

Descriptions of two previously undescribed species from the Outer Hebrides, Scotland, UK

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Introduction

The two new species described in this paper, *Cosmarium askernishense* and *Cosmarium charnainense*, were discovered in samples collected in 2021 as part of a survey of the desmid flora of the freshwater habitats of the Outer Hebrides (Johnson & Johnson, 2022).

Taxonomic Account

Cosmarium askernishense C.D.N. Johnson spec. nov. (figs. 1–3)

Description: Cells 1.25–1.37 times longer than broad with an acute, open sinus from the start. Semicells somewhat variable in outline, in frontal view broadly trapeziform with the lower lateral angle straight to marginally convex running smoothly into rounded lateral angles, the broadest part of the semicell about one third up from the isthmus. Upper laterals are slightly convex running smoothly into the apex which is also slightly convex. The cell wall is quite thick and uniformly and densely punctate (mucus pores). There is noticeable cell-wall thickening at the widest points and, less so, at the apex. In side view the semicells are orbicular with a lenticular wall thickening. The apical view is broadly ellipsoid with rather narrowly rounded poles and a considerable, broad wall thickening on either frontal side. Chloroplast axile with a single large pyrenoid per semicell. Zygosporangium unknown.

Dimensions: L: 34–36.5 µm, B: 26.5–28 µm, Is: 8–9 µm, Th: 18.5–19 µm, L/B: 1.25–1.37.

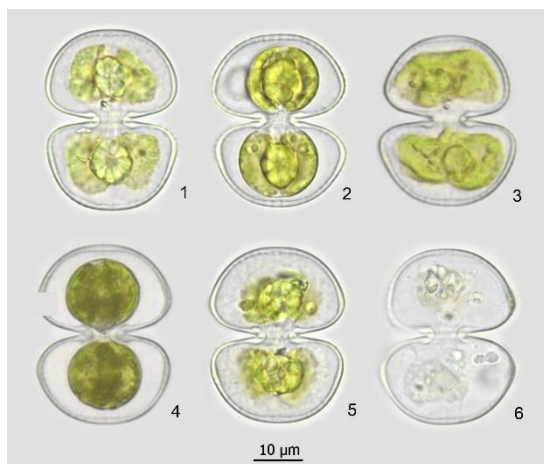


Figure 1. A montage of *C. askernishense* cells: Nos. 1,2,4,5 are representative of the species. The upper semicell of No. 3 has not completed its development. No. 6 is distorted and oblique but useful for emphasising the lateral wall thickening. Photograph © Chris Johnson.

Type: Fixed natural sample (plankton net through aquatics), collected by C.D.N. Johnson, 9 August 2021, deposited at the Natural History Museum, London, Accession No. BM013788934. (Holotype represented by fig. 3).

Type locality: UNITED KINGDOM. Loch a' Chafain, near Askernish, South Uist, Outer Hebrides.

Etymology: Named after the nearby township of Askernish, South Uist, Outer Hebrides.

Lat: 57.192549°N Long: 7.387511°W.

Occurrence: *C. askernishense* is currently only known from Loch a' Chafain, South Uist. (fig. 4). Cells were captured on two separate occasions (9 August 2021 and 31 July 2022) using a plankton net through marginal vegetation comprising: *Nymphaea alba*, *Potamogeton natans*, *Ranunculus flammula* & *Lobelia dortmanna*. The pH: 7.1–7.4, conductivity: 188 µS/cm.

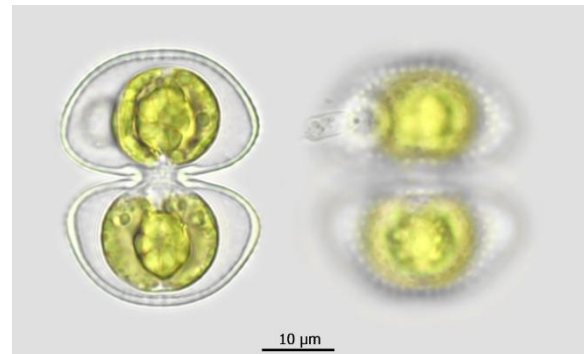


Figure 2. Vegetative cell of *C. askernishense* showing the numerous mucus pores. Photograph © Chris Johnson.

