

Research Article

New Records for the Turkish Freshwater Algal Flora in Twenty Five River Basins of Turkey, Part IV: Ochrophyta

Türkiye'deki 25 Nehir Havzasından Türkiye Tatlı Su Alg Florası İçin Yeni Kayıtlar, Bölüm IV: Ochrophyta

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Abstract

Turkish lakes have different morphometric and hydrological features as a result of different climates and noticeable altitude differences in Turkey that are necessary conditions to occur different habitats for algal diversity. The total number of algae taxa in the flora of Turkey has increased due to the growing number of studies on phytoplankton taxonomy and ecology in the last 40 years. This study aims to describe new planktonic algal taxa for the Turkish freshwater algal flora. A total of 56 Ochrophyta taxa were determined in this study, conducted from 2017 to 2019 in lakes lies in 25 river basins of Turkey. In 275 lakes, samples of phytoplankton were collected with water samplers from three depths (surface, middle, and bottom) of the euphotic zone, and then subsamples were obtained by mixing the water samples taken from these three depths. The plankton net with a pore diameter of 50 µm was also used for collecting samples of phytoplankton. The algal taxa was identified by using different types of compound and inverted microscopes in many laboratories. 30 Ochrophyta taxa of which were determined in this study, were reported as a new record for the first time for the freshwater algal flora of Turkey.

Keywords: *Ochrophyta, freshwater algae, new record, Turkey*

Öz

Türkiye gölleri, Türkiye farklı iklim tiplerine ev sahipliği yaptığından ve coğrafik olarak yükseklik farklılıkları bulundurduğundan dolayı farklı morfometrik ve hidrolojik yapıya sahip olup, bu durum alglerin biyoçeşitliliği için farklı habitat tipleri sağlamaktadır. Son 40 yılda, fitoplankton taksonomisi ve ekolojisi alanında yapılan çalışmaların artması sebebiyle Türkiye florasındaki toplam alg taksonu sayısı artmıştır. Bu çalışma, Türkiye tatlı su alg florası için yeni planktonik alg taksonlarını tanımlamayı amaçlamaktadır. 2017 ve 2019 yılları arasında Türkiye'deki 25 nehir havzasında bulunan göllerde yapılan çalışmada Ochrophyta divizyonuna ait 56 takson tanımlanmıştır. 275 gölde yapılan bu çalışmada fitoplankton örnekleri öfotik derinliğin 3 farklı bölgesinden (yüzey, orta, dip) su örnekleyicileri ile toplanmıştır. Daha sonra bu üç derinlikten alınan su örnekleri karıştırılarak su numuneleri alınmıştır. 50 µm göz açıklığına sahip plankton kepçesi de örnekleme sırasında ayrıca kullanılmıştır. Alg taksonlarının teşhisi farklı laboratuvarlardaki ışık ve ters mikroskopları kullanılarak gerçekleştirilmiştir. Çalışma sırasında, Türkiye tatlı su alg florası için ilk defa Ochrophyta divizyonuna ait 30 yeni takson bulunmuştur.

Anahtar kelimeler: *Ochrophyta, tatlı su algi, yeni kayıt, Türkiye*

Introduction

The number of studies on phytoplankton taxonomy and ecology, accepted as one of the biological quality elements according to the EU Water Framework Directive (WFD) (European Parliament & Council, 2000), has notably increased in recent years in Turkey. Due to Turkey's EU accession process, several projects, specified for biological quality components and funded by Directorate General for Water Management (DGWM) and General Directorate of State Hydraulic Works (DSİ) of the Ministry of Agriculture and Forestry, have been implemented successfully. Many studies for monitoring water quality of different river basins, a few studies for development and implementation of lake-management plans, and some index development projects to determine water quality by using biological

quality components have been completed (DGWM, 2020). This study is an outcome of one of these projects.

Planktonic Ochrophyta species are mostly unicellular or colonial flagellates, predominantly occurring in freshwater (John et al., 2003). Chrysophyceae, Synurophyceae, and Xanthophyceae are the main plankton groups that are found in a freshwater environment. They were mostly reported in relatively unpolluted freshwaters and good indicators of water quality (Harper et al., 2012).

Until now, in previous studies, more than 4325 Ochrophyta taxa were listed in the world (Guiry & Guiry, 2020), while 223 Ochrophyta taxa were recorded in the flora of Turkey. However, only 51 taxa were identified as freshwater taxa (Taşkın et al., 2019; Maraşlıoğlu & Gönüloğlu, 2020). In consequence of four different types of climate and noticeable altitude differences in Turkey, its lakes have different morphometric and hydrological features that are appropriate conditions for different algal species. In recent years, many new records were given for the algal flora of Turkey. A total of 250 new taxa were reported in Bacillariophyta (23), Chlorophyta (84), Charophyta (68), Cryptophyta (7), Cyanobacteria (22), Euglenozoa (25), Miozoa (11), Ochrophyta (8), and Rhodophyta (2) divisions. These records were mainly found in Susurluk, Sakarya, Fırat - Dicle, Yeşilirmak, Marmara, Doğu Karadeniz, Çoruh, Burdur, and Antalya basins. It has been seen that the contribution to new records is highest in Sakarya and Fırat - Dicle basins which have the largest surface area (Aysel et al., 1993; Öztürk et al., 1995a, 1995b; Şahin, 2000, 2002, 2007, 2009; Yağcı & Turna, 2002; Atıcı, 2002; Baykal et al., 2009; Sevindik et al., 2010, 2011, 2015, 2017; Özer et al., 2012; Akar & Şahin, 2014; Yüce & Ertan, 2014; Varol & Fucikova, 2015; Varol & Şen, 2016; Maraşlıoğlu & Soylu, 2018; Şahin & Akar, 2019a, 2019b; Morkoyunlu & Aktaş, 2020). As a consequence of these studies, the total number of taxa have increased in Turkey (Taşkın et al., 2019; Maraşlıoğlu & Gönüloğlu, 2020). Similar studies were done and new records were recorded in different parts of the world (Khondker et al., 2006; Alfasane & Khondker, 2007; Oliveira et al., 2013; Bartozek et al., 2018; Akhtar et al., 2019).

This study is one of the outcomes of the “Establishment of Reference Monitoring Network in Turkey” project, financially and technically supported by DGWM. In this project, 275 lakes in 25 river basins were studied, and a total of 1363 phytoplankton taxa were detected. 56 of total taxa were determined as Ochrophyta and 30 of the total number of Ochrophyta were recorded as new records for Turkish freshwater algae.

