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Research Article

New Records for the Turkish Freshwater Algal Flora in Twenty Five River Basins of Turkey, Part III: Miozoa, Haptophyta

Türkiye'deki 25 Nehir Havzasından Türkiye Tatlı Su Alg Florası İçin Yeni Kayıtlar, Bölüm III: Miozoa, Haptophyta

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Abstract

Turkish lakes have different morphometry and hydrology as a result of different climate types and noticeable altitude differences, which provide different habitats for algal diversity. In the last 40 years,

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the total number of algae taxa in the flora of Turkey has increased due to the studies on phytoplankton taxonomy and ecology. This study aims to describe new planktonic algal taxa for the Turkish freshwater algal flora. A total of 63 Miozoa and 2 Haptophyta taxa were determined in the project conducted from 2017 to 2019 in lakes of 25 river basins of Turkey. Our study was done as a part of the Project, namely "Establishment of Reference Monitoring Network in Turkey", financially and technically supported by the Ministry of Agriculture and Forestry, Directorate General for Water Management. In each lake, phytoplankton was sampled with water samplers from three depths (surface, middle, and bottom) of the euphotic zone, and then the water samples taken from these three depths were mixed for obtaining subsamples. Plankton net with a pore diameter of 50 µm was also used for sampling. Identification of the algal taxa was performed with various compound and inverted microscopes in many laboratories. During this study, 26 Miozoa and 2 Haptophyta taxa were found as new records for the freshwater algal flora of Turkey.

Keywords: *Miozoa, Haptophyta, Turkish freshwater, algae, new record*

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 çalışmalar 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 yapılan çalışmada Miozoa divizyosuna ait 63, Haptophyta divizyosuna ait 2 takson tanımlanmıştır. Bu çalışma Tarım ve Orman Bakanlığı Su Yönetimi Genel Müdürlüğü (SYGM) tarafından finansal ve teknik olarak desteklenen "Türkiye'de Referans İzleme Ağının Kurulması" adlı proje kapsamında gerçekleştirilmiştir. Her gölde fitoplankton öfotik derinliğin 3 farklı bölgesinden (yüzey, orta, dip) su örnekleyicisi ile alınarak örneklenmiştir. Daha sonra bu üç derinlikten alınan su örnekleri karıştırılarak su numunesi alınmıştır. 50 µm göz açıklığına sahip plankton kepçesi de örnekleme sırasında ayrıca kullanılmıştır. Alg taksonlarının teşhisi farklı laboratuvarlardaki ışık ve ters mikroskoplar kullanılarak gerçekleştirilmiştir. Çalışmada, Türkiye tatlı su alg florası için Miozoa divizyosuna ait 26 takson, Haptophyta divizyosuna ait 2 yeni takson bulunmuştur.

Anahtar kelimeler: *Miozoa, Haptophyta, Türk tatlı suları, alg, yeni kayıt*

Introduction

The number of studies on phytoplankton taxonomy and ecology, which is accepted as one of the biological quality elements according to the EU Water Framework Directive (WFD) (EC Parliament & Council, 2000), have increased in recent years in Turkey. Due to the compatibility process with European Union, several projects have been implemented, taking into account biological quality components funded by the Ministry of Agriculture and Forestry, Directorate General for Water Management (DGWM), and General Directorate of State Hydraulic Works (DSİ). Many water quality monitoring studies on different river basins, some lake management planning studies, and some index development projects to determine water quality using biological quality components have been completed (Directorate General for Water Management [DGWM], 2020). This study is also a part of the

"Establishment of Reference Monitoring Network in Turkey" project which is 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. Among these taxa, 63 Miozoa, and 2 Haptophyta taxa were determined.

Until now, more than 3550 Miozoa and 773 Haptophyta taxa were listed in previous studies in the world (Guiry & Guiry, 2020). Most of the species of Miozoa are free-swimming, unicellular organisms, and members of this group in fresh waters are found in plankton of both large bodies of water such as lakes and reservoirs, and smaller water bodies such as pools. Members of Haptophyta which have a unique organelle haptonema, are common in marine waters. Few planktonic species are known from freshwater habitats (John et al., 2003).

In the flora of Turkey, 235 Miozoa and 5 Haptophyta taxa were recorded in previous studies. However, only 45 Miozoa taxa were identified and no species were found in Haptophyta as freshwater taxa (Taşkın et al., 2019; Maraşlıoğlu & Gönülol, 2020). Due to the effects of four different types of climate, and noticeable altitude differences, Turkish lakes have different morphometry and hydrology that support distinct algal diversity. In recent years, many new records were given for the algal flora of Turkey (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), and the total number of taxa have increased (Taşkın et al., 2019; Maraşlıoğlu & Gönülol, 2020). The present study aims to contribute to the algal flora of Turkey. Therefore, 26 Miozoa and 2 Haptophyta were described in this paper as new records for Turkish freshwater algae.

