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RESEARCH PAPER

The Distribution of Cymbelloid Diatoms in Yalova Runningwaters

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Abstract

Diatoms are mostly characterized by their siliceous bipartite cell walls, forming a frustule. Diatoms are one of important groups for monitoring in lentic and lotic systems. Cymbelloid diatoms are one of the highest diversity in Turkish inland waters. In this study, the samples were collected from 25 stations from different habitats (epilithic, epipelic and epiphytic) in Yalova. As a result, 19 taxa belonging to the genera *Cymbella, Cymbopleura, Encyonema, Encyonopsis* and *Reimeria* were found in the study area and *Cymbella excisa*, *Encyonema reichardtii*, *Encyonopsis minuta*, *E. subminuta* and *Reimeria ovata* were recorded as "*new record*" for Turkish freshwater diatom flora.

Keywords: Cymbelloid diatoms, new records, running waters, Yalova.

Yalova Akarsularındaki Cymbelloid Diyatomelerin Dağılımı

Özet

Diyatomeler, silisli yapıda olup iki kabuğun biraraya gelmesiyle früstül halinde bulunurlar. Bu organizmalar, durgun ve akarsuların biyolojik açıdan kirlilik seviyelerinin tespitinde kullanılan önemli gruplardan biridir. Cymbelloid diyatomeler Türkiye sularındaki en fazla çeşitliliğe sahip diyatomelerden biridir. Bu çalışmada, Yalova'daki farklı habitatlardan (epilitik, epipelik ve epifitik) 25 istasyondan toplanmış diyatome örnekleri incelenmiştir. Sonuçta *Cymbella, Cymbopleura, Encyonema, Encyonopsis* ve *Reimeria* cinslerine ait toplam 19 takson tespit edilmiştir. Bunlardan *Cymbella excisa*, *Encyonema reichardtii*, *Encyonopsis minuta*, *E. subminuta* and *Reimeria ovata* Türkiye tatlısu diyatome florası için yeni kayıt durumundadır.

Anahtar Kelimeler: Cymbelloid diyatomeler, akarsu, Yalova, yeni kayıt.

Introduction

Diatoms are mostly characterized by their siliceous bipartite cell walls, forming a frustule. They are one of the most diverse group for freshwaters. They comprimise more than a half of the primary production in lentic and lotic systems (Stoermer and Smol, 2004). The biodiversity and assemblages of the diatoms is very essential in aquatic systems because they are used in evaluating the ecosystems' health and environmental change (Hall and Smol, 2004). Paleolimnological studies also use diatoms for assessing the ancient environmental status (Denys and De Wolf, 2004). However, correct identification of the diatoms is important to get reliable ecological information. The principal size characteristics e.g. valve length, breadth and length/breadth ratio as well as the shape of the ends are very important for identification (Krammer, 1997a). However, valve shape can be also important Krammer (2003).

The first cymbelloid diatom, *Cymbella cymbiformis* C. Agardh was designated by Agardh (1980). There were several but classical taxonomic contributions until the last quartile of the 20th century and the four genera were resident in the family; *Cymbella, Encyonema, Reimeria* and *Didymosphenia* (Kociolek and Spaulding, 2003). Just before and after the new millenium had arisen, the genera *Encyonopsis* Krammer (1997b), *Cymbopleura* (Krammer) Krammer (Lange-Bertalot & Genkal 1999) and *Delicata* Krammer (2003) were established. Recently, a total of 15 genera and many species have been included into the Cymbellaceae (Guiry and Guiry,

2016). There are more than 800 diatom taxa in Turkish inland waters and cymbelloid diatoms are over than 80 of them (at least 10%). The aim of the study was to investigate cymbelloid diatoms in running waters of Yalova.

Materials and Methods

Study area

In this study, totally 25 samples were collected and investigated from the running waters in Yalova: Kocadere, Korudere, Gökçedere, Samanlıdere, Balkandere, Safrandere streams and five mountanous springs (Figure 1). In the study, cymbelloid diatoms were given. However, the results will be separately published by genus level.

Sampling

The samples were collected from epilithic, epiphytic and epipelic habitats from the stations. For this purpose, some samples were collected from submerged stones by brushing for epilithic samples; using pipette aspirator for epipelic samples and using plastic bag for epiphytic samples. Simultaneously, some ecological parameters (dissolves oxygen-DO and conductivity-COND) were measured by Hach HQ40d multiparameter.

