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Desmid algae of some water reservoirs in the upper part of the Pyshma river basin, Russia

Десмидиевые водоросли некоторых водоёмов верхней части бассейна реки Пышмы, Россия

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Summary. The study of floristic composition of desmid algae (Desmidiales) has been undertaken in previously unexplored water bodies (Lake Chernobrovskoye, Mokhovoye fen, Chayach'ye fen, Shishevskoye fen, a pond on the Loginovka River), located in the upper part of the Pyshma River basin on the territory of the Middle Urals eastern macroslope. Ten species belonging to the genera *Closterium* (*Cl. acerosum*, *Cl. cornu*, *Cl. leibleinii*, *Cl. moniliferum*, *Cl. rostratum*, *Cl. sublaterale*), *Cosmarium* (*C. obtusatum*, *C. punctulatum*) and *Staurastrum* (*S. polymorphum*, *S. striatum*) were recorded. Based on the analysis of habitat preferences and seasonal dynamics of Desmidiales, it was assumed that eutrophication due to the runoff into water bodies from agricultural lands along river banks is a reason for the low species diversity. The oligo-mesotrophic species (*Closterium cornu*) recorded in Chayach'ye fen is possibly extant since a less eutrophicated stage. The discovery of 3 new species for the eastern macroslope of the Middle Urals (*Closterium sublaterale*, *Cosmarium obtusatum*, *Staurastrum striatum*) indicates a poor knowledge of the region from a phycofloristic point of view.
Key words. Affected water bodies, Beloyarsk district, biodiversity, Sverdlovsk oblast.

Реферат. Статья посвящена изучению флористического состава десмидиевых водорослей (Desmidiales) в ранее не изученных водоёмах (Озеро Чернобровское, Моховое болото, Чаячье болото, Шимовское болото, пруд на реке Логиновке), расположенных в верхней части бассейна реки Пышмы на территории восточного макросклона Среднего Урала. По итогам исследования было обнаружено 10 видов, принадлежащих родам *Closterium* (*Cl. acerosum*, *Cl. cornu*, *Cl. leibleinii*, *Cl. moniliferum*, *Cl. rostratum*, *Cl. sublaterale*), *Cosmarium* (*C. obtusatum*, *C. punctulatum*) и *Staurastrum* (*S. polymorphum*, *S. striatum*). На основании анализа экологической структуры и сезонной динамики выявленной флоры (доминируют эвтрофные и мезо-эвтрофные виды, мезотрофные отличаются меньшим обилием) высказано предположение, что малое число видов обусловлено эвтрофикацией, вызванной поступлением в водоёмы стоков с расположенных по их берегам сельскохозяйственных полей. Обнаруженный в Чаячьем болоте олиго-мезотрофный вид (*Closterium cornu*), возможно, является реликтом, сохранившимся с менее нарушенной стадии существования водоёма. Находка 3 новых для восточного макросклона Среднего Урала видов (*Closterium sublaterale*, *Cosmarium obtusatum*, *Staurastrum striatum*) свидетельствует о недостаточной изученности региона с альгофлористической точки зрения.
Ключевые слова. Белоярский район, биоразнообразие, нарушенные водоёмы, Свердловская область.

Introduction. The upper part of the Pyshma River basin is located in the south of the Middle Trans-Uralean province of the Middle Urals eastern macroslope (Chibilyov, Chibilyov, 2012). This territory is extremely rich in water bodies of various origins and trophic status. Most of the water bodies are lowland fens and shallow mesotrophic and meso-eutrophic lakes with a water surface area less than 1 km^2 (Andreeva, 1973). The developed hydrographic network creates necessary conditions for the formation of the rich Desmidiales flora (Brook, 1965). However, despite of it, this territory is almost completely deprived of the attention of phycologists: special studies were carried out exclusively on the economically important Beloyarsk reservoir.

In this work, which aims to expand knowledge on the species composition of desmid algae in the area under consideration, we present the results of phycofloristic studies in 5 previously unexplored water bodies.

Materials and methods. The study was carried on 5 different-type water bodies (fig. 1): one lake (Chernobrovskoe Lake), 3 fens of limnogenic origin (Mokhovoye fen, Chayech'ye fen and Shishimskoye fen) and one artificial pond on Loginovka river. The vegetation of the water bodies was represented by several species of sedges (*Carex acuta* L., *C. vesicaria* L.), thickets of cattail (*Typha latifolia* L.), reed (*Phragmites australis* (Cav.) Trin. ex Steud.), as well as clumps of willow (*Salix* sp.), birch (*Betula pubescens* Ehrh.) and pine (*Pinus sylvestris* L.) along the banks. All water bodies are surrounded by agricultural lands actively used for growing rye and corn.

