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Four New Records for the Freshwater Algae of Turkey

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ABSTRACT

Despite the fact that planktonic algae are a critical component of freshwater ecosystems, our understanding of their diversity and species distributions is still rather poor. This study contributes new information to the knowledge of Turkish freshwater microflora. A total of 84 phytoplankton samples were collected from 7 sites in the Tigris River from February 2008 to January 2009. Four taxa representing new records for the freshwater algal flora of Turkey were identified from the river. They belong to the following phyla: 1 (*Oscillatoria nitida*) to Cyanoprokaryota, 2 (*Micractinium bornhemiense* and *Lagerheimia wratislaviensis*) to Chlorophyta and 1 (*Audouinella chalybaea*) to Rhodophyta.

Keywords: Freshwater algal flora, new records, Tigris River, Turkey

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Türkiye Tatlısu Algleri için Dört Yeni Kayıt

Öz: Planktonik algler, tatlısu ekosistemlerinin önemli bir bileşeni olmasına rağmen, onların çeşitliliği ve tür dağılımları hakkındaki bilgimiz hala oldukça zayıftır. Bu çalışma, Türkiye'nin tatlısu mikroflora bilgisine katkıda bulunmaktadır. Şubat 2008 – Ocak 2009 tarihleri arasında Dicle Nehri'nde 7 siteden toplam 84 fitoplankton örneği toplandı. Nehirde, Türkiye tatlısu algleri için dört yeni tür teşhis edildi. Türlerden 1'i (*Oscillatoria nitida*) Cyanoprokaryota, 2'si (*Micractinium bornhemiense* ve *Lagerheimia wratislaviensis*) Chlorophyta ve 1'i (*Audouinella chalybaea*) Rhodophyta şubelerine aitti.

Anahtar kelimeler: Tatlısu algal flora, yeni kayıtlar, Dicle Nehri, Türkiye

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Introduction

Algae are the primary producers in aquatic ecosystems and they form the base of the aquatic food chain. Changes in the structure and the productivity of the algal community may induce direct structural changes in the rest of the ecosystem and/or indirectly affect the ecosystem by affecting water quality (Nyholm and Peterson 1997). Therefore, these aquatic organisms are also often used for water quality monitoring.

Our understanding of algal diversity and species distribution is still very poor in many regions of the world, and even in areas with extensive microfloristic records, most of such works are several decades old. Understandably, newer microfloristic studies tend to focus on previously unexplored localities and habitats (e.g., table mountains, desert and other soils – Kaštovský et al. 2011; Patzelt et al. 2014; Sherwood et al. 2015, respectively). However, when historically surveyed regions are revisited or new localities are added, new records are often found, further demonstrating that our knowledge still needs much improvement (e.g., Johansen et al. 2007; Fučíková et al. 2015). New and continuing surveys are especially important because of the changing and often deteriorating character of many habitats affected by human activities.

The number of algological studies in Turkish inland waters have seen a remarkable increase in recent years (Gül et al. 2013). According to Aysel (2005), 2030 taxa of freshwater algae had been recorded in Turkey. Since that year, new records of freshwater algae have been continuously added (Şahin 2007, 2009; Baykal et al. 2009; Sevindik et al.

2010, 2011; Özer et al. 2012; Akar and Şahin 2014; Yüce and Ertan 2014). The Tigris is one of Turkey's most important rivers but its algal flora is still poorly known. Özer et al. (2012) investigated for the first time the algae of the Tigris Basin andidentified 25 taxa new for Turkey in the samples collected from different habitats (plankton, epipelon, epiphyton, and epilithon) in the basin between December 2004 and November 2005. Varol and Şen (2014) reported that a total of 390 taxa were identified in the phytoplankton samples the Tigris River at seven sampling stations between February 2008 and January 2009. In the present study, four taxa from the Tigris River are reported for the first time in Turkish freshwaters.