Materials and Methods

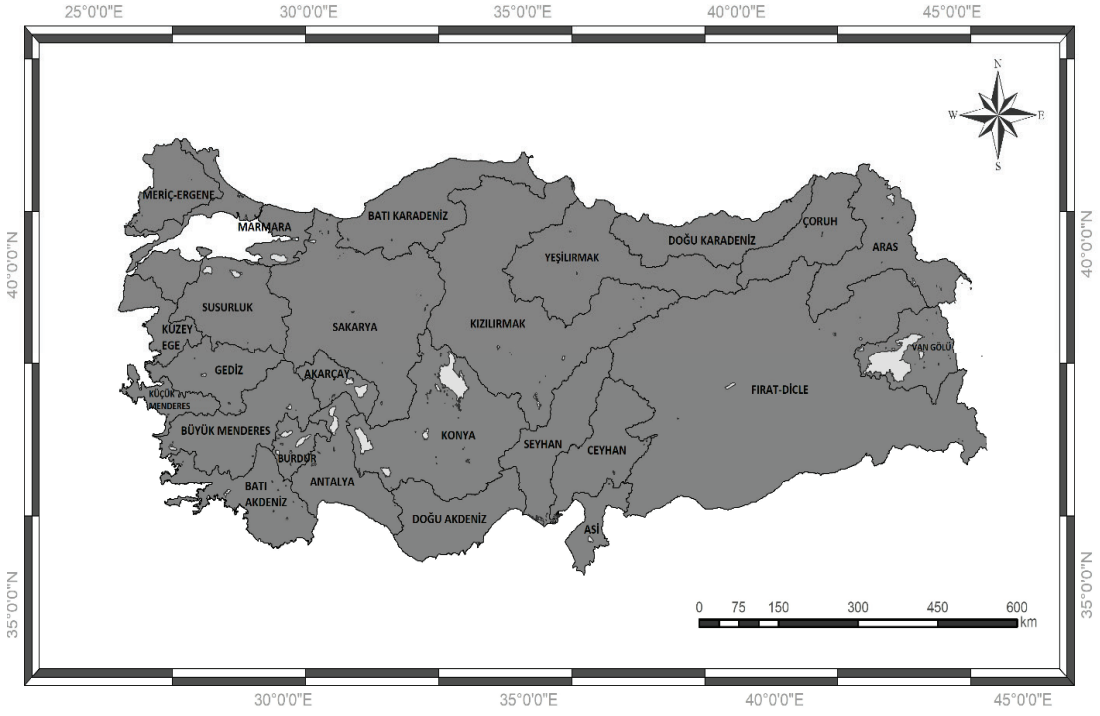
Study Area

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 General Directorate of State Hydraulic Works [DSİ], 2014). Considering the areas of river basins, the annual amount of water produced per unit area is the lowest in Akarçay Basin with 64,430 m^3/km^2, and the highest in Doğu Karadeniz Basin with 618,850 m^3/km^2 (Foreign Relation Office of DSİ, 2014). However, Lakes Region (Burdur Basin), South Marmara (Susurluk Basin), Lake Van and its surroundings

(Lake Van Basin), Lake Tuz, and its surroundings (Konya Basin) were the regions where the natural lakes are gathered (Hoşgören, 1994).

Figure 1

River Basins of Turkey



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

Table 1

Number of Studied Lakes in 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	Taşkısığı 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., Sugiylan 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	Gölhisar L., Girdev L., Avlan L., Dalaman Wetlands, Denizcik L., Kocagöl L., Kusuru 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., Uluabat 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., Kapıaçmaz 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 Demiroluk P., Adsız L., Pekmezli-Çatalçam P., Tufanbeyli Doğanbeyli P., Gümüşören R., Şıhlı P., Dölekli P., Kılıçlı P., Topacık P., Hüsniye P., Çavuşlu P.
Total	275	

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

Sampling and Identification

Phytoplankton was sampled three times (spring, summer, and fall) a year between 2017 and 2019 at the one, two, or three monitoring stations in each lake. Station numbers were determined as one for lakes which have a surface area smaller than 50 ha, two for lakes which have a surface area between 50 and 500 ha and, three for lakes which have 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. Phytoplankton was sampled with water samplers from three depths (surface, middle, and bottom) of the euphotic zone, and then the water samples taken from these three depths were mixed for obtaining subsamples. Plankton net with a pore diameter of 50 µm was also used for sampling. Samples were fixed with Lugol's solution. Identification of the algal taxa was performed with various compound and inverted microscopes according to the Huber-Pestalozzi (1976) 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 & Gönülol, 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 & Guiry (2020). Taxa were photographed with a camera attached to various microscopes.

Results

A total of 28 taxa (26 Miozoa, and 2 Haptophyta) are described below.

Phylum: Miozoa
Class: Dinophyceae
Order: Suessiales
Family: Suessiaceae
Genus: *Biecheleria*

Species: *Biecheleria ordinata* (Skuja) Moestrup 2018 (Figure 2a)
Synonyms: *Gymnodinium ordinatum* Skuja 1939*, Woloszynskia ordinata* (Skuja) Thompson 1950
Description: Cells flattened dorsoventrally, symmetrical when viewed from the front, broad oval, 18 µm long, 14 µm wide, and about 8 µm thick. Epivalva slightly larger, with a regular semicircular apex. Hypovalva somewhat smaller and slightly pointed dome-shaped towards the rear. Cingulum rather deep, very little below the middle or almost median. Sulcus limited to the hypovalva, well developed.
Ecology: This is freshwater species. The water quality indicator is sensitive.

Distribution: *Europe*: Britain, Netherlands, Romania, Scandinavia, Slovakia, Spain, Sweden. *North America*: Northwest Territories. *Australia and New Zealand*: Queensland, New Zealand.
Occurrence: It has been detected in freshwater habitats (lakes) in Batı Akdeniz, Sakarya, and Akarçay basins.

Family: Borghiellaceae
Genus: *Borghiella*
Species: *Borghiella woloszynskae* (Pascher) Moestrup 2018 (Figure 2b)
Synonyms: *Gymnodinium woloszynskae* Pascher 1923*, G. veris* Lindemann 1925
Description: Cells oval, 20 µm long, 18 µm wide. Epivalva conical with slightly convex edges. Hypovalva large, broadly rounded at the Antapex. Cingulum equatorial, broad, almost circular, slightly winding to the left. Sulcus limited to the hypovalva, also fairly wide, deeply incised, has a comb-like ridge on its right side.
Ecology: This is freshwater species. The water quality indicator is sensitive.
Distribution: *Europe*: Germany. *North America*: Northwest Territories. *Asia*: Japan.
Occurrence: It has been detected in freshwater habitats (lakes) in Sakarya and Fırat-Dicle basins.

Order: Dinophyceae ordo incertae sedis
Family: Dinophyceae familia incertae sedis
Genus: *Glenoaulax*

Species: *Glenoaulax inaequalis* (Schmarda) Diesing 1866 (Figure 2c)
Synonym: *Glenodinium inaequale* Schmarda
Description: Cells ovoid, 22 µm long, 18 µm wide. Epivalva considerably reduced in size than Hypovalva. Epivalva head-shaped to low dome-shaped, narrower, only about 1/3 as high as the Hypovalva. Hypovalva rounded, asymmetrical, bluntly pointed towards the Antapex. Cingulum quite broad; Sulcus widened backward.
Ecology: This is freshwater species. The water quality indicator is sensitive/tolerant.
Distribution: --
Occurrence: It has been detected in freshwater habitats (lakes) in the Sakarya basin.

