Turkish Journal of Water Science & Management
ISSN: 2536 474X / e-ISSN: 2564-7334

Volume: 5 Issue: 2 Year: 2021

Research Article

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

Türkiye'deki 25 Nehir Havzasından Türkiye Tatlı Su Alg Florası için Yeni Kayıtlar, BölümV: Cryptophyta

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Received Date: 08.12.2020, Accepted Date: 05.03.2021
DOI: 10.31807/tjwsm.837623

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Abstract

There is an increasing number of taxonomic and ecologic studies on phytoplankton, one of the biological quality elements according to the EU Water Framework Directive, in Turkey day by day. This study was carried on from 2017 to 2019 in 275 lakes lies in 25 river basins of Turkey with the aim of examining the taxonomy and biological diversity of the Cryptophyta group. It was the fourth part of the Project, entitled "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. The algal taxa was identified by using different light and inverted microscopes in many laboratories. A total of 24 Cryptophyta taxa were identified in the study. 9 of the identified Cryptophya taxa were presented as new records for the freshwater algal flora of Turkey.

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

Öz

AB Su Çerçeve Direktifi'ne göre biyolojik kalite unsurlarından biri olan fitoplankton konusunda Türkiye'de her geçen gün artan sayıda taksonomik ve ekolojik çalışma bulunmaktadır. Bu çalışma, Cryptophyta grubunun taksonomisini ve biyolojik çeşitliliğini incelemek amacıyla, Türkiye'nin 25 nehir havzasında yer alan 275 gölde 2017-2019 yılları arasında gerçekleştirilmiştir. Tarım ve Orman Bakanlığı Su Yönetimi Genel Müdürlüğü tarafından mali ve teknik olarak desteklenen "Türkiye'de Referans İzleme Ağının Kurulması" başlıklı projenin dördüncü bölümüdür. Her gölde fitoplankton, öfotik bölgenin üç derinliğinden (yüzey, orta ve alt) su örnekleyiciler ile örneklenmiş ve daha sonra bu üç derinlikten alınan su örnekleri karıştırılmıştır. Alg taksonlarının teşhisi ışık ve ters mikroskoplar kullanılarak gerçekleştirilmiştir. Çalışmada toplam 24 Cryptophyta taksonu tanımlanmıştır. Tespit edilen Cryptophya taksonlarından 9 tanesi Türkiye'nin tatlı su alg florası için yeni kayıt olarak sunulmuştur.

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

Introduction

Members of Cryptophya are cosmopolitan species, but they are rarely dominant organisms in the system. The taxonomy of these algae has been receiving considerable attention globally owing to their widespread occurrence in all aquatic habitats (Novarino, 2003). Despite being widespread in freshwater habitats, cryptomonads are a neglected group, with most reports in the literature consisting of lists of taxa with few illustrations of the specimens observed (John et al., 2003). Their ecology has universally received much less attention, and almost everything that is presently known about it is from the temperate region of the world (Bicudo et al., 2009). Recent researches have shown that even in well-sampled geographical regions and habitats, the true diversity of cryptomonads is often unknown (Hoef-Emden, 2007; Lane & Archibald, 2008; Choi et al., 2013; Martyneneko et al., 2020).

Until now, 223 Cryptophyta taxa were listed in previous studies in the world (Guiry & Guiry, 2020). Cryptomonads are unicellular, mainly pigmented, small (~5–50 μm) biflagellate protists found in diverse freshwater, brackish, and marine habitats. They are characterized by a distinct cellular asymmetry and flattened in shape, with an anterior groove or pocket. At the edge of the pocket there are typically two slightly unequal flagella (Hoef-Emden & Archibald, 2016).

Due to the effects of three 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, 2012; 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; Yüce & Aktaş, 2020), and the total number of taxa have increased (Taşkın et al., 2019; Maraşlıoğlu & Gönülol, 2020).

In this project, 275 lakes in 25 river basins were studied, and a total of 1363 phytoplankton taxa were detected. The present study aimed to contribute to the algal flora of Turkey by describing 9 species in Cryptophyta as new records for the Turkish freshwater algal flora.

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 small reservoirs (Foreign Relation Office of DSİ, 2014). Foreign Relation Office of DSİ data show that the volume of annual average precipitation is estimated to be 501 billion m^3 water, of which about 55% is lost to evapotranspiration, 31% flows into water bodies (158 billion m^3) and 14% feeds aquifers (69 billion m^3). The Dicle-Fırat Basin is Turkey's largest single volume of available exploitable freshwater resources, representing 28.5% (Foreign Relation Office of DSİ, 2014).

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 is given in Table 1. These lakes are grouped in 22 lake typologies based on altitude, lake depth, lake size and lakebed material (DGWM, 2015a). 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).

