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Species composition and distribution of centric diatoms from Türkmen Mountain (Sakarya River Basin/Turkey)

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Abstract: Diatoms are used for monitoring the environmental conditions of water. We have little information about centric diatoms in Turkish freshwaters. A total of 50 samples were collected from some springs and small streams of Türkmen Mountain. As a result, 7 species [*Cyclotella meneghiniana* Kützing, *C. ocellata* Pantocsek, *Cyclostephanos dubius* (Fricke) Round, *Handmannia balatonis* (Pantocsek) Kulikovskiy & Solak comb. nov., *Melosira varians* Agardh, *Stephanodiscus hantzschii* Grunow, and *S. minutulus* (Kützing) Cleve & Möller] were identified, and we also suggest in this study that a new combination for *Cyclotella balatonis* Pantocsek should be *Handmannia balatonis* **comb. nov.** and for *C. praetermissa* Lund should be *Handmannia praetermissa* **comb. nov.**

Key words: Centric diatoms, *Handmannia,* Türkmen Mountain, Turkey

1. Introduction

Diatoms are used for monitoring the environmental conditions of water. They indicate water quality level of many aquatic environments, and so they have been used in a number of countries in Europe as indicators of river pollution (Whitton et al., 1991).

The diatom communities in similar climatic conditions were studied with respect to the seasonal influences of environmental factors of the systems in different countries (Barinova et al., 2011; Latif et al., 2013; Sabancı, 2012; Shams et al., 2012).

In running waters, these organisms have been less studied than those found in lakes and reservoirs in Turkey (Şen et al., 1999; Yavuz & Çetin, 2000; Çetin & Şen, 2004; Koçer & Şen, 2012). Historically, Ehrenberg published one of the first studies on Turkish diatoms in 1844 based on material collected from the Murat (Euphrates) and Aras basins (Ehrenberg, 1844). Recently published diatom lists (Gönülol et al., 1996; Aysel, 2005; Baykal et al., 2009; Ongun Sevindik et al., 2010; Solak & Wojtal, 2010; Özer et al., 2012) report 799 diatom species, showing that the available literature is insufficient to characterise this biological group in the diverse Turkish aquatic systems. Pennate diatoms are the most frequently reported group, while reports of centrics are fewer (Solak et al., 2012b). The aim of this study was to reveal the centric diatoms of Türkmen Mountain.

1.1. Description of the study area

Türkmen Mountain belongs to the Sakarya river basin. In large cities administrated by metropolitan municipal authorities, domestic wastewater is treated before being released into nearby streams, but water treatment facilities are not installed or are out of use in many smaller towns. Despite sewage treatment facilities, domestic pollution seems to be increasing in rivers that flow near large cities, such as the Ankara, Eskişehir, and Kütahya areas (Atıcı & Ahıska, 2005; Solak et al., 2009, 2012a; Solak, 2011), and the aquatic environment is increasingly threatened by waste waters and nutrients from quickly developing urban areas and agricultural practices. Türkmen Mountain is one of the areas best preserved from anthropogenic changes areas in the basin. The localities (Table) are situated at the altitude of 954–1710 m a.s.l. and represent the typical rheocrene springs and small streams of the area. Some stations (Türkmenbaba, Güllüdere, İnli, and Çobanlar stations) represent near-natural conditions, whereas the others (Darıpınar, Dümbüldek, Güllüdere-Türkmenbaba, and Lütfiye-Güllüdere) have been eutrophicated by agricultural and anthropogenic activities.

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Table. The sampling stations of Türkmen Mountain (*spring, **stream).