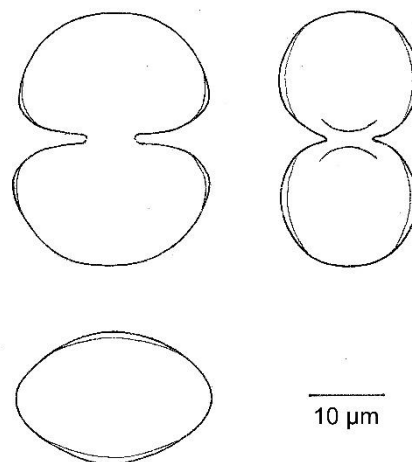


Figure 3. Drawing showing frontal, lateral and apical views of a single vegetative cell of *C. askernishense*. Drawing © Frans Kouwets.



Figure 4. Loch a' Chafain, South Uist. Photograph © Christine Johnson.

Discussion

Checking the literature; there is a clear similarity between the present species and the *Cosmarium contractum* complex. Many forms associated with this complex display a central cell-wall thickening and it is these taxa that I have concentrated on for comparative purposes.

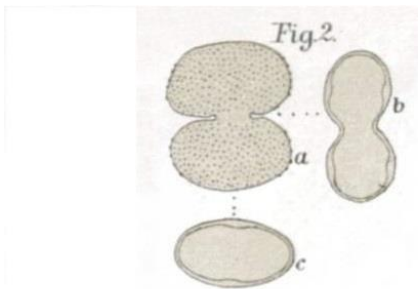


Figure 5. *C. ellipsoideum* var. *notatum* from Raciborski (1892). Dimensions: L: 33, B: 28, ls: 10, Th: 16 μ m, L/B: 1.18.

Cosmarium ellipsoideum var. *notatum* was first described by Raciborski (1892, p. 373, pl. 7:2) from Australia (fig. 5). From the same site, Playfair (1907, p. 193, pl. 5: 15) described *Cosmarium incrassatum*, which is regarded as synonymous with Raciborski's

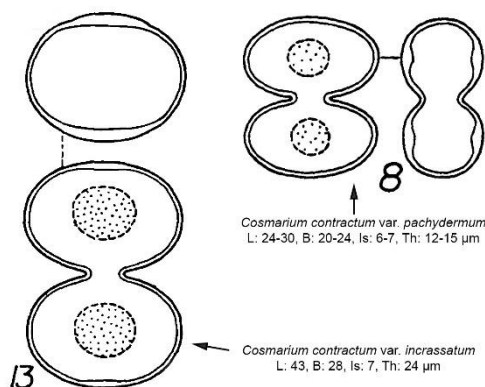


Figure 6. *C. contractum* var. *pachydermum* and var. *incrassatum* from Scott & Prescott (1958).

find. *C. ellipsoideum* F.E.V. Elfving 1881 currently is generally associated with *C. contractum* E.O.O. von Kirchner 1878 (see W. & G.S. West 1902, 1905). Also from Australia, Scott & Prescott (1958, p. 44, pls. 12: 8 & 13: 13) published two varieties: *C. contractum* var. *incrassatum* and var. *pachydermum*. (fig. 6). Most confusingly, under the same varietal names Scott & Prescott (1961) depict cells with a markedly different morphology from Indonesia. Away from northern Australia and south-east Asia, from eastern Canada Croasdale & Grönblad (1964, p. 176, pl. 11: 18) record *C. contractum* var. *incrassatum* with an aberrant morphology in addition to various other forms associated with *C. contractum* pointing to their broad species concepts, similar as that expressed by Scott & Prescott.