Figure 1

River Basins of Turkey

Sampling and Identification

Phytoplankton samples were collected from three depths (surface, middle, and bottom) of the euphotic depth with a water sampler in spring, summer, and fall of the each year between 2017 and 2019 at the sampling stations in each lake. Subsamples were used from the mixed water of the three depths. Plankton net with a pore diameter of 50 µm was also used for sampling. Phytoplankton determinations were carried out on subsamples preserved in acetic Lugol's solution that was sedimented in the counting chambers. Algal cells were counted on inverted microscopes following Huber-Pestalozzi (1968) and John et al. (2003). Determination of new taxa for Turkish freshwater algal flora were checked with the checklist of Aysel (2005), Taşkın et al. (2019), and the database of Turkish algae (Maraşlıoğlu & Gönülol, 2020). The currently accepted nomenclature and distribution of taxa have been given according to Guiry & Guiry (2020).

Table 1

Number of Studied Lakes in 25 River Basins

River Basins	Lakes
Burdur	6
Akarçay	10
Sakarya	23
Batı Karadeniz	14
Doğu Karadeniz	7
Yeşilırmak	14
Kızılırmak	23
Meriç-Ergene	5
Marmara	9
Antalya	9
Batı Akdeniz	13
Büyük Menderes	13
Gediz	6
Kuzey Ege	5
Küçük Menderes	6
Konya	18
Susurluk	9
Aras	3
Çoruh	8
Fırat-Dicle	17
Van	7
Asi	8
Ceyhan	18
Doğu Akdeniz	12
Seyhan	12
TOTAL	275

Results

A total of 24 Cryptophyta taxa were determined in a study conducted from 2017 to 2019 in 25 river basins of Turkey. 9 Cryptophyta taxa presented as new records for the freshwater algal flora of Turkey are described below.

Phylum: Cryptophyta
Class: Cryptophyceae
Order: Cryptomonadales
Family: Hemiselmidaceae
Genus: Chroomonas

Species: *Chroomonas breviciliata* Nygaard (Figure 2a)
Synonyms: -
Description: Cells 15-17 µm long, 4-6 µm wide, pearshaped, rounded front, pointed back and slightly pulled out to the side. 2 pyrenoid and very short flagella are present.
Ecology: This is a freshwater species.
Distribution: *Europe*: Netherlands, Romania.
Occurrence: It has been detected in freshwater habitats (lakes) in the Batı Akdeniz basin.

Family: Cryptochrysidaceae
Genus: Cryptochrysis

Species: *Cryptochrysis minor* Nygaard (Figure 2b)
Synonyms: -
Description: Cells 11 µm long and 6 µm wide, two slightly unequal flagella. Cells ellipsoidal, small, free-swimming, both ends equally and regularly rounded, anterior end convex which is asymmetrically bilobed; pyrenoid present in the dorsal position.
Ecology: This is a freshwater species.
Distribution: *Europe*: Germany; *South America*: Brazil; *South-west Asia*: Bangladesh.
Occurrence: It has been detected in freshwater habitats (lakes) in the Batı Akdeniz basin.

Family: Cryptomonadaceae
Genus: Cryptomonas

Species: *Cryptomonas anomala* F.E.Fritsch (Figure 2c)
Synonyms: -
Description: Cells 9-11µm wide, 21-24µm long, flagella equal, much shorter than the cell, 2 chloroplasts laterally placed with a circular pyrenoid, central or slightly displaced towards cell anterior.
Ecology: This is a freshwater species.
Distribution: *Europe*: Britain.

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

Species: *Cryptomonas phaseolus* Skuja (Figure 2d)
Synonyms: -
Description: Cells 8-13 µm long and 5-8 µm wide. The relatively small cells are ellipsoidal or slightly flattened on the ventral side. The gullet is subapical and extends to the middle of the cell. The flagella are subequal and are shorter than the cell.
Ecology: This is a freshwater species. This species is usually found in eutrophic waters.
Distribution: *Europe*: Austria, Germany, Netherlands, Scandinavia, Slovakia, Spain, Sweden; *North America*: Québec; *South America*: Brazil; *South-west Asia*: Bangladesh; *South-east Asia*: Singapore.
Occurrence: It has been detected in freshwater habitats (lakes) in Sakarya and Akarçay basins.

Species: *Cryptomonas reflexa* Skuja (Figure 2e)
Synonyms: -
Description: Cells 27-37 µm long, 12-16 µm wide, relatively bigger, broadly ovate or ellipsoidal, spindleshaped, anterior end curved, posterior end pointed. The species lacks pyrenoids but possesses two lateral chloroplasts.
Ecology: This is a freshwater species.
Distribution: *Europe*: Germany, Netherlands, Poland, Scandinavia, Slovakia, Sweden; *South America*: Brazil, Uruguay.
Occurence: It has been detected in freshwater habitats (lakes) in the Batı Akdeniz basin.

Species: *Cryptomonas tenuis* Pascher (Figure 2f)
Description: The cells are small with nearly parallel sides in lateral view but are usually slightly curved toward the ventral surface. Each contains two narrow chloroplasts and sometimes a light-refractive body is visible at the anterior end. The gullet is short and narrow.
Ecology: This is a freshwater species.
Distribution: *Europe*: Germany; *South America*: Brazil.
Occurrence: It has been detected in freshwater habitats (lakes) in the Batı Akdeniz basin.

