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Cosmarium tutum nom. nov. a new name for *Cosmarium perforatum* var. *skujae* (Charophyta, Desmidiaceae), a rare taxon newly found in Ukraine

IRYNA SHYNDANOVINA
Laboratory of preservation and biodiversity renewal, Institute for evolutionary ecology NAS of Ukraine, 03143, Kiev, 37 Lebedeva str., Ukraine, tel.:+38 044 526 20 51, fax +38 044 526 19 18.
i.shindanovina@gmail.com; https://orcid.org/0000-0002-5683-4894

> "I conceive, then, that the ultimate forms in this group which the waters present should be considered as species, and each coupled with its name."
> —William Archer (1830–1897)

Abstract

The flora of Chernihiv Polissya (northern Ukraine) is rich in rare taxa of desmids. One of these taxa is *Cosmarium perforatum* var. *skujae* Grönblad, the eighth documented occurrence of this taxon in Europe. Based on observations over several years, the morphology and taxonomy of *C. perforatum* var. *skujae* is discussed comparing it to the type variety *C. perforatum* var. *perforatum* living in the same habitat. Distinct morphological characters and differences in variability between these closely affiliated taxa are grounds for elevating *C. perforatum* var. *skujae* to the status of an independent species. In order to avoid homonymy with *Cosmarium skujae* Willi Krieger & Gerloff, a new name, *Cosmarium tutum* is proposed for this taxon.

Keywords: Chernihiv Polissya, Desmidiaceae, morphology, quarry pond, taxonomy, variability

Introduction

Whilst making a detailed study of desmids in Chernihiv Polissya (a woodland area with lots of marshy scrub situated in northern Ukraine) over several years, I found cells of the rare taxon *Cosmarium perforatum* var. *skujae* Grönblad (1945: 56) together with the type variety of *C. perforatum* P.Lundell (1871: 40), sometimes in the same sample drop. The type variety of *C. perforatum* is a rare species that was reported in thirteen countries of Europe. Only five findings of this taxon in Ukraine were reported so far (Palamar-Mordvintseva 2005: 161). My finding is the sixth one over the period of 130 years.

Starting from the early reportings of *C. perforatum* var. *perforatum* there appears to be more drawings that differ from the drawing of P.Lundell (1871: plate II, f. 16): Wolle (1885: plate XLVII, f. 32); Comère (1901: plate VII, f. 50); Conn et Webster (1908: plate XXXVIII, f. 249); Gistl (1926: plate XXVII, f. 9); Hübler (1926: plate 6, f. 16); Prescott (1938: plate II, f. 6), then those that are similar to it: Eichler (1890: plate VIII, f. 24); West and West (1905: plate LVIII, f. 4–5); Migula (1907: plate XXIII F, f. 4); Messikommer (1943: plate IX, f. 3). In the drawing done by Franken (1933: plate 8, f. 4) there are face, side and apical views of the cell similar to the iconotype and five more outlines of the cells varying from the drawing of P.Lundell (1871: plate II, f. 16).

The first author, who indicated variability of *C. perforatum* var. *perforatum* and the arising problem of identification of this taxon, was Gistl (1926: p. 469–470). Further Grönblad (1960: p. 40) considered it questionable "whether distinct taxa really can be maintained" because of "numerous intermediate forms" and even dichotypical cells.

Currently there are three taxonomically accepted varieties of *Cosmarium perforatum*: var. *porosum* Gutwinski (1890: 48), it was reported only once in Austria by Mugula (1907: 419), *C. perforatum* var. *rauchii* Ducelier (1918: 139–140), reported in five countries of Europe, and *C. perforatum* var. *skujae* Grönblad (1945: 56) reported in seven countries of Europe. Two of these varieties were found in Ukraine: var. *porosum* Gutwinski 1890 (former Austria-Hungary, now Ukraine), and var. *skujae*, first found by me in Chernihiv Polissya (northern Ukraine).

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On examining cells of var. *skujae* and type variety, distinct differences were observed, giving rise to a more detailed study of their morphological variability.

Materials and methods

Locality:—a group of ponds situated in Chernihiv Polissya (northern Ukraine). Originally these ponds were quarries for extracting sand with high silicon dioxide content used for glass industry. They are situated on the north of Chernihiv oblast on the boarder of eutrophic wetland Zamglay that is protected landscape area. Five ponds were sampled in total:

- Golube, Chorne and Zelene—former quarry ponds located two kilometres north of Oleshnya village, Chernihiv oblast, Ripky region, Ukraine;
- Zavodske—former quarry pond located two hundred meters east of Zavodske village, Chernihiv oblast, Ripky region, Ukraine;
- Quarry—part of working quarry, where excavations are finished. Located two kilometres north of Hrybova Rudnya village, Chernihiv oblast, Ripky region, Ukraine.