The samples were boiled with H_2O_2 and HCl to remove organic matter. After washing several times with distilled water the material was air-dried on cover glasses and mounted in Naphrax. Observations of the diatoms were performed with Nikon Ci Light Microscopes (LM) in Dumlupınar University Advenced Research Center (DPU-ILTEM). The diatoms were identified according to Krammer & Lange-Bertalot (1986) [C1]and Krammer (2002). The distribution of Turkish flora was done according to Gönülol (2016). Taxonomy of our research along with the data list published for the last century was adopted under a modern classification system (Fourtainer and Kociolek 2011, Guiry and Guiry 2016). The dimensions and distribution of the species were separately indicated for each species. Species and infraspecific taxa are arranged alphabetically in the text and plates.

Results

In this study, totally 25 samples from different streams and springs were investigated in Yalova and 19 taxa belonging to the genera *Cymbella*, *Cymbopleura*, *Encyonema*, *Encyonopsis* and *Reimeria* were found in the study area. As a result, *Cymbella excisa*, *Encyonema reichardtii*, *Encyonopsis minuta*, *E. subminuta* and *Reimeria ovata* were found as new record for Turkish freshwater diatom flora.

***Cymbella excisa* Kützing** Fig. 1-4

Ref. Krammer 2002 p.26-pl.8:1-26; Hofmann *et al*. 2011 p.150-pl.77:23-28; Bąk *et al*. 2012 p.81-pl.54

Dimension. Valve 21.26-22.05 µm length and 7.29-7.68 µm breadth, 12-13 striae in 10 µm.

Distribution in Yalova running waters: Rare species. It was found only in Samanlı stream.