Materials and Methods

Study Area

Turkey has 25 river basins (Figure 1), and inland water bodies in these basins consist of 200 natural lakes, 806 reservoirs, and 1000 ponds (Foreign Relation Office of DSİ, 2014). The natural lakes are mainly distributed in Burdur, Susurluk, Van and Konya basins (Hoşgören, 1994).

Figure 1

River Basins of Turkey



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

Table 1

Lakes Where the Research Was Conducted in the 25 River Basins

Basins	The number of studied lakes	Name of lake
Burdur	6	Acıgöl L., Burdur L., Karataş L., Salda L., Tefenni P., Keçiborlu Güneykent Uzundere P.
Akarçay	10	Akşehir L., Eber L., Akdeğirmen R., 26 Ağustos TP L., Karamık R., Ağzıkara P., Tınaztepe P., Gezler P., Şehit Uz. Çvş. Nurullah Oymak P., Tazlar Satı Gelin P.
Sakarya	23	Taşkıstığı L., Akgöl 2 L., Çubuk L., Poyrazlar L., Sapanca L., Işık Dağı Karagöl L., Çavuşcu L., Mogan L., Üçlerkayası P., Çubuk Karagöl L., Eymir L., Akgöl 1 L., Küçük Akgöl L., Avdan L., Kayuslu L., Karamurat L., Cüneyt Sönmez P., Çılgınlar P., Yıldırım Evci P., Ovacık L., Sülüklü L., Çamkoru TP P., Anagöl L.
Batı Karadeniz	14	Nazlı L., Büyük L., Derin L., Parçayır L., Abant L., Dipsiz L., Gölcük L., Keçi L., Yeniçağa L., Kuyudüzü L., Erze L., Koca L., Kuru L. Natural Park, Sazlı L.
Doğu Karadeniz	7	Gaga L., Sera L., Ulugöl L., Uzungöl L., Çamlu L., Çakır L., Limni L.
Yeşilırmak	14	Akgöl L., Aşağıtepecik (Gölova) L., Boraboy P., Büyük L., Düden L., Kaz L., Ladik L., Uyuz L., Karacaören Mevki L., Dipsiz L. 2, Sarıçiçek L., Yenihayat R., Dipsiz L. 1, Zinav L.
Kızılırmak	23	Gölbel L., Ulaş L.-2, Büyük Lota L., Hafik L., Küçük Lota L., Tödürge L., Arı L., Aygır L., Bakkal L., Dipsiz L., Elekci L., Ulaş L.-1, Ulaş L.-3, Deniz L., Yeşilgöl 1 L., Bardakçılı Mevki L., Yenidanişment Mevki L., Palanga L., Sugıylan Mevki L., Kayabaşı L., Kuru L., Sıraç L., Kızılçam L.
Meriç-Ergene	5	Gala L., Sığırcı L., Pamuklu L., Üsküp Sulama P., Domuz L.
Marmara	9	Habibler Mevki P., Great Dipsiz L., İznik L., Koca L., Karamaden L., Danamandıra L.-1, Danamandıra L.-2, Small Dipsiz L., Sinekli L.
Antalya	9	Eğirdir L., Kovada L., Gölcük L., Cemalalanı L., Duruca L., Eğri L., Küllü L., Titreyen L., Düden L.
Batı Akdeniz	13	Göhlisar L., Girdev L., Avlan L., Dalaman Wetlands, Denizcik L., Kocagöl L., Kusuuru L., Köycegiz L., Küçükdalyan L., Yeşilgöl L., Yazır L., Baranda L., Pozan L.

Table 1

(Continued)

Basins	The number of studied lakes	Name of lake
Büyük Menderes	13	Nazlı L., Büyük L., Derin L., Parçayır L., Abant L., Dipsiz L., Gölcük L., Keçi L., Yeniçağa L., Kuyudüzü L., Erze L., Koca L., Kuru L. Natural Park, Sazlı L.
Gediz	6	Gölcük L., Demirköprü R., Marmara L., Gördes R., Karagöl L., Küçükler R.
Kuzey Ege	5	Boz L., Güzelhisar R., Karagöl L., Sevişler R., Tepe L.
Küçük Menderes	6	Çatal L., Tahtalı R., Alaçatı R., Belevi L., Gebekirse L., Ürkmez R.
Konya	18	Sarıot L., Beyşehir L., Tuz L., Süleymanhacı L., Gök (Kozanlı) L., Meke L. (Meke Maarı), Gavur L., Dipsiz L., Acıgöl L. 2, Bakı L., Uyuz L., Acıgöl L. 1, Kayı L., Düden L., Kovalı L., Köpek L., Küçük L., Sülüklü L.
Susurluk	9	Manyas L., Ulubat L., Adsız-1 L., Gölbaşı L., Gölcük L., İkizcetepeler R., Karagöl L., Kilimli L., Nilüfer R.
Aras	3	Aktaş L., Çıldır L., Aygır L.
Çoruh	8	Adsız L., Boğa L., Balık L., Şavşat Karagöl L., Çil L., Borçka Karagöl L., Tortum L., Ürünlü P.
Fırat-Dicle	17	Kaz L., Ahır L., Haçlı L., Korlu L., Hazar L., Karagöl L., Yeşildere P., Palandöken P., Güroymak R., Kalecik R., Kapaçmaz P., Dedeyolu P., Güzelyurt Sulama P., Hasancık P., İncesu P., Otlukbeli L., Siverek Yeleken P.
Van	7	Akgöl L., Erçek L., Bostaniçi P., Arin L., Aygır L., Van L., Nazik L.
Asi	8	Reyhanlı (Yenihisar) L., Yayladağ R., Tahtaköprü R., Karagöl L., Adsız L., Yarseli R., Üçpınar P., Sapkanlı P.
Ceyhan	18	Gölbaşı L., Kartalkaya R., Kara L., B. Yapalak P., Korkmaz P., Zorkun P., Merk P., Yamaçoba P., Kızıliniş P., Arıklıkaş P., Karacaören P., Meletmez P., Postkabasakal P., Bağtepe P., Zerdali P., Kozan Aydın P., Yumurtalık Zeytinbeli P., Yumurtalık Ayvalık P.
Doğu Akdeniz	12	Aygır L., Uzun L., Değirmendere P., Cemilli Çevlik P., Hacınuhlu Kelce P., Akın P., Kızılöz P., Başyayla P., Göktepe P., Bağbaşı R., Yassıbağ P., Hadım-İnönü P.
Seyhan	12	Bahçelik R., Tufanbeyli Demirogluk P., Adsız L., Pekmezli-Çatalçam P., Tufanbeyli Doğanbeyli P., Gümüşören R., Şıhlı P., Dölekli P., Kılıçlı P., Topacık P., Hüsnüye P., Çavuşlu P.
Total	275	