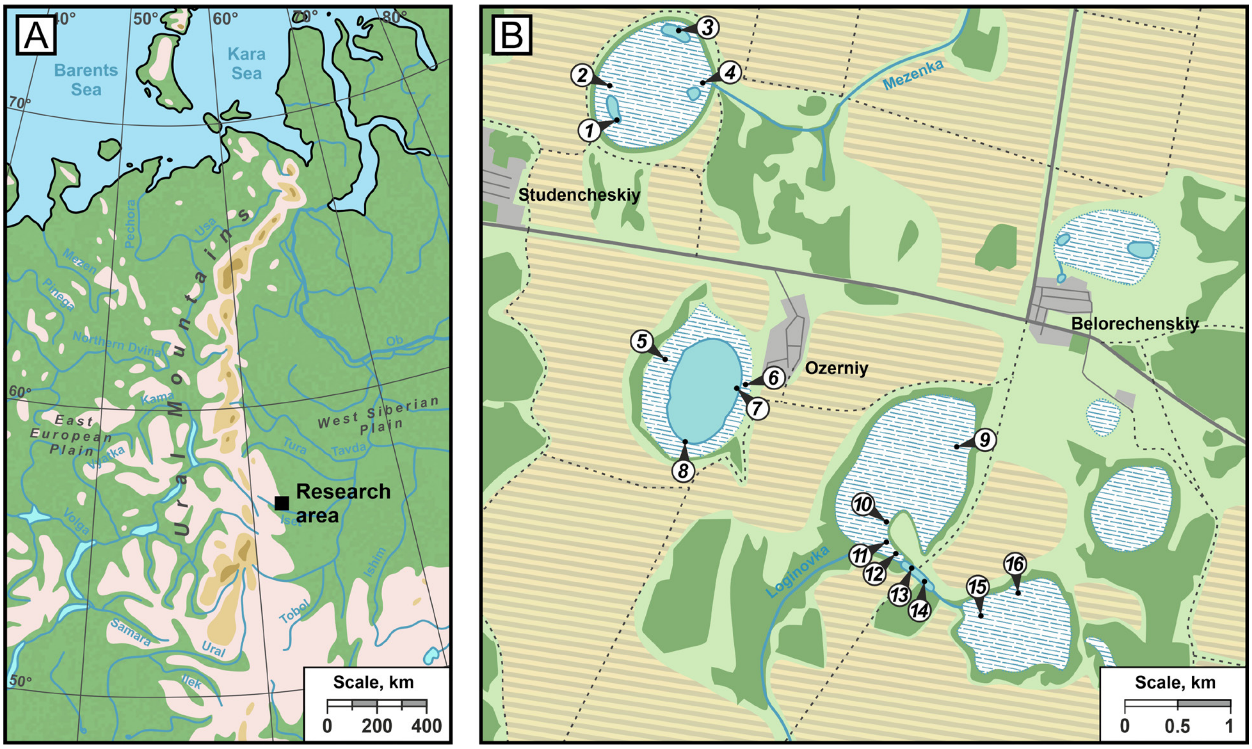

Fig. 1. Location of the research area in the Ural Mountains (A) and sampling sites in the studied water bodies (B): 1–4 – Mokhovoye fen, 5–8 – Chernobrovskoe Lake, 9–12 – Chayach'ye fen, 13–14 – pond on Loginovka river, 15-16 – Shishevskoye fen.

The sampling was conducted in the period from May to September 2014, using an Apstein plankton net with a 20 µm mesh size. In parallel with the collection of samples, the temperature and pH of water was measured using a portable pH-meter Milwaukee pH55 Martini. However, only the temperature was a subject to changes (10–15 °C in May, 18–24 °C in June, 15–29 °C in July, 16–20 °C in August and 9–11 °C in September), while the pH in all water bodies for the whole study period remained between 6.8–7.