Distribution in Turkey: NEW RECORD

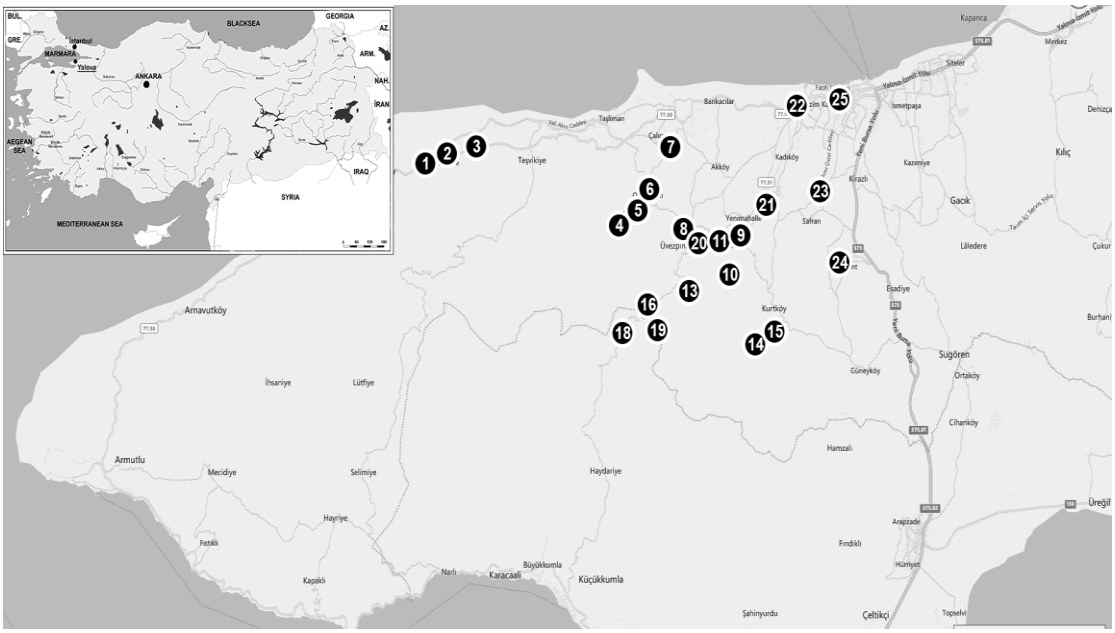

Figure 1. Distribution of investigated localities (1-Kocadere-1, 2-Kocadere-2, 3-Kocadere-3, 4-Korudere-1, 5-Korudere-2, 6-Korudere-3, 7-Korudere-4, 8-Gökçedere-1, 9-Gökçedere-3, 10-Samanlıdere-2, 11-Samanlıdere-3, 12-Mountanous spring-1, 13-Mountanous spring-2, 14-Havuzdere-1, 15-Havuzdere-2, 16-Samanlıdere-1, 17-Mountanous spring-3, 18-Mountanous spring-4, 19-Mountanous spring-5, 20-Gökçedere-2, 21-Samanlıdere-4, 22-Samanlıdere-5, 23-Safrandere-1, 24-Balkandere, 25-Safrandere-2).

***Cymbella lanceolata* (C.Agardh) C.Agardh** Fig. 5

Basionym. *Frustulia lanceolata* C.Agardh

Ref. Krammer 2002 p.125-pl.144: 1-3, 146:1-4, 148; Hofmann *et al*. 2011 p.153-pl.82:3-5; Bąk *et al*. 2012 p.83-pl.57

Dimension. Valve 145.00 µm length and 26.35 µm breadth, 9 striae in 10 µm.

Distribution in Yalova running waters: Rare species. It was found only in Korudere stream.

Distribution in Turkey: Common species in Turkish inland waters (Gönülol 2016).

***Cymbella tumida* (Brébisson) Van Heurck** Fig. 6-9

Basionym. *Cocconema tumidum* Brébisson

Ref. Krammer 2002 p.141-pl.162:1-8, 163:1-6, 164:1-8; Hofmann *et al*. 2011 p.157-pl.81:5-6; Bąk *et al*. 2012 p.85-pl.56

Dimension. Valve 36.16-71.36 µm length and 13.90-18.14 µm breadth, 11-14 striae in 10 µm.

Distribution in Yalova running waters: Common species in Gökçedere & Korudere streams.

Distribution in Turkey: Common species in Turkish inland waters (Gönülol 2016).

***Cymbopleura amphicephala* (Naegeli) Krammer** Fig. 10, 11

Basionym. *Cymbella amphicephala* Naegeli

Ref. Bąk *et al*. 2012 p.87-pl.60

Dimension. Valve 20.04-20.26 µm length and 8.21-8.29 µm breadth, 14 striae in 10 µm.

Distribution in Yalova running waters: Rare species. It occured in a mountainous spring (YL-19).

Distribution in Turkey: Common species in Turkish inland waters (Gönülol 2016).

***Cymbopleura* cf. *lange-bertalotii* Krammer** Fig. 12, 13

Ref. Krammer 2003 p.75-pl.99:1-4

Dimension. Valve 21.45-21.55 µm length and 9.49-10.32 µm breadth, 14-15 [C2]striae in 10 µm.

Distribution in Yalova running waters: Rare species. It occured in a mountainous spring (YL-12).

***Encyonema auerswaldii* Rabenhorst** Fig. 14-17

Ref. Krammer 1997a p.117-pl.65:1-8, 66:1-6

Dimension. Valve 25.84-33.22 µm length and 10.40-12.11 µm breadth, 10.11 striae in 10 µm.

Distribution in Yalova running waters: It was commonly found in Korudere & Safrandere streams.

Distribution in Turkey: Common species in Turkish inland waters (Gönülol 2016).

***Encyonema minutum* (Hilse) D.G.Mann** Fig. 18

Basionym. *Cymbella minuta* Hilse

Ref. Krammer 1997a p.53-pl.25:1-19; Hofmann *et al*. 2011 p.188-pl.87:33-40; Bąk *et al*. 2012 p.111-