The samples were taken from the euphotic zone of the ponds at a maximum depth of a meter by scraping off periphyton from dead and live plants and by squeezing water plants floating on the water surface (*Hydrocharis*, *Ceratophyllum*, *Phragmites,* etc.). *Cosmarium perforatum* var. *skujae* was found in five quarry ponds, No 1–5 (Table 1) and *C. perforatum* var. *perforatum* was found in three of five ponds, No 1, 2 & 4 (Table 1). The main identification references were: *Identification manual of the freshwater algae of Ukrainian RSR* (Palamar-Mordvintseva 1986), *Desmidiaceenflora von Österreich* (Lenzenweger 1999), and *A Practical Guide to the Desmids of the West of Ireland* (John & Williamson 2009).

TABLE 1. Location and ecological variables of investigated quarry ponds.

№	Name	GPS, (N/E)	Area, (m2)	pH	EC, µS.cm-1	Last sampling date	Specimen No
1	Golube	51.964 / 31.168	153525	7,2–7,7	72–74	03.09.2019	19–132
2	Chorne	51.968 / 31.159	24089	7,5–8,1	73–71	03.09.2019	19–134
3	Zelene	51.972 / 31.161	37900	9,5–10,1	55–56	03.09.2019	19–133
4	Zavodske	51.963 / 31.186	8625	7,5–7,7	36–38	03.09.2019	19–128
5	Quarry	51.969 / 31.100	36709	7,9–8,2	69–80	03.09.2019	19–137

The samples were fixed with 4% Formalin. Some preliminary study was done using live samples. Zeiss Primo Star microscope (samples of 2007–2010) and Olympus BX-51 microscope (samples of 2018, 2019) were used for examination. Photos were made with Canon EOS 1000D and Canon IXUS 850 IS. The photographs were prepared using Adobe Photoshop program. The cells were measured using ocular micrometre. To measure pH and conductivity, the EZODO 8200M was used.

Results

Cosmarium tutum Shyndanovina *nom. nov. et stat. nov.*

Replaced name: *Cosmarium perforatum* var. *rotundata* Skuja *Acta Hort. Bot. Univ. Latv.* 3: 164, pl. IV: figs 4, 5, 1928, *nom. illeg*., *non Cosmarium perforatum* var. *rotundatum* (*'rotundata'*) Børgesen *Vid. Medd. Naturh. For. Kjøbenhavn* 51: 327, no fig., 1899.

Homotypic synonym: *Cosmarium perforatum* var. *skujae* Grönblad *Memoranda Societatis pro Fauna et Flora Fennica* 21 p. 56, pl. I, figs 10–11, 1945.

Type locality: Sidrabezers [Sudrabezers Lake], near Riga, Latvia.

Lectotype (here designated, iconotype): *Acta Hort. Bot. Univ. Latv.* 3: 164, pl. IV: figs 4, 5, 1928.

Note: the name *skujae* is already present in *Cosmarium skujae* Willi Krieger & Gerloff (1965: 238). Given the nomenclatural confusion surrounding the name *rotundatum* (*'rotundata'*) and that names only have priority in their own rank, it is best to give this taxon a new name.

Etymology: "*tutus, -a, um*" is a Latin adjective meaning "safe, prudent, secure, protected, covered". This species is marked by an outer, semi-pellucid wall layer; external parts of pore channels look like small cylinders with an opening at the top (Fig. 1 A, E) and thus the cell looks like it is protected by them. Moreover, the word "*tutu",* (plural *"tutus*") is found in most European languages meaning a ballet skirt that is usually made of white semi-pellucid fabric bringing to mind the outer layer of this cell wall.

