



Records of desmids (Chlorophyta) newly found in Korea

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Abstract

The present study summarizes the taxonomic notes and Korean distribution of 29 taxa of the desmids (Chlorophyta) collected from several swamps, reservoirs, rivers, and high land wetlands in South Korea from 2009 to 2013. All of these consisting of 9 genera (*Tetmemorus* 1 taxon, *Pleurotaenium* 5 taxa, *Triploceras* 1 taxon, *Euastrum* 7 taxa, *Cosmarium* 6 taxa, *Staurastrum* 5 taxa, *Xanthidium* 1 taxon, *Hyalotheca* 2 taxa, and *Desmidiium* 1 taxon) are newly described in Korean freshwater algal flora. In this study, light microscopy of all of these are presented and briefly discussed with regard to their taxonomy, distribution and ecology within South Korea.

Key words: desmids, newly described, South Korea

INTRODUCTION

Many investigations on fresh-water algal flora have been carried out in Korea since Kawamura (1918) reported a species of *Centritractus* at Lake Seoho, Suwon (Chung 1968, 1970, 1975, 1976, 1979, 1982, 1993, Chung et al. 1972a, 1972b, Choi 1976, Lee 1978, Wui and Kim 1987a, 1987b, Kim 1993, 1996, Kim and Chung 1993, 1994, Kim et al. 2009). Until now, about 1,200 taxa of fresh-water chlorophytes have been recorded in Korea, and among them desmids account for 50% (about 600 taxa). However, this is only about 10% of the desmids reported throughout the world (6,000 species) (John et al. 2011) even though most of desmids are cosmopolitan species. Although desmids are green algae found in considerable range of freshwater habitats mostly characterized by low salinities, low conductivities, and acidic habitats such as *Sphagnum* bogs, peat bogs, marsh, swamps, and mountainous wetlands, many of these are especially abundant in acid bogs associated with *Sphagnum* and *Utricularia* species (Brook

1981, Brook and Williamson 2010). The most floristic or taxonomic studies of desmids from Korea were carried out along with other taxonomic groups of freshwater algae.

Although many diverse species of desmids are found within freshwater algal flora, only a few studies on this flora have been conducted in Korea (Skvortzov 1932, Choi 1976, Chung and Lee 1986, Kim 1996). Also, all of the most floristic or taxonomic studies on the desmids from Korea have investigated from lowland artificial lakes, swamps, reservoirs and ponds, but the investigation of freshwater algae on characteristic habitats such highland moorlands, mountainous *Sphagnum* bogs or wetlands, and small crater have not been carried out.

More than 500 samples were collected from various habitats throughout the country and were investigated for establishing fresh-water algal flora in Korea. This study reports 29 taxa of desmids newly recorded in Korea.

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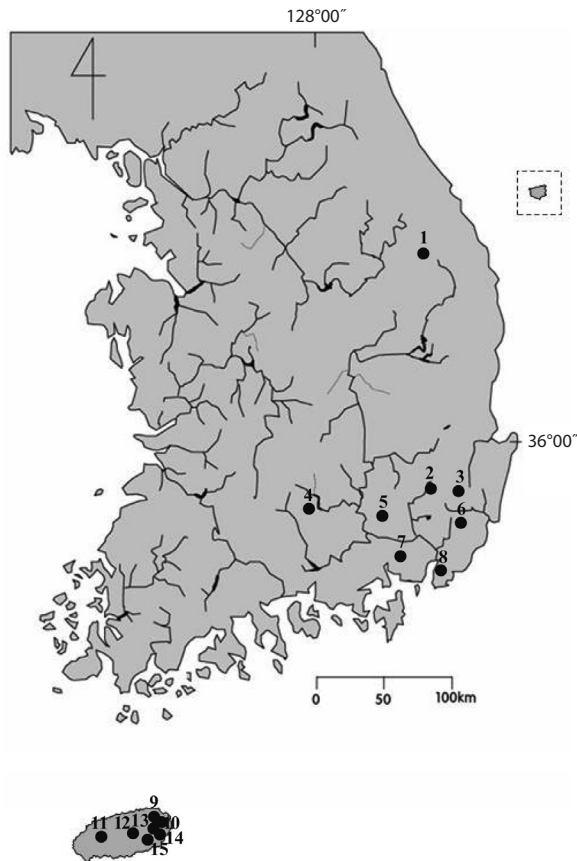