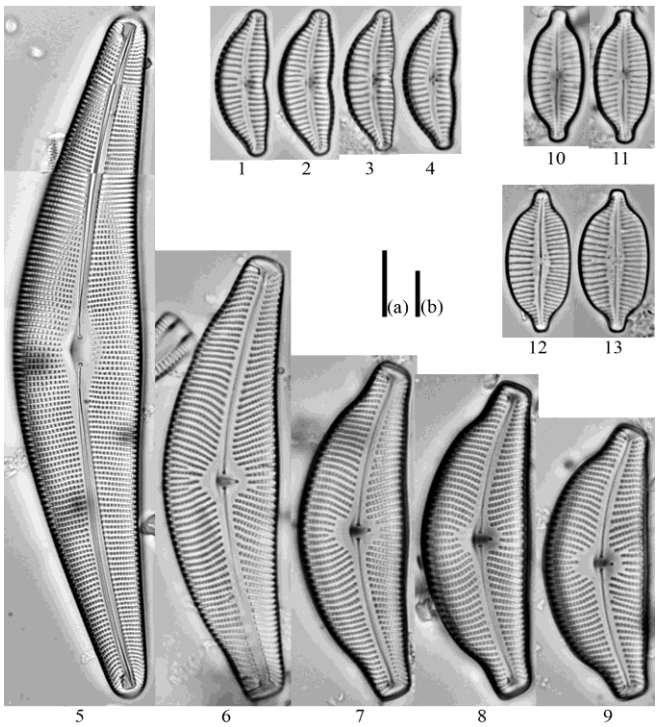

Figure 2. 1-4 - *Cymbella excisa* Kützing; 5 - *Cymbella lanceolata* (C.Agardh) C.Agardh; 6-9 - *Cymbella tumida* (Brébisson) Van Heurck; 10, 11 - *Cymbopleura amphicephala* (Naegeli) Krammer; 12, 13 - *Cymbopleura* cf. *lange-bertalotii* Krammer. Scale bar: 10 µm ("b" bar for only *C. lanceolata*).

pl.61

Dimension. Valve 14.31 µm length and 5.05 µm breadth, 16 striae in 10 µm.

Distribution in Yalova running waters: Rare species. It occured in Samanlıdere stream.

Distribution in Turkey: Common species in Turkish inland waters (Gönülol 2016).

***Encyonema prostratum* (Berkeley) Kützing** Fig. 19-22

Basionym. *Monema prostratum* Berkeley

Ref. Krammer 1997b p.38-pl.115:1-3, 116:1-6, 117:1-6, 118:1-6, 119:1-6; Hofmann *et al*. 2011 p.190-pl.86:1-4; Bąk *et al*. 2012 p.113-pl.60

Dimension. Valve 44.42-63.50 µm length and 18.53-21.02 µm breadth, 9-11 striae in 10 µm.

Distribution in Yalova running waters: It was commonly found in Korudere stream.

Distribution in Turkey: Common species in Turkish inland waters (Gönülol 2016).

***Encyonema reichardtii* (Krammer) D.G.Mann** Fig. 23

Basionym. *Cymbella reichardtii* Krammer

Ref. Krammer 1997b p.9-pl.103:1-24; Hofmann *et al*. 2011 p.191-pl.87:23-29; Bąk *et al*. 2012 p.113-pl.61

Dimension. Valve 11.60 µm length and 3.77 µm breadth, 22 striae in 10 µm.

Distribution in Yalova running waters: Rare species. It was found only in Samanlıdere stream.

Distribution in Turkey: NEW RECORDS.

***Encyonema silesiacum* (Beisch) D.G.Mann** Fig. 24, 25

Basionym. *Cymbella silesiaca* Bleisch

Ref. Krammer 1997a p.72-pl.4:1-18; Hofmann *et al*. 2011 p.192-pl.87:11-17; Bąk *et al*. 2012 p.114-pl.61

Dimension. Valve 28.47-46.33 µm length and 9.04-11.07 µm breadth, 12-14 striae in 10 µm.

Distribution in Yalova running waters: Rare species. It was found only in Samanlıdere stream.

Distribution in Turkey: Common species in Turkish inland waters (Gönülol 2016).

***Encyonema ventricosum* (C.Agardh) Grunow** Fig. 26

Basionym. *Frustulia ventricosa* C.Agardh

Ref. Krammer 1997a p.98-pl.6:5-17; Hofmann *et al*. 2011 p.192-pl.87:18-22; Bąk *et al*. 2012 p.114-pl.61

Dimension. Valve 16.65 µm length and 6.25 µm breadth, 13 striae in 10 µm.

Distribution in Yalova running waters: Rare species. It occured in a mountainous spring (YL-13).