L: Lake; P: Pond; R: Reservoir; R: Reeds

Sampling and Identification

Phytoplankton was sampled three times (spring, summer, and autumn) a year in 2017, 2018, and 2019 at the one, two, or three monitoring stations in each lake. The number of stations to be sampled were determined as one station for lakes that have a surface area smaller than 50 ha, two stations for lakes having a surface area between 50 and 500 ha, and three stations for lakes with a surface area higher than 500 ha ((Yer Üstü Suları, Yer Altı Suları ve Sedimentten Numune Alma ve Biyolojik Örnekleme Tebliği, 2015). One of the selected stations was determined at the deepest point of the lake. In 275 lakes, samples of the phytoplankton were collected with a water sampler from three depths (surface, middle, and bottom) of the euphotic zone (Secchi disk depth \times 2.5), and then subsamples were obtained by mixing the water samples, taken from these three depths. Plankton net with a pore diameter of 50 μ m was also used for collecting samples of phytoplankton. All samples were fixed with Lugol's solution. The algal taxa were identified by using different types of the compound and inverted microscopes in many laboratories according to the identification books of Huber-Pestalozzi (1962) and John et al. (2003). Identified taxa were checked with the checklist of Aysel (2005), Taşkın et al. (2019), and the database of Turkish algae (Maraşlıoğlu & Gönüloğlu, 2020), and then determined as new taxa for Turkish freshwater algal flora. The currently accepted nomenclature and distribution of taxa have been given according to Guiry and Guiry (2020). The new records were photographed with the cameras attached to the microscopes.

Results

A total of 30 Ochrophyta taxa are described below.

Phylum: Ochrophyta

Class: Bikosea

Order: Bicoecida

Family: Bicoecidae

Genus: *Bicosoeca*

Species: *Bicosoeca planctonica* Kisselev 1931 (Figure 2a)

Synonym: --

Description: Lorica bell-shaped, with a button-shaped bulge at the base, yellowish, composed of about 10 rings stacked in parallel, 14 μ m long, width at the mouth 13 μ m.

Ecology: This is freshwater species. The water quality indicator is tolerant.

Distribution: *Europe:* France, Romania, Scandinavia, Slovakia, Sweden.

Occurrence: It has been detected in freshwater habitats (lakes) in the Yeşilirmak basin.

Class: Chrysophyceae

Order: Hibberdiales

Family: Stylococcaceae

Genus: *Bitrichia*

Species: *Bitrichia chodatti* (Reverdin) Chodat 1926 (Figure 2b)

Synonym: *Diceras chodatii* Reverdin 1917

Description: Cells surrounded by a hyaline lorica with 2 curved processes, one often more curved than the other, 35 µm and 20 µm long respectively. Chloroplast single and without an eyespot. Cells 14 µm long, 6 µm wide.

Ecology: This is freshwater species. The water quality indicator is tolerant.

Distribution: *Europe:* Netherlands, Slovakia, Baltic Sea, Britain, Germany, Scandinavia, Spain. *North America:* Northwest Territories, Québec. *Middle East:* Israel.

Occurrence: It has been detected in freshwater habitats (lakes) in the Yeşilirmak basin.

Order: Chromulinales

Family: Chromulinaceae

Genus: *Chromulina*

Species: *Chromulina annulata* Conrad 1930 (Figure 2c)

Synonym: --

Description: Cells ovate, 1.5 times longer than wide, broadly rounded at the back, 5 µm long, 3 µm wide. Flagella apical, 1.5 times longer than the body. Chloroplast single, without an eyespot.

Ecology: This is freshwater species. The water quality indicator is sensitive.

Distribution: --

Occurrence: It has been detected in freshwater habitats (lakes) in the Sakarya basin.

Species: *Chromulina ovalis* Klebs 1893 (Figure 2d)

Synonym: --

Description: Cells ellipsoidal, 8 µm long, 5 µm wide. Flagella 1.5 times longer than the body. Chloroplast single, with an eyespot, and without a pyrenoid.

Ecology: This is freshwater species. The water quality indicator is sensitive.

Distribution: *Europe:* Black Sea, Britain, Germany, Latvia, Netherlands, Romania, Slovakia, Spain, Sweden. *North America:* Northwest Territories. *South America:*

Argentina. *Asia*: India, China, Japan, Taiwan. *Australia and New Zealand*: New South Wales, Queensland.

Occurrence: It has been detected in freshwater habitats (lakes) in the Çoruh basin.

Species: *Chromulina sphaeridia* J. Schiller 1929 (Figure 2e)

Synonym: --

Description: Cells regularly spherical, 7 µm in diameter. Flagella 2.5 times longer than the body. Chloroplast two, without an eyespot.

Ecology: This is freshwater species. The water quality indicator is sensitive.

Distribution: *Europe*: Slovakia.

Occurrence: It has been detected in freshwater habitats (lakes) in Batı Akdeniz and Sakarya basins.

Species: *Chromulina wislouchiana* Bourrelly 1957 (Figure 2f)

Synonym: *Chrysoglena verrucosa* Wislouch 1914

Description: Cells irregularly ellipsoidal, 20 µm long, 12 µm wide, with walls densely covered with rounded warts. Flagella one per cell. Chloroplast single and large, with an eyespot and without a pyrenoid.

Ecology: This is freshwater species. The water quality indicator is sensitive.

Distribution: *Europe*: Britain

Occurrence: It has been detected in freshwater habitats (lakes) in the Batı Akdeniz basin.

Genus: *Ochromonas*

Species: *Ochromonas granulosa* H. Meyer 1897 (Figure 2g)

Synonym: --

Description: Cells solitary, naked, with two unequal flagella. Cells ovoid, with tapered tail, 15 µm long, 8 µm wide. Chloroplast two, small, reduced, with an eyespot. Main flagellum as long as body-length.

Ecology: This is freshwater species. The water quality indicator is sensitive.

Distribution: *Europe*: Germany

Occurrence: It has been detected in freshwater habitats (lakes) in Sakarya and Akarçay basins.

Family: Dinobryaceae

Genus: *Chrysococcus*

Species: *Chrysococcus minutus* (F. E. Fritsch) Nygaard 1932 (Figure 2h)

Synonym: *Trachelomonas volvocina* f. *minuta* Fritsch 1918

Description: Lorica spherical, 5,5 µm in diameter, brown. Chloroplast single; one eyespot.

Ecology: This is freshwater species. The water quality indicator is sensitive.

Distribution: *South-west Asia:* India. *Arctic:* Svalbard (Spitsbergen). *Europe:* Baltic Sea, Britain, Germany, Netherlands, Romania, Scandinavia, Spain, Sweden. *North America:* Arkansas. *Australia and New Zealand:* New South Wales, Tasmania.