Order: Pyrenomonadales
Family: Pyrenomonadaceae
Genus: Pyrenomonas

Species: *Pyrenomonas ovalis* P.Kugrens, B.L.Clay & R.E.Lee (Figure 2g)
Synonyms: *Rhodomonas ovalis* Nygaard
Description: Cells oval to ellipsoid, measuring 14-16 µm long and 6-8 µm wide; often forming colonies embedded in mucilage; and have a single red chloroplast with two lobes. The pyrenoid is attached to both lobes, the chloroplast appears H-shaped due to the formation of a bridge between the two lobes. The nucleomorph is embedded within the pyrenoid.
Ecology: This is a freshwater species.
Distribution: Europe: Germany.
Occurrence: It has been detected in freshwater habitats (lakes) in Batı Akdeniz and Asi basins.

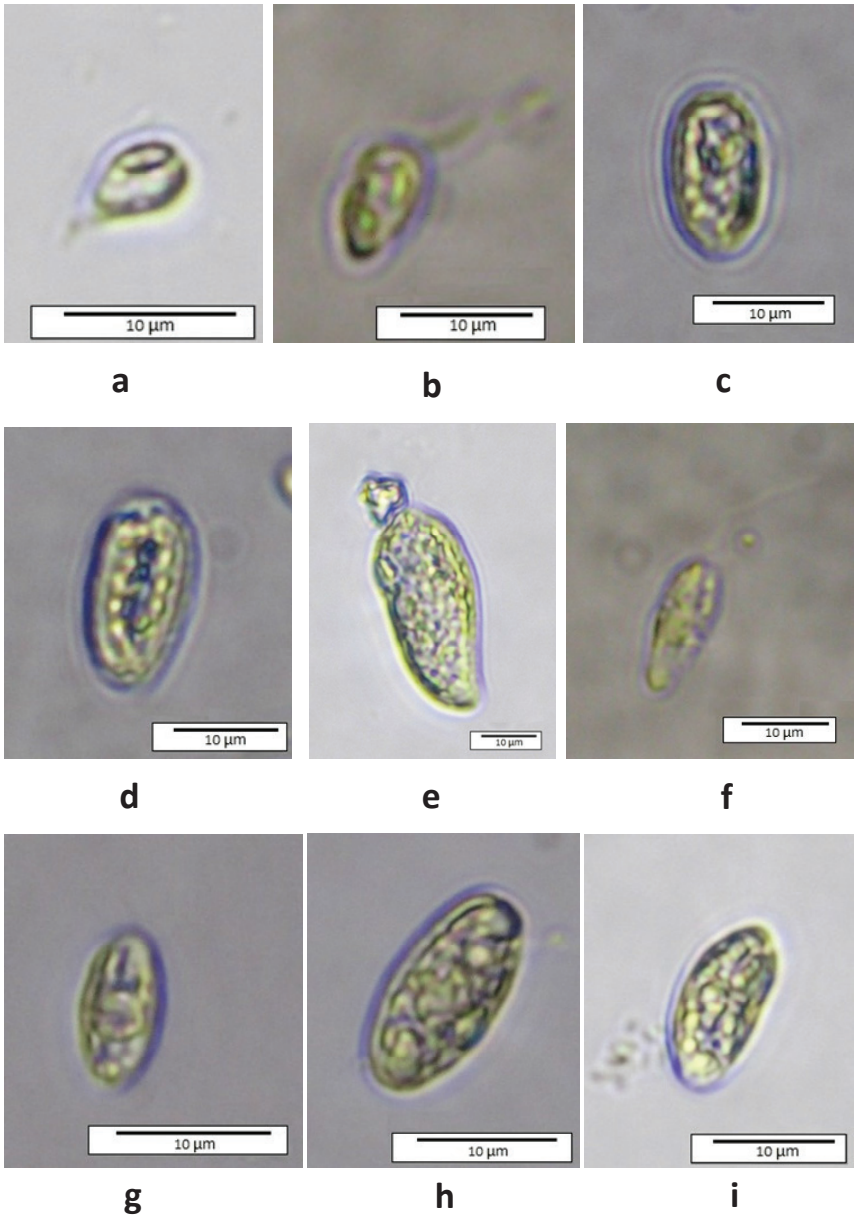
Order*:* Pyrenomonadales
Family*:* Pyrenomonadaceae
Genus: Rhodomonas

Species: *Rhodomonas rubra* Geitler (Figure 2h)
Synonyms: -
Description: Cells elongated oval to long elliptica, 13-20 µm long, 8-10 µm wide. A relatively large pyrenoid positioned centrally or slightly backwards. The chloroplast is clearly H-shaped, and the nucleomorph is located in an invagination of the pyrenoid.
Ecology: This is a freshwater species.
Distribution: *Europe*: Netherlands.
Occurrence: It has been detected in freshwater habitats (lakes) in Batı Akdeniz and Fırat Dicle basins.