Materials and Methods

Study area

The Tigris River is one of the largest rivers in Turkey with a catchment area of approximately 57,614 km$^{2.}$ The Tigris River originates in the Toros Mountains of Eastern Anatolia. It follows a south-eastern route to Cizre, where it forms the border between Turkey and Syria, and then runs a further 32 km before entering Iraq. Of its ca. 1900 km total length, 523 km is within Turkey (Varol et al., 2013). The Batman, Garzan, Botan and Hezil streams are major tributaries of the Tigris River in Turkey. Currently, there are two major dams on the Tigris River: the Kralkızı and the Dicle. The Kralkızı Dam is used for hydro-electric energy production, as is Dicle Dam in addition to irrigation and supplying drinking water for the city of Diyarbakır (Bekleyen et al. 2011).

Maximum flow in the Tigris River occurs from February through April, and minimum flow from August through October. The river discharge varies considerably at different locations, showing an increasing trend towards its downstream stretches due to inputs from its tributaries. Mean annual flow is 28.3 m^3/s at Diyarbakır (upstream) and 211.8 m^3/s at Cizre (downstream) (Varol et al. 2012).

The Tigris River basin has a subtropical plateau climate, with mean annual temperature of 14.6 °C at Maden, and 21.8 °C at Cizre. Total annual precipitation ranges from 294.1 mm at Cizre (downstream) to 611.1 mm at Maden (upstream), of which 82% occurs from October to April (Varol 2011).

Sampling and identification

Figure 1 shows the phytoplankton sampling sites. The samples were collected from seven sites (Maden (site 1), Eğil (site 2), Diyarbakır (site 3), Bismil (site 4), Batman (site 5), Hasankeyf (site 6) and Cizre (site 7)) at monthly intervals between February 2008 and January 2009. The samples were taken with a plankton net (55 µm mesh), preserved in the field with 4% formaldehyde solution, and examined with an Olympus BX51 microscope fitted with an Olympus DP71 digital camera (Olympus, Japan). Taxa were identified according to John et al. (2011), Kim and Kim (2012), Komarek and Anagnostidis (2005) and Eloranta and Kwandrans (2012). The currently accepted nomenclature was checked with AlgaeBase (Guiry and Guiry, 2015).

Results

Four taxa new for the freshwater algae of Turkey were identified during our study (Table 1). General information on the morphology and taxonomy of the taxa presented in this paper is given below.

Phylum : Cyanoprokaryota
Class : Cyanophyceae Schaffner
Subclass : Oscillatoriophycideae L. Hoffmann, J. Komárek & J. Kastovsky
Order : Oscillatoriales Cavalier-Smith
Family : Oscillatoriaceae Engler
Genus : *Oscillatoria* Vaucher ex Gomont
Species : *Oscillatoria nitida* Schkorbatov 1923 (Figure 2a, b)
References :Komarek and Anagnostidis (2005).
Description : Trichomes solitary, usually free-floating, cylindrical, not constricted at cross-walls, with very fine sheaths, greenish, 4-9 µm wide. Ends of terminal parts of trichomes straight, not attenuated. Cells always shorter than wide, 1.5-3 µm long, with homogeneous cell content, without granulation at distinct, transparent cross-walls; apical cells rounded, without thickened outer cell walls.
Distribution: Romania (Carauş 2012).
Occurrence: Collected at sites 4 (Bismil) and 6 (Hasankeyf).