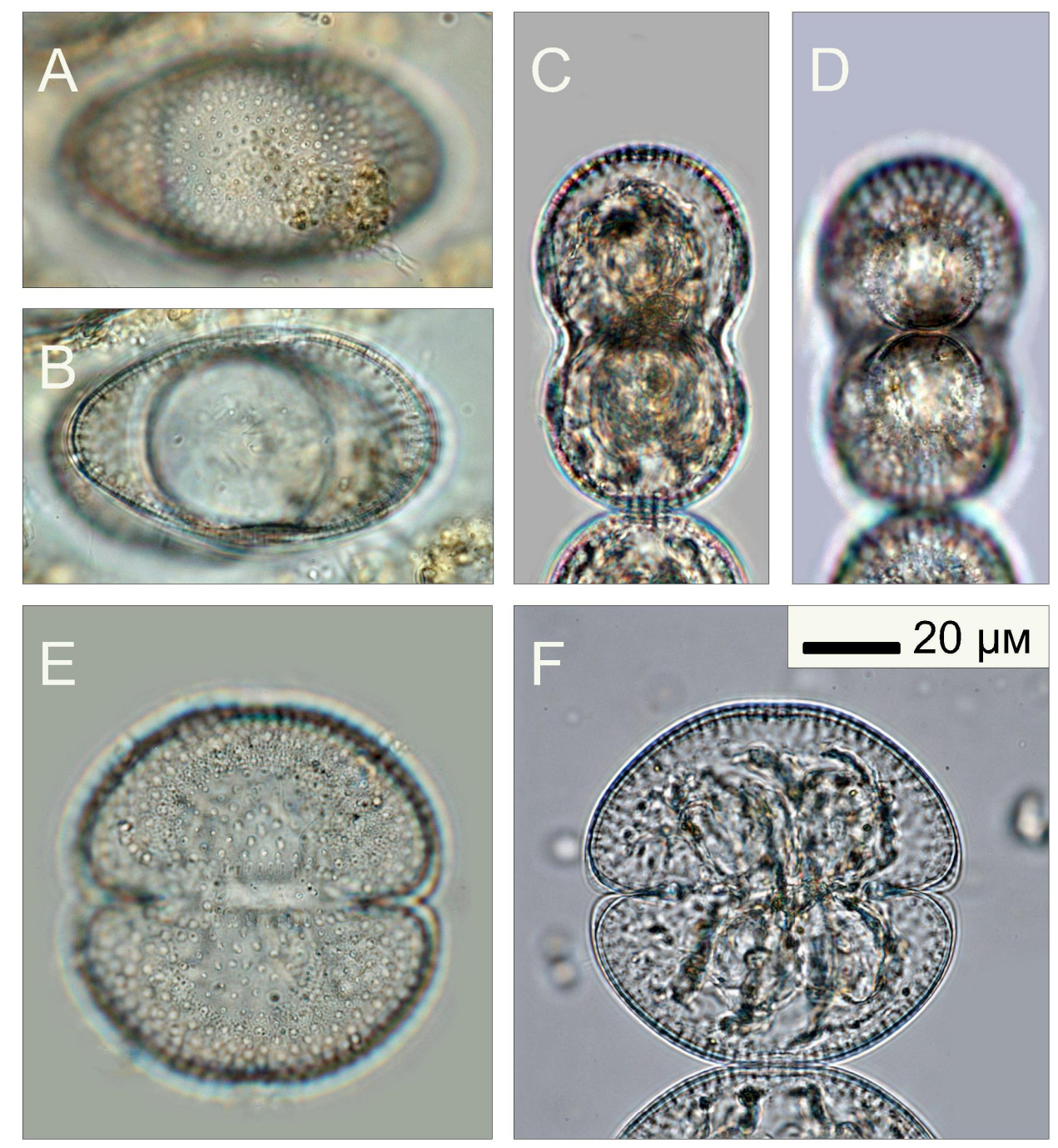

FIGURE 1. Photographs of *Cosmarium tutum* outline (**B, C, F**) and ornamentation (**A, D, E**). Scale bar: 20 µm (**A–F**). (Photos by Shyndanovina I.)

Discussion

Ecology and distribution in Europe

Ukrainian cells of *Cosmarium tutum* were for the first time found in Chernihiv Polissya, in 2005 Shyndanovina (2011). Quarry ponds, where it was found, were periodically sampled subsequently in 2006, 2007, 2008, 2010, 2018 and 2019, including winter samples collected under the layer of ice. In most cases *C. tutum* was found living in the same habitat as *C. perforatum* var. *perforatum* among species such as *Actinotaenium turgidum* (Brébisson ex Ralfs) Teiling (1954: 395); *Cosmarium pachydermum* P.Lundell (1871: 39) var. *pachydermum; Cosmarium obtusatum* (Schmidle) Schmidle (1898: 38) var. *obtusatum*; *Cosmarium margaritatum* (P.Lundell) J.Roy & Bisset (1886: 194) var. *margaritatum*; *Cosmarium angulare* L.N.Johnson (1894: 290) var. *angulare*; *Gonatozygon aculeatum* W.N.Hastings (1892: 29) var. *aculeatum*; *Micrasterias americana* Ehrenberg ex Ralfs (1848: xix) var. *americana*; *Micrasterias apiculata* Meneghini ex Ralfs (1848: 209) var. *apiculata*; *Micrasterias crux-melitensis* Ralfs (1848: 73) var. *crux-melitensis*; *Micrasterias furcata* C. Agardh ex Ralfs (1848: 73) var. *furcata*; *Pleurotaenium coronatum* (Brébisson) Rabenhorst (1868: 143) var. *coronatum*; *Pleurotaenium simplicissimum* Grönblad (1920: 27) var. *simplicissimum*; *Xanthidium antilopaeum* Kützing (1849: 177) var. *antilopaeum* (see Shyndanovina 2018, 2019).

Recordings of *C. tutum* from Europe are scarce. Since 1928 it has been reported and illustrated (without taking checklists into consideration) only by 5 authors in 7 countries (Fig. 2) with only 5 original drawings from Europe so far**.**

Cosmarium tutum was reported for the first time in Latvia by Skuja and published in 1928 under the name of *C. perforatum* var. *rotundata* (Skuja 1928: p. 164, plate IV: f. 4–5), an illegitimate name. For the type variety, Skuja indicated the following differentiating characters of var. *rotundata*: larger cell size, closed sinus, more rounded basal angles, scrobicles in central part of cell face of bigger size but in less quantity (20). The drawings made by Skuja represent only face and apical views, and only one cell wall layer is indicated. A double cell wall layer was described for the first time by Grönblad (1945), who found this variety in Finland and changed its name from var. *rotundata* to var. *skujae* as the name *C. perforatum* var. *rotundata* was already occupied (Børgesen 1899). Grönblad mentions a "hyaline outer membrane" covering the cell and underlines that the cell-wall is of "quite a different nature" (Grönblad 1945: 57–58). This outer wall layer is also shown in his drawing. However, a side view is lacking.