Species: *Rhodomonas tenuis* Skuja (Figure 2i)
Synonyms: -
Description: Cells 15-23 µm long, 6-9.5 µm wide, elongated, cylindrical or cylindrical-obovate, cross-section in the area of apex circular or slightly elliptical.
Ecology: This is a marine/freshwater species.
Distribution: *Europe*: Germany, Scandinavia, Sweden; North America: Northwest Territories.
Occurrence: It has been detected in freshwater habitats (lakes) in Sakarya and Asi basins.

Figure 2

Nine New Records of Cryptophyta Taxa



Note. a. *Chroomonas breviciliata*, b. *Cryptochrysis minor*, c. *Cryptomonas anomala*, d. *Cryptomonas phaseolus*, e. *Cryptomonas reflexa*, f. *Cryptomonas tenuis*, g. *Pyrenomonas ovalis*, h. *Rhodomonas rubra*, i. *Rhodomonas tenuis.*

Discussion and Conclusion

A total of 9 taxa were determined as new records for Turkish freshwater algae in the divisions of Cryptophyta. These taxa are dispersed into genus *Chroomonas* (1)*, Cryptochrysis* (1)*, Cryptomonas* (4)*, Pyrenomonas* (1)*, Rhodomonas* (2). Chryptophyta members have been determined in freshwaters but few species are found in the snow, soil, and marine habitats (Harper et al., 2012). Regarding their nutritional requirements, they are considered to be the responsible for the eutrophication, i.e. they can tolerate a wide spectrum of trophic conditions (Reynolds, 1976). Cryptophyceae have a wide environment spectrum, as they are typical of nutrients and organic matterrich waters (Rosen, 1981), but they can also tolerate occasional nutrient, especially N depletion (Haffner & McNeely, 1989). In the periphyton community in oligotrophic conditions, *C. phaseolus* was associated with the greatest ammonium content (Vercellino, 2001). Some freshwater species from Cryptophyta prefers the oxic/anoxic boundary layer (chemocline) near the lake bottom as type-habitat (Gervais 1997). *Cryptomonas phaseolus* was also found to co-exist simultaneously with *Cryptomonas undulata* in short-term changes in the light climate near the chemocline (Gervais 1998). It is clear that different cryptomonads may adapt to a wide variety of environmental conditions from calm, stratified, well-lit and nutrient-enriched summer conditions to cool, mixed and light-limited winter situations despite an apparent homogeneity of morphological, phylogenetic and functional characteristics (Cerino & Zingone, 2006). According to Barone & Naselli-Flores (2003), photoadaptive strategy and formation of resting forms are physiological mechanisms that could explain the Cryptophyta success in shallow systems. Based on Reynolds et al. (2002) functional groups, the genus Cryptomonas belongs to group Y, whose species are well adapted to living in several kinds of habitats, but mainly shallow enriched ones.

In the world 223 Cryptophyta taxa were identified up to now. In this study, we identified 24 species of which 9 species as the first record for Turkey from the genus of *Chroomonas, Cryptochrysis, Cryptomonas, Pyrenomonas* and *Rhodomona*s. Genus *Cryptomonas is* cosmopolitan in freshwater habitats, including temporary ponds, rivers, and lakes. More than 100 species have been assigned to Cryptomonas; including marine and blue-green forms. Recent taxonomic revisions have suggested that Cryptomonas should be restricted to the ovoid, olive-green to brown species found in fresh and slightly brackish waters. The majority of species have been described from European waters, but the genus is known from every continent. *Rhodomonas* is cosmopolitan and common, although rarely abundant, in marine and brackish waters and two freshwater species are known from Europe (Guiry & Guiry, 2020). The identified members are freshwater species in Kızılırmak,

Burdur, Seyhan, Batı Akdeniz, Konya, Susurluk, Sakarya, Akarçay, Fırat Dicle, and Asi basins from Turkey.

In conclusion, 9 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 in the world. The number of new records for the algal flora of Turkey is expected to increase in the future.

Acknowledgements

This study was supported by the Ministry of Agriculture and Forestry, Directorate General for Water Management. We would like to thank the executives and the staff of Çınar Engineering Consulting Co. who had executed the Project, namely "Establishment of Reference Monitoring Network in Turkey". This study is a part of this project which is financially and technically supported by Directorate General for Water Management (DGWM).

References

Akar, B., & Şahin, B. (2014). New desmid records of Karagöl Lake in Karagöl-Sahara National Park (Şavşat-Artvin/Turkey). *Turkish Journal of Fisheries and Aquatic Sciences, 14*(1), 269-274. **https://doi.org/10.4194/1303-2712-v14_1_29**

Akbulut, A., Yildiz, A., Sahin, B., Sen, B., Uzunöz, C., Solak, C., Basdemir, D., Sevik, F., Sönmez, F., Acikgöz, I., Pabuccu, K., Öztürk, M., Alp, M.T., Albay, M., Cakır, M., Özbay, Ö., Can, Ö., Akcaalan, R., Atici, T., ... Zengin, Z.T. (2019). *Türkiye Suyosunları Listesi* (E.Taskin, Ed.). Ali Nihay Gökyiğit Vakfı Yayını.