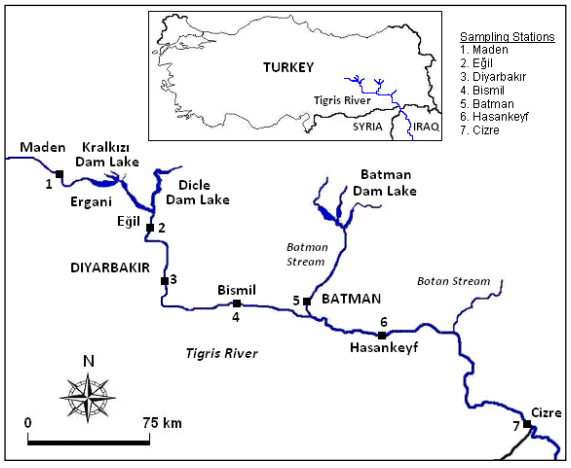
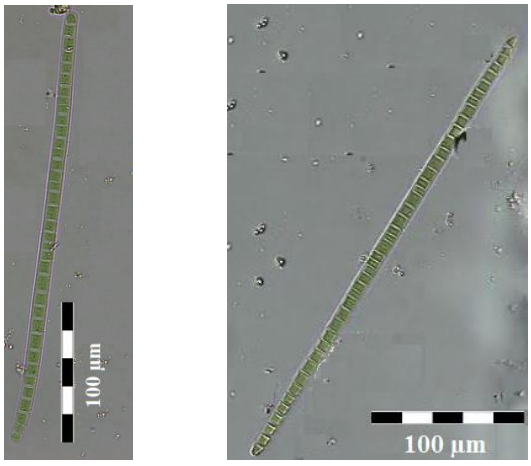


Figure 1. Map showing the sampling sites along the Tigris River.

Table 1. The names of four new taxa.

Phylum	Cyanobacteria	Chlorophyta		Rhodophyta
Class	Cyanophyceae	Trebouxiophyceae		Florideophyceae
Order	Oscillatoriales	Chlorellales		Acrochaetiales
Genus	*Oscillatoria*	*Micractinium*	*Lagerheimia*	*Audouinella*
Species	*O. nitida*	*M. bornhemiense*	*L. wratislaviensis*	*A. chalybaea*

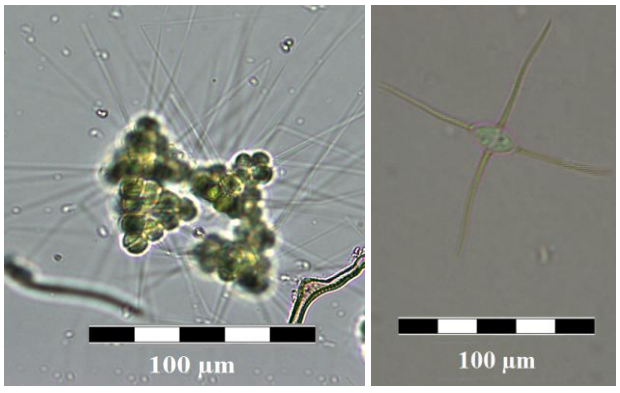
Phylum **:** Chlorophyta
Class **:** Trebouxiophyceae Friedl
Order **:** Chlorellales Bold & M. J. Wynne
Family **:** Chlorellaceae Brunnthaler
Genus **:** *Micractinium* Fresenius
Species **:** *Micractinium bornhemiense* (W. Conrad) Korshikov 1953 (Figure 3a)
References **:** John et al. (2011), Kim and Kim (2012).
Basionym **:** *Errerella bornhemiensis* W. Conrad
Homotypic Synonym: *Errerella bornhemiensis* W. Conrad 1914
Description : Coenobia in regular tetrads, usually producing regular pyramidal syncoenobia, often 8-16-32-64-128 celled; cells spherical, 6-8 µm in diameter, bearing a single spine 30-60 µm long.
Distribution: Romania (Carauş 2012), North America (Prescott 1962), Taiwan (Shao 2009), Britain (John et al. 2011), Germany (Tauscher 2014), China (Hu and Wei 2006), Korea (Kim and Kim 2012), Russian Far East (Medvedeva and Nikulina 2014), Singapore (Pham et al. 2011), New Zealand (Broady et al. 2012), Brazil (Menezes 2010).
Occurrence: Collected at site-6 (Hasankeyf).