Skuja (1949: plate XXVIII, drawing 11) illustrated var. *skujae* (*Cosmarium tutum*) from Burmese (Myanmar) material with apical and side views but with an open sinus. Apical view and sinus outline do not correspond with the description and illustration given by Skuja (1928), raising doubts about its identity. Grönblad (1960) later listed this taxon from Italy but no illustration was provided. Skuja (1956: p. 211 and 1964: p. 193–194) reported *C. perforatum* var. *skujae* (*Cosmarium tutum*) from Sweden. The author refers to his illustration of 1928, but no detailed description of Swedish cells is given in these publications. Capdevielle (1978: plate XI, drawing 2) reported *C. perforatum* var. *skujae* (*Cosmarium tutum*) from France. In the face view of the cell (the only view present) a second cell wall layer and 19 large scrobiculi can be seen. The scarce and inconsistent reporting of *Cosmarium tutum* in Europe and the polymorphism of *C. perforatum* var. *perforatum* and its varieties (Wysocka 1963) led to an assumption that differentiating characters of *C. perforatum* varieties including var. *skujae* (*Cosmarium tutum*) may "be based on taxonomically insignificant characters (compare Förster 1982)" (Kouwets 1987: 228). The taxonomical status of *C. perforatum* var. *skuja* (*Cosmarium tutum*) was clarified by Lenzenweger (1999: 54) who indicated that basal angles extensions are "*linsenförmigen*" (lens-shaped), which is another differentiating feature. However, the apical and the side views are still wanting.

The first complete drawing with the face, side and apical views of *C. perforatum* var. *skujae* (*Cosmarium tutum*) was done by John & Williamson (2009: 69, pl. 13 D) though they examined only one cell of this taxon found in the west of Ireland, and they emphasize the closed sinus as the main differentiating character of this variety, and indicated two-wall layers of the cell and reported that the Irish cell is "without any particular thickening of basal angles" (John & Williamson 2009: p. 76).

The dimensions of the Ukrainian cells are within the range given for the Latvian (Skuja 1928) and the Austrian (Lenzenweger 1999) populations, they also partly overlap with the dimensions of the French cells, exceeding by some microns the smaller limits of the last ones (Capdevielle 1978). The Irish and Finish cells are bigger than the Ukrainian cells though they are within upper limits given by Skuja, Capdevielle and Lenzenweger (Table 2).

TABLE 2. Dimensions of *Cosmarium tutum* found in Europe.

No	Author and year of publication	Location	Cell lin. length, mm	Cell breadth, mm	Cell thickness, mm	Isthmus, mm
1	Skuja 1928	Latvia, lake Sidrabezers [Sudrabezers Lake]	70–95	70–87	42–51	35–42
2	Grönblad 1945	South of Finland, lake Tvarminnetrask	87	87	49	49
3	Grönblad 1960	North of Italy, channel connecting two lakes	Dimensions not indicated			
4	Skuja 1956, 1964	Sweden, Långsjön lake to the south of Stockholm Laplandia, pond near Abisko	Dimensions not indicated			
5	Capdevielle, 1978	France, lake Cazaux-Sanguinet	75–92	76–82		38–44
6	Lenzenweger 1999	Austria, lake in northern Alps	70–95	60–85		30–50
7	John & Williamson 2009	West of Ireland, lake Loughaunierin	86,5	82,4	46,5	42
8	Shyndanovina 2019	North of Ukraine, quarry pond	72,9–80,7	72,2–80,5	42,6–46,0	38,5–42,7

