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GENERA *EUASTRUM* AND *MICRASTERIAS* (CHAROPHYTA, DESMIDIALES) FROM FENS IN THE SOUTHERN PART OF MIDDLE URALS, RUSSIA

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Abstract

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The floristic survey of the desmids in lakes of the southern part of Middle Urals revealed nine species representing the genus *Euastrum* and eight taxa belonging to the genus *Micrasterias*. Among them, four taxa (*Euastrum germanicum*, *E. verrucosum* var. *alatum*, *Micrasterias fimbriata*, *M. mahabuleshwarensis* var. *wallichii*) were new records to the Ural Region, whereas the other four taxa (*Euastrum verrucosum*, *Micrasterias americana*, *M. furcata* and *M. truncata*) were found for the first time in Middle Urals. Canonical correspondence analysis, which was performed to assess habitat preferences of the studied algae, showed that most species were more abundant in slightly acidic water and occurred predominantly in benthic habitats.

Keywords: Chelyabinsk Region, Conjugatophyceae, Desmidiaceae, distribution, new records, Sverdlovsk Region.

INTRODUCTION

The southern part of Middle Urals on its eastern macroslope, in contrast to other parts of its territory, has a number of lakes. Some of them such as Lakes Sinara and Itkul have large water surface areas (up to 30.1 km^2), great depths (up to 20 m) and, as a result, large reserves of fresh water, which is used by neighbouring villages, cities and industrial enterprises. In addition, these lakes usually have sandy or pebbly shores, which make them attractive for recreational purposes. For the above-mentioned reasons, these reservoirs have been actively studied since the beginning of the 20th century, including researches into the biodiversity of algae (Yarushina & Eremkina, 2000; Yarushina et al., 2004 and references therein; Eremkina, 2009).

Another, much larger part of water bodies of this territory is made up of shallower (less than 10 metres deep) and much smaller lakes (about 1 km across) with wetlands along the shores. These reservoirs have not been studied by algologists in detail despite the apparently favourable conditions for algae of various groups, including the order *Desmidiales*. Representatives of this order are known as sensitive indicators of a state of aquatic and wetland ecosystems (Brook, 1981; Coesel, 1975), which makes the studies on their biodiversity and ecology extremely important, especially in the regions with developed industry such as the territory under consideration.

The current work is devoted to study the biodiversity and ecology of the two Desmidiacean genera, *Micrasterias* and *Euastrum*, in the south-eastern part of Middle Urals. The results of this work will complement the knowledge about the biological diversity of these genera both in Middle Urals and in the Ural Region as a whole.

STUDY AREA

According to the administrative subdivision, the territory under consideration is situated in the Russian Federation, at the border of Sverdlovsk and Chelyab-

insk Regions. The studied area belongs to the Tobol River basin (Andreeva, 1973), and is situated near the southern border of Middle Urals, on its eastern slope (Fig. 1, A). Geologically, it belongs to the Middle trans-Uralean province (Chibilyov & Chibilyov, 2012). The region is characterized by a moderately continental climate with long cold winters, short warm summers and short springs and autumns. The average monthly air temperature varies from -15 to -16ºC in the coldest month (January) and from 16 to +17ºC in the warmest month (July). The annual precipitation is about 500–800 mm. The vegetation of the region is represented mainly by the middle taiga pine (*Pinus sylvestris* L.) forests, with ground cover depending on water availability dominated by grasses or *Sphagnum* mosses (predominantly *Sphagnum girgensohnii* Russow and *Sphagnum squarrosum* Crome). Due to the long-term impact of logging and fires, the vegetation dominated by pine has been replaced by birch (*Betula pendula* Roth, *Betula pubescens* Ehrh.) and aspen (*Populus tremula* L.) in large areas. Some territories are covered by post-forest meadows (Kulikov, 2010).

MATERIALS AND METHODS

The present research was carried out in 11 tectonic lakes in May–August 2013–2016 (Andreeva, 1973), wherein the largest three (Schelkunskoye, Okunkul, Karaguz) have pebbly banks and eutrophic water, the next five (Boevskoye, Tenyak, Cherkaskul, Maloye Yamskoye, Bolshoye Yamskoye) are mesotrophic open-water transition fens with floating peat mats