Atıcı, T. (2002). Nineteen new records from Sarıyar Dam Reservoir phytoplankton for Turkish Freshwater algae. *Turkish Journal of Botany, 26*(6), 485-490.

Aysel, V. (2005). Check-List of the Freshwater Algae of Turkey. *Journal of Black Sea/Mediterranean Environment*, *11*, 1-124. Retrieved November 10, 2020, from **https://blackmeditjournal.org/wp-content/uploads/1-124Vol11No1Aysel.pdf**

Aysel, V., Dural, B., & Gezerler-Şipal, U. (1993). Two new records of Cyanophyceae for the Algal Flora of Turkey. *Turkish Journal of Botany*, *17*, 263-266.

Barone, R., & Naselli-Flores, L. (2003). Distribution and seasonal dynamics of Cryptomonads in Sicilian water bodies. In L. Naselli-Flores, J. Padisák & M.T. Dokulil (Eds.). *Phytoplankton and equilibrium concept: the ecology of steady-state assemblages* (pp. 325-329). Kluwer Academic Publishers.

Baykal, T., Akbulut, T., Açıkgöz, İ., Udoh, A.U., Yıldız, K., & Şen, B. (2009). New records for the freshwater algae of Turkey. *Turkish Journal of Botany*, *33*, 141 - 152. **http://doi.org/10.3906/bot-0705-10**

Baykal, T., Erkaya, İ. A., Udoh, A. U., Akbulut, A., Yıldız, K., & Şen, B. (2012). New records for the freshwater algae of Turkey (Tigris Basin). *Turkish Journal of Botany*, *36*, 747 - 760. **http://doi:10.3906/bot-1108-16**

Bicudo, A. J. A., Sado, R. Y., & Cyrino, J. E. P. (2009). Growth and haematology of pacu**,** *Piaractus mesopotamicus***,** fed diets with varying protein to energy ratio. *Aquaculture Research*, *40*, 486-495. **https://doi.org/10.1111/j.1365-2109.2008.02120.x**

Cerino, F., & Zingone, A. (2006). A survey of cryptpmonad diversity and seasonality at a coastal Mediterranean site. *European Journal of Phycology*, *41* (4), 363-378. **https://doi.org/10.1080/09670260600839450**

Choi B., Son M., Jong Im Kim J. I., & Shin, W. (2013). Taxonomy and phylogeny of the genus Cryptomonas (Cryptophyceae, Cryptophyta) from Korea. *Algae*, 28, 307–330. **https://doi.org/10.4490/algae.2013.28.4.307**

Foreign Relation Office of General Directorate of State Hydraulic Works. (2014). *Water and DSİ – 60 years full of realized projects*.

Gervais, F.,(1997). *Cryptomonas undulata* spec. nov., a new freshwater cryptophyte living near the chemocline. *Nova Hedwigia,* 65: 353–364.

Gervais, F. (1998). Ecology of cryptophytes coexisting near a freshwater chemocline. *Freshwat. Biol*., 39: 61–78

Guiry, M. D., & Guiry, G. M. (2020). *AlgaeBase*. World-wide electronic publication, National University of Ireland, Galway. Retrieved May 20, 2020 **http://www.algaebase.org**

Haffner, G. D., & McNeely, R. (1989). Community structure in epilimnetic and metalimnetic phytoplankton assemblages. *Hydrobiologia, 182,* 59-71.

Harper, M. A., Cassie Cooper, V., Chang, F. H., Nelson, W. A., & Broady, P. A. (2012). Phylum Ochrophyta: brown and golden-brown algae, diatoms, silicioflagellates, and kin. *New Zealand Inventory of Biodiversity*, *3*, 114-163. Retrieved November 10, 2020, from **https://www.researchgate.net/publication/259824021_Phylum_Ochrophyta_brown_and_golden-brown_algae_diatoms_silicoflagellates_and_kin**

Hoef-Emden, K. (2007). Revision of the genus Cryptomonas (Cryptophyceae) II: Incongruences between classical morphospecies concept and molecular phylogeny in smaller pyrenoid-less cells. *Phycologia*, *46* (4), 402–428.

Hoef-Emden. K., & Archibald, J.M. (2016). Handbook of the Protists. Archibald J. et al. (Eds.), *Cryptophyta (Cryptomonads)* (pp. 1-41). Springer International Publishing**. https://doi.org/10.1007/978-3-319-32669-6_35-1**

Huber-Pestalozzi, G. H. (Eds.) (1968). *Das Phytoplankton des Süsswassers. Systematik und Biologie. 3. Teil: Cryptophyceae, Chloromonadophyceae, Dinophyceae*. E. Schweizerbart'sche Verlagsbuchhandlung.

John, D. M., Whitton, B. A., & Brook, A. J. (2003). *The Freshwater Algal Flora of the British Isles: An Identification Guide to Freshwater and Terrestrial Algae* (2nd ed.). Cambridge University Press.