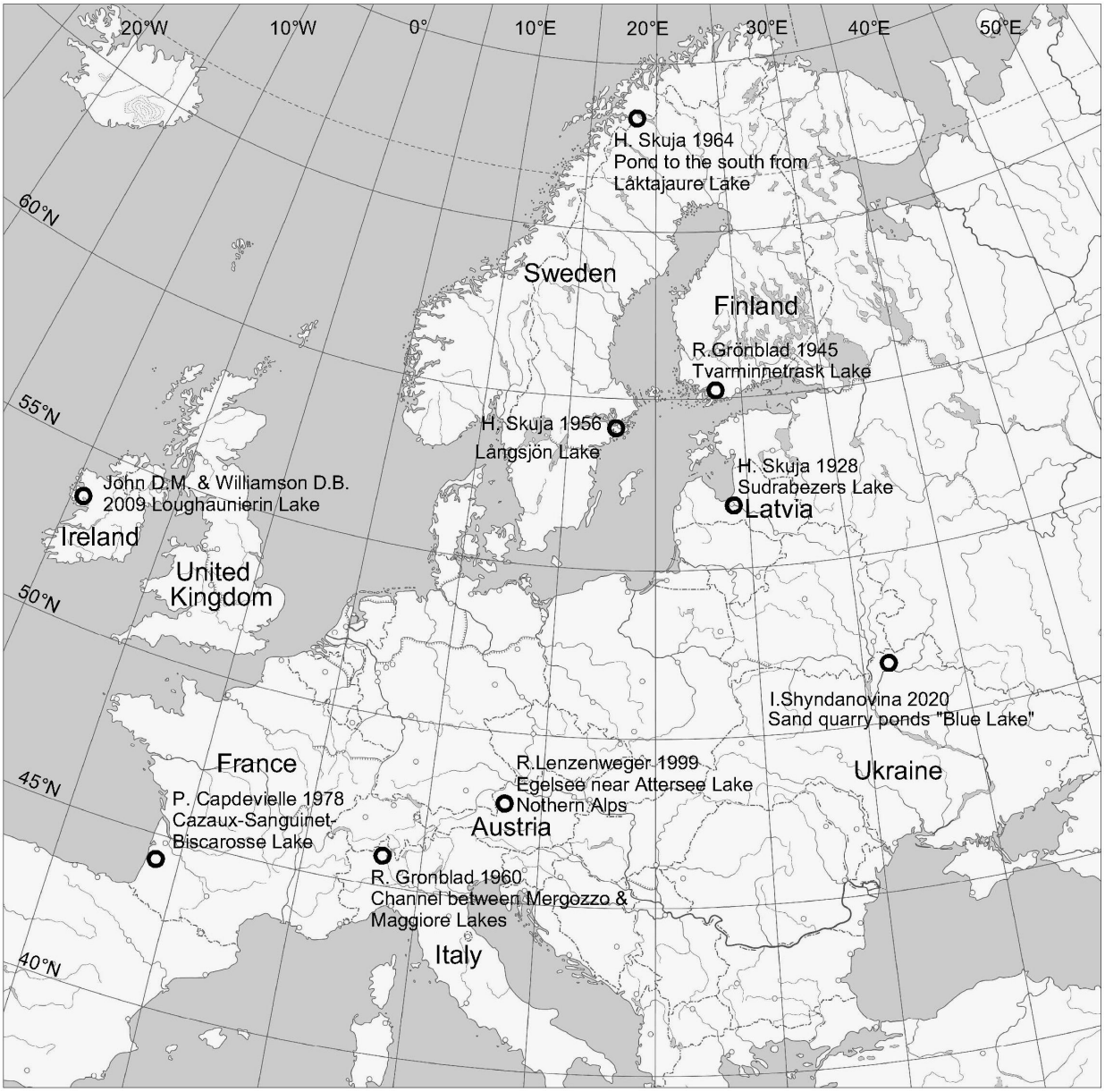

FIGURE 2. Map of distribution of *Cosmarium tutum* in Europe.

Description of *Cosmarium tutum* (Fig. 3)

Cells 72.9–80.7 µm lin. length, 72.2–80.5 µm breadth with length:breadth ratio of 0.95–1.07, 42.6–46.0 µm thickness, and isthmus of 38.5–42.7 µm, sub-circular, apex slightly truncate, sinus is always closed and moderately deep (isthmus equals half of the cell breadth). Semicell semicircular with broadly rounded basal angles the wall of which is provided with an outer, hyaline layer (Fig. 4C, D). A thickened zone with scattered, large (approx. 1 µm in diameter) scrobicles (about 30 in number) is to be seen in the centre of the semicell. The surface of this zone looks smooth in optical microscope, and all pore openings are inside scrobicles (Fig. 4A). The depth of the scrobicles decreases near the edge of this thickened zone without significant change of their diameter. At the base of the semicell, near to the isthmus, there is a line of pores visible in optical microscope as elongated pits, because they are in an inclined orientation to the observer. In apical view, the central part of the semicell is slightly concave linked to wall thickening on the sides. Semicell with one dicentric furcate chloroplast.