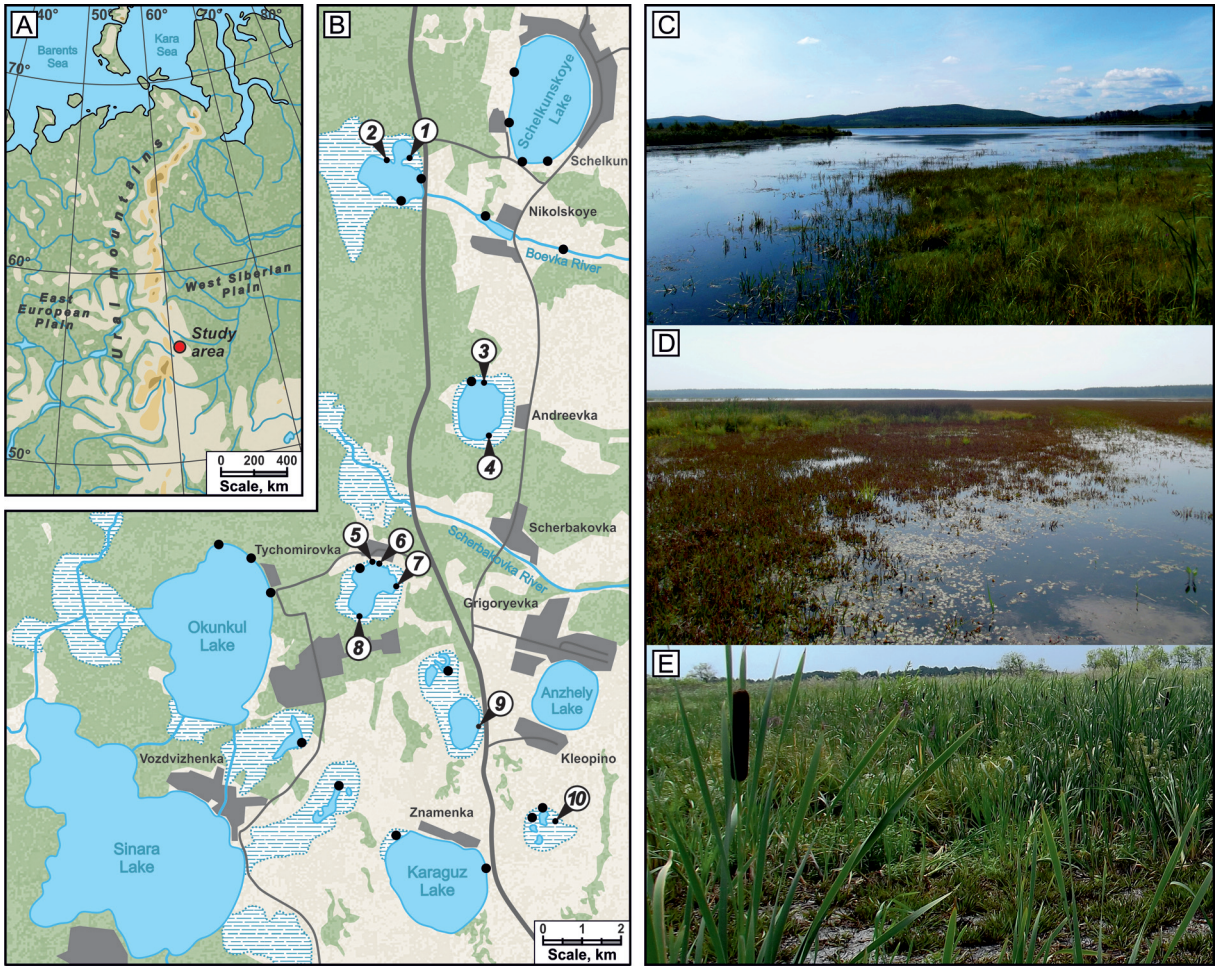

Fig. 1. Study area with sampling sites in the selected lakes (A, B) and photographs of typical biotopes (C – open-water transition fen in Lake Boevskoye, D – floating peat mat in Lake Tenyak, E – quaking fen in Lake Travyanoye). The numbers on the map indicate sampling sites on the lakes: 1–2 – Boevskoye, 3–4 – Tenyak, 5–8 – Cherkaskul, 9 – Bolshoye Yamskoye, 10 – Travyanoye

(Fig. 1 C, D), and the last three (Chigany, Bagaryay, Travyanoye) have almost turned into meso-eutrophic quaking fens (Fig. 1 E) (Yarushina et al., 2004). All mentioned lakes are located at the elevation of 251–257.8 metres above the sea level and have pH-value ranging from weakly acidic to slightly alkaline.

The sampling on each lake was made at several sites (Table 1 describes only those, where *Euastrum* and *Micrasterias* species were found). Plankton samples were collected using the Apstein plankton net with a mesh about 20 μm in size; benthos samples were taken with a small amount of substrate (silt, peat, and sapropel) into 50 ml plastic tubes. In parallel with the sampling, the temperature and pH of the water were measured using a portable pH-meter Milwaukee pH55 Martini.

The study of live algal samples was carried out using a light microscope Levenhuk 320, Micmed-2 and a digital camera Levenhuk C310 NG. Cell measurements were made using ToupView v.3.7 software. The abundance estimation was made according to a 6-point scale (Korde, 1956; Barinova & Medvedeva, 1996), where 1 – "single" with 1–5 cells per slide, 2 – "rare" with 10–15 cells, 3 – "common" with 25–30 cells, 4 – "frequent" with one cell over a slide transect, 5 – "very frequent" several cells over a slide transect, 6 – "abundant" with one or more cells in each field of view. Species identification was performed using flora books (Kosinskaya, 1960; Lenzenweger, 1996; Coesel & Meesters, 2007).

In the annotated list, the names of taxa were given in accordance with Algaebase (Guiry & Guiry, 2019). In species description, the following abbreviations were used: Dim. – cell dimensions; Descr. – short description of the cell morphology; Loc. – location, where the species was detected, given with

Table 1. Description of the sampling sites in which the *Euastrum* and *Micrasterias* species were found. Row numbers correspond to the site numbers in Fig. 1 B

No	Coordinates	pH	t, C°	Description
1	N 56°16'53.4" E 60°52'02.4"	6.0	22.0	Lake Boevskoye. The plankton and benthos samples were taken in wetlands near the lake shore covered with *Typha latifolia* L., *Phragmites australis* (Cav.) Trin. ex Steud., *Calla palustris* L. *Stratiotes aloides* L. and *Utricularia intermedia* Hayne were found in the water.
2	N 56°16'41.3" E 60°51'35.8"	6.1	22.0	Lake Boevskoye. Environmental conditions are similar to sampling site 1.
3	N 56°13'28.5" E 60°53'55.9"	6.0	19.0	Lake Tenyak. The plankton samples were taken in wetlands near the lake shore covered with *Phragmites australis Typha latifolia*, *Alisma plantago-aquatica* L., *Calla palustris*, *Comarum palustre* L., *Equisetum fluviatile* L. *Stratiotes aloides*, *Utricularia intermedia* Hayne and *Hydrocharis morsus-ranae* L. as well as thickets of *Chara globularis* Thuiller and macroscopic *Nostoc* sp. colonies were found in water.
4	N 56°12'39.3" E 60°53'54.4"	6.3	28.0	Lake Tenyak. The plankton and benthos samples were taken in the hollows of lake peat shore covered with *Typha latifolia* and *Phragmites australis*.
5	N 56°10'52.6" E 60°50'58.1"	7.0	20.0	Lake Cherkaskul. The plankton samples were taken in wetlands near the lake shore covered with *Typha latifolia*, *Phragmites australis*, *Alisma plantago-aquatica*, *Calla palustris*, *Comarum palustre*, *Equisetum fluviatile*. *Stratiotes aloides*, *Utricularia intermedia* were found in the water.
6	N 56°10'53.2" E 60°50'58.5"	8.0	27.1	Lake Cherkaskul. Environmental conditions are similar to sampling site 5.
7	N 56°10'37.9" E 60°51'58.1"	7.0	23.0	Lake Cherkaskul. Environmental conditions are similar to sampling site 5.
8	N 56°10'05.3" E 60°50'41.7"	6.9	21.0	Lake Cherkaskul. The plankton and benthos samples were taken in the hollows of lake peat shore covered with *Typha latifolia* and *Phragmites australis*.
9	N 56°08'40.1" E 60°53'51.4"	7.0	26.0	Lake Bolshoye Yamskoye. The plankton samples were taken in wetlands near the lake shore covered with *Typha latifolia*, *Phragmites australis*. *Stratiotes aloides*, and *Utricularia intermedia* were found in water.
10	N 56°07'15.3" E 60°55'24.4"	7.2	23.2	Lake Travyanoye. The plankton samples were taken in fen hollows near lake shore covered with dense thickets of *Typha latifolia*, *Phragmites australis*, *Comarum palustre* L. and *Calla palustris*.

the number of sampling site according to Table 1 and abundance of taxa in the sample (in brackets); Hab. – habitats, where the species usually occur (given according to the above-mentioned flora books); Distr. – distribution in the Ural Mountains and in the neighbouring regions; G. distr. – global distribution of species in the world (given according to the Algaebase and the above-mentioned flora books).