These varieties are considered here because they have a similar cell-wall thickening as seen in side and apical views. However, on closer examination the shape of the central wall thickening in the present form differs from the forms mentioned above in that it is less clearly defined covering a larger area. In addition, the forms mentioned above differ in their semicell shape, being ellipsoid in varying degrees both in frontal and apical view. In frontal view the sides are completely rounded with the widest point in the centre, without any differentiation between upper and lower angles. In apical view the poles of the semicell are broadly rounded in some forms resulting in a more oval shape.

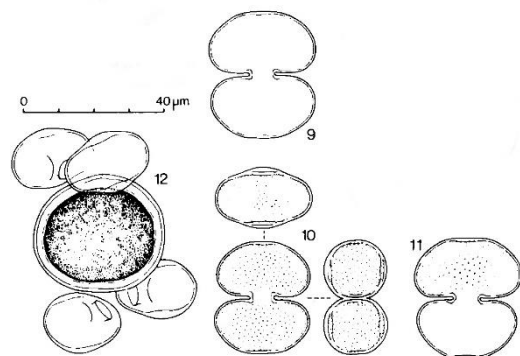


Figure 7. *C. contractum* var. *incrassatum* from Kouwets (1988).

Kouwets (1988, p. 66, fig. 3: 9-12) found cells which he identified as *C. contractum* var. *incrassatum* as described by Scott & Prescott (1958; see fig. 7). The semicells being trapezoid with the widest part about one third up from the isthmus (similar to the Askernish cells). However, as with the forms mentioned above, the apical view is elliptical with a well-defined, somewhat bulging wall thickening. In addition, the fractionally extended isthmus has produced sinuses which are slightly open at the apex and run parallel before opening widely. This

characteristic is rather similar to Raciborski's var. *notatum* but differs from the gradual widening from the apex of the sinuses of *C. askernishense*. The globose zygospores found in the French material clearly point to an affinity with *C. contractum*.

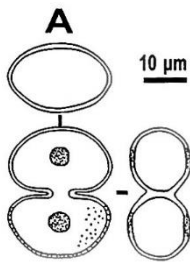
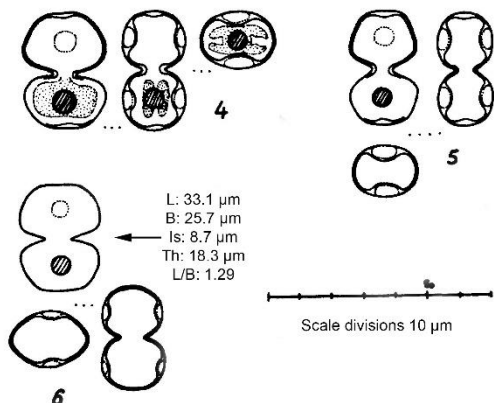


Figure 8. *C. contractum* var. *incrassatum* from John & Williamson (2009)

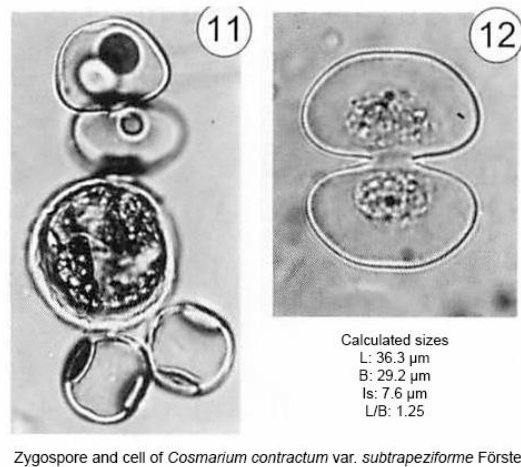
An interesting find from the west of Ireland by John & Williamson (2009, p. 63, pl. 12: A; see fig. 8) would seem to be an intermediate form between Kouwets' find from south-west France and the Askernish find. Named as *C. contractum* var. *incrassatum*, the length and breadth are similar to the Askernish cell but with a perceived narrower isthmus and smaller thickness. The shape of the sinuses matches closely those of Kouwets. Of note is the small amount of lenticular thickening in side view and no obvious thickening in apical view. Some similarity was also found with *C. contractum* var. *subtrapeziforme* Kurt Förster 1973. This variety was discovered in a ditch in Florida, USA (Förster l.c., p. 548, pl. 10: 4-5). However, it differed in having the upper laterals straight and drawn into the apex more sharply, with a narrower isthmus and a greater L/B ratio (1.4-1.75). On the same plate Förster (l.c., pl. 10: 6) illustrated an unnamed forma of var. *subtrapeziforme* which has closer similarities with *C. askernishense* in its outline shape and lenticular thickening, and particularly in its apical view being rugby-ball shaped with ends that are subacute (see our fig. 9).