The live algal samples were studied under a light microscope Levenhuk 320 and a digital camera Levenhuk C310 NG. Cell measurements were made using ToupView v.3.7 software. Species identification was performed using flora books (Kosinskaya, 1960; Coesel, Meesters, 2007). Taxa names is given according to the Algaebase (Guiry, Guiry, 2023).

List of species. The following annotated list provides 10 desmid species from Closteriaceae and Desmidiaceae families recorded in studied water bodies. Abbreviations used: **Loc**. – location, where the species was recorded (fig. 1B) with abundance estimation according to a 6-point scale given in brackets (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); **Dim**. – cell dimensions; **Descr**. – short description. Records of species new to region is marked with an asterisk (*).

Familia Closteriaceae Bessey

Closterium acerosum Ehrenberg ex Ralfs (Fig. 2: 1-2) – **Loc.:** 14 (2), 15 (2). **Dim.:** 278.8–413.4 × 54.5–61.4 µm, ends 11.8–11.9 µm wide. **Descr.:** cells almost straight, with a smooth colorless cell wall and truncate ends. Apical vacuoles contain numerous small crystals. Chloroplasts stelloid, with 4 visible ridges and 9 pyrenoids arranged in axial row. **Hab.:** eutrophic, acidic to alkaline.

Closterium cornu Ehrenberg ex Ralfs (Fig. 2: 3) – **Loc.:** 14 (1). **Dim.:** 202.6 × 11.8 μm, ends 3.9 μm wide. **Descr.:** cells almost straight, with a smooth colorless cell wall and narrowly rounded ends. Apical vacuoles contain 1 large crystal. Chloroplasts stelloid, with 1 visible ridge and 5 pyrenoids arranged in axial row. **Hab.:** oligo-mesotrophic, acidic.