Order: Gymnodiniales
Family: Gymnodiniaceae
Genus: *Gymnodinium*

Species: *Gymnodinium albulum* Lindemann 1928 (Figure 2d)
Synonym: *Gymnodinium profundum* Schiller 1932

Description: Apical part of the cell hemispherical, the same width or wider than the antapical part. Antapex narrowly rounded. Cingulum equatorial, circular, broad. Sulcus uncertain. Cells 17 µm in diameter.
Ecology: This is freshwater species. The water quality indicator is sensitive.
Distribution: *Europe*: Austria, Baltic Sea, Black Sea, Britain, Germany, Mediterranean, Scandinavia, Spain. *North America*: Maryland, Northwest Territories. *Asia*: Russia (Far East).
Occurrence: It has been detected in freshwater habitats (lakes) in Sakarya and Fırat-Dicle basins.

Species: *Gymnodinium eurytopum* Skuja 1948 (Figure 2e)
Synonym: --
Description: Cells broadly ellipsoidal, slightly flattened, 25 µm long, 20 µm wide. Cingulum well defined, sharply demarcated towards the Epivalva, almost equatorial, slightly twisted to the right. Sulcus almost restricted to the Hypovalva, rather deep, little pronounced towards the front. Epivalva almost hemispherical, somewhat less arched on the left than on the right. Hypovalva hemispherical.
Ecology: This is freshwater species. The water quality indicator is sensitive.
Distribution: *Europe*: Black Sea, Latvia, Portugal, Scandinavia, Slovakia, Sweden.
Occurrence: It has been detected in freshwater habitats (lakes) in the Fırat-Dicle basin.

Species: *Gymnodinium inversum* Nygaard 1929 (Figure 2f)
Synonym: --
Description: Cells ellipsoidal, very little flattened dorsoventrally, 30 µm long, wide 27 µm. Epivalva and Hypovalva broad, irregularly rounded, Hypovalva considerably larger than Epivalva. Cingulum broad, not very deep, twisting to the left. The sulcus is rather narrow, extends to the Antapex, and protrudes into the Epivalva. Nucleus broadly oval lies partly under the Cingulum.
Ecology: This is freshwater species. The water quality indicator is sensitive.
Distribution: *Europe*: Black Sea, Britain, Denmark, Scandinavia, Slovakia. *North America*: Northwest Territories.
Occurrence: It has been detected in freshwater habitats (lakes) in Batı Akdeniz and Fırat-Dicle basins.

Species: *Gymnodinium inversum* var. *elongatum* Nygaard 1950 (Figure 2g)
Synonym: --
Description: Cells elongate, longer than type, 35 µm long, wide 26 µm. Epivalva and Hypovalva equal in size. Epivalva subconical, narrowly rounded at the Apex, Hypovalva semi-oval. Nucleus central, broadly elliptical.

Ecology: This is freshwater species. The water quality indicator is sensitive.
Distribution: *Europe*: Britain, Denmark, Scandinavia.
Occurrence: It has been detected in freshwater habitats (lakes) in the Fırat-Dicle basin.

Species: *Gymnodinium lantzschii* Utermöhl 1925 (Figure 2h)
Synonym: *Gymnodinium minimum* Lantzsch 1914
Description: Cells small, rounded, 15 µm long, 13 µm wide. Apical part is rounded at the front, conical, with convex borders, Antapical part broad and flat rounded, slightly smaller than the Apical part. Cingulum clear, apparently twisted to the left. Sulcus only indicated. Nucleus central.
Ecology: This is freshwater species. The water quality indicator is sensitive.
Distribution: *Europe*: Netherlands, Austria, Baltic Sea, Black Sea, Germany, Scandinavia, Switzerland. *Australia and New Zealand*: Australia.
Occurrence: It has been detected in freshwater habitats (lakes) in Batı Akdeniz and Fırat-Dicle basins.

Species: *Gymnodinium mitratum* Schiller 1932 (Figure 2i)
Synonym: --
Description: Cells oval, not flattened, circular in cross-section, 25 µm long, 15 µm wide. Apex half-ovoid, longer than the Antapex. Cingulum exactly circular, somewhat behind the equator, fairly broad and deep, the upper edge somewhat protruding. Sulcus relatively wider than Cingulum, not reaching Antapex. Nucleus oval.
Ecology: This is freshwater species. The water quality indicator is sensitive.
Distribution: *Europe*: Austria, Germany, Mediterranean, Romania. *North America*: Mexico (Atlantic, Pacific). *Middle East*: Egypt. *Asia*: China.
Occurrence: It has been detected in freshwater habitats (lakes) in Batı Akdeniz and Akarçay basins.

Species: *Gymnodinium palustre* Schilling 1891 (Figure 2j)
Synonyms: *Gymnodinium carinatum* Schilling 1891*, G. zachariasii* Lemmermann 1900
Description: Cells elongated elliptical, 30 µm long, 20 µm wide. Apex considerably larger, elongated, bell-shaped, regularly rounded. Antapex short and broad. Cingulum circular, broad, and ± deeply sunk. Sulcus forming a deep, narrow groove. Nucleus central.
Ecology: This is freshwater species. The water quality indicator is sensitive.
Distribution: *Europe*: Mediterranean, Black Sea, Britain, Denmark, Germany, Poland, Slovakia, Sweden. *North America*: Laurentian Great Lakes. *Asia*: Japan.

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

Species: *Gymnodinium saginatum* Harris 1940 (Figure 2k)
Synonym: --
Description: Cells very rounded, 24 µm long, 20 µm wide. Epivalva and Hypovalva equal in size, separated by a narrow, deep cingulum; Sulcus rather narrow, extends to the base of Hypovalva; cell wall quite firm.
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 Konya basin.