Figs. 4-5: *Cosmarium contractum* var. *subtrapeziforme* Förster
Fig. 6: *Cosmarium contractum* var. *subtrapeziforme* forma

Figure 9. *C. contractum* var. *subtrapeziforme* from Förster (1973).

It should be noted that from the same region Förster reported two more varieties of *C. contractum*, viz. var. *incrassatum* and the new var. *ornatum* Kurt Förster 1973, both with oval-elliptic apical views. Kanetsuna & Yamagishi (2011, p. 17, pl. 6: 11) show an image of a zygospore of *C. contractum* var. *subtrapeziforme*, also from Florida. What can be seen of the attached cells would seem to fit Förster's concept. However, on the same plate (pl. 6: 12) is an image of a vegetative cell in face view which doesn't seem to fit Förster's concept and is nearer to *C. askernishense* in outline but lacking any noticeable wall thickening. This little-known variety would seem to be confined to Florida, USA and is not known from the western Palaearctic (see our fig. 10).



Zygospore and cell of *Cosmarium contractum* var. *subtrapeziforme* Förster

Figure 10. *C. contractum* var. *subtrapeziforme* from Kanetsuna & Yamagishi (2011).

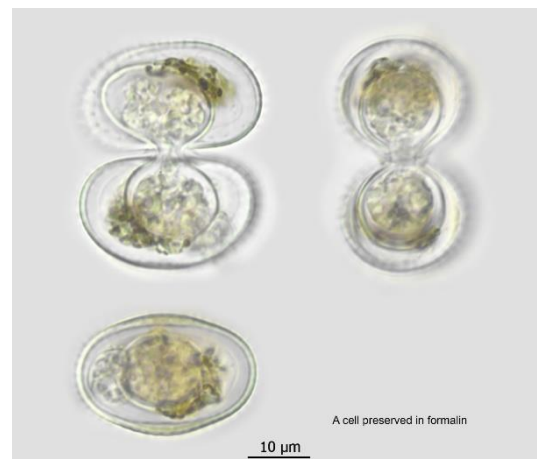


Figure 11. Frontal, lateral and apical views of a vegetative cell of a different form with broadly elliptic semicells, also related to the *C. contractum* complex (note that the frontal view is slightly distorted). Photograph © Chris Johnson.

The discussion above concerns the relationship between *C. askernishense* and the *C. contractum* complex. However, in addition to *C. askernishense* the sample contains a variety of forms with more oval-elliptic semicells that are obviously also related

to *C. contractum*. These forms have a rather broad central wall thickening and an elliptic apical view with broadly rounded poles. (see figures 11 & 12).