Distribution in Turkey: Rare species in Turkish inland waters. It was found in Mogan Lake (Demir *et al*. 2014), Kovada Lake (Morkoyunlu & Ertan 2014), Birecik & Karkamış reservoirs (Morkoyunlu *et al*. 2015).

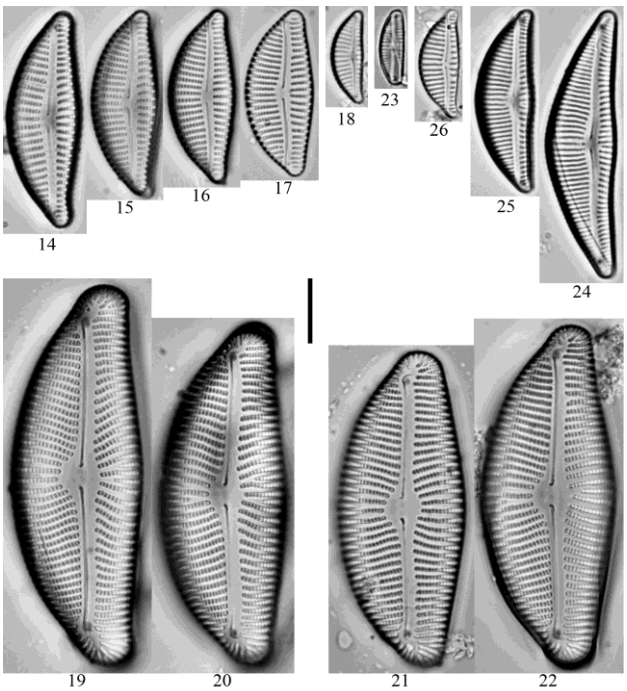

Figure 3. 14-17 - *Encyonema auerswaldii* Rabenhorst; 18 - *Encyonema minutum* (Hilse) D.G.Mann; 19-22 - *Encyonema prostratum* (Berkeley) Kützing; 23 - *Encyonema reichardtii* (Krammer) D.G.Mann; 24, 25 - *Encyonema silesiacum* (Beisch) D.G.Mann; 26 - *Encyonema ventricosum* (C.Agardh) Grunow. Scale bar: 10 µm.

***Encyonopsis microcephala* (Grunow) Krammer** Fig. 27-30

Basionym. *Cymbella microcephala* Grunow

Ref. Krammer 1997b p.91-pl.143: 1, 4, 5, 8-26; Hofmann *et al*. 2011 p.197-pl.89:35-39; Bąk *et al*. 2012 p.117-pl.61;

Dimension. Valve 12.47-14.76 µm length and 3.50-3.88 µm breadth, 23-24 striae in 10 µm.

Distribution in Yalova running waters: Rare species. It was found only in Samanlıdere stream.

Distribution in Turkey: Common species in Turkish inland waters (Gönülol 2016).

***Encyonopsis minuta* Krammer & Reichardt** Fig. 31-34

Ref. Krammer 1997b p.95-pl.143a: 1-29; Hofmann *et al*. 2011 p.198-pl.89:25-34

Dimension. Valve 10.55-14.46 µm length and 3.48-3.70 µm breadth, 23-25 striae in 10 µm.

Distribution in Yalova running waters: Common species. It was found only in Samanlıdere and Balkandere streams & mountanous springs (YL-17, YL-18).

Distribution in Turkey: NEW RECORD.

***Encyonopsis* cf. *minuta* Krammer & Reichardt** Fig. 35-37

Ref. Krammer 1997b p.95-pl.143a: 1-29; Hofmann *et al*. 2011 p.198-pl.89:25-34

Dimension. Valve 9.60-11.47 µm length and 3.56-3.73[C3] µm breadth, 22-24 striae in 10 µm.

Distribution in Yalova running waters: Rare species. It was found only in Samanlıdere stream.

***Encyonopsis subminuta* Krammer & Reichardt** Fig. 38-40

Ref. Krammer 1997b p.96-pl.144: 1-11, 16, 17; Hofmann *et al*. 2011 p.198-pl.89:17-21

Dimension. Valve 16.80-17.82 µm length and 3.80-4.26 µm breadth, 24-27 striae in 10 µm.

Distribution in Yalova running waters: Rare species. It was found only in Korudere and Gökçedere streams.

Distribution in Turkey: NEW RECORD.