The analysis of species composition similarity between the flora of the investigated lakes and the floras of different parts of the Ural Mountains was made using PAST 4.0 (Hammer et al., 2001). The assessment of influence of the environmental conditions (pH, temperature) and habitat preferences was performed using Canoco 5.0 for Windows (ter Braak & Šmilauer, 2012).

LIST OF SPECIES

Here we provide an illustrated annotated list of the *Micrasterias* and *Euastrum* species found in the studied lakes.

Genus *Euastrum* Ehrenberg ex Ralfs 1848

Euastrum bidentatum Nägeli 1849 (Fig. 2, 1). Dim.: 52.4 × 34.7 µm, polar lobe 20.5 µm wide, isthmus 11.6 µm wide. Descr.: cell elliptical in outline with deep closed sinus. Semi-cells with inflation in the mid-region, furnished with large granules. Basal lobes large, slightly concave on the top. Lateral lobes smaller, broadly rounded. Polar lobe convex with deep, narrow median incision and a spine on each angle. Cell wall granulated. Loc.: Lake Boevskoye No 1(1). Hab.: peat bogs, oligo-mesotrophic fens and rivers. Common at pH 5.5–7. Distr.: recorded in the Polar (Voronikhin, 1930; Patova & Demina, 2007; Briškaitė et al., 2016), Subpolar (Sterlyagova, 2008) and Middle (Tauson, 1947; Shakhmatov, 2014) Urals. Widespread in the most part of the East European Plain (Kosinskaya, 1960; Luknitskaya, 2006; Anissimova, 2017), known from the Middle Cis-Urals (Tauson, 1947) and West Siberia (Kosinskaya, 1960; Aleksyuk et al., 1989; Safonova & Shaulo, 2007; Shakhmatov & Pavlovskiy, 2019). G. distr.: widespread in both Northern and Southern Hemispheres.

Euastrum cf. denticulatum F.Gay 1884 (Fig. 2, 2) – Dim.: 25.8–37.1 × 21.1–29.8 µm, polar lobe 14.8–17.3 µm wide, isthmus 6.6–9.2 µm wide. Descr.: cell hexagonal in outline with deep closed sinus. Semi-cells with median inflation, furnished with large granules. Basal lobes large, slightly concaved on the top. Lateral lobes smaller, broadly rounded. Polar lobe truncated, with a v-shaped median incision and short spines on each angle. Cell wall has denticulations on the lobe margins. Loc.: Lake Boevskoye No 1(3); Lake Tenyak No 3(3). Hab.: peat bogs with *Sphagnum*, oligo-mesotrophic lakes and fens. Common at pH 4–7.2. Distr.: recorded in the Polar (Briškaitė et al., 2016), Subpolar (Sterlyagova, 2008) and Middle (Shakhmatov, 2014; as *E. pulchellum* in Shakhmatov et al., 2018) Urals. Widespread in the most part of the East European Plain (Kosinskaya, 1960; Luknitskaya, 2006; Anissimova, 2017), known from West Siberia (Kosinskaya, 1960; Naumenko, 1992). G. distr.: widespread in both Northern and Southern Hemispheres.

Euastrum dubium Nägeli 1849 (Fig. 2, 3) – Dim.: 29.3 × 21.5 µm, polar lobe 11.6 µm wide, isthmus 5.9 µm wide. Descr.: cell hexagonal in outline with deep closed sinus. Semi-cells with small inflation at the mid-region. Basal and lateral lobes are almost equally developed. Polar lobe with a deep, narrow median incision. Cell wall smooth. Note: the studied specimen does not have small granules on the polar lobe angles, which are characteristic of a type variety. This fact, as well as the dimensions and shape of the cell, pointed on the fact that the species can be determined as *E. dubium* var. *tritum* West et G.S.West, 1908. Unfortunately, the finding of the only individual of this alga does not allow us to conclude whether this morphological feature is a characteristic of a single cell or of the entire population in the water body. Loc.: Lake Cherkaskul No 5(1). Hab.: peat bogs with *Sphagnum*, oligo-mesotrophic lakes and rivers. Prefers pH 6.5–6.6. Distr.: The species was recorded in the Polar (Patova & Demina, 2007), Subpolar (Sterlyagova, 2008), Middle (Kossinskaya, 1960) and South (Yarushina et al., 2004) Urals. Widespread in the most part of the East European Plain (Kosinskaya, 1960; Luknitskaya, 2006; Anissimova, 2017), known from West Siberia (Valeyeva, 2006). G. distr.: widespread in both Northern and Southern Hemispheres.

Euastrum germanicum (Schmidle) Willi Krieger 1937 (Fig. 2, 4) – Dim.: 55.4–60.8 × 49.1–55.1 µm, polar lobe 18.6–20.5 µm wide, and isthmus 13.2–13.7 µm wide. Descr.: cell octagonal in outline with deep

closed sinus. Semi-cells with large inflation at the mid-region, furnished with circular rows of large granules. Basal and lateral lobes are equally developed. Polar lobe with slightly concaved apex. Cell wall granulated on the surface of lobes. Loc.: Lake Boevskoye No 2(3); Lake Cherkaskul No 5(2), 7(1); Lake Bolshoye Yamskoye No 9(1). Hab.: peat bogs with *Sphagnum*, mesotrophic lakes and rivers. Common at slightly acidic to neutral water. Distr.: this species has not been previously recorded in the Ural Mountains or in the neighbouring regions. The nearest regions, where this species was found are the northwest (Kossinskaya, 1960) and central (Anissimova, 2017) parts of the East European Plain and West Siberia (Kossinskaya, 1960). G. distr.: widespread in Eurasia.

Euastrum *cf.* ***insulare*** (Wittrock) J.Roy 1877 (Fig. 2, 5) – Dim.: 27.6 × 20.7 µm, polar lobe 14.1 µm wide, isthmus 6.1 µm wide. Descr.: cell hexagonal in outline with deep closed sinus. Semi-cells with small inflation at the mid-region. Basal and lateral lobes are equally developed. Polar lobe with a wide, but not deep v-shaped concavity. The cell wall of the studied specimen is smooth. Note: the identification of this alga is based on the morphological features of the cell. A similar species, *Euastrum lacustre* (Messikommer) Coesel, 1984 (Coesel, 1984; Coesel & Meesters, 2007) can be distinguished by the cell wall structure visible in an electron microscope only. Loc.: Lake Bolshoye Yamskoye No 9(1). Hab.: peat bogs with *Sphagnum*, oligo-mesotrophic lakes and fens. Common at pH 4.5–7.4. Distr.: recorded in the Polar (Briškaitė et al., 2016) and Middle (Korde, 1949; Kossinskaya, 1960) Urals. Known from the central (Anissimova, 2017) and the north-west (Luknitskaya, 2013; Luknitskaya, 2017) parts of the East European Plain as well as from West Siberia (Kossinskaya, 1960). G. distr.: widespread in both Northern and Southern Hemispheres.