Lane, C. E., & Archibald, J. M. (2008). New marine members of the genus Hemiselmis (Cryptomonadales, Cryptophyceae). *Journal of Phycology*, *44* (2), 439–450. **https://doi.org/10.1111/j.1529-8817.2008.00486.x**

Maraşlıoğlu, F., & Gönülol, A. (2020). *Türkiyealgleri* [Data set]. Hitit University. **http://turkiyealgleri.hitit.edu.tr**

Maraşlıoğlu, F., & Soylu, E. N. (2018). New Diatom Records for Turkish Freshwater Algal Flora from Lakes Ladik (Samsun, Turkey) and Hazar (Elazığ, Turkey). *Turkish Journal of Fisheries and Aquatic Sciences*, *18* (3), 463-474. **https://www.researchgate.net/deref/http%3A%2F%2Fdx.doi.org%2F10.4194%2F1303-2712-v18_3_12**

Martynenko, N. A., Gusev, E. S., Kulizin, P. V., Guseva, E. E., McCartney, & K. Kulikovskiy, M. S. (2020). A new species of Cryptomonas (Cryptophyceae) from the Western Urals (Russia). *European Journal of Taxonomy*, *649*, 1-12. **https://doi.org/10.5852/ejt.2020.649**

Ministry of Agriculture and Forestry, General Directorate of Water Management. (2015a). *Türkiye'de Havza Bazında Hassas Alanların ve Su Kalitesi Hedeflerinin Belirlenmesi Projesi Final Raporu 1*.

Novarino, G. (2003). A companion to the identification of cryptomonad flagellates (Cryptophyceae=Cryptomonadea). In L. Naselli-Flores et al. (Eds.). *Phytoplankton and equilibrium concept: The ecology of steady-state assemblages* (pp. 225-270). Kluwer Academic Publishers. **https://doi.org/10.1007/978-94-017-2666-5_20**

Özer, T., Erkaya, İ. A., Udoh, A. U., Akbulut, A., Yildiz, K., & Şen, B. (2012). New records for the freshwater algae of Turkey (Tigris Basin). *Turkish Journal of Botany*, *36* (6), 747-760. **http://doi.org/10.3906/bot-1108-16**

Öztürk, M., Gönülol, A., & Öztürk, M. (1995a). Türkiye alg florası için yeni bir kayıt: Pleurotaenium trabecular (Ehr.) ex Nägeli (Desmidiaceae), *Ondokuz Mayıs University Journal of Science*, *6* (1), 212-218.

Öztürk, M., Gezerler-Şipal, U., Güner, H., Gönülol, A., & Aysel, V. (1995b). Closterium kuetzingii Bréb. var. kuetzingii (Conjugatophyceae, Desmidiales), A new record for the algal flora of Turkey. *Ege Journal of Fisheries and Aquatic Sciences*, *12* (1-2), 145-149.

Reynolds, C.S. (1976). Succession and vertical distribution of phytoplankton in response to thermal stratifi cation in a lowland lake, with special reference to nutrient availability. *Journal of Ecology*, *64*, 529-551.

Reynolds, C. S., Huszar, V., Kruk, C., Naselli-Flores, L., & Melo, S. (2002). Towards a functional classifi cation of the freshwater phytoplankton. *Journal of Plankton Research, 24*, 417-428. **https://doi.org/10.1093/plankt/24.5.417**

Rosen, G. (1981). Phytoplankton indicators and their relations to certain chemical and physical factors. *Limnologica, 13*, 263-296.

Sevindik, T. O., Celik, K., & Gönülol, A. (2010). Twenty-four new records for the freshwater algae of Turkey. *Turkish Journal of Botany*, *34*, 249 - 259. **http://doi.org/10.3906/bot-0906-56**

Sevindik, T.O., Celik, K., & Gönülol, A. (2011). Twenty new records for Turkish freshwater algal flora from Çaygören and İkizcetepeler reservoirs (Balıkesir, Turkey). *Turkish Journal of Fisheries and Aquatic Sciences*, *11*, 399 - 406. **http://doi.org/10.4194/1303-2712-v11_3_09**

Sevindik, T. O., Gönülol, A., Önem, B., Tunca, H., & Arabacı, S. (2015). Thirty new records for Turkish freshwater algal flora from Danamandıra Ponds (Silivri, İstanbul) and North Mollaköy Lake (Sakarya). *Biological Diversity and Conservation*, *8* (2), 4-15.

Sevindik, T. O., Gönülol, A., Tunca, H., Gürsoy, N.Y., Küçükkaya, Ş. N., & Durgut, K. Z. (2017). Nineteen new records for Turkish freshwater algal flora from Lake Taşkısığı and Lake Little Akgöl. *Biological Diversity and Conservation, 10* (1), 69-78.

Şahin, B. (2000). Some new records for freshwater algal flora of Turkey. *Flora Mediterranea,* 10, 223-226.

Şahin, B. (2002). Contribution to the desmid flora of Turkey. *Algological Studies*, 107, 39-48. **https://doi.org/10.1127/algol_stud/107/2002/39**

Şahin, B. (2007). Two new records for the freshwater algae of Turkey. *Turkish Journal of Botany*, 31(2), 153-156.

Şahin, B. (2009). Contribution to the desmid flora of Turkey. *Turkish Journal of Botany, 33* (6), 457-460.