Stations	Latitude N	Longitude E	Altitude (m) a.s.l.
Darıpınar*	39°22′21.52″	30°15′23.53″	1298
Çobanlar plateau*	39°27′48.42″	30°20′25.26″	1512
Dümbüldek plateau*	39°21′51.60″	30°13′18.12″	1130
Gölcük plateau*	39°26′24.84″	30°22′25.92″	1627
Güllüdere plateau*	39°24′34.92″	30°21′47.16″	1366
İdris plateau*	39°24′00.96″	30°24′44.94″	1421
İnli plateau*	39°27′48.42″	30°20′02.28″	1572
Lütfiye-Güllüdere**	39°23′42.90″	30°19′00.30″	1396
Söğüt-Lütfiye**	39°24′14.76″	30°20′09.42″	1340
Güllüdere-Türkmenbaba**	39°23′42.30″	30°21′53.76″	1358
Söğüt plateau*	39°22′13.74″	30°15′46.56″	1361
Türkmenbaba plateau*	39°26′10.14″	30°23′01.74″	1710
Uluköy plateau*	39°29′13.99″	30°09′45.03″	954
Seydi**	39°22′06.02″	30°15′57.20″	990
Akındere**	39°27′12.26″	30°21′42.34″	1381

2. Materials and methods

The samples were collected from epilithic, epiphytic, and epipelic habitats in 10 springs and 5 small streams between May and December 2007 (Table). A total of 50 samples from submerged stones were collected monthly by brushing for epilithic samples (from stones 10 cm^2 in area), using a pipette aspirator for epipelic samples (sucking up the surface sediment), and plastic bags were used for epiphytic samples (shaking vigorously and squeezing in the bag). The samples were boiled with H_2O_2 and HCl to remove organic matter (Swift, 1967). 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 a Nikon Eclipse 600 Light Microscope (LM). The micrographs were taken with a Nikon DS-Fi1 camera.

The diatoms were identified according to the methods of Krammer and Lange-Bertalot (1991), Håkansson (2002), Houk et al. (2010), and Budzyńska and Wojtal (2011). The dimensions, distributions, and ecology were separately indicated for each species.

3. Results

Amongst the samples of 3 centric taxa (Solak et al., 2012b) that have been recognised as commonly reported diatoms from Turkey, we have identified 7 species in the material collected from 10 springs and 5 small streams of Türkmen Mountain (Figures 1–3).

3.1. *Cyclotella meneghiniana* Kützing (Figure 1)

(Krammer & Lange-Bertalot, 1991; Håkansson, 2002; Houk et al., 2010).

Dimensions: Valves 7.5–12.0 µm in diameter and 7.0–7.5 striae in 10 µm.

Distribution on Türkmen Mt.: İdris, Akındere from epilithic samples.

Distribution in Turkey: Lakes and rivers in Eastern Anatolia (Fırat river basin), and Inner Anatolia (Konya closed river basin).

General distribution and ecology: Tychoplanktonic, mesopolysaprobic, and eutrophentic species (Van Dam et al., 1994), classified as alkaliphilous (Håkansson, 1993; Van Dam et al., 1994).

3.2. *Cyclotella ocellata* Pantocsek (Figure 2)

(Krammer & Lange-Bertalot, 1991; Håkansson, 2002; Houk et al., 2010).

Dimension: Valves 5.5–19.0 µm in diameter and 19–22 striae in 10 µm.

Distribution on Türkmen Mt.: Çobanlar, Darıpınar, Dümbüldek, Gölcük, İdris, Seydi, Söğüt-Lütfiye, Türkmenbaba, and Uluköy from epilithic, epiphytic, and epipelic samples.

Distribution in Turkey: Lakes and rivers in Eastern Anatolia (Fırat, Çoruh, and Aras river basins), Aegean (Küçük Menderes river basin), Mediterranean (Antalya and Asi river basins), and Inner Anatolia (Konya closed river basin).