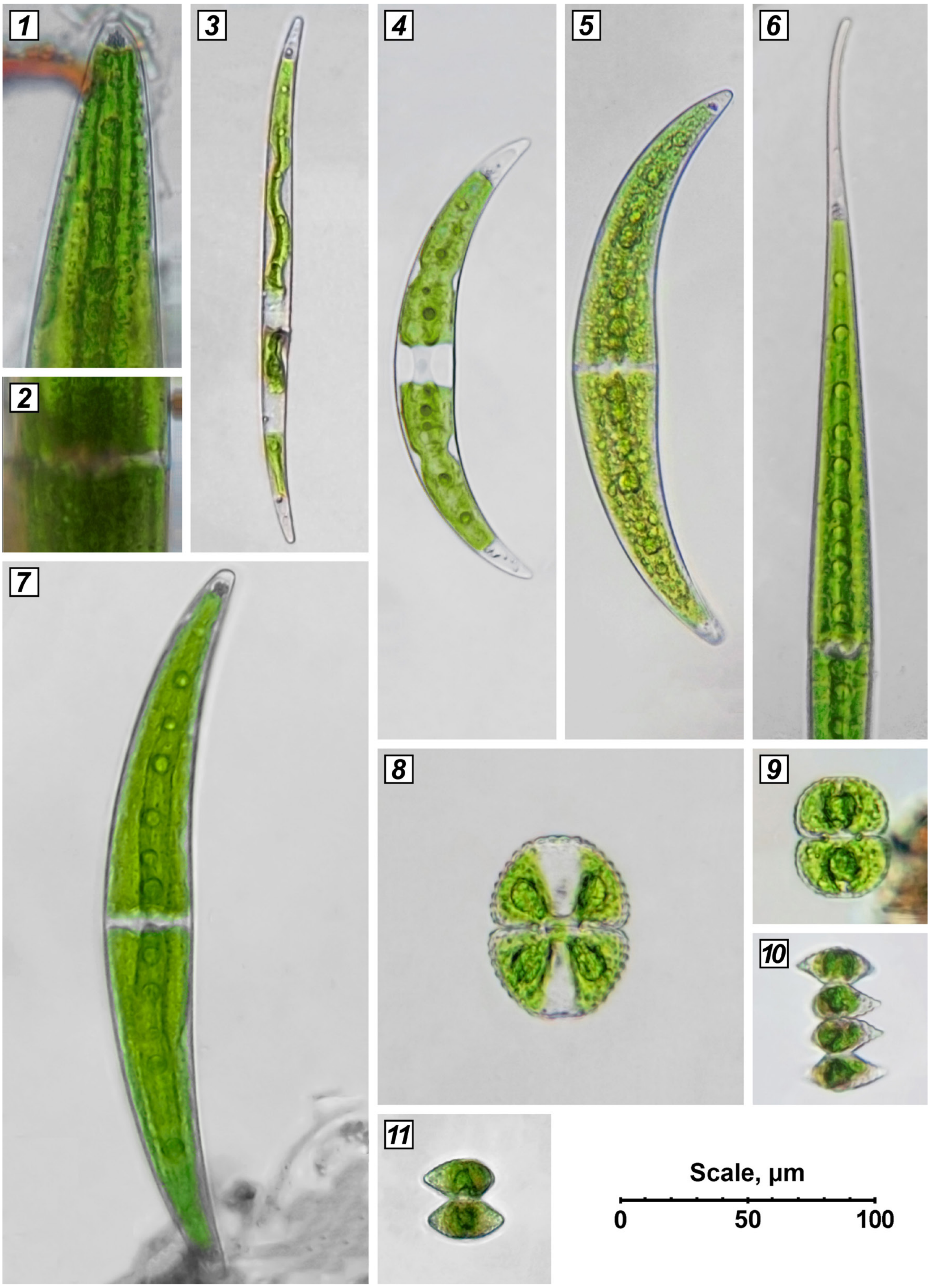

Fig. 2. Desmids recorded in the studied water bodies: 1–2 – *Closterium acerosum*, 3 – *Cl. cornu*, 4 – *Cl. leibleinii*, 5 – *Cl. moniliferum*, 6 – *Cl. rostratum*, 7 – *Cl. sublaterale*, 8 – *Cosmarium obtusatum*, 9 – *C. punctulatum*, 10 – *Staurastrum polymorphum*, 11 – *S. striatum*.

Closterium leibleinii Kützing ex Ralfs (Fig. 2: 4) – **Loc.:** 12–15 (3). **Dim.:** 169.4–210.6 × 17.8–25.4 μm, ends 4.1–6.2 μm wide. **Descr.:** cells moderate curved (up to 119–125°), with smooth colorless cell wall and acute ends. Apical vacuoles contain several small crystals. Chloroplasts stelloid, with 1 visible ridge and 2–5 pyrenoids arranged in axial row. Hab.: eutrophic, circumneutral to alkaline.

Closterium moniliferum Ehrenberg ex Ralfs (Fig. 2: 5) – **Loc.:** 1 (3), 4 (3), 12–15 (3). **Dim.:** 226.3–273.8 × 32.6–39.0 μm, ends 7.1–8.1 μm wide. **Descr.:** cells moderate curved (up to 64–6°), with smooth colorless cell wall and broadly rounded ends. Apical vacuoles contain numerous small crystals. Chloroplasts stelloid, with 2 visible ridges and 4-9 pyrenoids arranged in axial row. **Hab.:** meso-eutrophic, slightly acidic to alkaline.

Closterium rostratum Ehrenberg ex Ralfs (Fig. 2: 6) – **Loc.:** 14 (1). **Dim.:** 475.9 × 25.2 μm, ends 4.7 μm wide. **Descr.:** cells almost straight, fusiform in midregion and with ends attenuated in long horn-like processes. Cell wall striate and colorless. Apical vacuoles contain several small crystals. Chloroplasts stelloid, with 1 visible ridge and 10 pyrenoids arranged in axial row. **Hab.:** mesotrophic, acidic.

****Closterium sublaterale*** Ruzicka (Fig. 2: 7) – **Loc.:** 13–15 (3). **Dim.:** 293.8–337.2 × 37.4–41.6 μm, ends 8.1–10.3 μm wide. **Descr.:** cells slightly curved (up to 39–53°), with slightly striate colorless cell wall and roundly truncated ends. Apical vacuoles contain numerous small crystals. Chloroplasts stelloid, with 2 visible ridges and 7–9 pyrenoids arranged in axial row. **Hab.:** mesotrophic, slightly acidic to slightly alkaline.

Familia Desmidiaceae Ralfs

****Cosmarium obtusatum*** (Schmidle) Schmidle (Fig. 2: 8) – **Loc.:** 7 (2), 9 (2). Dim.: 68.67–71.07 × 54.5–54.8 μm, isthmus 18.0–19.5 μm wide. **Descr.:** cells roundly hexagonal in outline with deep linear sinus. Semicells trapezoidal with crenate margins. Cell wall covered by several intramarginal rows of granules. Chloroplasts furcoid, tetracentric. **Hab.:** meso-eutrophic, slightly acidic to alkaline.