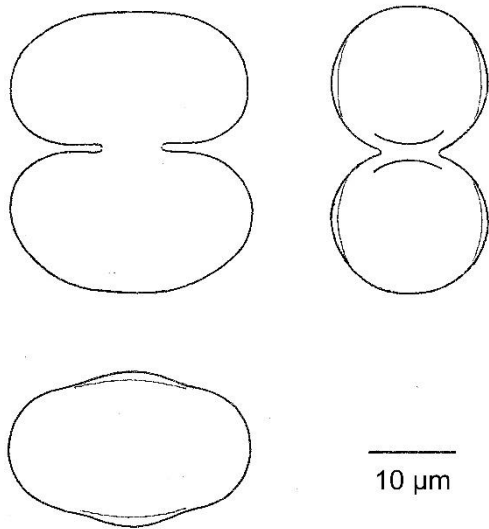


Figure 12. Drawing showing frontal, lateral and apical views of a single vegetative cell of the form with elliptic semicells. Drawing © Frans Kouwets.

Moreover, the dimensions vary within wider limits than *C. askernishense*: 31–36 x 25–31.5 µm. These forms are more in agreement with Raciborski's var. *notatum* mentioned above; intermediate forms or dichotypical cells were not encountered. The true relation between the present new species with trapeziform semicells and the forms with more elliptic semicells is unknown. Molecular studies may throw more light on this subject.

Finally, two more species should be considered in identifying the Askernish form. Taylor (1934) described *Cosmarium refringens* from Newfoundland with somewhat rounded trapeziform semicells with thickened lateral angles and a prominent sublenticular central wall thickening (Taylor l.c., p. 265, pl. 50: 10). Unfortunately, no apical view was given. Croasdale (1956) mentioned it from Alaska but figured a form with more hexagonal semicells and a very widely gaping sinus (Croasdale l.c., p. 50, pl. 6: 1). However, she also figured an apical view which is rhomboid with rather narrowly rounded poles. From Finland Grönblad (1920) described *Cosmarium subcoliferum* which is somewhat intermediate between Taylor's and Croasdale's forms, in apical view showing even more narrowly rounded poles (Grönblad l.c., p. 49, Pl. 5: 16–18). Krieger & Gerloff (1962, p. 82) transferred it as var. *subcoliferum* to *C. refringens*. Last mentioned taxon seems to be very rare and only a few finds have been published; their relation with the

C. contractum complex and the Askernish form is unknown and needs further study after new finds.

Conclusion

C. contractum is a confused species complex with some cells displaying smooth walls and others with a noticeable thickening – the above-mentioned taxa fall into the latter group. There are similarities in some aspects of the cells' morphology with the Askernish desmid such as the wall thickening, but there are other notable differences as described. An argument could be made to add another variety or, indeed, a forma to this complex but the author feels this would just add to the confusion. The author considers that there is sufficient difference to warrant species rank.

Cosmarium charnainense C.D.N. Johnson spec. nov.
(figs. 13–17)

Description: Cells small, about as long as broad to marginally broader than long. Sinus slightly open with a rounded apex and parallel sides for half the length, then opening widely to broadly rounded basal angles. Semicells trapezoid-hexagonal with the lower lateral angles divergent and more or less straight. The broadest part is just above the median point. Upper lateral angles acutely convergent and retuse. Apex truncate or slightly retuse. Each semicell has two small granules disposed asymmetrically: in front view the left granule is placed near the left lateral angle whereas the right granule is placed near the right apical angle. In apical view the asymmetry is clearly seen. Side view is orbicular. The cell-wall is smooth with numerous mucilage pores. Chloroplast axile with a single pyrenoid per semicell.

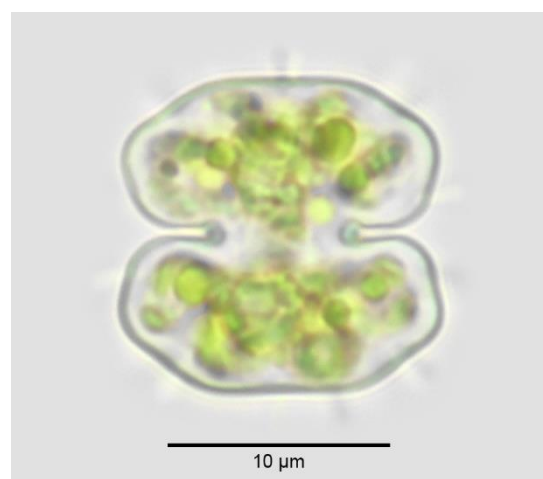


Figure 13. Vegetative cell of *C. charnainense* from the type material. Note the radiating strands of mucus along its outline, associated with cell wall pores. Photograph © Chris Johnson.