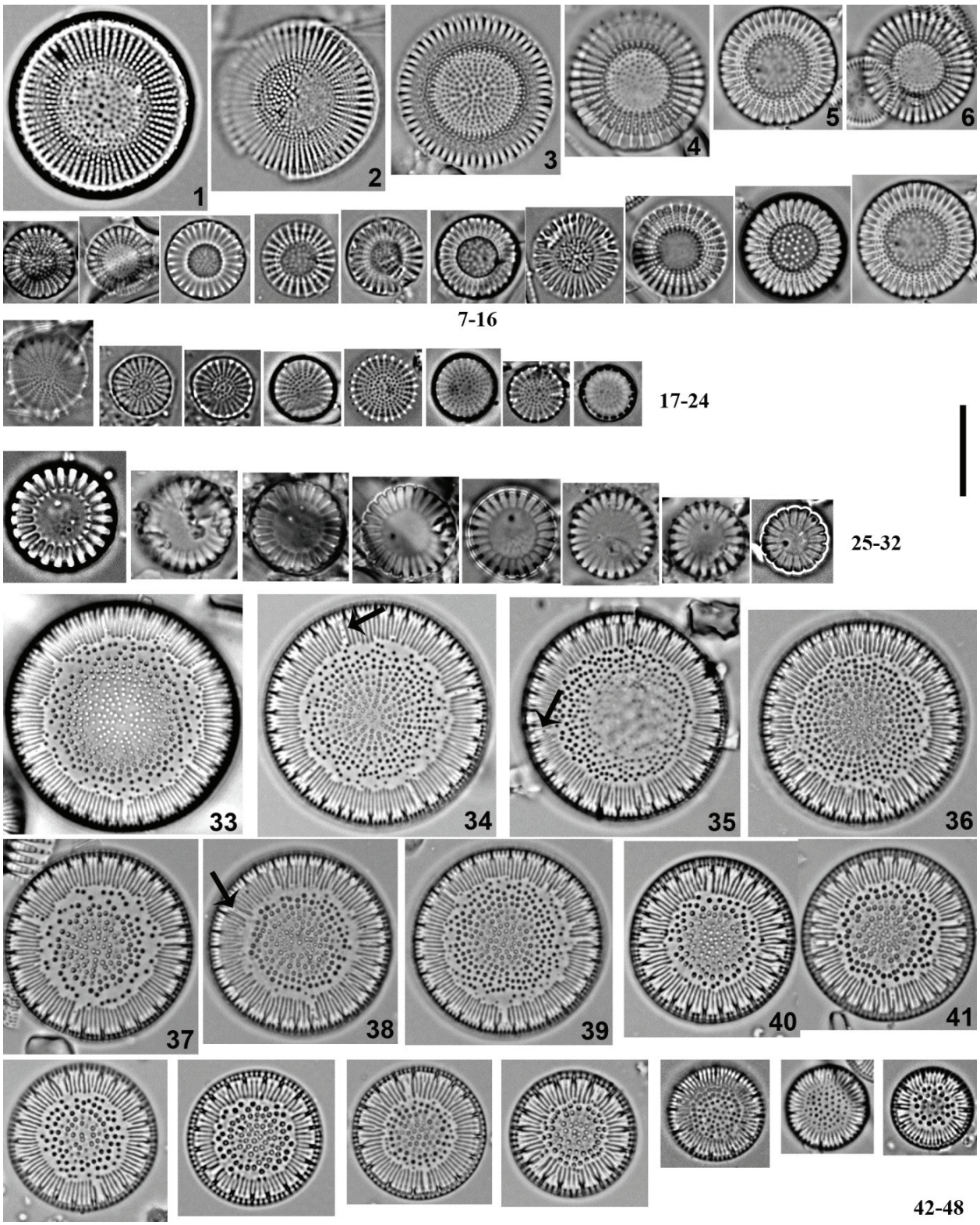

Figure 1. 1–16 = *Cyclostephanos dubius*, 17 = *Stephanodiscus hantzschii*, 18–24 = *Stephanodiscus minutulus*, 25–32 = *Cyclotella meneghiniana*, 33–48 = *Handmannia balatonis*. 1–48 = light microscope. The arrows indicate distinctive features of *H. balatonis* (ex: external rimoportula openings) separating it from similar species. Scale bar = 10 μm. 1–24, 33–39, 42, 46–48 = Darıpınar; 25, 32 = İdris; 26–31 = Akındere; 40, 41, 43–45 = Dümbüldek.