Euastrum oblongum Ralfs 1848 (Fig. 2, 6) – Dim.: 179.8–180.1 × 93.4–93.8 µm, polar lobe 50.6–51.6 µm wide, isthmus 26.6–26.9 µm wide. Descr.: cell narrowly elliptical in an outline with deep closed sinus. Semi-cells with three inflations at the mid-region and with one inflation on each lobe. Basal and lateral lobes are equally developed, concave on the apex. Polar lobe convex with a deep, narrow median incision. Cell wall smooth. Loc.: Lake Tenyak No 3(2). Hab.: peat bogs with *Sphagnum*, mesotrophic lakes and fens. Prefers pH 5.3–7.4. Distr.: recorded in the Polar (Voronikhin, 1930; Briškaitė et al., 2016), Middle (Shakhmatov, 2014) and South

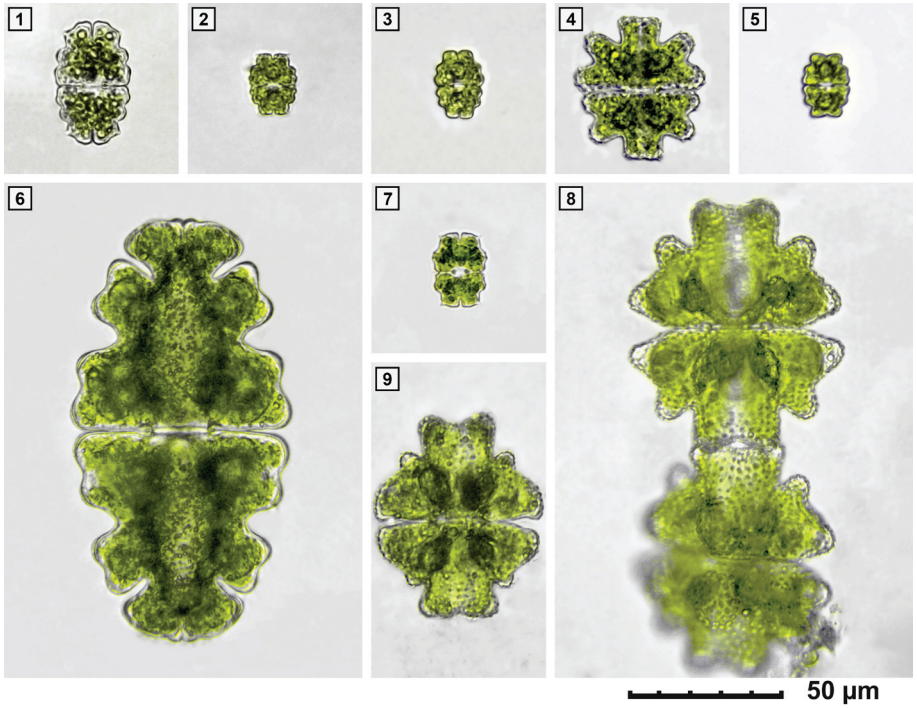

Fig. 2. *Euastrum* species from the studied area: 1 – *E. bidentatum*, 2 – *E. cf. denticulatum*, 3 – *E. dubium*, 4 – *E. germanicum*, 5 – *E. cf. insulare*, 6 – *E. oblongum*, 7 – *E. cf. pulchellum*, 8 – *E. verrucosum*, 9 – *E. verrucosum* var. *alatum*

(Snitko & Sergeeva, 2003; Snitko, 2009) Urals. Widespread in the most part of the East European Plain (Kosinskaya, 1960; Luknitskaya, 2006; Anissimova, 2017), and known from West Siberia (Kosinskaya, 1960; Safonova & Shaulo, 2007; Shakhmatov & Pavlovskiy, 2019). G. distr.: widespread in both Northern and Southern Hemispheres.

Euastrum cf. pulchellum Brébisson 1856 (Fig. 2, 7) – Dim.: 32.1–35.1 × 23.5–25.0 μm, polar lobe 13.9–18.7 μm wide, isthmus 6.7–9.7 μm wide. Descr.: cell octagonal in outline with deep closed sinus. Semi-cells with a median inflation furnished with three large granules. Basal and lateral lobes are well developed, with granules at the margins. The polar lobe has a deep median incision and two spines on the angles. Loc.: Lake Boevskoye No 1(2); Lake Bolshoye Yamskoye No 9 (1). Hab.: peat bogs with *Sphagnum*, mesotrophic lakes and fens. Common at pH 6.7–7.4. Distr.: known from the Polar (Briškaitė et al., 2016) and Middle (Shakhmatov, 2014) Urals. Widespread in the most part of the East European Plain (Kosinskaya, 1960; Luknitskaya, 2006; Anissimova, 2017), and known from West Siberia (Shakhmatov & Pavlovskiy, 2019). G. distr.: widespread in both Northern and Southern Hemispheres.

Euastrum verrucosum Ehrenberg ex Ralfs 1848 (Fig. 2, 8) – Dim.: 101.4–107.2 × 90.3–91.2 μm, polar lobe 37.9–41.7 μm wide, isthmus 23.2–25.7 μm wide. Descr.: cell octagonal in outline with deep, closed to about two thirds of its length sinus. Semi-cells with three inflations: one large is at the centre of a semi-cell and a single inflation is situated on each basal lobe. All inflations are furnished with circular rows of large granules. The basal lobes are larger than the lateral. Polar lobe concave. Cell wall is covered by regularly distributed granules. Note: The variety of this species, *Euastrum verrucosum* var. *reductum* Nordstedt, 1880 is known from the South Urals (Snitko, 2009). Loc.: Lake Boevskoye No 1(3), 2(3); Lake Tenyak No 3(2); Lake Cherkaskul No 6(1). Hab.: peat bogs with *Sphagnum* and mesotrophic fens. Common at pH 4.5–7.8. Distr.: recorded in the Polar (Briškaitė et al., 2016) and Subpolar (Voronikhin, 1930; Sterlyagova, 2008) Urals. Widespread in the most part of the East European Plain (Kosinskaya, 1960; Luknitskaya, 2006), known from West Siberia (Kosinskaya, 1960). G. distr.: widespread in both Northern and Southern Hemispheres.