Occurrence: It has been detected in freshwater habitats (lakes) in the Batı Akdeniz basin.

Genus: *Dinobryon*

Species: *Dinobryon cylindricum* var. *alpinum* (O. E. Imhof) H. Bachmann 1911 (Figure 2i)

Synonym: --

Description: Lorica 35 µm long, not cylindrical but more vase-shaped; colonies many-celled and rather dense.

Ecology: This is freshwater species. The water quality indicator is sensitive.

Distribution: *Europe:* Britain, France, Germany, Scandinavia, Spain, Sweden. *North America:* Arkansas, Northwest Territories, Québec. *South America:* Argentina. *Australia and New Zealand:* New Zealand, Tasmania.

Occurrence: It has been detected in freshwater habitats (lakes) in the Susurluk basin.

Species: *Dinobryon korshikovii* Matvienko ex Kapustin 2019 (Figure 2j)

Synonym: *Dinobryon elegans* Korshikov 1926

Dinobryon elegantissimum Bourrelly 1957

Description: Lorica solitary, the campanulated posterior region gradually attenuated, lateral margins slightly convex with marked undulations, 40 µm long, 10 µm wide.

Ecology: This is freshwater species. The water quality indicator is sensitive.

Distribution: *Europe:* Netherlands, Britain, Bulgaria, Scandinavia. *South America:* Brazil. *North America:* Québec. *Asia:* Japan.

Occurrence: It has been detected in freshwater habitats (lakes) in Küçük Menderes and Büyük Menderes basins.

Genus: *Kephyrion*

Species: *Kephyrion littorale* J. W. G. Lund 1942 (Figure 2k)

Synonym: --

Description: Lorica ovoid to bowl-shaped, with a thickening around the mouth, 7 µm long, 5 µm wide, brownish; single flagellum.

Ecology: This is freshwater species. The water quality indicator is sensitive.

Distribution: *Europe:* Britain, Germany, Netherlands, Romania, Scandinavia, Slovakia, Sweden. *Asia:* China, Tajikistan.

Occurrence: It has been detected in freshwater habitats (lakes) in Yeşilırmak and Doğu Karadeniz basins.

Species: *Kephyrion rubri-claustri* Conrad 1939 (Figure 3a)

Synonym: --

Description: Lorica barrel-shaped with an equatorial bulge, 6.5 µm long, 5 µm wide; single flagellum.

Ecology: This is freshwater species. The water quality indicator is sensitive.

Distribution: *Europe:* Baltic Sea, Black Sea, Britain, Germany, Netherlands, Romania, Scandinavia, Slovakia, Spain, Sweden, Ukraine. *Asia:* Taiwan, Tajikistan.

Occurrence: It has been detected in freshwater habitats (lakes) in Batı Akdeniz, Sakarya, and Akarçay basins.

Genus: *Kephyriopsis*

Species: *Kephyriopsis ovum* Pascher & Ruttner (Figure 3b)

Synonym: --

Description: Lorica transversely truncated ovoid, a little longer than wide, mostly with a clear thickening ring, 10 µm long, 9 µm wide.

Ecology: This is freshwater species. The water quality indicator is sensitive.

Distribution: *Europe:* Netherlands

Occurrence: It has been detected in freshwater habitats (lakes) in the Asi basin.

Genus: *Pseudokephyrion*

Species: *Pseudokephyrion cinctum* (J. Schiller) Gerlinde Schmid 1939 (Figure 3c)

Synonym: *Kephyriopsis cincta* J. Schiller 1926

Description: Lorica cylindrical, brownish, rounded at the basal end, slightly narrowing towards the apical end, 9 µm long, 6 µm wide; flagella 2, unequal.

Ecology: This is freshwater species. The water quality indicator is sensitive.

Distribution: *Europe:* Slovakia. *North America:* Arkansas.

Occurrence: It has been detected in freshwater habitats (lakes) in the Sakarya basin.

Species: *Pseudokephyrion entzii* W. Conrad 1939 (Figure 3d)

Synonym: --

Description: Lorica elongated, brownish, rather thin-walled, broadly rounded at the basal end, then rising almost cylindrically, only slightly widening towards the apical end, 5 µm long, 4 µm wide; flagella 2, unequal.

Ecology: This is freshwater species. The water quality indicator is sensitive.

Distribution: *Arctic:* Svalbard (Spitsbergen). *Europe:* Britain, Czech Republic, Germany, Netherlands, Scandinavia, Slovakia, Sweden. *North America:* Northwest Territories, Québec. *Asia:* Tajikistan.

Occurrence: It has been detected in freshwater habitats (lakes) in Batı Karadeniz, Sakarya, Yeşilirmak, Akarçay, Fırat-Dicle and Asi basins.

Species: *Pseudokephyrion minutissimum* Conrad (Figure 3e)

Synonym: --

Description: Lorica very small, brown, quite thick, smooth, basal part almost hemispherical, apical part with a wider narrowed mouth, 5 µm long, 4 µm wide; single flagellum.

Ecology: This is freshwater species. The water quality indicator is sensitive.

Distribution: *Europe:* Romania. *North America:* Québec. *Asia:* Russia (Far East), Tajikistan.

Occurrence: It has been detected in freshwater habitats (lakes) in Sakarya, Fırat-Dicle, and Asi basins.

Species: *Pseudokephyrion ovum* (Pascher & Ruttner) Conrad 1939 (Figure 3f)

Synonym: --

Description: Lorica bowl-shaped, 8 µm long, 5 µm wide, brownish; single flagellum.

Ecology: This is freshwater species. The water quality indicator is sensitive.

Distribution: *Europe:* Britain, Germany, Netherlands, Spain, Sweden. *North America:* Northwest Territories. *Asia:* Tajikistan.

Occurrence: It has been detected in freshwater habitats (lakes) in Yeşilirmak and Doğu Karadeniz basins.

Species: *Pseudokephyrion pilidium* Schiller 1929 (Figure 3g)

Synonym: --

Description: Lorica conical, rounded at the back, side walls below the wide mouth initially concave, then slightly convex, 12 µm long, 9 µm wide; flagella 2, unequal.

Ecology: This is freshwater species. The water quality indicator is sensitive.

Distribution: *Europe:* Germany, Netherlands. *North America:* Arkansas.

Occurrence: It has been detected in freshwater habitats (lakes) in Batı Akdeniz and Fırat-Dicle basins.

Species: *Pseudokephyrion pseudospirale* Bourrelly 1957 (Figure 3h)

Synonym: --

Description: Lorica ovoid, broadest at the middle, 7.5 µm long, 5 µm wide, with a helical thickening making 3 turns, brownish; chloroplast single; flagella 2, unequal.