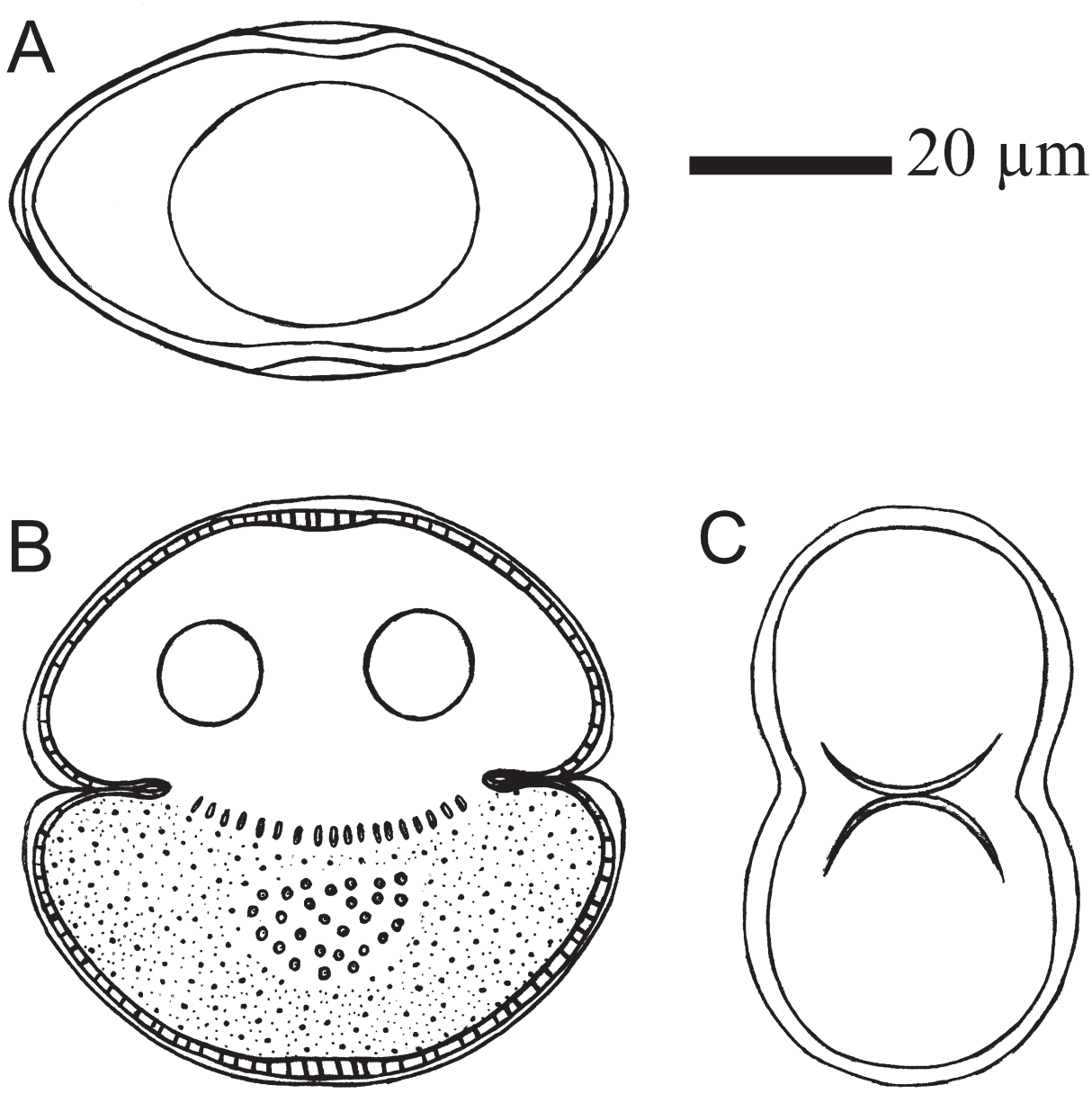

FIGURE 3. Drawing of *Cosmarium tutum*: apical (**A**), face (**B**) and side view (**C**). Scale bar: 20 µm (**A–C**). (Drawn by Shyndanovina I.)

Comparison of *Cosmarium tutum* with the type variety of *C. perforatum*

Cell dimensions of the *Cosmarium tutum* appeared to be consistently larger than those of *C. perforatum* var. *perforatum* (Table 3). The cell wall of *C. tutum* is considerably thicker than the wall of var. *perforatum* and is provided with a semi-pellucid outer layer that forms an extension of the basal angles. Pores of both taxa look similar but different thickness

of the cell wall makes the external part of pore channels look somewhat different. Pore channels of *C. tutum* look like small cylinders (or warts) with a pore opening at the top, while those of *C. perforatum* var. *perforatum* look like shorter cylinders or disks with a pore opening at the top (Fig. 1A, D, E; Fig. 4A, B). Both taxa have a similarly thickened zone with large scrobicles in the central part of the semicell with pore openings inside them. However, scrobicles in *C. tutum* are more scattered and more widely spaced (Fig. 4A, B). Thickening of the basal angles of *C. tutum* is of a regular lens-shaped form. It can be more or less strongly developed but always is of regular shape (Fig. 4C, D). Basal angles of *C. perforatum* var. *perforatum*, on the contrary, show a thickening of the main membrane, variable in shape (Fig. 4E, F). The sinus of *C. tutum* is always closed. Sinus of the type variety of *C. perforatum* is more or less widely open.

