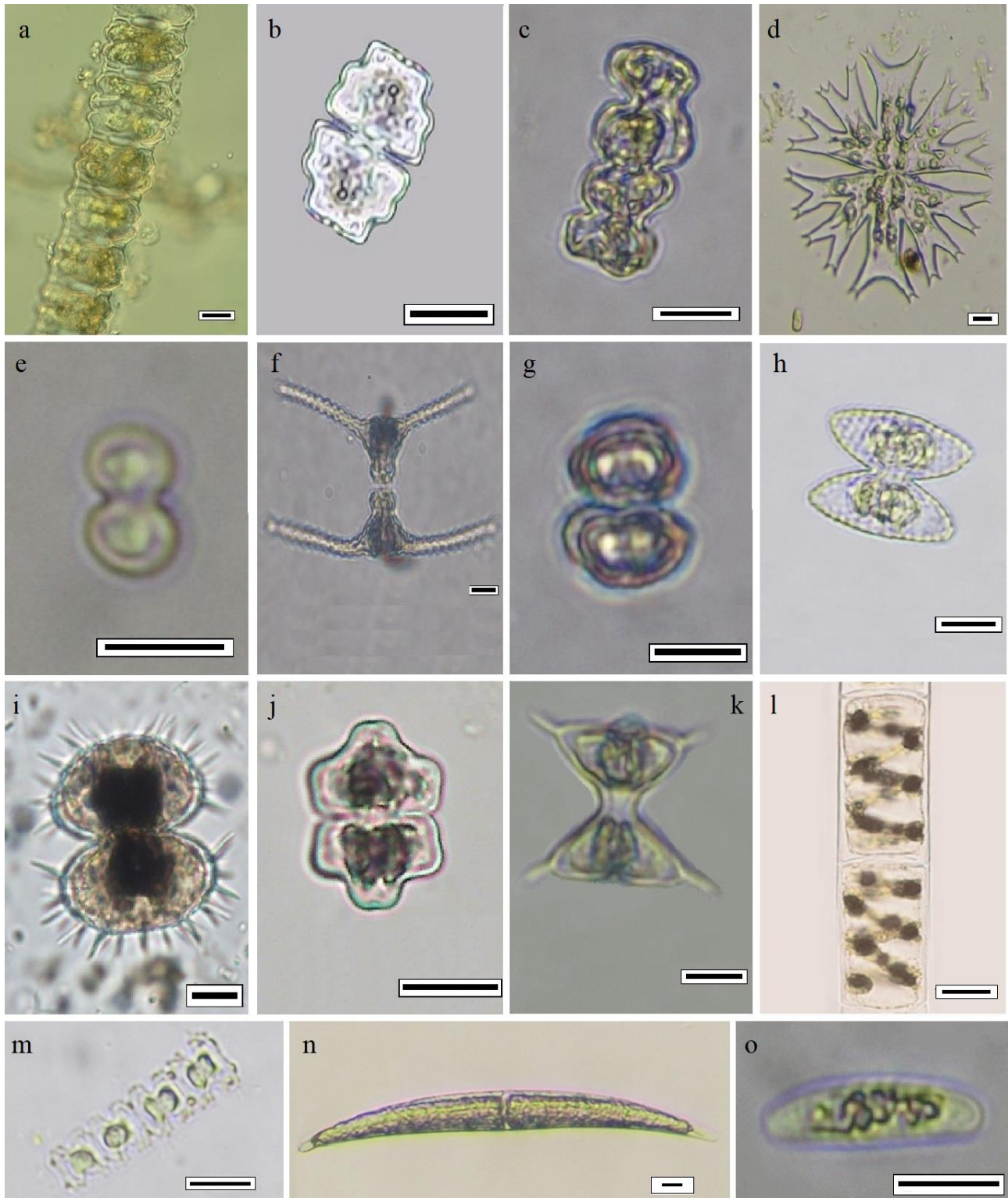


Fig. 3. Microscopic view of determined Desmidiaceae and Zygnematales species; **a)** *Desmidium aptogonum*, **b)** *Euastrum lacustre*, **c)** *Groenbladia undulata*, **d)** *Micrasterias furcata*, **e)** *Spondylosium panduriforme*, **f)** *Staurastrum pingue* var. *planctonicum*, **g)** *Staurastrum muticum* f. *minus*, **h)** *Staurastrum striatum*, **i)** *Staurastrum teliferum*, **j)** *Staurastrum trilobulatum*, **k)** *Stauroidesmus triangularis* var. *brevispina*, **l)** *Spirogyra decimina* var. *elongata* **m)** *Teilingia quadrispinata* f. *evoluta*, **n)** *Closterium diana* var. *rectius*, **o)** *Closterium pygmaeum*. Scales 10 μ m.

Acknowledgement

We would like to thank the executives and the staff of Çınar Engineering Consulting Co. (Turkey) who had executed the Project (Establishment of Reference Monitoring Network in Turkey, 2017-2019).

Ethics Committee Approval: Since the article does not contain any studies with human or animal subject, its approval to the ethics committee was not required.

Author Contributions: Concept: F.M., T.O.S., Desing: F.M., E.N.S., T.O.S., Execution: F.M., E.N.S., N.D., A.Ç., H.S., B.Ö., T.O.S., B.T., Material supplying: F.M., E.N.S., N.D., A.Ç., H.S., B.Ö., T.O.S., T.C., C.N.S., B.T., Data acquisition: F.M., E.N.S., N.D., A.Ç., H.S., B.Ö., T.O.S., T.C., C.N.S., B.T., Data

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analysis/interpretation: F.M., E.N.S., A.Ç., H.S., B.Ö., T.O.S., B.T., Writing: F.M., E.N.S., T.O.S., Critical review: F.M., T.O.S., T.C., Y.K.

Conflict of Interest: The authors have no conflicts of interest to declare.

Funding: This study was supported by the Ministry of Agriculture and Forestry, Directorate General of Water Management (Project number: 2011K050400).

Editor-in-Chief note: Burak Öterler and Tuğba Ongun Sevindik are members of Trakya University Journal of Natural Sciences Editorial Board. However, they weren't involved in the decision process during manuscript evaluation.

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