Some new and interesting desmids (Streptophyta, Desmidiales) from lakes and a floating bog near Mt. Adams, Skamania County, Washington (USA)

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Abstract
The desmid flora in lakes and ponds in the Mt. Adams region of the Cascade Range in Washington State (USA) is not well studied due to the remote and seasonally inaccessible nature of the area. Samples collected from three lakes and a floating bog revealed three new taxa: *Cosmarium vangeestii*, *Staurastrum cascadense*, and *Staurastrum orbiculariforme*. *Cosmarium turpinii var. eximium* was raised in rank and rendered the new name *Cosmarium turpinioides*.

keywords: algae, desmids, taxonomy, new taxa, *Cosmarium*, *Staurastrum*, Cascades, Mt. Adams

Introduction
The Cascades Range is an extensive mountain range stretching from British Columbia (Canada) to Northern California (USA). One of the most remote mountains in the Cascades is Mt. Adams, located in the southern portion of Washington State (USA). Mt. Adams has an elevation of 3742 m, making it the second highest mountain in Washington and one of the largest active stratovolcanoes in the Cascades, with the most recent eruption occurring 3800 years ago (USGS, 2023). The Mt. Adams region supports 843 species of terrestrial plants, which is the most diverse flora of any mountainous region in the Pacific Northwest (Biek & McDougall, 2007). The lakes we sampled were surrounded by coniferous forests, with shorelines dominated by ferns, mosses, sedges, heather, blueberries, and other acid-loving vegetation. The bedrock in the region is mostly basalt or andesite, so the surface water is poorly buffered. The climate is cool most of the year (average high = 15.1 C; average low = 1.4 C), with short summers and extended periods when the lakes are covered with snow and ice. The average annual precipitation at nearby Trout Lake is 111 cm of rain and 253 cm of snow (WRCC, 2023). Despite the abundance of lakes in the Mt. Adams area, there are no published records of desmids from the area. Preliminary sampling in 2018 by M. Suhrbier revealed that the lakes contained a rich desmid community; subsequent sampling in 2019 and 2023 produced more than 150 desmid taxa, including 4 taxa endemic to North America (*Cosmarium cosmetum* West et G.S. West 1896, *Cosmarium eloiseanum* Wolle 1883, *Micrasterias muricata* Ralfs 1848, and *Staurastrum arctiscon* var. *truncatum* Irénée-Marie 1938) and taxa newly described in this manuscript: *Cosmarium vangeestii*, *Staurastrum cascadense*, and *Staurastrum orbiculariforme*. In addition it is proposed to give *Cosmarium turpinii* var. *eximium* the status of a separate species *Cosmarium turpinioides*.

