



## The Distribution of Cymbelloid Diatoms in Yalova Runningwaters

Cüneyt Nadir Solak<sup>1</sup>, Aydın Kaleli<sup>1</sup>, Özgür Baytut<sup>2</sup>

<sup>1</sup> Dumlupınar Üniversitesi, Biyoloji Bölümü, Kütahya, Turkey.

<sup>2</sup> Ondokuz Mayıs Üniversitesi, Biyoloji Bölümü, Samsun, Turkey.

\* Corresponding Author: Tel.: +90.532 3544909;  
E-mail: cnsolak@gmail.com

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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, epipellic 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 (epilithic, epipellic 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 comprise 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 mountainous 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<sub>2</sub>O<sub>2</sub> 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 Advanced 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.

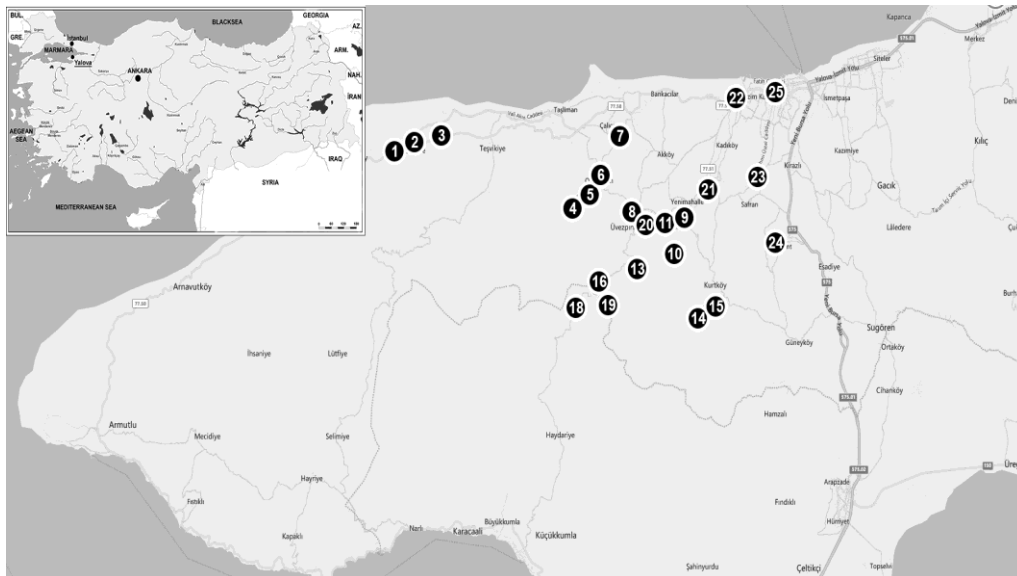
### *Cymbella excisa* Kützing Fig. 1-4

Ref. Krammer 2002 p.26-pl.8:1-26; Hofmann et al. 2011 p.150-pl.77:23-28; Bâk 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

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



**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-Mountainous spring-1, 13-Mountainous spring-2, 14-Havuzdere-1, 15-Havuzdere-2, 16-Samanlıdere-1, 17-Mountainous spring-3, 18-Mountainous spring-4, 19-Mountainous spring-5, 20-Gökçedere-2, 21-Samanlıdere-4, 22-Samanlıdere-5, 23-Safrandere-1, 24-Balkandere, 25-Safrandere-2).

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; Båk 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; Båk 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. Båk 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 occurred 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 occurred 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.

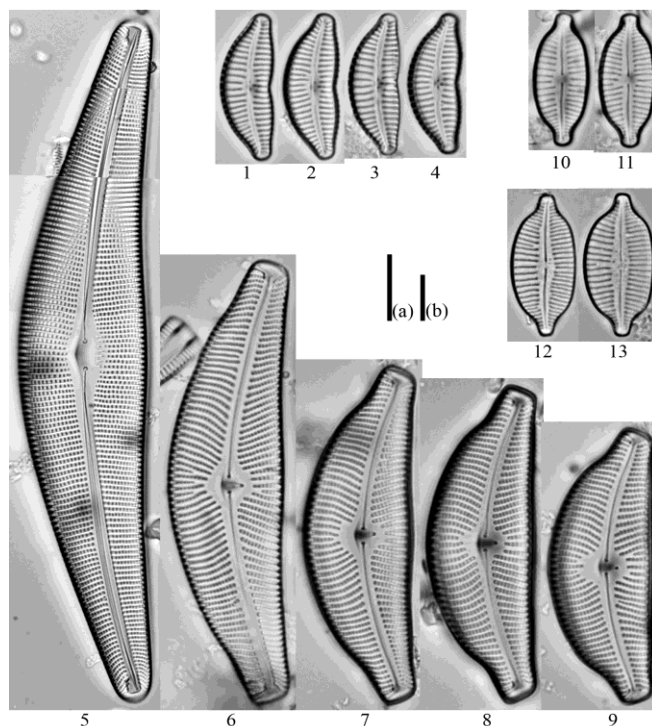
Distribution in Turkey: Common species in Turkish inland waters (Gönülol 2016).