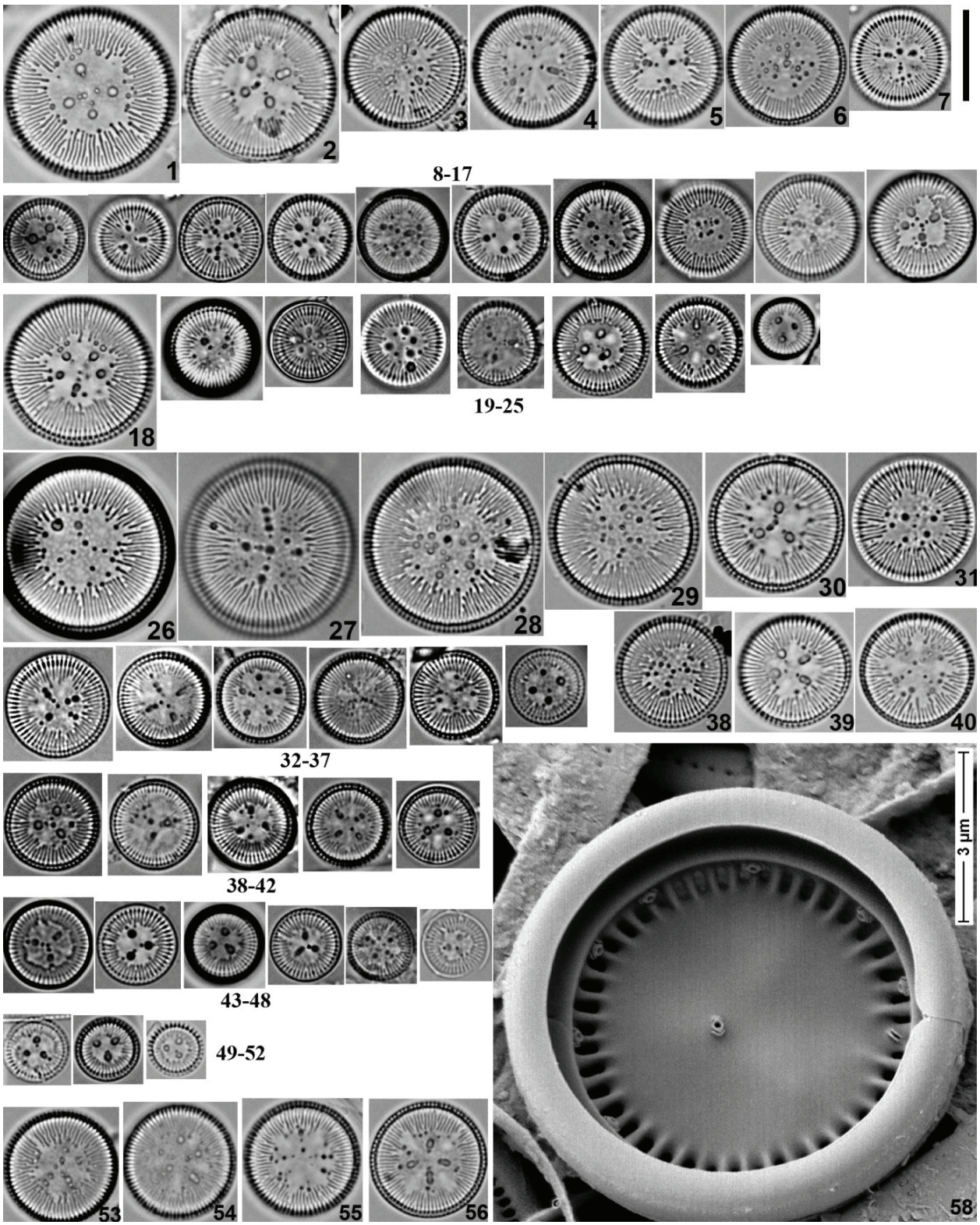

Figure 2. 1–58 = *Cyclotella ocellata*. 1–57 = light microscope; 58 = scanning electron microscope, internal valve view. Scale bar = 10 µm. 1–7 = Dümbüldek; 18–20 = Çobanlar; 21, 22 = İdris; 23, 24 = Seydi; 25 = Gölcük; 8–17, 26–29, 30–57 = Darıpınar.