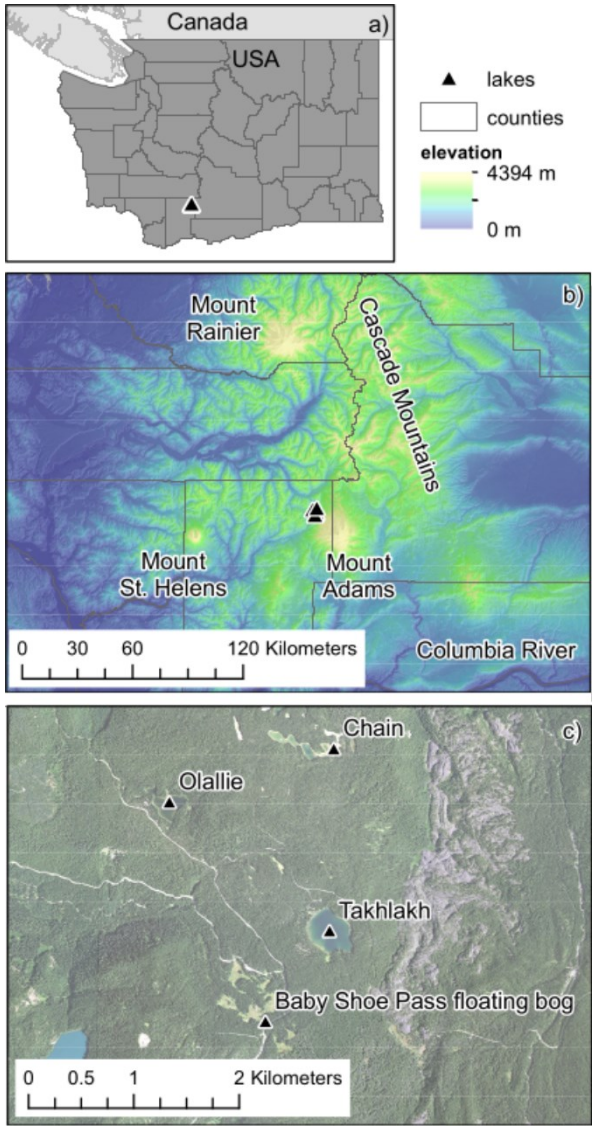

Figure 1. Map of study sites in Washington State showing major geological features and aerial imagery of lakes. Data provided by A. Strecker, Western Washington University, data sources: USGS 30-m digital elevation models (2018) and USDA National Agriculture Imagery Program (2015).

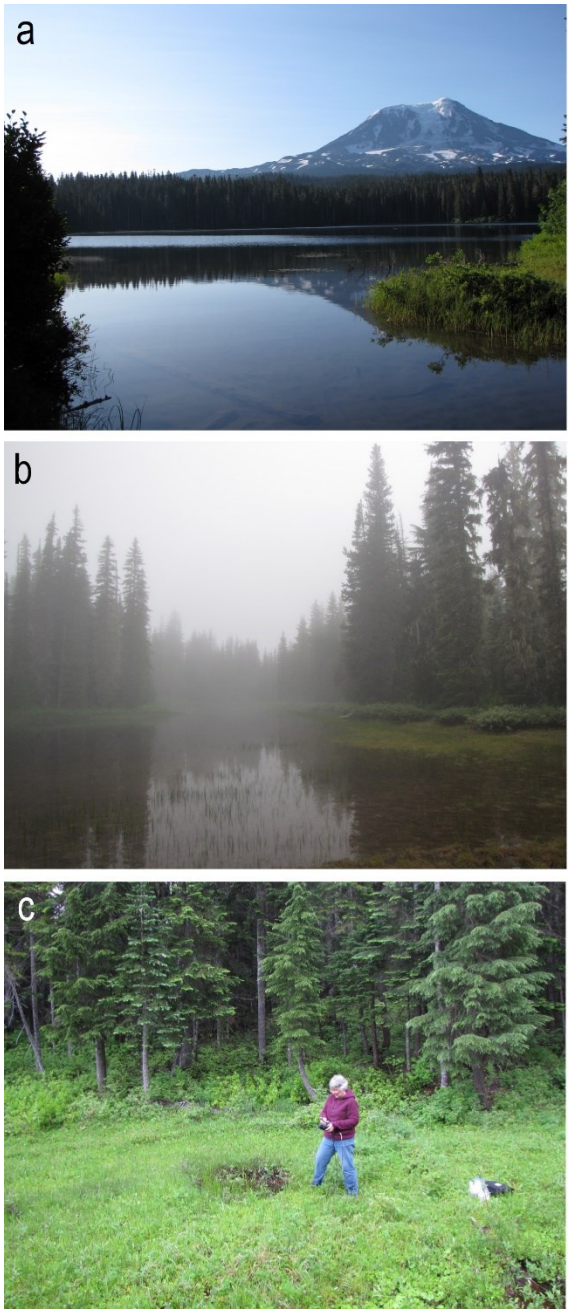

Figure 2. Photos of Takhlakh Lake (a), Chain Lake (b), and R. Matthews sampling the floating bog (c).
Figures a-b © R. Matthews; Figure c © G. Matthews, used with permission.

We sampled four sites near Mt. Adams in Skamania County, Washington (USA): Chain-of-Lakes (Chain Lake), Olallie Lake, Takhlakh Lake, and a small unnamed floating bog near Babyshoe Pass adjacent to Forest Road 23 (figs. 1, 2). All three lakes are popular fishing and camping sites but are only accessible for a short time during the summer due to heavy snowfall and rough road conditions in this remote region of Washington. The floating bog is approximately 100 m in length and 30 m wide, at the widest point. The bog consists of short, dense, mat-like floating vegetation, with numerous small openings that revealed darkly stained, slow moving water beneath the floating mat. The surrounding area contains many large, wet meadows and shallow ponds**.** All sites are in heavily forested areas above 1300 m elevation. Takhlakh and Olallie Lakes are about 13 ha each; Chain Lake is a series of small, hydrologically connected lakes and ponds, with a combined surface area of <5 ha; the estimated surface area of the floating bog is about 0.2 ha. Nearshore water samples collected on 3 July and 30 July 2019 indicated that all sites had poorly buffered water (alkalinity <10 mg/L as $CaCO_3$), with very low conductivities (<25 µS) and nutrient concentrations (nitrate/nitrite <15 µg-N/L; orthophosphate <5 µg-P/L). The boggy sites (Chain Lake and the floating bog) were slightly acidic (pH ≤6.5) while the larger lakes (Takhlakh and Olallie) were near neutral (pH ~7.1).