Euastrum verrucosum* var. *alatum Wolle 1884 (Fig. 2, 9) – Dim.: 81.1–86.3 × 71.7–72.8 μm, polar lobe 33.4–39.0 μm wide, isthmus 19.5–20.6 μm wide. Descr.: this variety differs from the type variety by the basal lobes that have beak-shaped endings curved to the sinus. Loc.: Lake Cherkaskul No 8(2). Hab.: peat bogs with *Sphagnum* and mesotrophic fens. Common at pH 4.5–7.8. Distr.: widespread in the most part of the East European Plain (Kosinskaya, 1960), and known from West Siberia (Kosinskaya, 1960). G. distr.: widespread in both Northern and Southern Hemispheres.

Genus *Micrasterias* C. Agardh ex Ralfs 1848

Micrasterias americana Ehrenberg ex Ralfs 1848 (Fig. 3, 1) – Dim.: 128.3–130.3 × 122.9–123.5 μm, polar lobe 70.4–70.8 μm wide, isthmus 30.0–31.6 μm wide. Descr.: cells hexagonal in outline with deep, closed in the most part sinus. Semi-cells with well-developed lateral lobes divided on secondary lobules of a different size. Polar lobes concave, with asymmetrically placed short additional process on each side. Cell wall is smooth, with dentation on the margins of lobes. Loc.: Lake Boevskoye No 1(1); Lake Cherkaskul No 8(1). Hab.: peat bogs with *Sphagnum*, mesotrophic lakes and fens. Common at pH 5–7.5. Distr.: recorded in the Subpolar (Sterlyagova, 2008) and South (Snitko & Snitko, 2017) Urals. Widespread in the most part of the East European Plain (Kosinskaya, 1960; Anissimova, 2017) and known from West Siberia (Naumenko, 2019). G. distr.: widespread in both Northern and Southern Hemispheres.

Micrasterias apiculata Meneghini ex Ralfs 1848 (Fig. 3, 2–3) – Dim.: 222.1–259.4 × 178.6–204.4 μm, polar lobe 64.8–80.1 μm wide, isthmus 34.8–40.1 μm wide. Descr.: cells elliptical in outline with narrowly open sinus. Semi-cells with well-developed lateral lobes divided to the third order and median inflation with a circle of four spines. The polar lobe has v-shaped concavity and thick curved spines on the angles. Cell wall covered by the irregularly placed spines (Fig. 3, 3). Note: The samples of *Micrasterias radiosa* var. *murrayi* from Lake Medvezhye located in the South Urals (Snitko & Snitko, 2017) may belong to *M. apiculata*. The cell size and the shape of the polar and lateral lobes as well as the characteristic location of the spines on their margins, agree with *M. apiculata*, which is clearly visible in the micrograph given in the paper. Unfor-

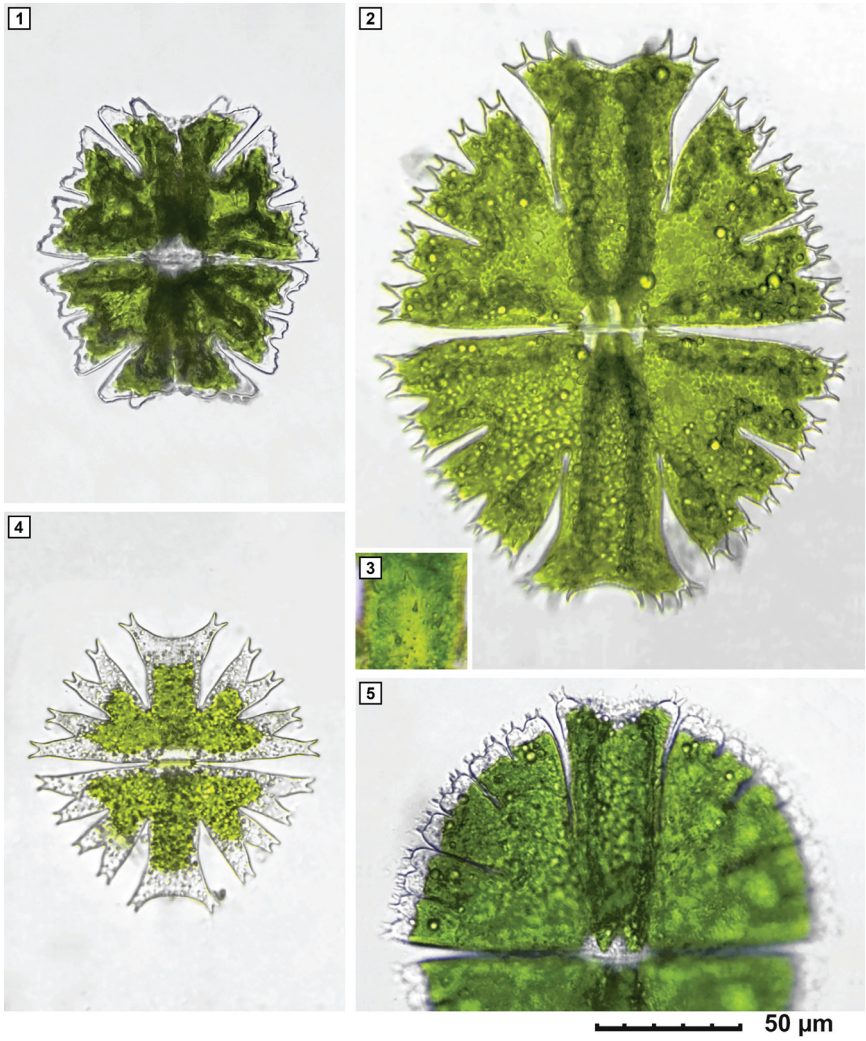

Fig. 3. *Micrasterias* species from the studied area: 1 – *M. americana*, 2–3 – *M. apiculata* (microphotograph 3 shows spines on the surface of the cell wall), 4 – *M. crux-melitensis*, 5 – *M. fimbriata*

tunately, the authors gave no data on the presence or absence of spines on the surface of the cell wall. Nevertheless, the distribution of *M. apiculata* may include the South Urals. Loc.: Lake Boevskoye No 1(3), 2(3); Lake Tenyak No 3(2). Hab.: peat bogs with *Sphagnum*, mesotrophic lakes and fens. Common at pH 5.8–6.8. Distr.: recorded in the Polar (Voronikhin, 1930) and Middle (Shakhmatov, 2014) Urals. Widespread in the most part of the East European Plain (Kosinskaya, 1960; Anissimova, 2017) and known from West Siberia (Naumenko, 2019). G. distr.: widespread in both Northern and Southern Hemispheres.