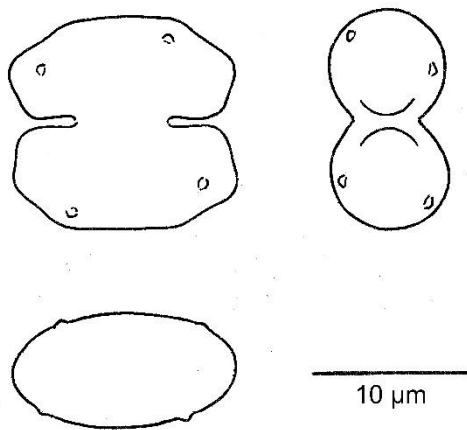


Figure 14. Drawing of frontal, lateral and apical views of a single cell. Drawing © Frans Kouwets.

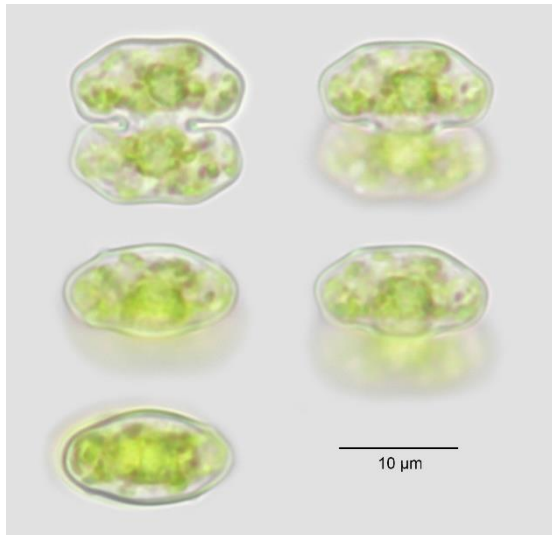


Figure 15. Vegetative cells of *C. charnainense*. Note the small granules in oblique and apical views. Photograph © Chris Johnson.

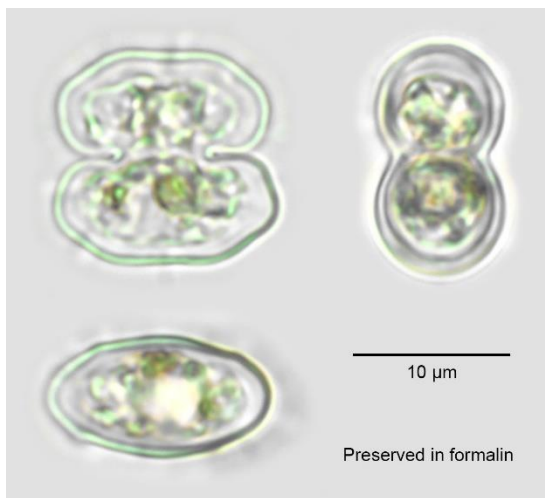


Figure 16. Vegetative cells of *C. charnainense* in formalin. Photograph © Chris Johnson.

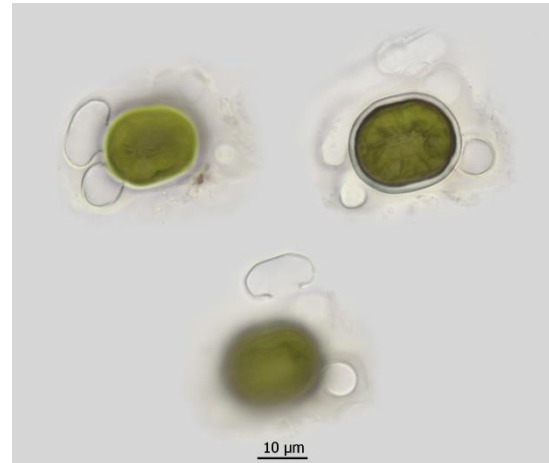


Figure 17. Zygospore of *C. charnainense* at three focal points. Photograph © Chris Johnson.