Materials and Methods

Nearshore algae samples were collected on 3 July 2019, 30 July 2019, and 1 August 2023 by towing a 20-µm mesh plankton net through open water at an angle from slightly above the sediments to 0.3 meters below the surface. The plankton samples were placed in 250-mL wide-mouth polycarbonate jars, leaving 5-10 cm of air space. Additional material was scraped or squeezed from submerged and shoreline vegetation. In 2019, an unpreserved aliquot from each sample was placed in a cooler and kept in the dark until the live algae could be examined in the laboratory. The remaining portions from the 2019 samples were preserved in 4% buffered formalin or 1-2% buffered glutaraldehyde; all samples collected in 2023 were preserved in the field in 4% buffered formalin.

The live and formalin-preserved algae were examined using a Nikon 80i microscope equipped with brightfield, phase contrast, and differential interference contrast (DIC). Digital images were collected using Nikon DS-Fi2 or Excelis 4K UHD microscopy cameras, with cell measurements and scale annotations added using custom scripts and the Gnu Image Manipulation Program (GIMP 2.10-30). Cell measurements were based on a minimum of 10 cells, with measurement accuracy verified using a stage micrometer. The glutaraldehyde-preserved algae were used to create digital SEM images following protocols developed by the Institute for Watershed Studies, Western Washington University, Bellingham, Washington (USA).

Taxonomic Account

Cosmarium turpinioides Coesel et Matthews stat. et nom. nov. (figs. 3-6)
Homotypic replaced synonym: *Cosmarium turpinii* var. *eximium* West et G.S.West 1908: A monograph of the British Desmidiaceae Volume 3, Ray Society, London, p. 192, pl. 83: 3.

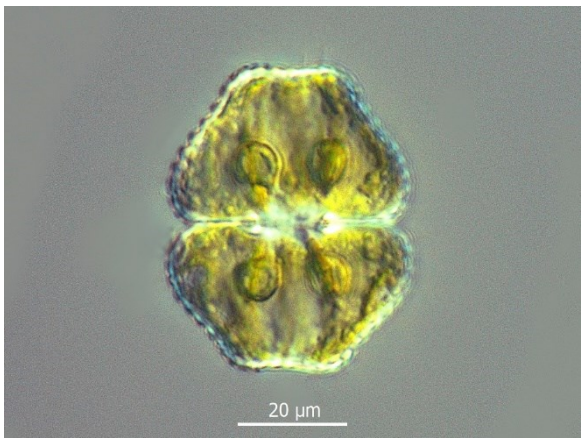

Figure 3. *C. turpinioides* in frontal view. Photo © R. Matthews.

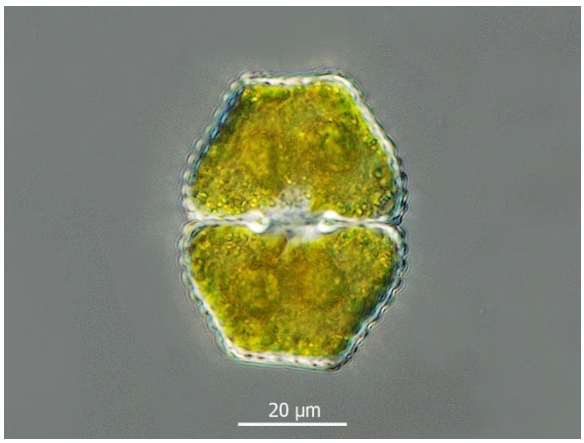

Figure 4. *C. turpinioides* in frontal view. Photo © R. Matthews.