***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; Båk et al. 2012 p.111-pl.61

Dimension. Valve 14.31 µm length and 5.05 µm



**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*).

breadth, 16 striae in 10  $\mu\text{m}$ .

Distribution in Yalova running waters: Rare species. It occurred 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; Bâk et al. 2012 p.113-pl.60

Dimension. Valve 44.42-63.50  $\mu\text{m}$  length and 18.53-21.02  $\mu\text{m}$  breadth, 9-11 striae in 10  $\mu\text{m}$ .

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; Bâk et al. 2012 p.113-pl.61

Dimension. Valve 11.60  $\mu\text{m}$  length and 3.77  $\mu\text{m}$  breadth, 22 striae in 10  $\mu\text{m}$ .

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; Bâk et al. 2012 p.114-pl.61

Dimension. Valve 28.47-46.33  $\mu\text{m}$  length and 9.04-11.07  $\mu\text{m}$  breadth, 12-14 striae in 10  $\mu\text{m}$ .

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

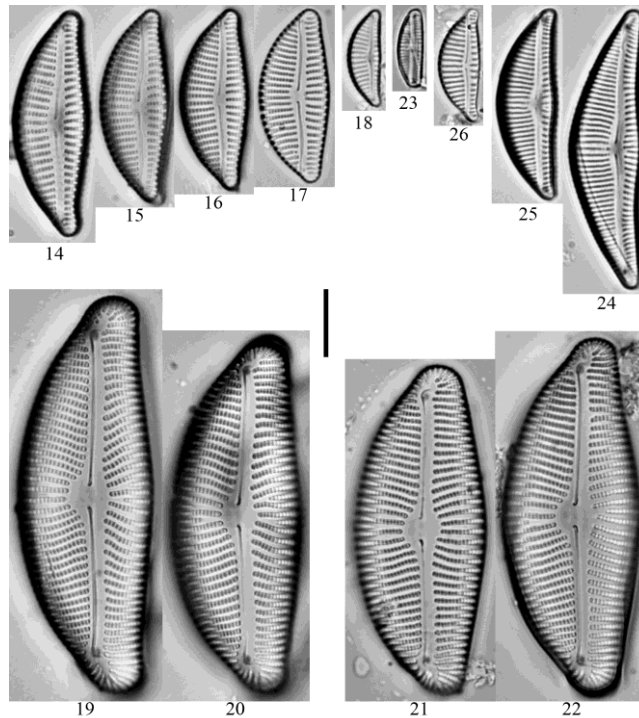
Ref. Krammer 1997a p.98-pl.6:5-17; Hofmann et al. 2011 p.192-pl.87:18-22; Bâk et al. 2012 p.114-pl.61

Dimension. Valve 16.65  $\mu\text{m}$  length and 6.25  $\mu\text{m}$  breadth, 13 striae in 10  $\mu\text{m}$ .

Distribution in Yalova running waters: Rare species. It occurred 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).

***Encyonopsis microcephala* (Grunow) Krammer**



**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  $\mu\text{m}$ .

Fig. 27-30

Basionym. *Cymbella microcephala* GrunowRef. Krammer 1997b p.91-pl.143: 1, 4, 5, 8-26;  
Hofmann et al. 2011 p.197-pl.89:35-39; Bık et al. 2012 p.117-pl.61;Dimension. Valve 12.47-14.76  $\mu\text{m}$  length and 3.50-3.88  $\mu\text{m}$  breadth, 23-24 striae in 10  $\mu\text{m}$ .

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

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

***Encyonopsis minuta* Krammer & Reichardt** Fig. 31-34Ref. Krammer 1997b p.95-pl.143a: 1-29;  
Hofmann et al. 2011 p.198-pl.89:25-34Dimension. Valve 10.55-14.46  $\mu\text{m}$  length and 3.48-3.70  $\mu\text{m}$  breadth, 23-25 striae in 10  $\mu\text{m}$ .

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

Distribution in Turkey: NEW RECORD.

***Encyonopsis cf. minuta* Krammer & Reichardt** Fig. 35-37Ref. Krammer 1997b p.95-pl.143a: 1-29;  
Hofmann et al. 2011 p.198-pl.89:25-34Dimension. Valve 9.60-11.47  $\mu\text{m}$  length and 3.56-3.73[C3]  $\mu\text{m}$  breadth, 22-24 striae in 10  $\mu\text{m}$ .

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  $\mu\text{m}$  length and 3.80-4.26  $\mu\text{m}$  breadth, 24-27 striae in 10  $\mu\text{m}$ .

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, 46Basionym. *Cymbella sinuata* var. *ovata* Hustedt  
Ref. Levkov & Ector 2010 p.479-figs.14-20Dimension. Valve 19.55-23.39  $\mu\text{m}$  length and 6.03-6.55  $\mu\text{m}$  breadth, 8-9 striae in 10  $\mu\text{m}$ .