Species: *Gymnodinium tatricum* Woloszynska 1919 (Figure 2l)
Synonym: --
Description: Cells oval, very slightly flattened, with broadly rounded Epi- and Hypovalva, 37 µm long, 30 µm wide. Epivalva semi-oval, Hypovalva not entirely hemispherical. Epivalva larger and somewhat less flattened dorsoventrally than Hypovalva. Cingulum broad, slightly twisting to the left. Sulcus incised deep into the Hypovalva, with a ridged left margin. Nucleus large, oval.
Ecology: This is freshwater species. The water quality indicator is sensitive.
Distribution: *Europe*: Austria, Poland, Slovakia.
Occurrence: It has been detected in freshwater habitats (lakes) in the Fırat-Dicle basin.

Genus: *Nusuttodinium*

Species: *Nusuttodinium acidotum* (Nygaard) Takano & Horiguchi 2014 (Figure 2m)
Synonym: *Gymnodinium acidotum* Nygaard 1950
Description: Cells broadly pear-shaped, slightly flattened dorsoventrally, 31 µm long, 29 µm wide. Epivalva conical, with a narrowly rounded Apex. Hypovalva about the same size briefly pointed at the Antapex. Cingulum equatorial, broad, slightly winding to the left. Sulcus straight, running in the middle line of the cell, narrow, reaching to Antapex. Nucleus median, ellipsoidal.
Ecology: This is freshwater species. The water quality indicator is sensitive.
Distribution: *Europe*: Netherlands, Denmark. *North America*: Northwest Territories, Louisiana, Missouri. *Asia*: Taiwan, Japan.
Occurrence: It has been detected in freshwater habitats (lakes) in the Fırat-Dicle basin.

Species: *Nusuttodinium aeruginosum* (Stein) Takano & Horiguchi 2014 (Figure 2n)

Synonym: *Gymnodinium aeruginosum* Stein 1883
Description: Cells elongated, dorsoventrally flattened, 20 µm long, 16 µm wide. Epivalva larger and slimmer, bell-shaped, rounded. Hypovalva also bell-shaped, but broader, often slightly indented Antapex. Cingulum completely encircles the body, slightly post-median, deeply sunk. Sulcus spanning far into the Apical part, reaching to the rear end.
Ecology: This is freshwater species. The water quality indicator is sensitive.
Distribution: *Europe*: Baltic Sea, Black Sea, Austria, Czech Republic, Britain, France, Italy, Germany, Romania, Netherlands, Portugal, Scandinavia, Slovakia, Denmark, Sweden, Finland. *North America*: Québec, Tennessee, Maryland. *South America*: Argentina, Brazil. *Asia*: China, Japan, Taiwan, Tajikistan. *Australia and New Zealand*: New South Wales, New Zealand, Queensland, Tasmania.
Occurrence: It has been detected in freshwater habitats (lakes) in Sakarya, Akarçay, and Fırat-Dicle basins.

Order: Peridiniales
Family: Peridiniales incertae sedis
Genus: *Glenodinium*

Species: *Glenodinium paululum* Lindemann 1928 (Figure 2o)
Synonym: --
Description: Cells oval, dorsoventrally hardly flattened, 17 µm long, 9 µm wide. Epivalva conically pointed. Cingulum is relatively broad, circular, slightly subequatorial. Sulcus very indistinct, on the Epivalva it is only slightly developed, on the Hypovalva the Sulcus region slopes downwards.
Ecology: This is freshwater species. The water quality indicator is sensitive/tolerant.
Distribution: *Europe*: Baltic Sea, Black Sea, Romania, Scandinavia.
Occurrence: It has been detected in freshwater habitats (lakes) in the Batı Akdeniz basin.

Family: Peridiniaceae
Genus: *Parvodinium*

Species: *Parvodinium africanum* var. *tatricum* (Woloszynska) Moestrup 2018 (Figure 2p)
Synonym: *Peridinium africanum* var. *tatricum* (Woloszynska) Schiller 1935
Description: Cells elongated ovate, somewhat slimmer than the type, 32 µm long, 24 µm wide. The median Apical plate is enclosed by the 4 Apical plates. Hypovalva with three blunt corners, each with a short spine. Right Antapical plate large. On the

Hypovalva, the left edge of the lower cingulate ring is covered with few delicate spines. The right edge of the Sulcus has a larger sting. Nucleus oval, central.
Ecology: This is freshwater species. The water quality indicator is sensitive.
Distribution: *Europe*: Slovakia, Poland, Russia. *Asia*: Taiwan.
Occurrence: It has been detected in freshwater habitats (lakes) in Sakarya and Fırat-Dicle basins.

Species: *Parvodinium centenniale* (Playfair) Carty 2008 (Figure 3a)
Synonym: *Peridinium centenniale* (Playfair) Lefèvre 1932
Description: Cells almost spherical, very weakly flattened dorsoventrally, 45 µm long, 41 µm wide. Epivalva hemispherical, considerably larger than Hypovalva. Cingulum strongly twisted to the left, with noticeably thick margins. Sulcus spanning very little over the Epivalva, slightly widening towards the rear.
Ecology: This is freshwater species. The water quality indicator is sensitive.
Distribution: *Europe*: Netherlands, Slovakia, Spain, France, Poland. *Australia and New Zealand*: New South Wales, Queensland, Tasmania. *Central America*: Belize. *Africa*: Ivory Coast, Madagascar. *South-east Asia*: Indonesia, Sumatra.
Occurrence: It has been detected in freshwater habitats (lakes) in the Sakarya basin.

Species: *Parvodinium lubieniense* (Woloszynska) Carty 2008 (Figure 3b)
Synonym: *Peridinium lubieniense* Wolszynska 1916
Description: Cells oval, hardly flattened dorsoventrally, 33 µm long, 28 µm wide. Apex opening present. Cingulum broad, very slightly twisting to the left. Sulcus extends little to the Epivalva, widens very little backward, and does not reach to Antapical pole. Epivalva bell-shaped, somewhat larger than Hypovalva. Hypovalva conical, with 5 post-equatorial plates + 2 Antapical plates of equal size. Nucleus oval, central.
Ecology: This is freshwater species. The water quality indicator is sensitive.
Distribution: *Europe*: Netherlands, Scandinavia, Spain, Sweden, Black Sea, France, Germany, Poland, Romania, Ukraine.
Occurrence: It has been detected in freshwater habitats (lakes) in Akarçay and Fırat-Dicle basins.