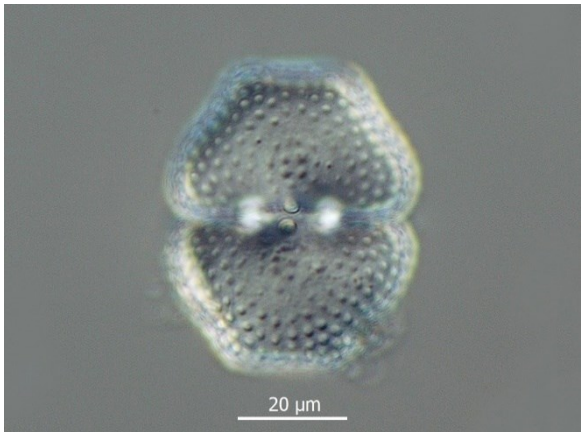

Figure 5. *C. turpinioides* in frontal view showing surface granulation. Photo © R. Matthews.

The above-mentioned variety was described by West & West in their well-known monograph of British desmids from a single site in Ireland. The main difference with the much more common nominate variety of *C. turpinii* Brébisson is in the central tumour of the semicell: a single one in var. *eximium* versus a double one in var. *turpinii*. Moreover, semicells in var. *eximium* are characterized by a big supraisthmial granule that is missing in the nominate variety. In our opinion, those differences are important enough to distinguish var. *eximium* at species level. Because the name of *Cosmarium eximium* was already given to a different taxon (West & West, 1895), we had to choose a different name. Comparing the cell outline of the specimens in our area of investigation with that in the floras by West & West (1908, pl. 83: 3) and Prescott et al. (1981, pl. 276: 1), the lateral semicell sides are less strongly converging. In that respect there is more agreement with the picture of *C. turpinii* var. *eximium* in Prescott & Vinyard (1965, pl. 12: 18) and Irénée-Marie (1938, pl. 25: 1). As yet, we are inclined to consider that difference part of morphological variability. Cell dimensions in our samples ranged from 53-57 µm in length and 39-45 µm in breadth.

Occurrence: *C. turpinioides* was of common occurrence in Chain Lake and the floating bog, and of incidental occurrence in Olallie Lake. We know it also from the Ibex Valley in Canada (YT).

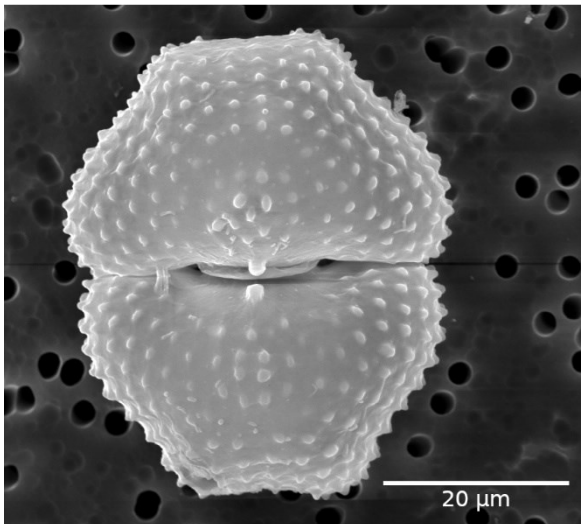

Figure 6. SEM photo of *C. turpinioides* in frontal view. Photo © R. Matthews.

***Cosmarium vangeestii* Coesel et Matthews spec. nov. (figs. 7-10)**

Description: Cells 1.2-1.3 times as long as broad. Sinus deep, narrowly linear with a dilated extremity. Semicells in frontal view truncate-pyramidate with convex lateral sides and broadly rounded angles. Cell wall beset with coarse, conical granules arranged in regular, oblique, decussate series. Each granule is surrounded by six, deep cell wall pits including a pore apparatus. Semicells in apical view are broadly elliptic and slightly inflated at the middle. The chloroplast contains two pyrenoids. Dimensions: L: 71-84 µm, B: 57-67 µm.