Micrasterias crux-melitensis (Ehrenberg) Trevisan 1842 (Fig. 3, 4) – Dim.: 114.1–130.3 × 104.8–127.3 µm, polar lobe 36.9–40.9 µm wide, isthmus 18.6–19.5 µm wide. Descr.: cell hexagonal in outline with narrowly open sinus. Semi-cells with well-developed lateral lobes dividing to the second order. Polar lobe concave. Cell wall smooth. Note: *Micrasterias crux-melitensis* is a very polymorphic species with a high number of infra-specific taxa, some of which have disputable status (Neustupa et al., 2010) and probably have no taxonomical significance. For this reason, here we present only the species name for this alga. It should be noted that all the samples found in the studied lakes can be identified as *M. crux-melitensis* var. *protuberans* Grönblad, which differs from the type variety by a more extended polar lobe and horizontally elongated lower lateral lobules of the second order. Loc.: Lake Boevskoye No 2(2); Lake Tenyak No

3(2); Lake Cherkaskul No 6(1). Hab.: peat bogs with *Sphagnum*, mesotrophic lakes and fens. Common at pH 5.3–8. Distr.: recorded in the Polar (Voronikhin, 1930; Briškaitė et al., 2016), Middle (Shakhmatov, 2014; Shakhmatov et al., 2018) and South (Snitko & Snitko, 2017) Urals. Widespread in the most part of the East European Plain (Kosinskaya, 1960; Anissimova, 2017), and known from West Siberia (Kosinskaya, 1960; Naumenko 2019). G. distr.: widespread in both Northern and Southern Hemispheres.

Micrasterias fimbriata Ralfs 1848 (Fig. 3, 5) – Dim.: 216.3 × 194.3 µm, polar lobe 53.5 µm wide, isthmus 35.4 µm wide. Descr.: the cell is almost circular in outline, with deep, closed on the most part sinus. Semi-cells with well-developed lateral lobes, the lower of them are divided up to the third order, whereas the upper lobe is divided to the fourth order. Polar lobe concave, with two small subapical spines and two thick, slightly curved spines on its angles. Cell wall smooth. Loc.: Lake Boevskoye No 1(1). Hab.: peat bogs with *Sphagnum*, mesotrophic lakes and fens. Common at pH 6–7. Distr.: this species has not been previously recorded in the Ural Mountains, but widespread in the most part of the East European Plain (Kosinskaya, 1960; Luknitskaya, 2006; Anissimova, 2017) and known from West Siberia (Naumenko & Ptukhina 2013; Naumenko 2019). G. distr.: widespread in Eurasia and North America.

Micrasterias furcata C.Agardh ex Ralfs 1848 (Fig. 4, 1) – Dim.: 143.5–166 × 124.5–151.3 µm, polar lobe 67.9–69.7 µm wide, isthmus 23.3–23.6 µm wide. Descr.: the cells are elliptical in outline with narrowly opened deep sinus. Semi-cells with well-developed lateral lobes divided to the third order. Lobules of the third order are strongly elongated. The polar lobe is concave, with elongated angles. Cell wall is smooth.

Note: A variety of this species, *M. furcata* var. *pseudocrux* (Grönblad) C. E. M. Bicudo & L. Sormus (as *M. radiata* var. *pseudocrux* Grönblad), is known from Lake Bolshoye Miassovo in the South Urals (Snitko & Sergeeva, 2003). Loc.: Lake Boevskoye No 1(3), 2(3); Lake Tenyak No 3(2). Hab.: peat bogs with *Sphagnum*, mesotrophic lakes and fens. Common at pH 6.5–6.9. Distr.: recorded in the Polar (Briškaitė et al., 2016) and South (Snitko & Snitko, 2017) Urals. Widespread in the most part of the East European Plain (Kosinskaya, 1960; Anissimova, 2017), known from West Siberia (Kosinskaya, 1960; Naumenko 2019). G. distr.: widespread in both Northern and Southern Hemispheres.

Micrasterias mahabuleshwarensis* var. *wallichii (Grunow) West et G.S.West 1905 (Fig. 4, 2) – Dim.: 183.6–186.6 × 149.0–161.1 µm, polar lobe 90.8–101.2 µm wide, isthmus 29.6–32.7 µm wide. Descr.: cells hexagonal in outline with widely opened sinus. Semi-cells with well-developed lateral lobes, the lowest of which is undivided, whereas the upper is divided to the second order. Polar lobe with short processes on its angles and asymmetrically placed additional processes on each side. The cell wall is covered by rows of small thick spines. Note: Earlier (Shakhmatov, 2015) this variety was erroneously reported for this territory as *M. mahabuleshwarensis* var. *europaea*, based on the presence of small spines on the apex of the polar lobe. However, considering the size and the shape of the cell as well as the shape of the lateral lobes, we conclude that the specimens from Middle Urals belong to *M. mahabuleshwarensis* var. *wallichii*. Loc.: Lake Boevskoye No 2(2); Lake Tenyak No 4(1). Hab.: peat bogs with *Sphagnum*, mesotrophic moorland pools. Common in slightly acidic water. Distr.: this variety has not been previously recorded in the Ural Mountains or neighbouring regions. The nearest localities, where it was found, are the northwest part of the East European Plain (Kosinskaya, 1960; Luknitskaya, 2010) and the Far East (Medvedeva & Nikulina, 2014). However, the type variety of this species as well as *M. mahabuleshwarensis var. europaea* (W.B. Turner) Willi Krieger is known from Western Siberia (Naumenko, 2019). G. distr.: widespread in Eurasia, North America and Australia.

Micrasterias rotata Ralfs 1848 (Fig. 4, 3–4) – Dim.: 303.4–318.6 × 257.2–275.7 µm, polar lobe 50.3–61.6 µm wide, isthmus 39.3–42.3 µm wide. Descr.: cells from broadly elliptical to circular in outline with deep closed sinus. Semi-cells with well-developed lateral lobes divided to the fourth order. Polar lobe with a v-shaped concavity. Cell wall is smooth. Loc.: Lake Boevskoye No 1(3), 2(3); Lake Travyanoye No 10(1). Hab.: peat bogs with *Sphagnum*, mesotrophic lakes and fens with *Utricularia*. Common at pH 4.9–8. Distr.: recorded in the Polar (Patova & Demina, 2007), Middle (Shakhmatov, 2014) Urals. Widespread in the most part of the East European