Genus: *Peridinium*

Species: *Peridinium gatunense* Nygaard 1925 (Figure 3c)
Synonym: *Peridinium cinctum* var. *gatunense* (Nygaard) Nygaard 1932
Description: Cells round, slightly wider than long, 42 µm long, 40 µm wide, very little flattened dorsoventrally. Epi- and Hypovalva roughly the same size, both are truncated, conical, with a humped contour. Cingulum strongly twisted to the left,

broad, at the edges wide hyaline ridges. Sulcus very little, encompassing the Epivalva, widening little backward, not reaching the Antapical pole. Antapical plates are always very large and often of the same size.
Ecology: This is freshwater species. The water quality indicator is sensitive.
Distribution: *Europe*: Netherlands, Sweden, Ukraine. *Australia and New Zealand*: New South Wales, Northern Territory, Tasmania, Western Australia. *America*: Laurentian Great Lakes, Québec, Tennessee, Belize, Cuba, Argentina, Brazil. *Middle East*: Iraq. *Asia*: China, Myanmar (Burma), Singapore.
Occurrence: It has been detected in freshwater habitats (lakes) in Susurluk, Kızılırmak, Batı Karadeniz, Burdur, Seyhan, Doğu Akdeniz basins.

Species: *Peridinium gatunense* f. *majus* Lefèvre (Figure 3d)
Synonym: --
Description: Larger than type, 75 µm long, without hyaline crests on the edges of the Cingulum.
Ecology: This is freshwater species. The water quality indicator is sensitive.
Distribution: --
Occurrence: It has been detected in freshwater habitats (lakes) in the Fırat-Dicle basin.

Species: *Peridinium gutwinskii* Woloszynska 1912 (Figure 3e)
Synonym: --
Description: Cells oval, almost circular in cross-section, 35 µm long, 30 µm wide. Apex opening present. Epivalva conical. Cingulum deep, divides the cell into an almost equally large Epivalva and Hypovalva. Sulcus extends to the Epivalva, expands backward, but does not reach to the rear margin.
Ecology: This is freshwater species. The water quality indicator is sensitive.
Distribution: *Europe*: Netherlands. *South America*: Brazil. *South-west Asia*: Khandesh. *Australia and New Zealand*: Northern Territory.
Occurrence: It has been detected in freshwater habitats (lakes) in the Asi basin.

Species: *Peridinium volzii* var. *cyclicum* Lindemann (Figure 3f)
Synonym: --
Description: Differs from the main type only in the mutual location of the Apical plates. The ventral and median apical Plates are as long as wide; they are arranged more circularly and smaller than the type. Cell 56 µm long, 50 µm wide.
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.

Family: Peridiniopsidaceae
Genus: *Peridiniopsis*

Species: *Peridiniopsis armata* (Levander) Stein & Borden 1980 (Figure 3g)
Synonym: *Glenodinium armatum* Levander 1900
Description: Cells almost spherical, 19 µm long, 18 µm wide, with a short sting on the left side of the rear edge. Epivalva significantly larger than Hypovalva. Cingulum slightly twisting to the left. Sulcus limited to the Hypovalva, running to the rear end. Nucleus oval, located in Antapical part.
Ecology: This is freshwater species. The water quality indicator is sensitive/tolerant.
Distribution: *Europe*: Baltic Sea, Scandinavia. *North America*: Laurentian Great Lakes, Québec. *Middle East*: Iraq. *Asia*: Russia (Far East).
Occurrence: It has been detected in freshwater habitats (lakes) in Batı Akdeniz and Burdur basins.

Species: *Peridiniopsis kulczynskii* (Woloszynska) Bourrelly 1968 (Figure 3h)
Synonym: *Peridinium kulczynskii* Woloszynska 1916
Description: Cells oval, slightly flattened dorsoventrally, Apex opening present, 36 µm long, 31 µm wide. Cingulum twisting to the left. Sulcus slightly overlapping the Epivalva, expanded on Hypovalva, reaching to the rear end. Valves in the same size. Epivalva and Hypovalva rounded. Nucleus oval, central.
Ecology: This is freshwater species. The water quality indicator is sensitive/tolerant.
Distribution: *Europe*: Denmark, Poland. *North America*: Laurentian Great Lakes, Kansas. *Middle East*: Iraq.
Occurrence: It has been detected in freshwater habitats (lakes) in Burdur and Seyhan basins.

Species: *Peridiniopsis pygmaea* var. *brigantina* (Lind.) Moestrup & Calado 2018 (Figure 3i)
Synonym: *Peridinium pygmaeum* f. *brigantinum* Lindemann 1923
Description: Differs from the main type in the considerable reduction in the size of the 3 Apical plates. Cell 50 µm long, 36 µm wide.
Ecology: This is freshwater species. The water quality indicator is sensitive/tolerant.
Distribution: --
Occurrence: It has been detected in freshwater habitats (lakes) in the Fırat-Dicle basin.

Family: Protoperidiniaceae
Genus: *Protoperidinium*

Species: *Protoperidinium achromaticum* (Levander) Balech 1974 (Figure 3j)
Synonym: *Peridinium achromaticum* Levander 1902
Description: Cells rhombic, dorsoventrally slightly flattened, marginalized at the rear end, 28 µm long, 30 µm wide. Apex opening present. Cingulum almost circular. Sulcus limited to the Hypovalva, broad, carrying a small spine on the right, ending on the posterior end of the Hypovalva with a clearly defined, arched ridge. Epivalva conical. Nucleus elongated kidney-shaped, central.
Ecology: This is freshwater species. The water quality indicator is sensitive.
Distribution: *Europe*: Latvia, Netherlands, Baltic Sea, Black Sea, Britain, Helgoland, Scandinavia. *North America*: Mexico. *South America*: Brazil. *South-west Asia*: Lebanon. *Asia*: Caspian Sea, China, Russia (Far East), Tajikistan. *Australia and New Zealand*: Australia.
Occurrence: It has been detected in freshwater habitats (lakes) in the Susurluk basin.