The zygospore is subglobose with dark olive-green mesospore and almost black edge, the transparent exospore has the gametangial cells embedded. Dimensions: L: 14.0–14.7 µm. B: 14.4–15.4 µm. ls: 6.2–6.9 µm. Th: 8.1–8.3 µm. L/B: 0.95–1.01. Zygospore: 22.3 x 18.7 µm.

Type: Fixed natural sample (plankton net through a shallow boggy pool), collected by C.D.N. Johnson, 8 May 2021, deposited at the Natural History Museum, London, Accession No. BM013788933. (Holotype represented by fig. 14).

Type locality: UNITED KINGDOM. By Wind Farm, near Loch a' Charnain, South Uist, Outer Hebrides. Lat: 57.358016N Long: 7.293079W.

Etymology: named after the nearby scattered settlement of Loch a' Charnain, South Uist, Outer Hebrides.



Figure 18. Sample site, near Loch a' Charnain, South Uist. Photograph © Christine Johnson.

Occurrence: *Cosmarium charnainense* is currently only known from a shallow moorland pool, near Loch a' Charnain, South Uist (fig. 18). Samples were taken using a plankton net through marginal vegetation comprising: *Nymphaea alba*, *Potamogeton natans* & *Ranunculus flammula*. The

substratum is peaty and acidic with a pH 5.3.
conductivity: 88 µS/cm.

Discussion

There are other taxa with small granules that are asymmetrically disposed in a similar manner. First, we need to consider *Cosmarium sphagnicola* [as *sphagnicolum*] W. & G.S. West 1897. They presented a clear description with detailed figures (W. & G.S. West l.c., p. 486, pl. 6: 13-14; see fig. 19). These drawings are replicated in their flora (W. & G.S. West 1908, p. 71, pl. 71: 11-14). As dimensions they gave L: 10.5-11.5, B: 11-13.5, ls: 5-5.5, Th: 6.5 µm. Interestingly, the granules are placed symmetrically within each truncate apical angle as if unaware of their true disposition. This taxon and later varieties are all markedly smaller than *C. charnainense* and

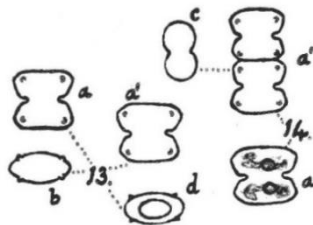


Figure 19. Image of *C. sphagnicola* [as *sphagnicolum*] from West & West (1897).

have a broader isthmus relative to size. Also, the nominate variety in face view is broadest near the apex. They are acidophiles, usually associated with *Sphagnum*. Compare the recently described *Cosmarium sphagnicoliforme* M.C. van Westen & P.F.M. Coesel 2021 which has a rather similar morphology but still smaller dimensions: L: 6.5-9.5,

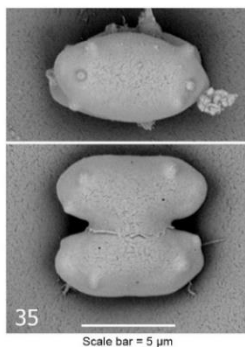


Figure 20. SEM Image of *C. sphagnicoliforme* from Van Westen & Coesel (2021).

B: 6.5-10, ls: 4.5-5.5, Th. about 5 µm (van Westen & Coesel 2021, p. 247, figs 7, 27-29, 35; see our fig. 20). *Cosmarium pygmaeum* W. Archer 1864 also displays the same granular pattern but in addition has a central papilla (Archer 1864, pl. 6: 45-49). The taxonomy of this species is complicated and only mentioned here in having a similar granular configuration. Even at its largest (L: 7-13, B: 7-13 µm.) it is smaller than the taxon under discussion

with which it most interestingly co-occurred in the sample studied.