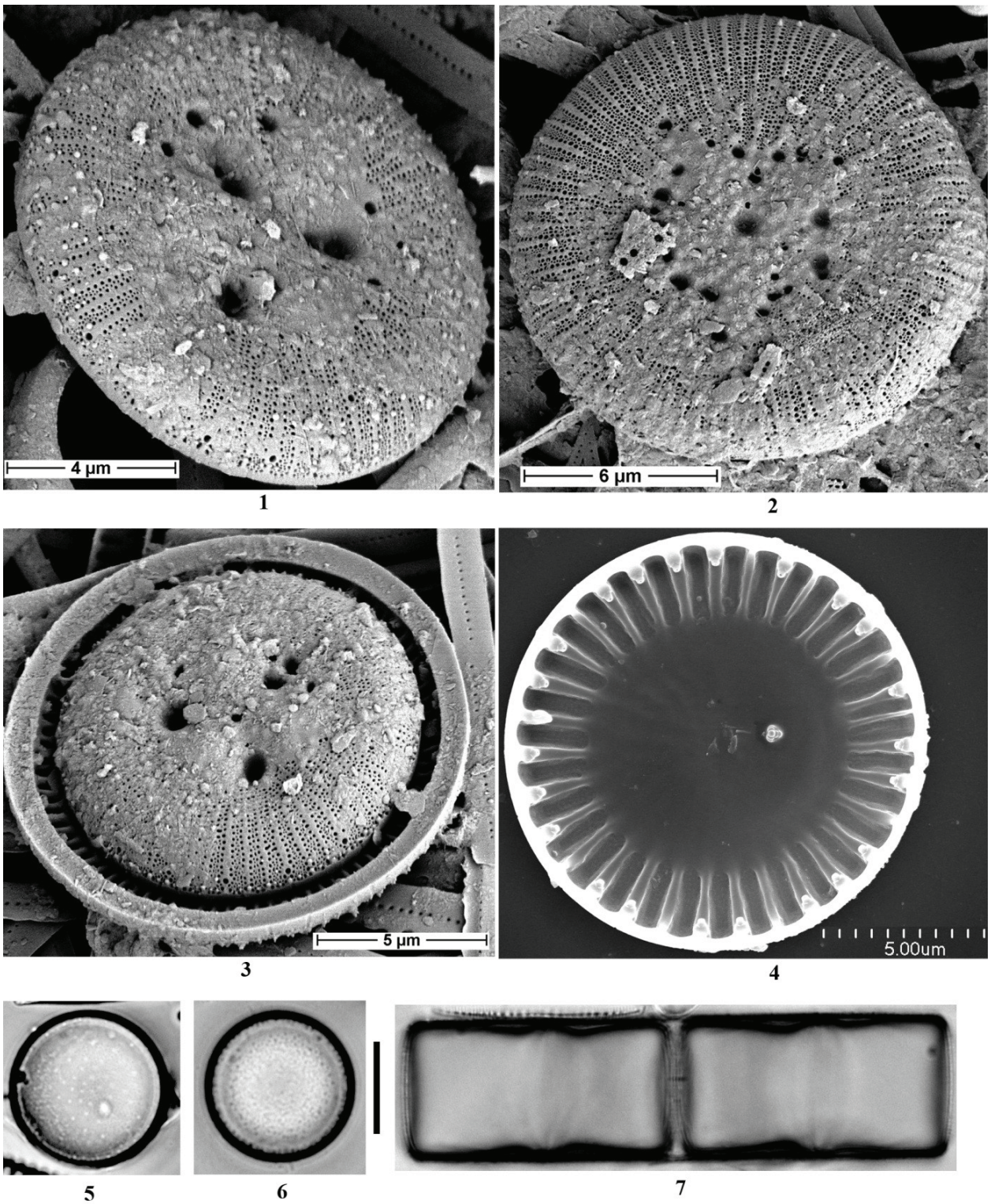

Figure 3. 1–3 = *Cyclotella ocellata*, 4 = *Cyclotella meneghiniana*, 5–7 = *Melosira varians*. 1–3 = scanning electron microscope, external valve view; 4 = scanning electron microscope, internal valve view; 5–7 = light microscope. Scale bar = 10 µm. 1–3, 5–7 = Darıpınar; 4 = Akındere.

General distribution and ecology: Euplanktonic, oligosaprobic, and mesoeutrophentic species (Denys, 1991; Van Dam et al., 1994), classified as alkaliphilous (Håkansson, 1993; Van Dam et al., 1994).

3.3. *Cyclostephanos dubius* (Fricke) Round

Basionym: *Cyclotella dubia* Fricke 1900.

(Krammer & Lange-Bertalot, 1991; Håkansson, 2002).

Dimension: Valves 7.5–20.0 µm in diameter and 10–14 striae in 10 µm.

Distribution on Türkmen Mt.: Darıpınar from epipelic samples.

Distribution in Turkey: Rare species; only lakes and rivers in Eastern Anatolia (Fırat river basin) and Western Anatolia (Susurluk river basin).

General distribution and ecology: Euplanktonic, mesosaprobic, and eutrophentic species (Denys, 1991; Van Dam et al., 1994), classified as alkaliphilous and alkalibiontic (Håkansson, 1993; Van Dam et al., 1994).

3.4. *Handmannia balatonis* (Pantocsek) Kulikovskiy & Solak **comb. nov.**

Basionym: *Cyclotella balatonis* Pantocsek 1902, Kieselalgen oder Bacillarien des Balaton. Resultate der Wissenschaftlichen Erforschung des Balatonsees, herausgegeben von der Balatonsee-Commission der Ung. Geographischen Gesellschaft. Commissionsverlag von Ed. Hölzel. Wien. 2(2): p. 104 (134), plate 15, figs. 319, 332.