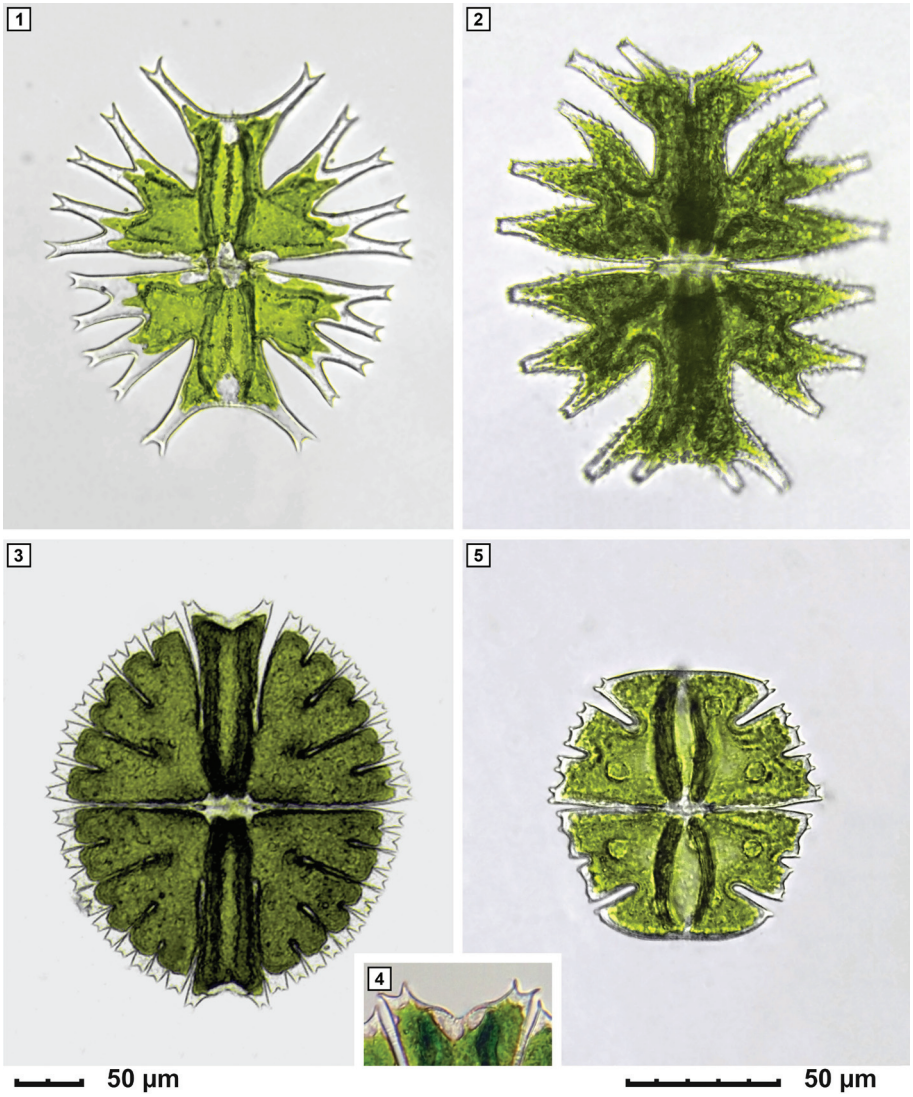

Fig. 4. *Micrasterias* species found in the studied area: 1 – *M. furcata*, 2 – *M. mahabuleshwarensis* var. *wallichii*, 3–4 – *M. rotata*, 4 – *M. rotata* (a part of a polar lobe), 5 – *M. truncata.* For the microphotograph 3, the scale is on the left; for microphotographs 1, 2, 4 and 5, the scale is on the right

Plain (Kosinskaya, 1960; Luknitskaya, 2006; Anissimova, 2017), known from the Middle Cis-Urals (Martynenko & Boronnikova, 2016; Martynenko, 2017) and West Siberia (Kosinskaya, 1960; Naumenko & Gidora, 2017; Naumenko 2019; Shakhmatov & Pavlovskiy, 2019). G. distr.: **w**idespread in both Northern and Southern Hemispheres.

Micrasterias truncata Brébisson ex Ralfs, 1848 (Fig. 4, 5) – Dim.: 96.8–111.7 × 94.9–112.5 µm, polar lobe 65.1–73.9 µm wide, isthmus 24.7–26.8 µm wide. Descr.: cells from elliptical to almost circular in outline with deep, closed in the most part sinus. Semi-cells with well-developed lateral lobes divided to the second order. Polar lobe is slightly concave, with 1–2 short thick spines on the angles. Cell wall is smooth. Loc.: Lake Boevskoye No 1(2); Lake Travyanoye No 10(1). Hab.: peat bogs with *Sphagnum*, mesotrophic lakes and fens. Common at pH 4.5–7. Distr.: recorded in the Subpolar (Voronikhin, 1930) and South (Snitko & Snitko, 2017) Urals. Widespread in the most part of the East European Plain (Kosinskaya, 1960; Luknitskaya, 2006; Anissimova, 2017), known from the Middle Cis-Urals (Martynenko, 2017) and West Siberia (Kosinskaya, 1960; Naumenko, 2019). G. distr.: widespread in both Northern and Southern Hemispheres.

RESULTS AND DISCUSSION

The worldwide diversity of the genera *Euastrum* and *Micrasterias* is about 189–265 and 56–75 species, respectively (Gontcharov, 2008; Guiry, 2013). Despite the large number of species, these groups are poorly represented in the Ural Mountains. To date, only 27 *Euastrum* and 16 *Micrasterias* species have been recorded in the Urals. The highest number of the *Euastrum* and *Micrasterias*, namely 15 and 8 species and sub-specific taxa, respectively, have been found in water bodies and wetlands of the Polar Urals (Briškaitė et al., 2016; Patova & Demina, 2007, 2008; Voronikhin, 1930). Smaller number of species are known from the Subpolar (14 *Euastrum and* 4 *Micrasterias*) and Southern (6 *Euastrum and* 10 *Micrasterias*) Urals (Snitko & Sergeeva, 2003; Snitko, 2009; Snitko & Snitko, 2017; Sterlyagova, 2008; Voronikhin, 1930; Yarushina et al., 2004). Middle Urals has up to date the lowest diversity – 8 *Euastrum* and 4 *Micrasterias* species (Bogdanov et al. 2007; Korde, 1949; Shakhmatov, 2014; Shakhmatov, 2017).

In the current study, nine taxa (eight species and one variety) that belong to the genus *Euastrum* and eight taxa from the genus *Micrasterias* were found in the studied lakes. Four species (*Euastrum germanicum*, *E. verrucosum* var. *alatum*, *Micrasterias fimbriata*, *M. mahabuleshwarensis* var. *wallichii*) were discovered within the Ural Mountains Region for the first time. These species along with *Euastrum verrucosum*, *Micrasterias americana*, *M. furcata M. truncata* have not been previously found in Middle Urals.