Ecology: This is freshwater species. The water quality indicator is sensitive.

Distribution: *Europe:* Britain, Germany, Netherlands, Slovakia. *North America:* Arkansas. *Asia:* India. *Antarctic and Antarctic islands:* Signy Island.

Occurrence: It has been detected in freshwater habitats (lakes) in Batı Akdeniz and Firat-Dicle basins.

Species: *Pseudokephyrion ruttneri* (Schiller) Gerlinde Schmidt 1939 (Figure 3i)

Synonym: *Kephyriopsis ruttneri* Schiller 1929

Description: Lorica cylindrical with an apical constriction, transparent, 7 µm long, 5 µm wide, flagella 2 per cell.

Ecology: This is freshwater species. The water quality indicator is sensitive.

Distribution: *Europe:* Britain, Spain.

Occurrence: It has been detected in freshwater habitats (lakes) in the Batı Akdeniz basin.

Order: Paraphysomonadales

Family: Paraphysomonadaceae

Genus: *Chrysosphaerella*

Species: *Chrysosphaerella longispina* Lauterborn 1896 (Figure 3j)

Synonym: --

Description: Cells with their narrowed basal ends are united to form spherical colonies, which are held together by a gel. Cells ovoid, 8 µm long, 6 µm wide. Colony diameter 60 µm. Flagella 20 - 30 µm.

Ecology: This is freshwater species. The water quality indicator is sensitive.

Distribution: *Europe:* Britain, Germany, Ireland, Netherlands, Romania, Russia (Europe), Scandinavia, Sweden. *North America:* Arkansas, Laurentian Great Lakes, Newfoundland, Ontario, Québec, Virginia. *South America:* Argentina. *Asia:* India, Russia (Far East). *Australia and New Zealand:* New Zealand.

Occurrence: It has been detected in freshwater habitats (lakes) in the Asi basin.

Class: Synurophyceae

Order: Synurales

Family: Mallomonadaceae

Genus: *Mallomonas*

Species: *Mallomonas anglica* (N. Carter) Huber-Pestalozzi 1941 (Figure 3k)

Synonym: *Pseudomallomonas anglica* N. Carter 1937

Description: Cells ellipsoidal, 20 µm long, 8 µm wide. Flagella 22 µm long, with a large bluish basal grain at the base. Two chloroplasts, no stigma, no pyrenoid.

Ecology: This is freshwater species. The water quality indicator is sensitive.

Distribution: *Europe:* Britain, Netherlands.

Occurrence: It has been detected in freshwater habitats (lakes) in the Fırat-Dicle basin.

Species: *Mallomonas caudata* Iwanoff [Ivanov] 1899 (Figure 3l)

Synonym: --

Description: Cells elliptical, 25 µm long, 10 µm wide. Bristles densely covering cells, curved and coarsely serrated. Scales large, elliptical, without any visible structure.

Ecology: This is freshwater species. The water quality indicator is sensitive.

Distribution: *Europe:* Baltic Sea, Britain, France, Germany, Greece, Netherlands, Romania, Russia (Europe), Scandinavia, Slovakia, Spain, Sweden, Ukraine. *North America:* Arkansas, Florida, Laurentian Great Lakes, Newfoundland, Northwest Territories, Ontario, Québec, Tennessee. *South America:* Argentina, Brazil. *Middle East:* Iraq. *Asia:* India, Vietnam, China, Korea, Russia, Taiwan, Tajikistan. *Australia and New Zealand:* Queensland, New South Wales.

Occurrence: It has been detected in freshwater habitats (lakes) in the Çoruh basin.

Species: *Mallomonas majorensis* Skuja 1939 (Figure 3m)

Synonym: --

Description: Cells ovoid, 15 µm long, 9 µm wide. Flagella 7 µm. Bristles completely absent.

Ecology: This is freshwater species. The water quality indicator is sensitive.

Distribution: *Europe:* Britain, Netherlands, Romania, Slovakia, Spain, Sweden. *North America:* Arkansas, Québec. *Asia:* Russia (Far East).

Occurrence: It has been detected in freshwater habitats (lakes) in the Fırat-Dicle basin.

Species: *Mallomonas teilingii* Conrad 1927 (Figure 3n)

Synonym: *Mallomonas litomesa* var. *major* Teiling 1912

Mallomonas tridentata Nygaard 1949

Description: Cells broadly spindle-shaped, 15 µm long, 7 µm wide. Bristle as long as body length. Chloroplast two.

Ecology: This is freshwater species. The water quality indicator is sensitive.

Distribution: *Europe:* Netherlands, Britain, Germany, Netherlands, Romania, Sweden. *South America:* Brazil.

Occurrence: It has been detected in freshwater habitats (lakes) in the Sakarya basin.

Species: *Mallomonas tonsurata* Teiling 1912 (Figure 3o)

Synonym: *Mallomonas heterotricha* Nygaard 1949

Description: Cells ovoid, 12 µm long, 7 µm wide, bristles forming an apical tuft, a group of short curved bristles surrounded by some longer straight ones.

Ecology: This is freshwater species. The water quality indicator is sensitive.

Distribution: *Europe:* Baltic Sea, Britain, France, Germany, Greece, Latvia, Netherlands, Romania, Scandinavia, Slovakia, Spain, Sweden. *North America:* Arkansas, Florida, Laurentian Great Lakes, Québec. *South America:* Argentina, Brazil. *Asia:* China, Japan, Russia, Taiwan, India, Myanmar (Burma), Vietnam. *Australia and New Zealand:* Australia, New South Wales, New Zealand, Northern Territory, Tasmania, Victoria.

Occurrence: It has been detected in freshwater habitats (lakes) in the Yeşilirmak basin.

Order: Chloramoebales

Family: Chloramoebaceae

Genus: *Phacomonas*

Species: *Phacomonas pelagica* Lohmann 1903 (Figure 3p)

Synonym: --

Description: Protoplast lens-shaped, broadside almost circular, narrow side elliptical, 10 µm long, 6 µm wide. Chloroplast two.

Ecology: This is freshwater species. The water quality indicator is sensitive.

Distribution: *Europe:* Britain

Occurrence: It has been detected in freshwater habitats (lakes) in the Fırat-Dicle basin.

Class: Xantophyceae

Order: Mischococcales

Family: Centritractaceae

Genus: *Centritractus*

Species: *Centritractus africanus* F. E. Fritsch & M. F. Rich 1930 (Figure 3r)

Synonym: *Centritractus lemmermanni* Skvortsov & Noda 1969

Description: Cells solitary, long, cylindrical, slightly curved, with a spine at each apex, 20 µm long, 4 µm wide. Cell membrane tough. Spines slightly curved, 22 µm long.