(Khursevich & Kociolek, 2012; Budzyńska & Wojtal, 2011).

Dimension: Valves 9–25 µm in diameter and 19–21 striae in 10 µm.

Distribution on Türkmen Mt.: Darıpınar from epipelic and epiphytic samples.

Distribution in Turkey: According to the last checklist, prepared by Aysel (2005), the species is a new record for Turkey.

General distribution and ecology: Up until now, there has been confusion around the ecology of the species; however, it can be a large population in an eutrophic to hypereutrophic water body (Budzyńska & Wojtal, 2011).

3.5. New combination in the genus *Handmannia*:

Handmannia praetermissa (Lund) Kulikovskiy & Solak **comb. nov.**

Basionym: *Cyclotella praetermissa* Lund 1951, Hydrobiologia 3(1), p. 93-99; fig. 1 A-H, 2 A-L.

Taxonomical necessity is discussed by us below because this taxon was not found in Turkey (Aysel, 2005).

3.6. *Melosira varians* Agardh

(Hustedt, 1930; Krammer & Lange-Bertalot, 1991).

Dimension: Valves 7–22 µm in diameter.

Distribution on Türkmen Mt.: Darıpınar from epipelic samples.

Distribution in Turkey: Mediterranean (Antalya river basin), Eastern Anatolia (Fırat, Aras, and Çoruh river basins), Aegean (Küçük Menderes and Gediz river basins), and Inner Anatolia (Konya closed, Kızılırmak, and Sakarya river basins).

General distribution and ecology: Tychoplanktonic, mesosaprobic, and eutrophentic species (Lange-Bertalot, 1979; Denys, 1991; Van Dam et al., 1994), classified as alkaliphilous (Håkansson, 1993; Van Dam et al., 1994).

3.7. *Stephanodiscus hantzschii* Grunow

(Krammer & Lange-Bertalot, 1991; Håkansson, 2002).