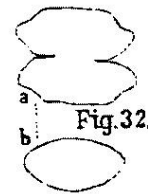


Figure 21. Image of *C. abbreviatum* f. *germanicum* from Raciborski (1889).

A taxon with similar morphology is *Cosmarium abbreviatum* f. *germanicum* M. Raciborski 1889 (Raciborski l.c., p. 79, pl. 5: 32; as *germanica*). Dimensions: L: 15, B: 16, ls: 6.6, Th: 7.5 µm. Krieger & Gerloff (1969) raised it to variety and presented a copy of Raciborski's drawings (Krieger & Gerloff l.c., p. 242, pl. 42: 16; see fig. 21). This taxon differs from the Charnain desmid in having a closed sinus for half its length, broadly rounded basal angles, the broadest point on the median line, and lacking granules. It is also smaller on average. *Cosmarium polygonum* (C.W. von Nägeli) W. Archer [in A. Pritchard 1861] is another problematic species as the original diagnosis lacked clarity. *C. polygonum* var. *depressum* E.A. Messikommer 1942 was first

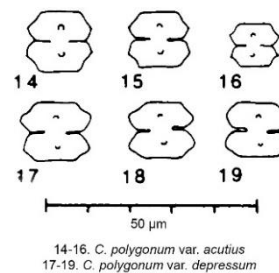
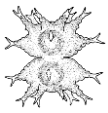


Figure 22. Images of *C. polygonum* var. *acutius* and var. *depressum* from Coesel (1991).

found in the Swiss Alps. A small taxon (its dimensions have been approximated from the fractions given: L: 8-8.9, B: 9.2-10, ls: 3 µm.) with narrowly open sinus, strongly produced lateral angles on the median line and a central protuberance (Messikommer l.c., p. 147, pl. 5: 8). He also noted granular asymmetry similar to the Charnain desmid but stated that the apical granules frequently are almost invisible. See Coesel (1991, p. 45, pl. 9: 17-19) for an expanded size-range of this taxon (fig. 22). The figures show a central protuberance but no granulation. Another variety: *C. polygonum* var. *acutius* E.A. Messikommer 1942 is compared by the author with *C. sinostegos* J.G. Schaarschmidt 1883 (Messikommer l.c., p. 148, pl. 9: 17-19). These taxa are slightly smaller than var. *depressum* and have a spicule at the widest lateral point, plus a small protuberance. This is also



recorded and illustrated by Coesel (1991, p. 45, pl. 9: 14-16) on the same plate for comparison (fig. 22). The taxonomical complexity of this group of small *Cosmarium* forms is demonstrated by the fact that in a later publication *C. polygonum* var. *depressum* and var. *acutius* were both considered identical to the equally problematic *Cosmarium polygonatum* M. Halász 1940 (Coesel & Meesters 2007, p. 132, pl. 69: 3-9).

Note: A consistent asymmetrical granular pattern displayed in a limited number of species, such as the first two species mentioned in the discussion, is very unusual and suggests a common heritage, perhaps going back millennia. This characteristic granular pattern has also been noted on *C. polygonum* var. *depressum* as a transient feature. As these indistinct granules are very difficult to observe in a light microscope, they are easily overlooked. Consideration of this phenomenon is perhaps deserving of more attention.

Conclusion

C. sphagnicola and *C. pygmaeum*, with their similar granular configuration, such as the first two species mentioned have the closest affinity to the Charnain taxon but the differences and problems noted above preclude associating it with *C. charnainense* as it would cause confusion. The other taxa mentioned are largely smooth-walled with the possible exception of a central protuberance, which is a feature of many. They differ morphologically as discussed with the main differences being generally smaller size with a narrower isthmus: the L/B ratio is lower (0.7–0.9). The author feels this desmid is sufficiently distinct to warrant species rank.

Acknowledgements

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