Ecology: This is freshwater species. The water quality indicator is tolerant.

Distribution: *Europe:* Bulgaria, Germany, Netherlands, Romania, Spain, Ukraine. *America:* Brazil, Cuba. *Africa:* D. R. of Congo. *Asia:* India. *Australia and New Zealand:* New Zealand.

Occurrence: It has been detected in freshwater habitats (lakes) in Sakarya and Asi basins.

Genus: *Pseudotetraëdron*

Species: *Pseudotetraëdron neglectum* Pascher 1912 (Figure 3s)

Synonym: --

Description: Cells narrowly oblong, 12 µm long, with four spines. Spine length 13 µm.

Ecology: This is freshwater species. The water quality indicator is sensitive.

Distribution: *Europe:* Czech Republic, Netherlands. *Asia:* Russia (Far East).

Occurrence: It has been detected in freshwater habitats (lakes) in the Batı Akdeniz basin.

Family: Botryochloridaceae

Genus: *Ducellieria*

Species: *Ducellieria chodatii* var. *armata* (Skuja) Teiling 1957 (Figure 3t)

Synonym: --

Description: Cells conical, 10 µm in diameter, connected at the hexagonal base by bridges 7 µm long and 1.5 µm thick. Horn-like 10-12 µm long extension protruded from the top of the outer cells. Coenobia 65 µm in size.

Ecology: This is freshwater species. The water quality indicator is sensitive.

Distribution: --

Occurrence: It has been detected in freshwater habitats (lakes) in the Sakarya basin.

Discussion and Conclusion

A total of 30 taxa were determined as new records for Turkish freshwater algae in the division of Ochrophyta. These taxa were dispersed into genus *Bicosoeca*, *Bitrichia*, *Chromulina* (4), *Ochromonas*, *Chrysococcus*, *Dinobryon* (2), *Kephyrion* (2), *Kephyriopsis*, *Pseudokephyrion* (7), *Chrysosphaerella*, *Mallomonas* (5),

Phacomonas, *Centrtractus*, *Pseudotetraëdron*, *Ducellieria*. Previously 2 taxa in *Bicosoeca*, 12 taxa in *Dinobryon*, 1 taxon in *Pseudokephyrion*, 4 taxa in *Mallomonas*, and 1 taxon in *Centrtractus* genus were recorded in Turkey (Taşkın et al., 2019; Maraşlıoğlu & Gönülol, 2020). However, 10 genus (*Bitrichia*, *Chromulina*, *Ochromonas*, *Chrysococcus*, *Kephyrion*, *Kephyriopsis*, *Chrysosphaerella*, *Phacomonas*, *Pseudotetraëdron*, *Ducellieria*) and taxa in these 10 genus were found as a new record for the first time for algal flora of Turkey.

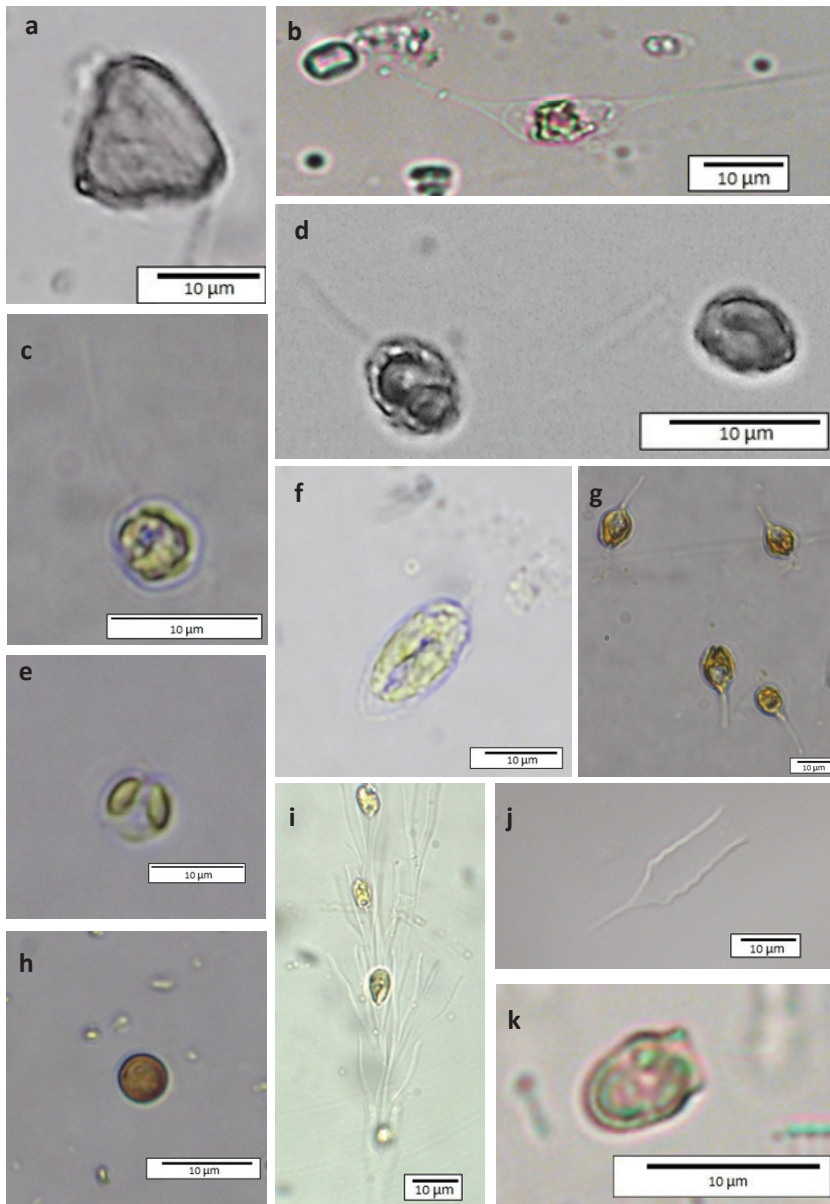
Only *Bicosoeca* is in Bikosea class, the others are in Chrysophyceae and Xantophyceae classes. The members of the Chrysophyceae class have been determined mostly in freshwaters but few species were found in the snow, soil, and marine habitats (Harper et al., 2012). A large majority of Xanthophyceae members were found in freshwater and soil, while some of them have distributed in brackish and marine habitats (Maistro et al., 2016). The members of freshwater Ochrophyta are characterized in oligotrophic lakes and ponds. Their ecological status is generally sensitive, but *Bicosoeca planctonica* and *Bitrichia chodatti* are tolerant.