The species of the *Euastrum* and *Micrasterias* were found only in five lakes – Boevskoye, Tenyak, Cherkaskul, Bolshoye Yamskoye and Travyanoye, where the fen habitats are most developed. However, these reservoirs were not equally rich in the species composition of the studied genera. The highest similarity level (42.8%) of the *Euastrum* and *Micrasterias* species composition was observed in Lakes Boevskoye and Tenyak. These lakes were the most species rich: in the first one, five species of the *Euastrum* and all eight species of the *Micrasterias* were found, while from the second lake, three species of the *Euastrum* and four species of the *Micrasterias* were reported. It is noteworthy that almost all taxa found in these two lakes perform a fairly high abundance, with the exception of three species – *Euastrum bidentatum*, *Micrasterias crux-melitensis* and *M. fimbriata*. Lake Cherkaskul has a significantly lower level of similarity (18.8%) with the afore-mentioned water reservoirs; three species of the *Euastrum* and four species of the *Micrasterias* were found in it. Only *Euastrum germanicum* had its highest abundance in this lake. The lowest similarity with other studied water reservoirs was observed in Lakes Bolshoye Yamskoye and Travyanoye, where only two *Euastrum* and two *Micrasterias* species were found, respectively.

The assessment of the influence of such important for desmid algae physicochemical parameters as water temperature and pH (Brook, 1981) showed that the effect of temperature was not significant, but pH significantly (CCA, $p = 0.01$, pseudo-F = 1.7) explained 30% of the data variability. The most abundant species prefer neutral to slightly acidic water, which is consistent with literature data on their ecology (Kosinskaya, 1960; Coesel & Meesters, 2007; Šťastný, 2010; Anissimova, 2017; Naumenko, 2019) (Fig. 5). Preference of slightly acidic and neutral values of pH by the studied taxa partly clarifies their absence in other studied lakes, where pH values ranged from 8 to 9.

In parallel with the assessment of the influence of physicochemical factors, the analysis of habitat preferences of the detected algae was carried out. Based on the results presented in Fig. 5, some of the species were attributed to the inhabitants of plankton (*Euastrum germanicum*, *E. oblongum* and *Micrasterias crux-melitensis*), some were associated both with plankton

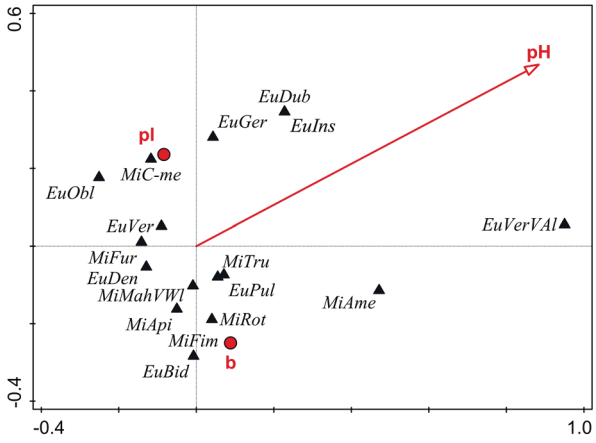

Fig. 5. CCA biplot describing the abundance of the *Euastrum* and *Micrasterias* species in relation to pH and habitats (pl – planktonic, b – benthic). Abbreviations of species include the first two letters of a genus, three letters of species names, and two letters of a variety name

and benthos (*Euastrum cf. denticulatum*, *E. verrucosum* and *Micrasterias furcata*), whereas most of the species were found predominantly in benthic habitats.

Comparison of the investigated flora with literature data on different parts of the Ural Mountains (Fig. 6) showed a low similarity level ranging from 21% with the species composition of the genera in the Polar Urals to 38% with the floras of the Middle and Polar Urals. Moreover, the similarity of the species composition between different parts of Ural Region was also low (from 11 to 35%). Nevertheless, such level of similarity may be explained rather by a poor knowledge of algal floras than by its peculiarities, especially considering the fact that most of the algae found in the Ural Mountains are widely distributed around the world from equatorial to Polar Regions.

Summing up, the *Euastrum* and *Micrasterias* flora of the studied reservoirs consists mostly of acidophilic and benthic species, which is characteristic of the algae under consideration. However, the significant number of species recorded for the first time in the territory of the Ural Mountains and particularly in Middle Urals points to the fact that algal flora of the region is still quite poorly investigated.

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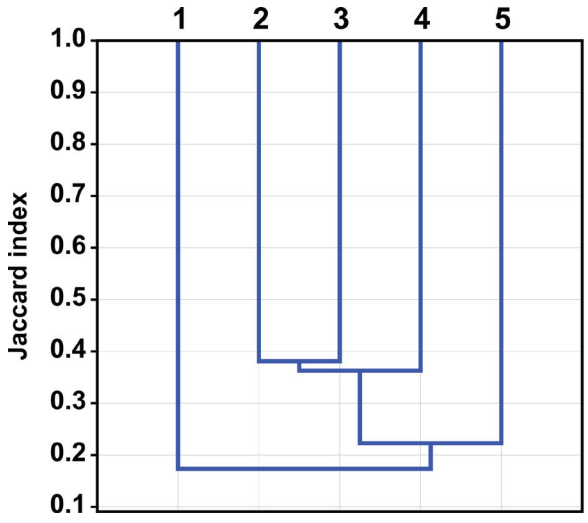

	1	2	3	4	5
1		0,17	0,32	0,13	0,18
2	0,17		0,38	0,11	0,35
3	0,32	0,38		0,21	0,38
4	0,13	0,11	0,21		0,24
5	0,18	0,35	0,38	0,24	

Fig. 6. Dendrogram and matrix (the Jaccard index) showing similarity of the identified *Euastrum* and *Micrasterias* flora (3) with literature data on the South (1), Middle (2), Subpolar (4) and Polar (5) Urals

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EUASTRUM IR *MICRASTERIAS* (CHAROPHYTA, DESMIDIALES) GENČIŲ DVYNIEČIAI VIDURIO URALO (RUSIJA) PIETINĖS DALIES EŽERUOSE

Andrei S. Shakhmatov

Santrauka

Floristinio dvyniečių tyrimo metu Vidurio Uralo pietinės dalies ežeruose buvo aptiktos devynios *Euastrum* genties ir aštuonios *Micrasterias* genties rūšys ir vidurūšiniai taksonai. Jų tarpe, keturi taksonai (*Euastrum germanicum*, *E. verrucosum* var. *alatum*, *Micrasterias fimbriata*, *M. mahabuleshwarensis* var. *wallichii*) buvo pirmą kartą aptikti Uralo regione, tuo tarpu kitos keturios rūšys (*Euastrum verrucosum*, *Micrasterias americana*, *M. furcata* and *M. truncata*) – naujos Vidurio Uralo regionui. Rūšių prieraišumo buveinės atžvilgiu įvertinimui atlikta kanoninė korespondencijos analizė parodė, kad dauguma rūšių gausiau vystėsi silpnai rūgštiniuose ežeruose ir vyravo bentoso buveinėse.