Phylum: Haptophyta
Class: Coccolithophyceae
Order: Prymnesiales
Family: Chrysochromulinaceae
Genus: *Chrysochromulina*

Species: *Chrysochromulina parva* Lackey 1939 (Figure 3k)
Synonym: *Erkenia subaequiciliata* Skuja 1948
Description: Cells ovoidal, 5 µm wide and 3 µm thick; flagella two per cell, 10 µm long; chloroplasts two.
Ecology: This is freshwater species. The water quality indicator is tolerant.
Distribution: *Arctic*: Svalbard (Spitsbergen). *Europe*: Black Sea, Britain, Germany, Netherlands, Romania, Scandinavia, Slovakia, Sweden, Spain. *North America*: Arkansas, Northwest Territories, Ontario, Québec. *South America*: Brazil. *Asia*: India, China. *Middle East*: Israel.
Occurrence: It has been detected in freshwater habitats (lakes) in the Antalya basin.

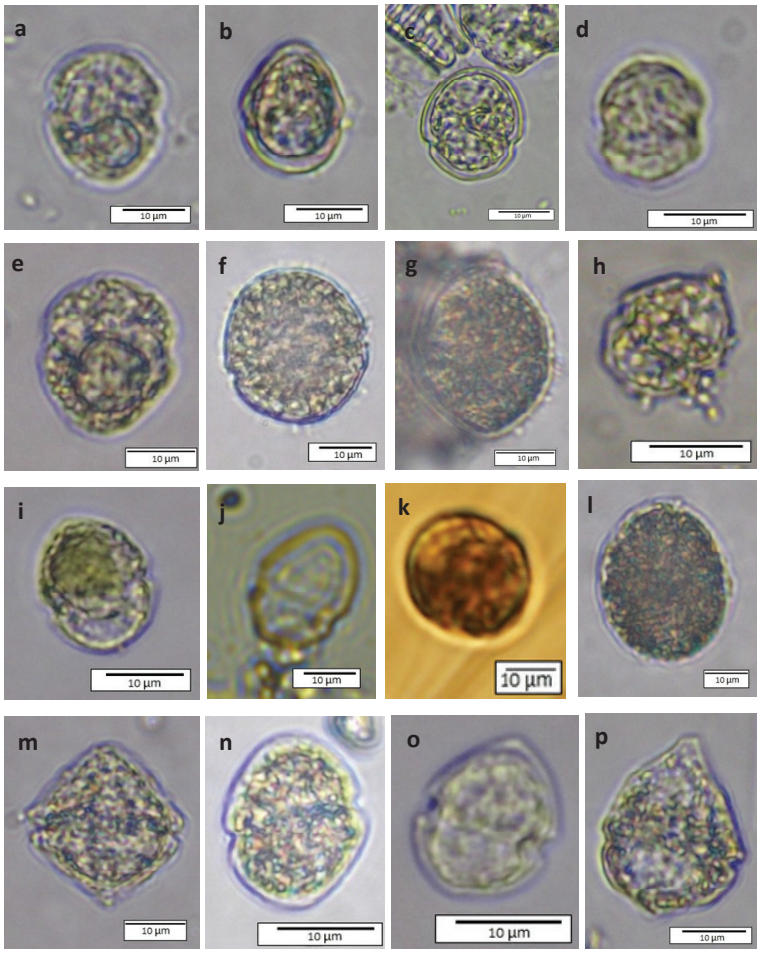
Order: Coccolithales
Family: Hymenomonadaceae
Genus: *Hymenomonas*

Species: *Hymenomonas roseola* Stein 1878 (Figure 3l)
Synonym: *Hymenomonas stagnicola* (Chodat & Rosillo) Kamptner
Description: Motile cells metabolic, ellipsoidal, 25 µm long, 12 µm wide; slightly emarginate at anterior end; flagella two per cell; haptonema short; coccoliths circular with a jagged top.

Ecology: This is brackish water species. The water quality indicator is tolerant.
Distribution: *Europe*: Britain, Czech Republic, Germany, Netherlands, Romania, Scandinavia, Slovakia, Sweden. *Caribbean Islands*: Cuba.
Occurrence: It has been detected in brackish water habitats (lakes) in the Antalya basin.