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, 44Basionym. *Cymbella sinuata* GregoryRef. Hofmann et al. 2011 p.526-pl.89:50-61;  
Bık et al. 2012 p.297-pl.62Dimension. Valve 13.90-20.57  $\mu\text{m}$  length and 4.33-5.16  $\mu\text{m}$  breadth, 12.0-13.5 striae in 10  $\mu\text{m}$ .

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

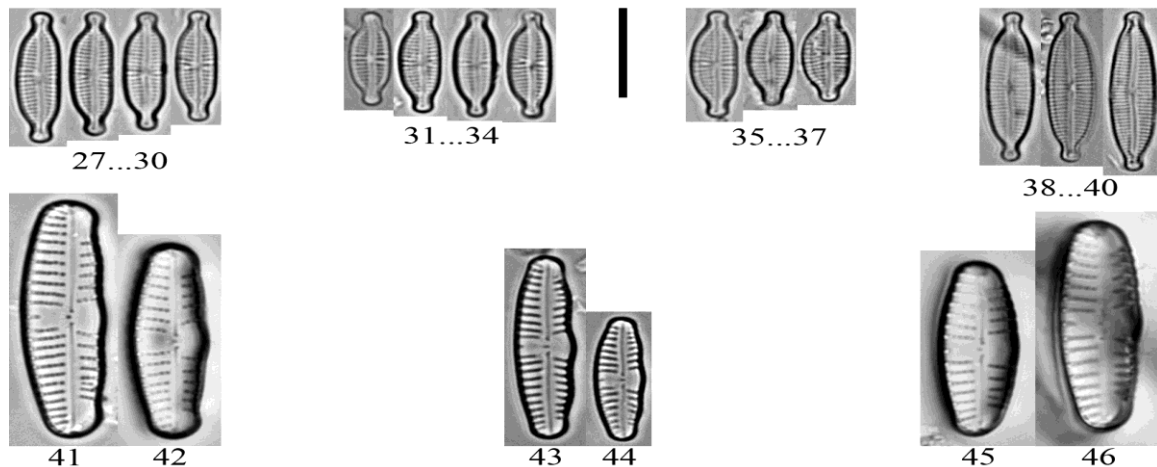
Distribution in Turkey: Common species in Turkish inland waters (Gönüloğlu 2016).

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

Ref. Bık et al. 2012 p.297-pl.62

Dimension. Valve 21.51-26.89  $\mu\text{m}$  length and 5.65-7.01  $\mu\text{m}$  breadth, 9-10 striae in 10  $\mu\text{m}$ .

Distribution in Yalova running waters: Rare



**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  $\mu\text{m}$ .

species. It was found 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, Gönülo 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. langebertalotii*, *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  $\mu\text{S}/\text{cm}^2$ ) while, *E. minuta* were found in Samanlıdere stream (DO: 10.01 mg/L, COND: 167  $\mu\text{S}/\text{cm}^2$ ). Also, *E. reichardtii* was rarely found in Samanlıdere stream. For *Cymbopleura cf. langebertalotii*, the species was found only in a mountainous spring (YL-12). The species is close to *C. langebertalotii*. However, the axial area is different and also, stria number is more than *C. langebertalotii* (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 mountainous springs)

	in Turkey (Gönülo 2016)	Status	Current Study	
				Watercourses in Yalova
<i>Cymbella excisa</i>	New Record	Rare		Samanlıdere
<i>C. lanceolata</i>	Common	Rare		Korudere
<i>C. tumida</i>	Common	Common		Gökçedere & Korudere
<i>Cymbopleura amphicephala</i>	Common	Rare		Mountainous spring (YL-19)
<i>Cymbopleura cf. langebertalotii</i>	-	Rare		Mountainous spring (YL-12)
<i>Encyonema auerswaldii</i>	Common	Rare		Korudere & Safrandere
<i>E. minutum</i>	Common	Rare		Samanlıdere
<i>E. prostratum</i>	Common	Rare		Korudere
<i>E. reichardtii</i>	New Record	Rare		Samanlıdere
<i>E. silesiacum</i>	Common	Rare		Samanlıdere
<i>E. ventricosum</i>	Rare	Rare		Mountainous spring (YL-13)
<i>Encyonopsis microcephala</i>	Common	Rare		Samanlıdere
<i>E. minuta</i>	New Record	Common	Samanlıdere, Balkandere &	Mountainous spring (YL-17, YL-18)
<i>Encyonopsis cf. minuta</i>	--	Rare		Samanlıdere
<i>E. subminuta</i>	New Record	Rare		Korudere
<i>Reimeria ovata</i>	New Record	Rare		Korudere
<i>Reimeria sinuata</i>	Common	Rare		Korudere
<i>R. uniseriata</i>	Rare	Rare	Korudere	

2015-98).

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