Although these 30 taxa are mostly distributed in Europe, some species have been found in Australia and New Zealand, Asia, Africa, North and South America. Only *Pseudokephyrion pseudospirale* has been determined in Antarctic and Antarctic islands (Guiry & Guiry, 2020). These new records in Ochrophyta were found in Batı Akdeniz, Büyük Menderes, Küçük Menderes, Susurluk, Sakarya, Yeşilirmak, Doğu Karadeniz, Akarçay, Meriç Ergene, Çoruh, Fırat-Dicle, and Asi Basins from Turkey.

In conclusion, 30 new records were added to the freshwater algal flora of Turkey with this study. It was observed that these taxa were distributed in different regions of the world. The number of new records for the algal flora of Turkey is expected to increase in the future.

Figure 2

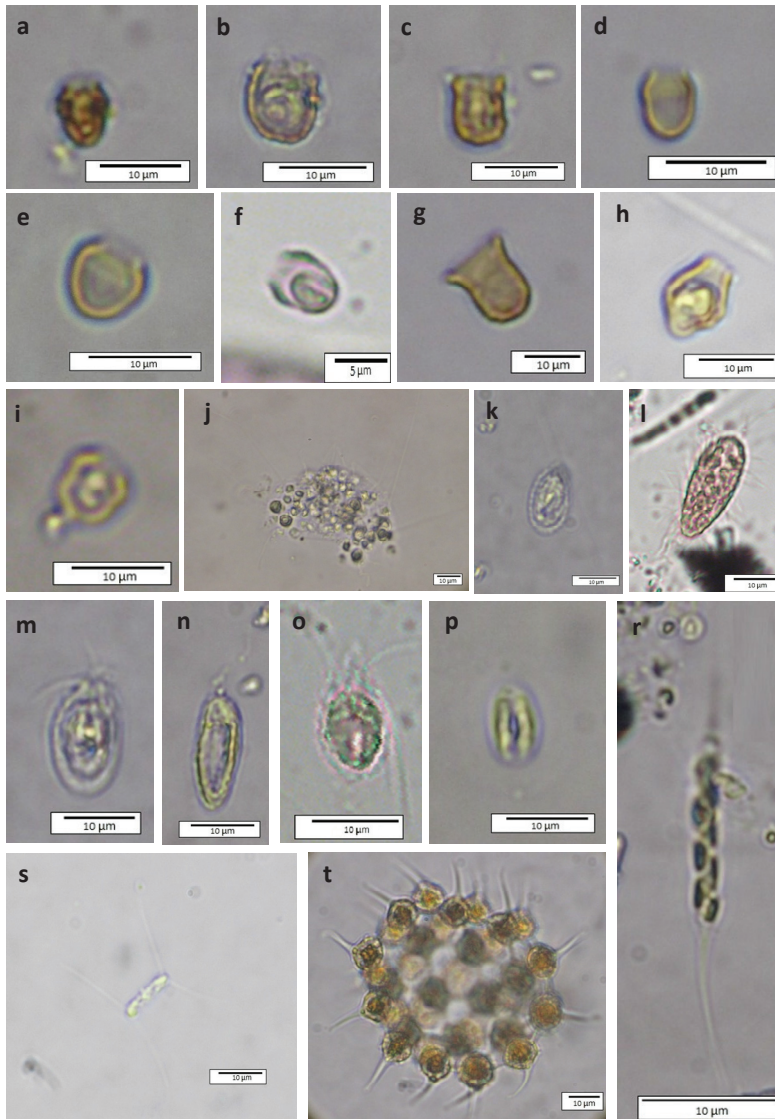
Eleven New Records of Ochrophyta Taxa



Note. a. *Bicosoeca planctonica*, b. *Bitrichia chodatti*, c. *Chromulina annulata*, d. *Chromulina ovalis*, e. *Chromulina sphaeridia*, f. *Chromulina wislouchiana*, g. *Ochromonas granulosa*, h. *Chrysococcus minutus*, i. *Dinobryon cylindricum* var. *alpinum*, j. *Dinobryon korshikovii*, k. *Kephyrion littorale*.

Figure 3

Nineteen New Records of Ochrophyta Taxa



Note. a. *Kephyrion rubri-claustri*, b. *Kephyriopsis ovum*, c. *Pseudokephyrion cinctum*, d. *Pseudokephyrion entzii*, e. *Pseudokephyrion minutissimum*, f. *Pseudokephyrion ovum*, g. *Pseudokephyrion pilidium*, h. *Pseudokephyrion pseudospirale*, i. *Pseudokephyrion ruttneri*, j. *Chrysosphaerella longispina*, k. *Mallomonas anglica*, l. *Mallomonas caudata*, m. *Mallomonas majorensis*, n. *Mallomonas teilingii*, o. *Mallomonas tonsurata*, p. *Phacomonas pelagica*, r. *Centritractus africanus*, s. *Pseudotetraëdron neglectum*, t. *Ducellieria chodatii* var. *armata*.

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**Extended Turkish Abstract
(Genişletilmiş Türkçe Özet)**

**Türkiye’deki 25 Nehir Havzasından Türkiye Tatlı Su Alg Florası İçin Yeni Kayıtlar, Bölüm
IV: Ochrophyta**

Avrupa Birliği Su Çerçeve Direktifine (WFD) göre biyolojik kalite bileşenlerinden biri olarak kabul edilen fitoplankton üzerine Türkiye’de yapılan taksonomik ve ekolojik çalışmaların sayısı her geçen gün artmaktadır. Avrupa Birliği müktesebatına uyum çalışmaları çerçevesinde Tarım ve Orman Bakanlığı Su Yönetimi Genel Müdürlüğü (SYGM) ve Devlet Su İşleri (DSİ) Genel Müdürlüğüne biyolojik kalite bileşenlerinin de dikkate alındığı çok sayıda proje gerçekleştirilmiştir. Birçok nehir havzasında yapılan su kalitesi izleme çalışmaları, göl yönetim planı çalışmalarının bazıları, biyolojik kalite bileşenleri kullanılarak su kalitesini belirlemek için geliştirilen indeks geliştirme projeleri tamamlanmıştır. “Türkiye’de Referans İzleme Ağının Kurulması” Projesinin bir parçası olan bu çalışma da Su Yönetimi Genel Müdürlüğü tarafından desteklenen çalışmalardan biridir. Proje kapsamında 25 nehir havzasında bulunan 275 gölde çalışmalar yürütülmüş ve toplam 1363 fitoplankton taksonu tespit edilmiştir. Bu taksonlardan 56 tanesi Ochrophyta divizyonuna aittir.