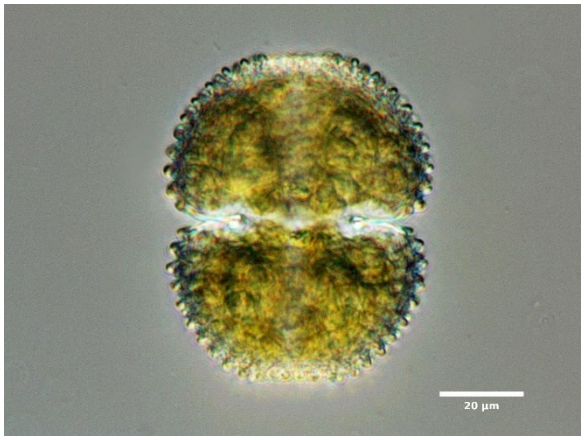

Figure 7. *C. vangeestii* in frontal view. Photo © R. Matthews.

Type: Nearshore sample from Chain Lake (GPS 46.2936, -121.5991), preserved as a fixed natural sample in 4% buffered formalin, collected by R. Matthews, 3 July 2019, archived at the United States Algal Collection (Accession No. 239845), Smithsonian Institution, Washington, D.C. (USA), partly illustrated in our fig. 7.

Differential diagnosis: *C. vangeestii* should be compared with *C. magnificum* Nordstedt, *C. decoratum* West et G.S.West, and *C. superbum* Taylor. Those species have a similar, roughly truncate-pyramidate cell outline and characteristic cell wall sculpturing consisting of granules that are each surrounded by six, deep pits. *C. magnificum* Nordstedt (1888: 62, pl. 6: 19), described from New Zealand, resembles our *C. vangeestii*, but differs by its larger dimensions (cell length 108-120 µm) and its cell wall granules, which are truncate-emarginate instead of conical. *C. decoratum* West et G.S.West (1895: 61, pl. 7: 21) described from Madagascar, is trapeziform in the frontal view outline rather than pyramidal, and rhomboidal in apical view instead of elliptic. *C. superbum* Taylor (1934: 268, pl. 52: 2), described from Newfoundland, might be identical to our newly described species, but the figure in question gives rise to doubt. Semicells in frontal view are approximately semicircular rather than pyramidal, and are less broadly elliptic in apical view. In addition, the granules are more widely spaced, and the cell wall pits are not clearly distinguishable from the granules, so the characteristic sexangular pattern (not mentioned in the text) cannot be perceived.

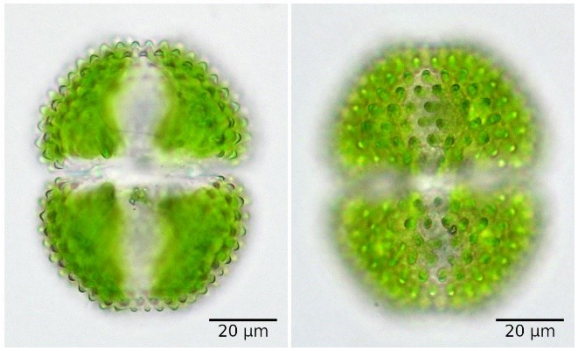

Figure 8. *C. vangeestii* in frontal view with different focal points. Photo © A. van Geest, used with permission.

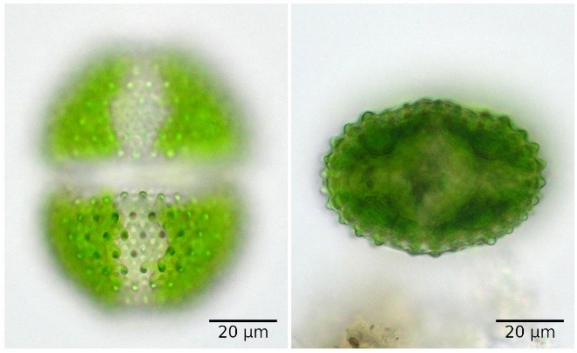

Figure 9. *C. vangeestii* in frontal view (left) and apical view (right). Photo © A. van Geest, used with permission.

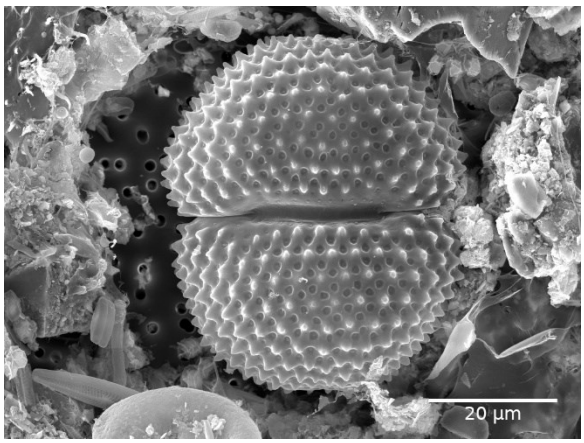

Figure 10. SEM photo of *C. vangeestii* in frontal view. Photo © R. Matthews.