Varol, M., & Fucikova, K. (2015). Four new records for the freshwater algae of Turkey. *Journal of Limnology and Freshwater Fisheries Research*, *1* (2), 83-88. **http://doi.org/10.17216/LimnoFish-5000119624**

Varol, M., & Şen, B. (2016). New records of Euglenophyceae for Turkish freshwater algae. *Turkish Journal of Fisheries and Aquatic Sciences*, *16* (2), 219-225. **http://doi.org/10.4194/1303-2712-v16_2_01**

Vercellino, I. S. (2001). *Sucessão da comunidade de algas perifíticas em dois reservatórios do Parque Estadual das Fontes do Ipiranga, São Paulo: infl uência do estado trófi co e do período climatológico* [Master of Science Thesis, Universidade Estadual Paulista] Rio Claro, 176.. **https://www.infraestruturameioambiente.sp.gov.br/institutodebotanica/2001/01/sucessao-da-comunidade-de-algas-perifiticas-em-dois-reservatorios-do-parque-estadual-da-fontes-do-ipiranga-sao-paulo-influencia-do-estado-trofico-e-periodo-climatologico**

Yağcı, M. A., & Turna, İ. İ. (2002). A new record for the algal flora of Turkey: Chaetomorpha crassa (C. ag.) kütz. (Cladophoraceae, Chlorophyceae). *Turkish Journal of Botany*, *26* (3), 171-174.

Yer Üstü Suları, Yer Altı Suları ve Sedimentten Numune Alma ve Biyolojik Örnekleme Tebliği. (2015). Official Gazette, No: 29274. **https://www.resmigazete.gov.tr/eskiler/2015/02/20150221-11.htm**

Yüce, A. M., & Aktaş (2020). Tahtalı, Davuldere ve Çayırköy Göletlerinin (Kocaeli) Algleri ve Su Kaliteleri Üzerine Bir Çalışma. *Iğdır Üniversitesi Fen Bilimleri Enstitüsü Dergisi (Journal of the Institute of Science and Technology*, 10(3): 1539-1550, ISSN: 2146-0574, eISSN: 2536-4618 **DOI: 10.21597/jist.66682**

Yüce, A.M., & Ertan, Ö. O. (2014). A new record for the freshwater algae of Turkey. *Scientific Research Journal*, *2* (4), 21-22.

Extended Turkish Abstract
(Genişletilmiş Türkçe Özet)

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

Su kaynaklarının dengeli kullanımı ve korunmasını amaçlayan Su Çerçeve Direktifi (SÇD) biyolojik kalite bileşenlerinden birisi olan fitoplanktonu biyolojik izleme çalışmalarında biyolojik kalite unsuru olarak kabul etmektedir. Su Çerçeve Direktifi ile, fiziksel ve kimyasal verilerin su kütlesinin kalitesinin belirlenmesinde yeterli olmayacağı, asıl belirleyici etmenlerden birisi olarak sucul floranın izlenmesi gerektiği belirtilmektedir. Bu konuda yapılan taksonomik ve ekolojik çalışmaların sayısı Türkiye'de her geçen gün artmaktadır. Bu amaçla Tarım ve Orman Bakanlığı Su Yönetimi Genel Müdürlüğü (SYGM) ve Devlet Su İşleri (DSİ) tarafından gerçekleştirilen çok sayıda proje bulunmaktadır. "Türkiye'de Referans İzleme Ağının Kurulması" projesinin bir parçası olan bu araştırma Su Yönetimi Genel Müdürlüğü tarafından desteklenmiştir. Tamamlanan bu projede 25 nehir havzasında 275 göl çalışılmıştır ve toplam 1363 fitoplankton taksonu tespit edilmiştir. Çalışmada toplam 24 Cryptophyta taksonu tanımlanmıştır. Tespit edilen Cryptophya taksonlarından 9 tanesi Türkiye'nin tatlı su alg florası için yeni kayıt olarak sunulmuştur.

AB Su Çerçeve Direktifi'ne göre biyolojik kalite unsurlarından biri olan fitoplankton konusunda Türkiye'de her geçen gün artan sayıda taksonomik ve ekolojik çalışma bulunmaktadır. Bu çalışma, Cryptophyta grubunun taksonomisini ve biyolojik çeşitliliğini incelemek amacıyla, Türkiye'nin 25 nehir havzasında yer alan 275 gölde 2017-2019 yılları arasında gerçekleştirilmiştir. Tarım ve Orman Bakanlığı Su Yönetimi Genel Müdürlüğü tarafından mali ve teknik olarak desteklenen "Türkiye'de Referans İzleme Ağının Kurulması" başlıklı projenin dördüncü bölümüdür. 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. Her gölde fitoplankton, öfotik bölgenin üç derinliğinden (yüzey, orta ve alt) su örnekleyiciler ile örneklenmiş ve daha sonra bu üç derinlikten alınan su örnekleri karıştırılmıştır. Fitoplanktonun teşhis ve sayımları sayım lamlarında çökeltilmiş asetik Lugol solüsyonunda korunan örnekler üzerinde ışık ve ters mikroskoplar kullanılarak gerçekleştirilmiştir. Alg taksonları, veri tabanlarından sinonim durumları ve sistematik kategorileri kontrol edilerek sınıflandırılmıştır. Tespit edilen taksonlar güncel literatürdeki takson kayıt listesi ile karşılaştırılarak yeni kayıt olarak tanımlanmıştır.