Cosmarium punctulatum Brébisson (Fig. 2: 9) – **Loc.:** 7 (1). **Dim.:** 46.9 × 36.83 μm, isthmus 13.39 μm wide. **Descr.:** cells square-shaped in outline with deep linear sinus. Semicells with broadly rounded angles and slight inflation in median part. Cell wall covered by longitudal rows of small granules. Chloroplasts furcoid, monocentric. **Hab.:** meso-eutrophic, slightly acidic to alkaline.

Staurastrum polymorphum Brébisson in Ralfs (Fig. 2: 10) – **Loc.:** 7 (3). **Dim.:** 27.6–28.2 × 31.86–35.3 μm (without processes 18.8–18.4 wide), isthmus 9.9–10 μm wide. **Descr.:** cells with almost parallel processes with 3 small spines on the ends. Semicells cup-shaped, 3-radiate in apical view. Sinus widely open with acute apex. Cell wall covered by concentric rows of small granules on processes. Chloroplasts furcoid, monocentric. **Hab.:** mesotrophic, acidic.

****Staurastrum striatum*** (West et G.S. West) Ruzicka (Fig. 2: 11) – **Loc.:** 13–14 (3). **Dim.:** 19.4–19.8 × 18.5–18.9 μm, isthmus 6.9–7.9 μm wide. **Descr.:** Cells without processes. Semicells rhomboid, 3-radiate in apical view, with roundly truncated angles. Sinus widely open with acute apex. Cell wall covered by concentric rows of small granules around semicell angles. Chloroplasts furcoid, monocentric. **Hab.:** mesotrophic.

Results and discussion. The lakes and fens of the south-eastern part of Middle Urals have a high richness of desmid algae (Shakhmatov, 2015). We expected that the studied reservoirs are not an exception. However, as a result of research, we found only 3 species in Chernobrovskoe Lake, 1 in Mokhovoye fen, 3 in Chayach'ye fen, 4 in Shishevskoye fen and 7 in the pond on Loginovka River.

An analysis of the habitat preferences of the identified species revealed that the most species were indifferent to pH (only two acidophilic species were found – *Closterium cornu* and *Cl. rostratum*). In relation to the trophic status, desmid communities were dominated by the eutrophic (*Closterium acerosum*, *Cl. leibleinii*) and meso-eutrophic (*Closterium moniliferum*, *Cosmarium obtusatum*, *C. punctulatum*) species. Mesotrophic species (*Closterium rostratum*, *Cl. sublaterale*, *Staurastrum polymorphum*, *S. striatum*), which also present in communities are slightly less abundant. Noteworthy is a single record of an oligo-mesotrophic species (*Closterium cornu*) in Chayach'ye fen.

Observations of the seasonal dynamics of algal flora in the studied reservoirs similarly showed remarkable results. The desmid algae were observed mostly from May to the end of June. In mid-July desmids completely disappeared and were replaced by an abundance of euglenoids (*Phacus orbicularis* Hübner, *Lepocinclis spirogyroides* B.Marin et Melkonian) as well as blue-green (*Aphanizomenon flos-aquae* Ralfs ex Bornet et Flahault) and zygnematalean algae (*Spirogyra* sp., *Mougeotia* sp.), which coincided with the application of fertilizers to the surrounding fields.

We assume that the discovered poverty of the Desmidiales species composition is caused by habitat disturbance, with the main disturbing factor a water eutrophication through the runoff from agricultural fields, which is indirectly confirmed by changes in the community structure. According to P. F. M. Coesel (1975), communities of desmid algae, containing less than 10 taxa and composed simultaneously of eutrophic, mesotrophic and oligotrophic species, are characteristic of heavily disturbed water bodies. At the same time, mesotrophic and oligotrophic species are considered as «relics» of less disturbed conditions. Strong eutrophication is also evidenced by the dominance of species of *Closterium* and *Staurastrum* both in terms of the number of species and their abundance (Coesel, 1982).

Despite the obvious poverty of the recorded flora, 3 species (*Closterium sublaterale*, *Cosmarium obtusatum*, *Staurastrum striatum*) were found on the territory of the Middle Urals eastern macroslope for the first time. However, this fact indicates rather a poor study of the region from a phycofloristic point of view.

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