Figure 2

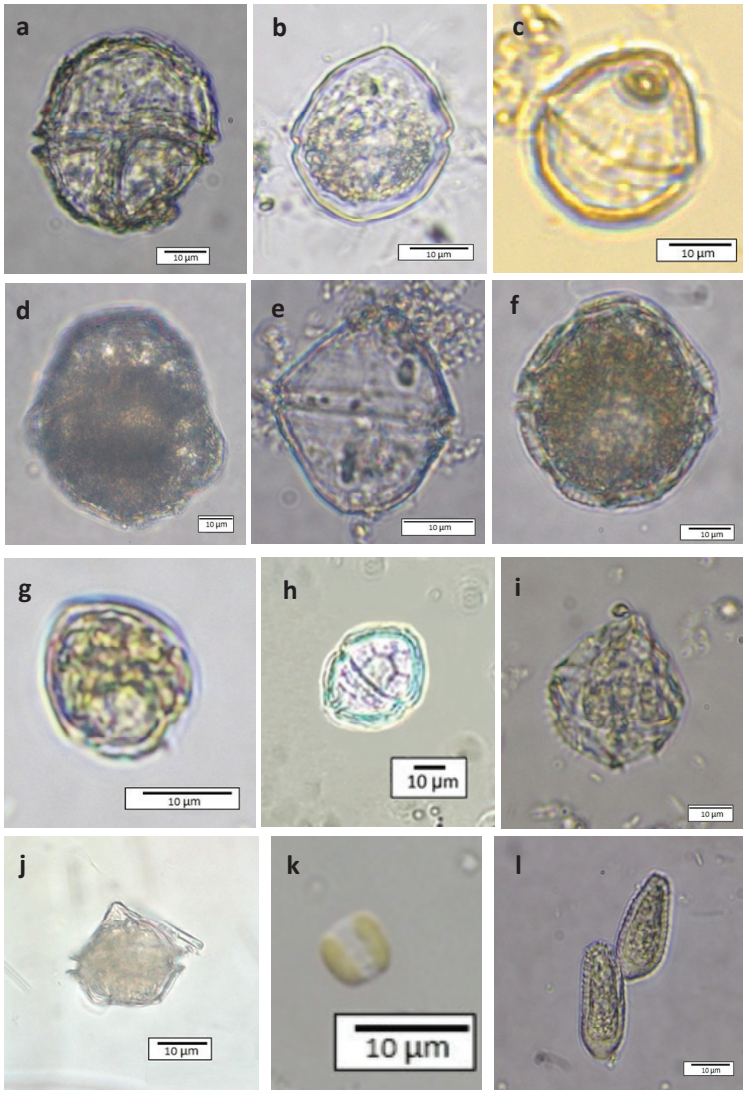
Sixteen New Records of Miozoa Taxa



Note. a. *Biecheleria ordinata*, b. *Borghiella woloszynskae*, c. *Glenoaulax inaequalis,* d. *Gymnodinium albulum,* e. *Gymnodinium eurytopum,* f. *Gymnodinium inversum,* g. *Gymnodinium inversum* var. *elongatum,* h. *Gymnodinium lantzschii,* i. *Gymnodinium mitratum,* j. *Gymnodinium palustre,* k. *Gymnodinium saginatum,* l. *Gymnodinium tatricum,* m. *Nusuttodinium acidotum,* n. *Nusuttodinium aeruginosum,* o. *Glenodinium paululum,* p. *Parvodinium africanum* var. *tatricum.*

Figure 3

Ten New Records of Miozoa and Two New Records of Haptophyta Taxa



Note. a. *Parvodinium centenniale,* b. *Parvodinium lubieniense,* c. *Peridinium gatunense,* d. *Peridinium gatunense* f. *majus,* e. *Peridinium gutwinskii,* f. *Peridinium volzii* var. *cyclicum,* g. *Peridiniopsis armata,* h. *Peridiniopsis kulczynskii,* i. *Peridiniopsis pygmaea* var. *brigantina,* j. *Protoperidinium achromaticum,* k. *Chrysochromulina parva,* l. *Hymenomonas roseola.*

Discussion and Conclusion

A total of 28 taxa were determined as new records for Turkish freshwater algae in the divisions of Miozoa, and Haptophyta.

Miozoa contributes to the new records with 26 taxa and these taxa are into genus *Biechleria, Borghiella, Glenoaulax, Gymnodinium* (9*), Nusuttodinium* (2), *Glenodinium, Parvodinium* (3), *Peridinium* (4)*, Peridiniopsis* (3*),* and *Protoperidinium.* The species of Miozoa are found in marine waters as well as fresh waters as planktonic and rarely parasitic species (Keshri et al., 2013; Gómez, 2012). Rawson (1956) determined the members of Miozoa in mesotrophic waters. Their ecological states are generally sensitive, but *Glenoaulax inaequalis, Glenodinium paululum, Peridiniopsis armata, Peridiniopsis kulczynskii,* and *Peridiniopsis pygmaea* var. *brigantina* are sensitive/tolerant.

Although all of them were recorded in Europe, some species were found in Australia and New Zealand, Asia, North and South America. Only *Parvodinium centenniale* were determined in Africa (Guiry & Guiry, 2020). The identified members are freshwater species in Kızılırmak, Burdur, Seyhan, Batı Akdeniz, Konya, Susurluk, Sakarya, Yeşilırmak, Batı Karadeniz, Akarçay, Doğu Akdeniz, Fırat-Dicle, and Asi basins.

The two taxa (*Chrysochromulina parva* and *Hymenomonas roseola*) were recorded as new records in Haptophyta. These taxa were the first record identified in freshwater and brackish water habitats in Turkey. Both species were found in the Antalya basin. *C. parva* is a cosmopolitan species and has been observed almost worldwide (Kristiansen, 1971; Diaz & Lorenzo, 1990; Wujek & Saha, 1991). Hansen et al. (1994) have reported that this species can grow in mass development, and this feature caused to toxic effects for fishes. *C. parva* has been found in the Arctic, Europe, North America, South America, China, and Middle East (Guiry & Guiry, 2020). *H. roseola* inhabits highly eutrophic waters such as polluted rivers but this species have been observed in various ponds and small lakes (Lackey, 1939; Huber-Pestalozzi 1941; Bourrelly, 1968). The species generally prefers the brackish waters. The distribution of *H. roseola* is in Europe and the Caribbean Islands (Guiry & Guiry, 2020).

In conclusion, 28 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.

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Extended Turkish Abstract
(Genişletilmiş Türkçe Özet)

Türkiye'deki 25 Nehir Havzasından Türkiye Tatlı Su Alg Florası İçin Yeni Kayıtlar, Bölüm III: Miozoa, Haptophyta

Avrupa Birliği Su Çerçeve Direktifi'ne (SÇD) göre biyolojik kalite bileşenlerinden biri olarak kabul edilen fitoplankton üzerine Türkiye'de yapılan taksonomik ve ekolojik çalışmaların sayısı her geçen gün artmaktadır. Avrupa Birliği'ne uyum çerçevesinde Tarım ve Orman Bakanlığı Su Yönetimi Genel Müdürlüğü (SYGM) ve bağlı kuruluşu Devlet Su İşleri (DSİ) tarafından biyolojik kalite bileşenleri de dikkate alınarak gerçekleştirilen çok sayıda proje bulunmaktadır. Birçok farklı nehir havzasında yapılan su kalitesi izleme çalışmaları, bazı göl yönetim planı çalışmaları, 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 Su Yönetimi Genel Müdürlüğü tarafından mali ve teknik olarak desteklenmiştir. Proje kapsamında 25 nehir havzasında 275 göl çalışılmış ve toplam 1363 fitoplankton taksonu tespit edilmiştir. Bu taksonlardan 63 tanesi Miozoa, 2 tanesi Haptophyta divizyolarına aittir.

Bugüne kadar dünya genelinde yapılan çalışmalarda 3550 Miozoa ve 773 Haptophyta taksonu tanımlanmıştır. Miozoa divizyosunun birçok türü serbest yüzen, tek hücreli organizmalardır ve bu grubun üyeleri tatlı sularda hem göl ve baraj gölü gibi büyük hacimli su kütlelerinde hem de gölet gibi daha küçük hacimli su kütlelerinde bulunmaktadır. Haptonema denen eşsiz bir organele sahip Haptophyta divizyosu üyeleri ise denizel ortamlarda yaygındırlar. Tatlı su habitatlarında az sayıda planktonik türün varlığı bilinmektedir.