Ehrenberg'in bilinen ilk gözlemleri yapmasının üzerinden yaklaşık iki yüzyıl geçmiştir. Kriptomonadlar, tüm su habitatlarında genellikle çok yüksek populasyon yoğunluklarında bulunan bir gruptur. Şimdiye kadar dünya genelinde yapılan çalışmalarda 21 genusa ait 223 Cryptophyta taksonu tanımlanmıştır. Bu çalışmada, teşhis edilen 24 türden 9 tür yeni kayıt olarak tanımlanmıştır. Cryptophyta divizyosunda bulunan taksonlar Chroomonas (1), Cryptochrysis (1), Cryptomonas (4) Pyrenomonas (1) and Rhodomonas (2) cinsleri içinde dağılım göstermiştir. Daha önce ülkemizde yapılan çalışmalarda Chroomonas cinsine ait 7, Cryptomomas cinsine ait 11, Rhodomonas cinsine ait 2 tür belirlenmiştir. Bu çalışma ile ilk defa Cryptochrysis ve Pyrenomonas cinslerine ait 2 tür Türkiye alg florası olarak yeni kayıt olarak belirlenmiştir.

Kriptomonadlar tek hücreli, pigmentli, küçük (~5–50 μm) biflagellatlı tatlı, acı ve denizel habitatlarda yayılış gösteren organizmalardır. Belirgin bir hücresel asimetri ile karakterize edilirler, bir ön oluk veya cep ile şekil olarak düzleştirilmiştir. Cebin kenarında tipik olarak iki tane eşit

olmayan flagella vardır. Kriptomonadların hem bitki benzeri hem de hayvan benzeri özellikler sergilediği göz önüne alındığında, taksonomileri tartışmalıdır ve bazı türler alglerden ziyade protozoalar olarak kabul edilir. Tüm aquatik habitatlarda yaygın olarak bulunmaları nedeniyle küresel olarak büyük ilgi görmektedir. Bu organizmalar sakin, iyi aydınlanan ve besin açısından zengin yaz koşullarından serin, karışık ve ışıkla sınırlı kış koşullarına kadar çok çeşitli çevresel koşullara uyum sağlayabilir. Bu sınıfın üyeleri daha çok tatlı su ortamlarında tespit edilseler de denizel habitatlarda, karasal yüzeylerde, toprakta, yeraltı suyunda ve karda da yayılış gösterebildiği bilinmektedir. Cryptophyta grubu, besin maddeleri ve organik madde bakımından zengin sular için tipik olduklarından geniş bir çevre spektrumuna sahiptirler. Ancak oligotrofik suları tercih eden türleri de bulunmaktadır. Bazı türleri, uygun koşullar altında aşırı çoğalmalar gösterirler, ancak toksik olup olmadıkları bilinmemektedir. Bazı cryptomonad türleri göl tabanına yakın oksik/ anoksik sınır tabakasını (kemoklin) tercih edebilmektedir. Bu şartlarda *Cryptomonas phaseolus* türünün kemoklin yakınlarında düşük ışık şiddetinde bulunabildiği tespit edilmiştir. Aynı türün amonyumu çok yüksek olduğu oligotrofik sularda da yayılış gösterdiği bilinmektedir. Yapılan araştırmada da yeni kayıt olarak tespit edilen bu türün ekolojik toleransının yüksek olduğu anlaşılmaktadır.

Tespit edilen taksonların büyük çoğunluğunun Avrupa'da dağılım gösterdiği görülmektedir. Bunun yanısıra Asya, Kuzey Amerika, Güney Amerika'da da yayış gösterdikleri tespit edilmiştir. Türkiye'de ise bu taksonlar Kızılırmak, Burdur, Seyhan, Batı Akdeniz, Konya, Susurluk, Sakarya, Akarçay, Fırat Dicle, and Asi havzalarında kayıt edilmiştir.

Cryptophyta grubunun taksonomisini ve biyolojik çeşitliliğini incelemek amacıyla yapılan bu çalışma ile Türkiye tatlı su alg florasına 9 yeni kayıt eklenmiştir. Ayrıca 2 cinse ait tür bu çalışmada ilk defa tayin edilerek Türkiye tatlı su alg florasına sunulmuştur. Bu taksonların dünyanın farklı bölgelerinde de dağılım gösterdikleri tespit edilmiştir. Cryptomonad türleri kavramının gelecekteki gelişimi ve dayandığı taksonomi, gelişen bilim ve teknoloji, ekolojik ve moleküler genetik çalışmalarının sayısının artışıyla ilerleyen yıllarda yapılacak çalışmalarla Türkiye alg florası için yeni kayıtların sayısının artması beklenmektedir.