Dimension: Valve 9 µm in diameter and 10 striae in 10 µm.

Distribution on Türkmen Mt.: Darıpınar from epipelic samples.

Distribution in Turkey: Rare species found only in lakes and rivers in Eastern Anatolia (Fırat, Dicle, Aras, and Çoruh river basins).

General distribution and ecology: Euplanktonic, mesopolysaprobic, and hypereutrophentic species (Denys, 1991; Van Dam et al., 1994), classified as alkalibiontic (Håkansson, 1993; Van Dam et al., 1994).

3.8. *Stephanodiscus minutulus* (Kützing) Cleve & Möller (Figure 3)

Basionym: *Cyclotella minutula* Kützing 1844.

(Krammer & Lange-Bertalot, 1991; Håkansson, 2002).

Dimension: Valves 6–7 µm in diameter and 13–17 striae in 10 µm.

Distribution on Türkmen Mt.: Darıpınar from epiphytic samples.

Distribution in Turkey: Rare species found only in lakes and rivers in Eastern Anatolia (Fırat river basin).

General distribution and ecology: Tychoplanktonic, mesosaprobic, and hypereutrophentic species (Denys, 1991; Van Dam et al., 1994), classified as alkaliphilous and alkalibiontic (Håkansson, 1993; Van Dam et al., 1994).

4. Discussion

In this study, 7 centric diatoms were revealed to belong to species with widespread distribution in the Holarctic (Krammer & Lange-Bertalot, 1991). According to the last checklist of Turkish freshwater diatoms (Aysel, 2005), *Handmannia balatonis* comb. nov. is interestingly a new record for Turkey. This species is closely related to other widespread taxa, like *Handmannia comta* (Ehrenberg) Kociolek & Khursevich 2012, *Handmannia bodanica* (Eulenstein) Kociolek & Khursevich 2012, and *Handmannia radiosa* (Grunow) Kociolek & Khursevich 2012. However, *Handmannia balatonis* differs from the other species by the complexity of some of its features. One of the most important features is that external rimoportula openings are situated at the end of shortened striae, well discernible under LM as gaps/notae (Budzyńska & Wojtal, 2011). The morphology and distribution of this species was well described by Budzyńska and Wojtal (2011). These authors also pointed out that this species prefers

ecologically mesotrophic conditions in lakes or slightly running waters.

Because of a new taxonomical concept for the invalid genus *Puncticulata* Håkansson, we suggest that a new combination for *Cyclotella balatonis* Pantocsek should be *Handmannia balatonis* comb. nov. *Puncticulata* as a genus was described by Håkansson (2002) with type species *Cyclotella comta* (Ehrenberg) Kützing and its allies, including *Cyclotella austriaca* (M. Peragallo) Hustedt. However, the latter species was described first as *Handmannia austriaca* by Peragallo in Handmann (1913). This means that the generic name *Handmannia* would have priority over the epithet *Puncticulata*. Taxonomical problems with this group of cyclotelloid species were also recognised by Houk et al. (2010). They discussed these species under the traditional genus *Cyclotella* (Kützing) Brébisson sensu lato (Houk et al., 2010). According to the new taxonomical concept, we also suggest in this article a new combination for another species from this group: *Handmannia praetermissa* (Lund) comb. nov.

Among the species, *C. meneghiniana* and *C. ocellata* were common diatoms, while the other species were very rare in Turkish freshwaters (Aysel, 2005). In this study, *C. ocellata* was very common, too. According to Aysel (2005), *S. hantzschii* and *S. minutulus* were present only in Eastern Anatolian freshwaters. According to Van Dam et al. (1994), these species had mesosaprobic characteristics. We found them in the Darıpınar station, where conductivity was very high. The same results were found in Nilüfer Stream (Dere et al., 2006). However, *C. meneghininana* and *C. ocellata* were also found in some saline lakes by Akbulut (2010). In order to speak more definitively about ecology and distribution in Turkish freshwaters, we need further investigations.

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