***Reimeria ovata* (Hustedt) Levkov & Ector** Fig. 45, 46

Basionym. *Cymbella sinuata* var. *ovata* Hustedt

Ref. Levkov & Ector 2010 p.479-figs.14-20

Dimension. Valve 19.55-23.39 µm length and 6.03-6.55 µm breadth, 8-9 striae in 10 µm.

Distribution in Yalova running waters: Rare species. It was found only in Korudere stream.

Distribution in Turkey: NEW RECORD.

***Reimeria sinuata* (Gregory) Kociolek & Stoermer** Fig. 43, 44

Basionym. *Cymbella sinuata* Gregory

Ref. Hofmann *et al*. 2011 p.526-pl.89:50-61; Bąk *et al*. 2012 p.297-pl.62

Dimension. Valve 13.90-20.57 µm length and 4.33-5.16 µm breadth, 12.0-13.5 striae in 10 µm.

Distribution in Yalova running waters: Rare species. It was founf only in Korudere stream.

Distribution in Turkey: Common species in Turkish inland waters (Gönülol 2016).

***Reimeria uniseriata* Sala, Guerrero & Ferrario** Fig. 41, 42

Ref. Bąk *et al*. 2012 p.297-pl.62

Dimension. Valve 21.51-26.89 µm length and 5.65-7.01 µm breadth, 9-10 striae in 10 µm.

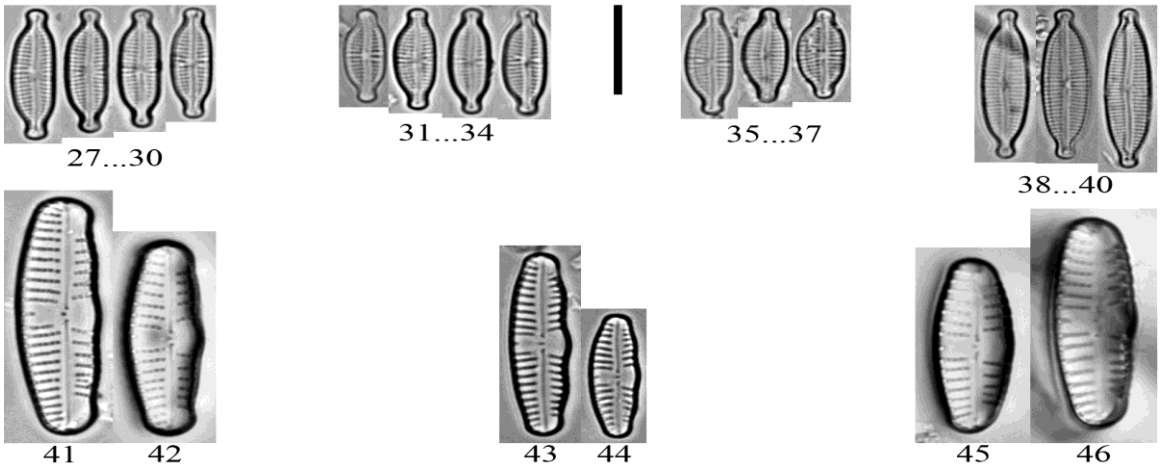

Figure 4. 27-30 - *Encyonopsis microcephala* (Grunow) Krammer; 31-34 - *Encyonopsis minuta* Krammer & Reichardt; 35-37 - *Encyonopsis* cf. *minuta* Krammer & Reichardt; 38-40 - *Encyonopsis subminuta* Krammer & Reichardt; 41, 42 - *Reimeria uniseriata* Sala, Guerrero & Ferrario 43, 44 - *Reimeria sinuata* (Gregory) Kociolek & Stoermer; 45, 46 - *Reimeria ovata* Levkov. Scale bar: 10 µm.

Distribution in Yalova running waters: Rare species. It was founf only in Korudere stream.

Distribution in Turkey: Rare species in Turkish inland waters. It was found only in Felent stream (Solak *et al*. 2012b).

Discussion

Regarding to existence of the species in Turkish inland waters, *Cymbella lanceolata, C. tumida, Cymbopleura amphicephala, Encyonema auerswaldii, E. minutum, E. prostratum, E. silesiacum* and *Encyonopsis microcephala* were "common species" while, *Encyonema ventricosum* and *Reimeria uniseriata* were "rare species" in the waters (Solak *et al*. 2012b, Gönülol 2016).