To increase confusion, all three of the above-mentioned species have separate infraspecific taxa that differ greatly from the original species descriptions. *C. magnificum* var. *granulorum* A.M.Scott et Prescott (1961: 61, pl. 24: 3), described from Indonesia, has a comparable cell size as *C. decoratum* and *C. superbum*, and very much resembles *C. decoratum* West et G.S.West as depicted in that same paper (Scott & Prescott 1961,

pl. 25: 1). As our taxon from the Cascades Range does not correspond to any of the above-discussed taxa, we think it justified and desirable to describe it on the basis of detailed photographs as a new species.

Etymology: the species is named after our late friend and colleague, Alfred van Geest, who contributed extensively to the identification of the desmid flora of Northwest Washington.

Occurrence: C*. vangeestii* appeared to be widely distributed in Chain and Takhlakh Lakes and in the floating bog. Outside of the Cascade Range it was also found in numerous lakes in Mt. Baker area (Whatcom County, Washington), along the Mt. Loop Highway (Forest Route 20; Snohomish County, Washington), and along Chilkoot trail in Canada (BC). Almost certainly, photos of a species identified (with a question mark) as *Cosmarium decoratum* in Thomasson (1962: 449, figs. 19-20), which originated from a small mountain lake in NW Oregon (USA), also refer to our newly described C. vangeestii.

Staurastrum cascadense Coesel et Matthews spec. nov. (figs. 11-14)
Description: Cells about as long as broad, with a deep, variably open, slightly undulate sinus, and broadly rounded angles. Semicells in frontal view are subsemicircular. Cell wall equally furnished with short, blunt spines arranged in concentric series around the angles. Semicells in apical view 3-angular, with almost straight sides, and broadly rounded angles. Dimensions: L: 44-53 µm, B: 45-48 µm.

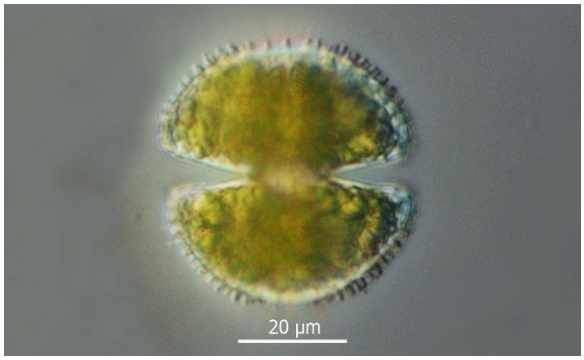

Figure 11. *St. cascadense* in frontal view focused on outline. Photo © R. Matthews.

Type: Nearshore sample from the floating bog (GPS 46.2694, -121.6045), preserved as a fixed natural sample in 4% buffered formalin, collected by R. Matthews, 3 July 2019, archived at the United States Algal Collection (Accession No. 239846), Smithsonian Institution, Washington, D.C. (USA), partly illustrated in our figs 11-14.

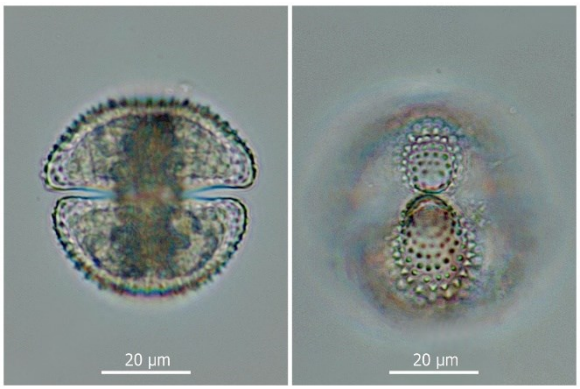

Figure 12. *St. cascadense* in frontal view focused on periphery (left) and on protruding lobe (right). Photo © R. Matthews.