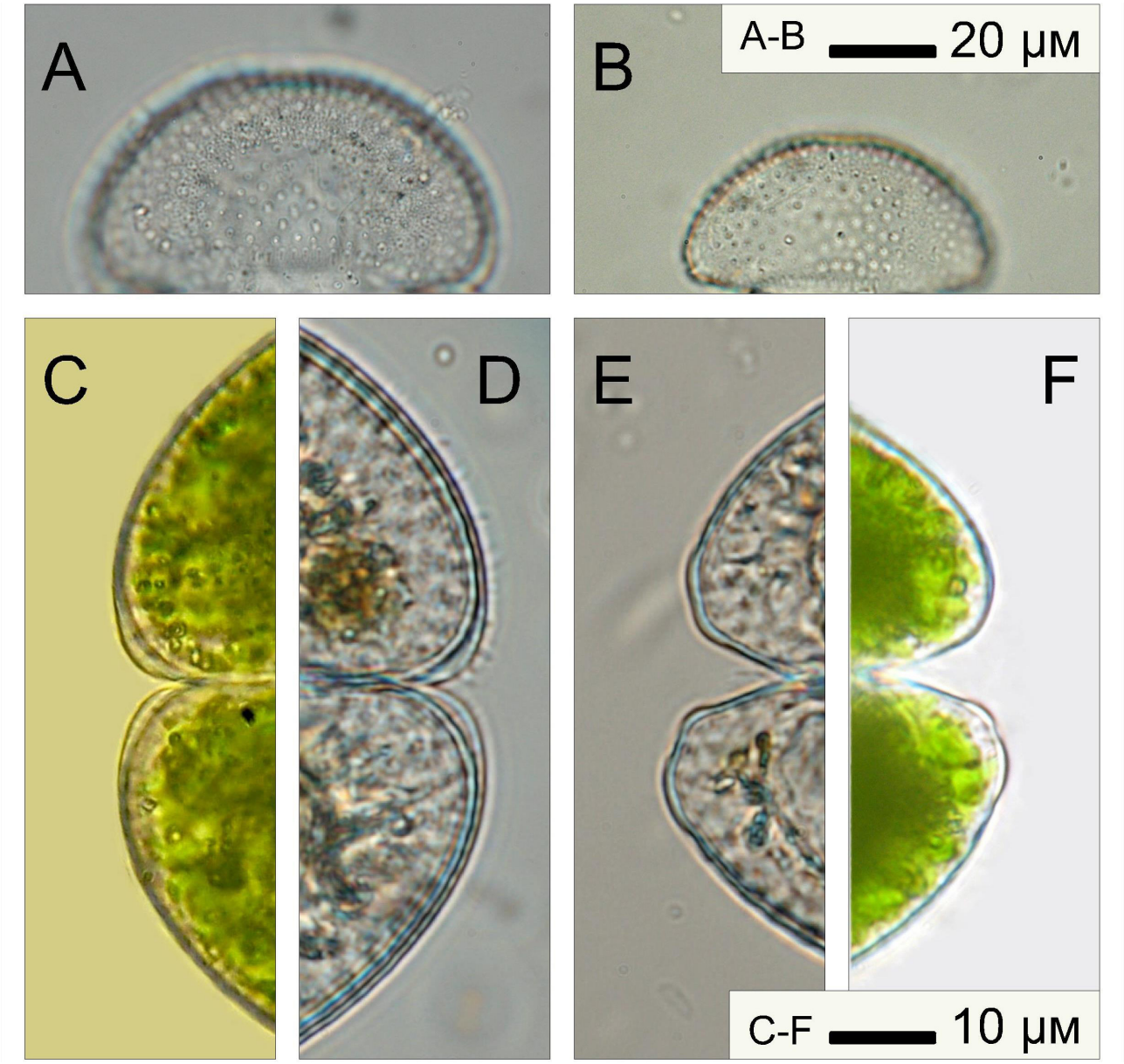

FIGURE 4. Photographs of *Cosmarium tutum* (**A, C, D**) and *C. perforatum* var. *perforatum* (**B, E, F**): zone with large scrobicles (**A, B**); basal angles (**C**–**F**). Scale bar: 20 µm (**A**–**B**), 10 µm (**C**–**F**). (Photos by Shyndanovina I.)

Variability

High variability of the type variety of *C. perforatum* is well known (e.g., Gistl 1926, Grönblad 1960, Kouwets 1987; Förster 1982; Lenzenweger 1999). Morphological variation in Ukrainian material in the outline of semi-cells, in shape of basal angles, in thickening of the basal angles, in presence or absence of papillae at the basal angles, and in degree of sinus opening (Fig. 5F, H–M) was observed. There seems to be no published information on variability in *C. tutum*, probably because it is a rare taxon, but from year to year in Ukraine there seems to be very little variation in *C. tutum* (Fig. 5A–G).

The differences between *C. perforatum* var. *perforatum* and *C. tutum* are sufficient to justify raising the latter to the status of a separate species.