a b

Figure 2. a, b- *Oscillatoria nitida* Schkorbatov

Phylum **:** Chlorophyta
Class **:** Trebouxiophyceae Friedl
Order **:** Chlorellales Bold & M. J. Wynne
Family **:** Oocystaceae Bohlin
Genus **:** *Lagerheimia* R. Chodat
Species **:** *Lagerheimia wratislaviensis* Schröder 1897 (Figure 3b)
References **:** John et al. (2011).
Homotypic Synonym: *Bernardia wratislavensis* (Schröder) Playfair 1917
Heterotypic Synonyms: *Lagerheimia wratislawiensis* var. *trisetigera* G.M.Smith 1926, *Chodatella budapestinensis* var. *trisetigera* G.M.Smith 1926, *Lagerheimia wratislaviensis* f. *brevispina* F.Caballero 1945, *Lagerheimia wratislaviensis* f. *gracilis* Hortobágyi 1973, *Chodatella budapestinensis* Hortobágyi 1973
Description : Cells 2.5-11µm wide, 5-14 µm long, ovoid, somewhat narrowed towards apices, with a single spine at each apex and 2-3 opposite each other at equator, arranged crosswise in one plane; spines 8-31 µm long.
Distribution: Germany (Tauscher 2014), Romania (Carauş 2012), Spain (Trevino et al. 2009), Britain (John et al. 2011), Russian Far East (Medvedeva and Nikulina 2014), New South Wales (Day et al. 1995)
Occurrence : Collected at site-4 (Bismil).



a b

Figure 3. a- *Micractinium bornhemiense* (W.Conrad) Korshikov, b- *Lagerheimia wratislaviensis* Schröder

Phylum : Rhodophyta
Subphylum : Eurhodophytina
Class : Florideophyceae Cronquist
Subclass : Nemaliophycidae T. Christensen
Order : Acrochaetiales Feldmann
Family : Acrochaetiaceae Fritsch ex W. R. Taylor
Genus : *Audouinella* Bory de Saint-Vincent
Species : *Audouinella chalybaea* (Roth) Bory de Saint-Vincent 1823 (Figure 4a-b)
References : Eloranta and Kwandrans (2012).
Basionym : *Conferva chalybaea* Roth
Homotypic Synonym: *Conferva chalybaea* Roth 1806, *Ectocarpus chalybeus* (Roth) Lyngbye 1819, *Chantransia chalybe*a (Roth) Fries 1825, *Pseudochantransia chalybae*a (Roth) Brand 1909
Heterotypic Synonym:*Trentepohlia aeruginosa* C.Agardh 1824, *Trentepohlia pulchella* f. *chalybea* C.Agardh 1824
Description : Cells with blue-coloured chloroplasts; narrow branch angles, cell length/ width ratio > 3, main filament < 13 µm wide, monospores 9-12 µm long.
Note : *A. hermannii* is distinguished from *A. chalybaea* by having a reddish colour.
Distribution: Germany (Tauscher 2014), Romania (Carauş 2012), Slovenia (Vrhovsek et al. 2006), China (Hu and Wei 2006), Russian Far East (Medvedeva and Nikulina 2014).
Occurrence : Collected at sites 4 (Bismil) and 6 (Hasankeyf).

a b

Figure 4. a, b- *Audouinella chalybaea* (Roth) Bory de Saint-Vincent

Discussion

Global biodiversity is facing a major threat brought on by human action: climate change and habitat destruction and degradation have a worldwide impact. Continuing, systematic species surveys are critical for detecting possible decline of sensitive species. Unfortunately, our knowledge of microscopic biodiversity lags far behind the amount of information available about macroscopic flora and fauna. With respect to freshwater algae, comprehensive floristic literatures are available for some European countries and North America and are often specific to a particular algal group such as desmids or diatoms (e.g., Coesel and Meesters 2007; Siver and Hamilton 2011).

The Turkish algal checklist now contains well over 2000 species, but is likely far from complete (Sevindik et al. 2010). In the phytoplankton samples taken from the Tigris River, we recognized four taxa, which represented first records for the freshwater algal flora of Turkey. Most of the taxa found in the Tigris River are well known, and only *Oscillatoria nitida* is rarely reported worldwide (Komarek and Anagnostidis 2005). This study is offered as a contribution toward characterizing Turkey's freshwater algae and complements a more comprehensive list published in Varol and Şen (2014).

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