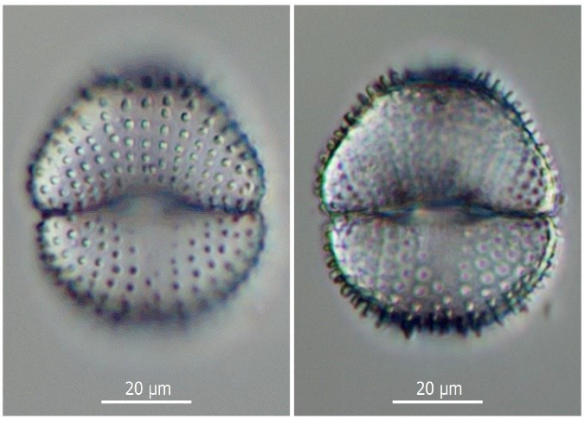

Figure 13. *St. cascadense* in back view showing surface granulation (left) and back view focused on outline (right). Photo © R. Matthews.

Differential diagnosis: *Staurastrum cascadense* could be compared with *St. pyramidatum* West, a species with roughly similar cell outline, ornamentation, and dimensions (West 1892: 179; West et al. 1923: 68, pl. 138: 10-12). However, cells in *St. pyramidatum* are slightly longer than broad, with semicells that in outline tend to be trapeziform, while cells in *St. cascadense* are almost circular. The most remarkable difference, however, is in the shape of the cell sinus: linear in *St. pyramidatum* versus slightly undulate in *St. cascadense*.

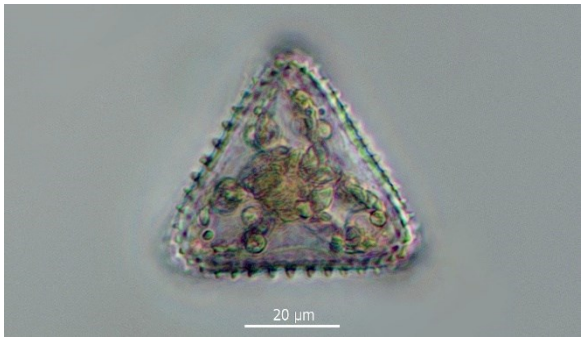

Figure 14. *St. cascadense* in apical view. Photo © R. Matthews.

Occurrence: In the Cascade Range, *St. cascadense* was only encountered in samples from the floating bog. This species was not present in other sites in the Mt. Adams area nor in numerous lakes and ponds samples farther north in the Cascades (R. Matthews, unpublished data). The floating bog is adjacent to a large wetland with many small ponds, so it is possible that this species occurs in similar habitats in the region.

Staurastrum orbiculariforme Coesel et Matthews spec. nov. (figs. 15-18)
Description: Cells about as long as broad, with a deep, slightly open, acute-angled sinus and broadly rounded angles. Semicells in frontal view subsemicircular, with the basal angles usually somewhat produced. The cell wall is smooth, with equally distributed, scattered pores. Semicells in apical view 3-angular, with broadly rounded angles and slightly concave sides. Cell length 38-47 µm, cell breadth 33-51 µm.

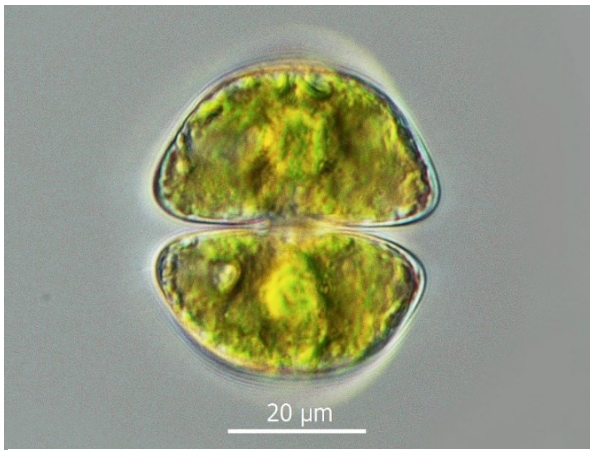

Figure 15. *St. orbiculariforme* in frontal view. Photo © R. Matthews.