Dört farklı iklim tipinin etkisi altında olması ve coğrafik olarak farklı yüksekliklerin bulunması sebebiyle Türkiye'de bulunan göllerin morfometresi ve hidrolojisi de farklılıklar göstermektedir ve bu durum alg biyoçeşitliliğini de desteklemektedir. Son yıllarda Türkiye alg florası için çok sayıda yeni kayıt bildirilmiştir ve tespit edilen toplam alg sayısı artış göstermiştir. Bu çalışmanın amacı da Türkiye alg florasına tespit edilen yeni kayıtlar ile katkıda bulunmaktır.

Türkiye'de bulunan 25 nehir havzasında 200 kadar doğal göl, 806 kadar baraj gölü ve 1000 kadar göletin var olduğu tespit edilmiştir. 25 nehir havzasında gerçekleştirilen bu çalışmada ise baraj gölleri de dahil olmak üzere 275 göl örneklenmiştir. Çalışılan göllerin 22 göl tipolojisinde gruplandığı belirlenirken, 26º19′ - 43º54′D ve 35º56′ - 42º00′K koordinatları arasında bulundukları tespit edilmiştir. Üzerinde çalışma yapılan göllerin coğrafi olarak deniz seviyesi (Gala Gölü) ile 2757 m (Çamlu Gölü) arasındaki farklı yüksekliklerde dağılım gösterdikleri görülmektedir.

2017 ve 2019 tarihleri arasında her bir gölde yılda üç defa (ilkbahar, yaz, sonbahar) olmak üzere bir, iki ya da üç farklı istasyondan fitoplankton örneklenmiştir. 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 gölün en derin noktasında seçilmiştir. Öfotik bölgenin (Secchi diski derinliği × 2.5) üç farklı derinliğinden (yüzey, orta ve dip) su örnekleyicisi ile alınan su örnekleri karıştırılarak alt su numunesi alınmıştır. 50 µm göz açıklığına sahip plankton kepçesi de örnekleme sırasında ayrıca kullanılmıştır. Alg taksonlarının teşhisi farklı laboratuvarlardaki ışık ve ters mikroskoplar kullanılarak gerçekleştirilmiş ve mikroskoplara bağlı kameralar vasıtasıyla fotoğrafları çekilmiştir. Taksonların yeni kayıt olup olmadığı Türkiye'deki güncel literatürlerde yer alan kayıtlarla karşılaştırılıp tespit edilmiştir. Aynı zamanda takson isimlerinin güncelliği kontrol edilip türlerin dünyadaki dağılımı da belirlenmiştir.

Bu çalışmada Türkiye tatlı su algleri için yeni kayıt olarak 26 Miozoa ve 2 Haptophyta taksonu tanımlanmıştır. Miozoa divizyosunda bulunan taksonlar *Biechleria, Borghiella, Glenoaulax, Gymnodinium* (9*), Nusuttodinium* (2), *Glenodinium, Parvodinium* (3), *Peridinium* (4)*, Peridiniopsis* (3*),* ve *Protoperidinium* cinsleri içinde dağılım göstermiştir. Miozoa türlerinin denizel ekosistemlerin yanında tatlı su ekosistemlerinde de planktonik ve nadiren de parazitik olarak dağılım gösterdikleri bilinmektedir. Aynı zamanda daha çok mezotrofik ortamları tercih ettikleri tespit edilmiştir. Yeni kayıt olarak tespit edilen Miozoa taksonlarının büyük çoğunluğunun ekolojik durumu hassas olarak tespit edilmekle birlikte, *Glenoaulax inaequalis, Glenodinium paululum, Peridiniopsis armata, Peridiniopsis kulczynskii* ve *Peridiniopsis pygmaea* var. *brigantina* taksonlarının hassas/toleranslı oldukları belirlenmiştir.

Her ne kadar tespit edilen taksonlar dünya geneline bakıldığında genellikle Avrupa'da kayıt edilse de bazı türlerin Avustralya, Yeni Zelanda, Asya, Kuzey ve Güney Amerika'da da rapor edildiği görülmektedir. Sadece *Parvodinium centenniale* türü Afrika'da bulunmuştur. Türkiye'de bu taksonlar Kızılırmak, Burdur, Seyhan, Batı Akdeniz, Konya, Susurluk, Sakarya, Yeşilırmak, Batı Karadeniz, Akarçay, Doğu Akdeniz, Fırat-Dicle ve Asi havzalarında kayıt edilmiştir.

Sadece *Chrysochromulina parva* ve *Hymenomonas roseola* olarak iki takson Haptophyta divizyosunda tespit edilmiştir. Her iki tür de Antalya Havzasında bulunmaktadır. *C. parva* kozmopolitan bir türdür ve dünya üzerinde birçok farklı bölgede rapor edilmiştir. Kuzey kutbu, Avrupa, Kuzey Amerika, Güney Amerika, Çin, orta doğu bu türün tespit edildiği bölgelere örnek olarak verilebilir. Ayrıca bu türün aşırı çoğalma gösterebildiği ve bu durumun balıklar için toksik etki oluşturabildiği bildirilmiştir. *H. roseola* kirli nehirler gibi çok ötrofik ortamlarda bulunabilmektedir fakat aynı zamanda birçok farklı gölet ve küçük gölde de tespit edilmiştir. Aynı zamanda acı su ortamlarını da tercih edebilmektedir. *H. roseola* türünün Avrupa'da ve Karayip Adalarında dağılım gösterdiği görülmektedir.

Sonuç olarak, bu çalışma ile birlikte 28 yeni kayıt Türkiye tatlı su alg florasına eklenmiştir. Bu taksonların dünyanın farklı bölgelerinde de dağılım gösterdikleri tespit edilmiştir. İlerleyen yıllarda yapılan çalışmalarda Türkiye alg florası için yeni kayıtların sayısının artması beklenmektedir.