Bugüne kadar dünya genelinde bu alanda yapılan çalışmalarda 4325 Ochrophyta taksonu tanımlanmıştır. Planktonik Ochrophyta türleri genellikle tek hücreli ya da koloniyal formda olan kamçılı alglerdir ve daha çok tatlı su ekosistemlerinde dağılım gösterirler.

Türkiye dört farklı iklim tipine ve farklılık gösteren topografyaya sahip olması nedeniyle göllerinin morfolojik ve hidrolojik özellikleri de farklılıklar göstermektedir; bu özellikler alg biyoçeşitliliğini de desteklemektedir. Son yıllarda Türkiye alg florası için çok sayıda yeni kayıt bildirilmiştir, böylece tespit edilen toplam alg sayısında kayda değer artış görülmüştür. Bu çalışmanın amacı Türkiye alg florasına yeni kayıtlar tespit ederek katkıda bulunmaktır.

Türkiye’nin 25 nehir havzasında 200 kadar doğal göl, 806 kadar baraj gölü ve 1000 kadar gölet bulunmaktadır. 25 nehir havzasında gerçekleştirilen bu çalışmada baraj gölleri de dahil olmak üzere 275 göl örneklenmiştir. Çalışılan göller 26°19’ - 43°54’D ve 35°56’ - 42°00’K koordinatları arasında bulunmakta olup 22 göl tipolojisinde gruplanmıştır. Ayrıca çalışma yapılan göller deniz seviyesi (Gala Gölü) ile 2757 m (Çamlı Gölü) arasında farklı yüksekliklerde dağılım göstermektedir.

Yılda üç defa (ilkbahar, yaz ve sonbahar) olmak üzere 2017 ve 2019 tarihleri arasında her bir gölde yüzey alanları büyüklüğüne göre bir, iki ya da üç farklı istasyondan fitoplankton örnekleri alınmıştır. Göl yüzey alanı 50 hektardan küçük göller için bir, 50 ve 500 hektar arası olan göller için iki, 500 hektardan büyük göller için üç örnekleme istasyonu seçilmiştir. İstasyonlardan biri ise mutlaka gölün en derin noktasında belirlenmiştir. Öfotik bölgenin (Secchi diski derinliği × 2.5) üç farklı derinliğinden (yüzey, orta ve dip) su örnekleycisi ile alınan su örnekleri karıştırılarak alt su numunesi alınmıştır. Ayrıca örnekleme sırasında 50 µm göz açıklığına sahip plankton kepeci de kullanılmıştır. Alg taksonları farklı laboratuvarlardaki ışık ve ters mikroskopları kullanılarak teşhis edilmiştir. Mikroskoplara bağlı dijital kameralarla da fotoğrafları çekilmiştir. Türkiye’deki güncel literatürlerdeki takson kayıt listesi ile çalışmada tespit edilen taksonlar karşılaştırılmış ve yeni kayıt olup olmadığı tespit edilmiştir. Aynı zamanda takson isimlerinin güncelliği kontrol edilip, türlerin dünyadaki dağılımı da belirlenmiştir.

Bu çalışmada Türkiye tatlı su algleri için yeni kayıt olarak 30 Ochrophyta taksonu tanımlanmıştır. Ochrophyta diviziyosunda bulunan taksonlar *Bicosoeca*, *Bitrichia*, *Chromulina* (4), *Ochromonas*, *Chrysococcus*, *Dinobryon* (2), *Kephyrion* (2), *Kephyriopsis*, *Pseudokephyrion* (7), *Chrysophaerella*, *Mallomonas* (5), *Phacomonas*, *Centrtractus*, *Pseudotetraëdron* ve *Ducellieria* cinsleri içinde dağılım göstermiştir. Daha önce Türkiye’de yapılan çalışmalarda *Bicosoeca* cinsine ait 2, *Dinobryon* cinsine ait 12, *Pseudokephyrion* cinsine ait 1, *Mallomonas* cinsine ait 4, *Centrtractus* cinsine ait 1 takson rapor edilmiştir. Bununla birlikte bu çalışma ile birlikte ilk defa 10 cinse (*Bitrichia*, *Chromulina*, *Ochromonas*, *Chrysococcus*, *Kephyrion*, *Kephyriopsis*, *Chrysophaerella*, *Phacomonas*, *Pseudotetraëdron*, *Ducellieria*) ait taksonlar Türkiye alg florası için yeni kayıt olarak belirlenmiş bulunmaktadır.

Sadece *Bicosoeca* cinsi Bikosea sınıfı içinde bulunmaktadır. Diğer taksonlar Chrysophyceae ve Xanthophyceae sınıfları içinde dağılım göstermektedir. Chrysophyceae sınıfı üyeleri daha çok tatlı su ortamlarında tespit edilselerde çok az türün kar florasında, toprak florasında ya da denizel habitatlarda dağılım gösterdiği bilinmektedir. Xanthophyceae sınıfı üyelerinin büyük bir çoğunluğu tatlı su ve karasal habitatlarda dağılım gösterirken bazılarının acı su ve denizel habitatlarda da bulunduğu görülmektedir. Ochrophyta diviziyosuna ait alglerin genellikle oligotrofik göl ve göletleri tercih ettikleri bildirilmiştir. Ekolojik durumları genellikle hassas olan bu grubun üyelerinden *Bicosoeca planctonica* ve *Bitrichia chodatti* taksonları toleranslı olarak belirlenmiştir.

Her ne kadar tespit edilen bu 30 takson çoğunlukla Avrupa’da dağılım gösterse de, bazı türler Avustralya, Yeni Zelanda, Asya, Afrika, Kuzey ve Güney Amerika gibi dünyanın farklı bölgelerinde dağılım göstermektedir. Sadece *Pseudokephyrion pseudospirale* türü a Kuzey Kutup ve Güney Kutup bölgelerinde bulunan adalarda tespit edilmiştir. Türkiye’de bu taksonların ise Batı Akdeniz, Büyük Menderes, Küçük Menderes, Susurluk, Sakarya, Yeşilirmak, Doğu Karadeniz, Akarçay, Meriç Ergene, Çoruh, Fırat-Dicle ve Asi havzalarında dağılım gösterdiği bilinmektedir.

Sonuç olarak, bu çalışma ile birlikte 30 yeni kayıt, Türkiye tatlı su alg florasına eklenmiştir. Ayrıca 10 cinse ait takson da yapılan bu çalışmayla ilk defa kayıt altına alınmıştır. Bu taksonların dünyanın farklı bölgelerinde de dağılım gösterdikleri tespit edilmiştir. İlerleyen yıllarda yapılacak çalışmalarla Türkiye alg florası için yeni kayıt sayısının artması beklenmektedir.