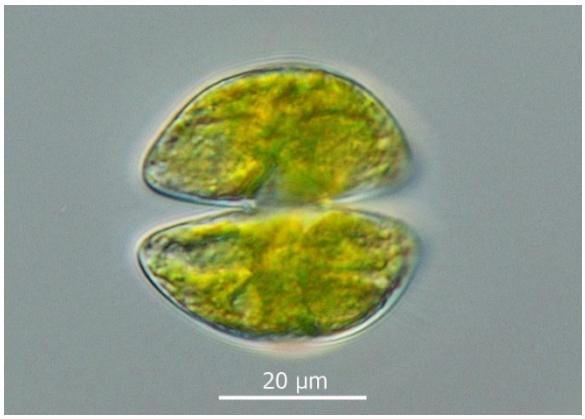

Figure 16. *St. orbiculariforme* in frontal view. Photo © R. Matthews.

Type: Nearshore sample from Chain Lake (GPS 46.2936, -121.5991), preserved as a fixed natural sample in 4% buffered formalin, collected by R. Matthews, 30 July 2019, archived at the United States Algae Collection (Accession No. 239847), Smithsonian Institution, Washington, D.C. (USA), partly illustrated in our figs. 17-18.

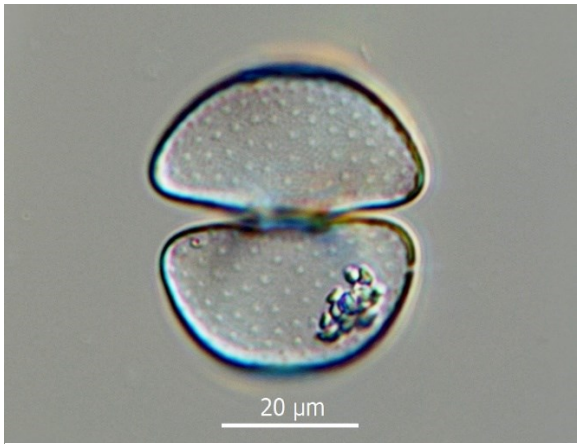

Figure 17. *St. orbiculariforme* in back view showing pore arrangement. Photo © R. Matthews.

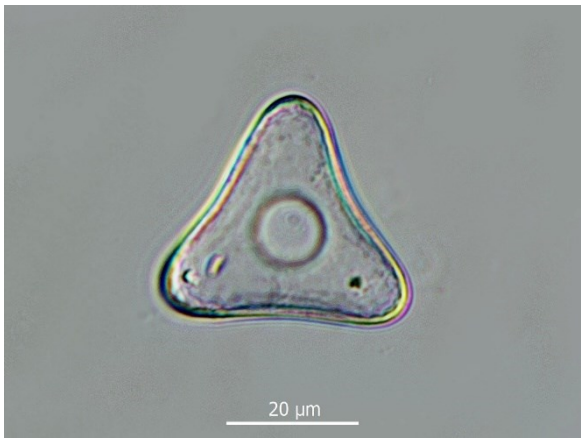

Figure 18. *St. orbiculariforme* in isthmial view. Photo © R. Matthews.

Differential diagnosis: as its name indicates, the above newly described species much resembles *Staurastrum orbiculare* Ralfs. Unfortunately, under the name of *Staurastrum orbiculare*, Ralfs (1848, pl. 21: 5) depicted a number of cells distinctly different in outline, which is most likely attributable to different taxa. In practice, for identification of those taxa, the flora by West & West (1912) is usually taken into account. In their view, *St. orbiculare* Ralfs should be considered a medium-sized species (cell length > 50 µm), with subcircular cells that are slightly longer than broad, and a narrowly linear sinus with a slightly dilated extremity. Cells of our algal form under discussion are smaller, relatively broader, and, most important, are characterized by an open, acute-angled sinus, usually in combination with basal semicell angles that are somewhat produced. Considering the many cell forms

published in algal literature under the name of *St. orbiculare*, many of them attributed to an infraspecific variety, we found only one example corresponding to our above-described form: *St. orbiculare* var. *protractum* Playfair in Prescott et al. (1982, pl. 330: 7). However, the original picture of that taxon in Playfair (1912, pl. 54: 25) shows a species with elliptic-rhomboid semicells instead of subsemicircular ones, so it refers to quite another species. As our algal form in question appeared very consistent in shape and cell dimensions, we think it justified to describe it as a separate taxon, and prefer to rank it as species rather than variety. We want to get rid of that latter rank, as much as desirable, because many infraspecific desmid taxa may be attributed to their own ecological or biogeographical characteristics.

Occurrence: S*t. orbiculariforme* was frequently encountered in Chain Lake, the floating bog, and incidentally in Olallie Lake.

Acknowledgments

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