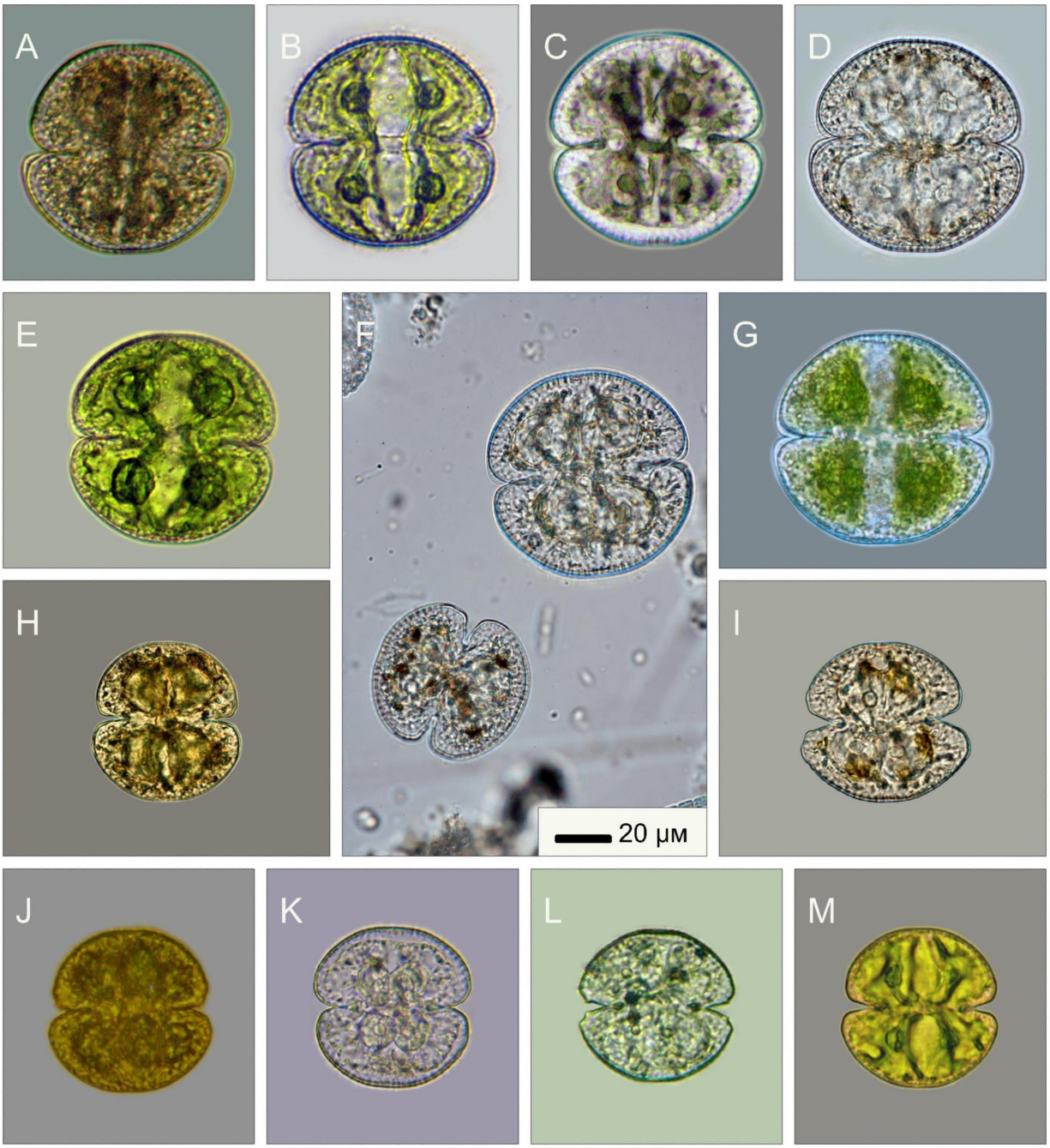

FIGURE 5. Photographs of *Cosmarium tutum* (**A-E, G**); *C. perforatum* var. *perforatum* (**H-M**); both taxa in one drop (**F**). Samples of 2007—**A**; 2008—**B**, **J**; 2009—**L**; 2010—**C**, **K**; 2018—**D**, **E**, **F**, **H, I**, **M**; 2019—**G**. Scale bar: 20 µm (**A**–**M**). (Photos by Shyndanovina I.)

TABLE 3. Dimensions of *Cosmarium tutum* and *C. perforatum* var. *perforatum,* based on my observations of Ukrainian cells (over 60 cells measured in total).

Taxa		Lin. Length (L), µm	Breadth (B), µm	L/B	Thickness, µm	Isthmus, µm
C. tutum	from, µм	72,9	72,2	0,95	42,6	38,5
	to, µм	80,7	80,5	1,07	46,0	42,7
C. perforatum var *perforatum*	from, µм	56,8	55,6	1,00	31,8	28,7
	to, µм	61,9	59,0	1,09	33,0	32,7

Conclusion

Detailed study of *Cosmarium perforatum* var. *porosum* and var. *rauchii* – two other varieties of *C. perforatum*, is still needed to set clear boundaries of this rare and highly variable species.

Repeated sampling of the same habitats provided sufficient grounds, i.e., detailed knowledge of variability and morphological discriminative characters, to separate two taxa that were supposed by pervious authors to belong a single species. It cannot be stressed enough that it is necessary to observe cells of more than just one population for clear definition of many species in the very variable desmids (cf. Kouwets 2008). Such knowledge of variability allows clear definition of discriminative characters shared by the taxa, also the presence or absence of cells polymorphism is an important differentiating indicator. The present paper confirms significance of careful examination of cell morphology, including cell wall nature and ornamentation, for identification and taxonomy of desmids (cf. Coesel 1984; Šťastný & Kouwets 2012). The two taxa described in the present paper have different number of cell membranes, and other morphological differences are shown here. The problem for the genus *Cosmarium* and other genera of desmids is that it is still not clear what degrees of differences must be present to justify recognizing two species. My unequivocal delineation of a rare taxon from the type variety and their amended diagnoses create the basis for further integrative taxonomical research in desmids.

Such sand-quarry ponds, being an environment transformed by humans, are home to many rare taxa of desmids (Shyndanovina 2018, 2019) that are not always found in natural water bodies located nearby, and I draw attention to study of desmids diversity of such ponds as habitats important for flora of desmids and other algae.

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