Considering the distribution of the species in this study, *Cymbella excisa, Encyonema minutum, E. reichardtii, E. silesiacum, Encyonopsis microcephala* and *Encyonopsis* cf. *minuta* were found only in Samanlıdere stream while, *Cymbella lanceolata, Encyonema prostratum, Encyonopsis subminuta, Reimeria ovata, R. sinuata* and *R. uniseriata* were in Korudere stream. In Turkish freshwater diatom flora, cymbelloid diatoms are one of the biggest group. Interestingly, the diversity of the group was not high number while, six species were reported first time for Turkey: *Cymbella excisa*, *Cymbopleura* cf. *lange-bertalotii*, *Encyonema reichardtii*, *Encyonopsis minuta*, *E. subminuta* and *Reimeria ovata*. *C. excisa* is cosmopolitan, abundant in mountains and occurs in moderately electrolyte content ([C4]Krammer 2002; Bey & Ector 2013). The species was found in Samanlıdere stream (DO: 8.93 mg/L, COND: 240). *E. minuta* is pollution-sensitive species, occurs in alkaline waters and *E. subminuta* is probably cosmopolitan species of calcareous environments at pH close to neutral, poor in organic matter and to moderately impacted by nutrients (Bey & Ector 2013) and the species was also recorded newly for diatom flora of Serbia (Vidaković *et al*. 2016). *R. ovata* occurs rarely in oligotrophic cold water (Levkov & Ector 2010). *E. reichardtii* is calcareous and predominantly meso- to eutrophic species (Hofmann *et al*. 2011). *E. subminuta* and *R. ovata* were found in Korudere stream (DO: 7.71 mg/L, COND: 193 µS/cm^2) while, *E. minuta* were found in Samanlıdere stream (DO: 10.01 mg/L, COND: 167 µS/cm^2). Also, *E. reichardtii* was rarely found in Samanlıdere stream. For *Cymbopleura cf. lange-bertalotii*, the species was found only in a mountainous spring (YL-12). The species is close to *C. lange-bertalotii*. However, the axial area is different and also, stria number is more than *C. lange-bertalotii* (9-11 in Krammer 2003). *Encyonopsis* cf. *minuta* was found only in Samanlıdere stream. Outline of the species is different than *E. minuta* (Table 1).

The diversity of diatoms in Turkey is relatively low compared to the world record and there are several reasons why the taxa have not been recorded in Turkey. Some species are probably confused to the morphologically similar taxa. So, the samples would be investigated attentionally. Another reason is that the results should be supported by plates which involved figures of identified species to check correct identification.

Acknowledgement

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Table 1. The distribution of the diatom taxa in Yalova watercourses (Balkandere, Havuzdere, Gökçedere, Kocadere, Korudere, Safrandere, Samanlıdere and mountanous springs)

		Current Study	
	in Turkey (Gönülol 2016)	Status	Watercourses in Yalova
Cymbella excisa	New Record	Rare	Samanlıdere
C. lanceolata	Common	Rare	Korudere
C. tumida	Common	Common	Gökçedere & Korudere
Cymbopleura amphicephala	Common	Rare	Mountanous spring (YL-19)
Cymbopleura cf. *lange-bertalotii*	-	Rare	Mountanous spring (YL-12)
Encyonema auerswaldii	Common	Rare	Korudere & Safrandere
E. minutum	Common	Rare	Samanlıdere
E. prostratum	Common	Rare	Korudere
E. reichardtii	New Record	Rare	Samanlıdere
E. silesiacum	Common	Rare	Samanlıdere
E. ventricosum	Rare	Rare	Mountanous spring (YL-13)
Encyonopsis microcephala	Common	Rare	Samanlıdere
E. minuta	New Record	Common	Samanlıdere, Balkandere & Mountanous spring (YL-17, YL-18)
Encyonopsis cf. *minuta*	--	Rare	Samanlıdere
E. subminuta	New Record	Rare	Korudere
Reimeria ovata	New Record	Rare	Korudere
Reimeria sinuata	Common	Rare	Korudere

and Dumlupınar University Foundation (Grant no: 2015-98).

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