Fig. 1. Location of sampling sites in the territory of Korea. Numbers on the map represent as follow: 1, Darongi pond; 2, Imdang weir; 3, Okbang wetlands; 4, Motje; 5, Jangcheok reservoir; 6, Mujechineup; 7, Junam reservoir; 8, Samlak wet-lands; 9, Dongbaek-dongsan; 10, Deokcheon pond; 11, Sumenmulbangdi; 12, Mulyoungari; 13, Micheongul; 14, Samdalri; 15, Uriseungmajang. See detailed information of sampling site in Table 1.

MATERIALS AND METHODS

The samples were collected at 15 different water bodies such as lowland swamps, reservoirs, mountainous wetlands, sphagnum bogs, orum (very small and shallow caldera lakes) from 2009 to 2013 (Fig. 1 and Table 1). The samples were obtained by means of spoid, plankton net (mesh size, 25 µm) or by squeezing submerged macrophytes. Living materials was immediately examined. After first examination, materials were fixed with 5% formalin for permanent preservation and detail identification. Microscopic examinations were made at ×200-1000 magnification under an Axio Imager A2 microscope (Carl Zeiss, Jena, Germany) and photomicrographs were taken with an AxioCam HRC camera (Carl Zeiss). Water temperature, pH, and conductivity were measured in the field by means of a HI8314 membrane pH meter (HANNA instruments, Smithfield, RI, USA) and a HI9835 EC meter (HANNA instruments). All the taxa recorded are illustrated with photomicrographs. The materials were deposited in the National Institute of Biological Resources (NIBR) and Department of Biology Kyungpook National University. The following abbreviations are used: Dist., distribution; rr, very rare; r, rare; c, common; cc, abundant.

RESULTS AND DISCUSSION

***Pleurotaenium cylindricum* (Turner) Schmidle (Fig. 2a and 2b)**

References: Krieger 1937, p. 419, pl. 45, fig. 1; Prescott et

Table 1. Informations of sampling sites

Site no.	Location	Characteristic of Sampling site	pH	EC (µS/cm)	Altitude (m)
1	38°12'55" N, 128°07'15" E	highland pond	6-7.5	30-50	1,200
2	35°42'25" N, 128°55'00" E	Weir located at the middle part of the Dongchang stream	6.7-7.5	112-145	100
3	35°46'20" N, 129°05'05" E	Abandoned paddy field ditch located at highland	6.2-7.5	27-45	480
4	35°36'45" N, 128°13'55" E	Small shallow pond located at top area of small mountain	6.6-7.7	65-120	80
5	35°26'10" N, 128°29'35" E	Old shallow mesotrophic reservoir	7.2-8.3	103-155	30
6	35°27'50" N, 129°08'30" E	Highland <i>Sphagnum</i> bog	5.2-6.7	25-35	650
7	35°18'35" N, 128°39'50" E	Old shallow mesotrophic reservoir	6.8-7.5	160-197	30
8	35°10'40" N, 128°58'20" E	Artificial wet-lands located at river-side	6.7-7.5	44-121	5
9	33°31'10" N, 126°42'30" E	Natural oligotrophic rock pond	6.1-7.5	44-108	60
10	33°30'20" N, 126°46'30" E	Artificial small shallow pond	6.5-7.4	90-140	100
11	35°25'20" N, 128°59'30" E	<i>Sphagnum</i> bog located at near the middle of Mt. Hanla	5.4-6.6	25-45	860
12	33°22'50" N, 126°41'20" E	Oligotrophic adventive crater	5.6-7.0	36-55	480
13	33°23'10" N, 126°50'05" E	Natural small shallow pond	5.8-7.5	36-70	100
14	33°22'30" N, 126°46'20" E	Artificial small shallow pond	6.8-7.5	36-55	80
15	33°23'35" N, 126°48'09" E	Natural small shallow pond	5.9	70.2	70

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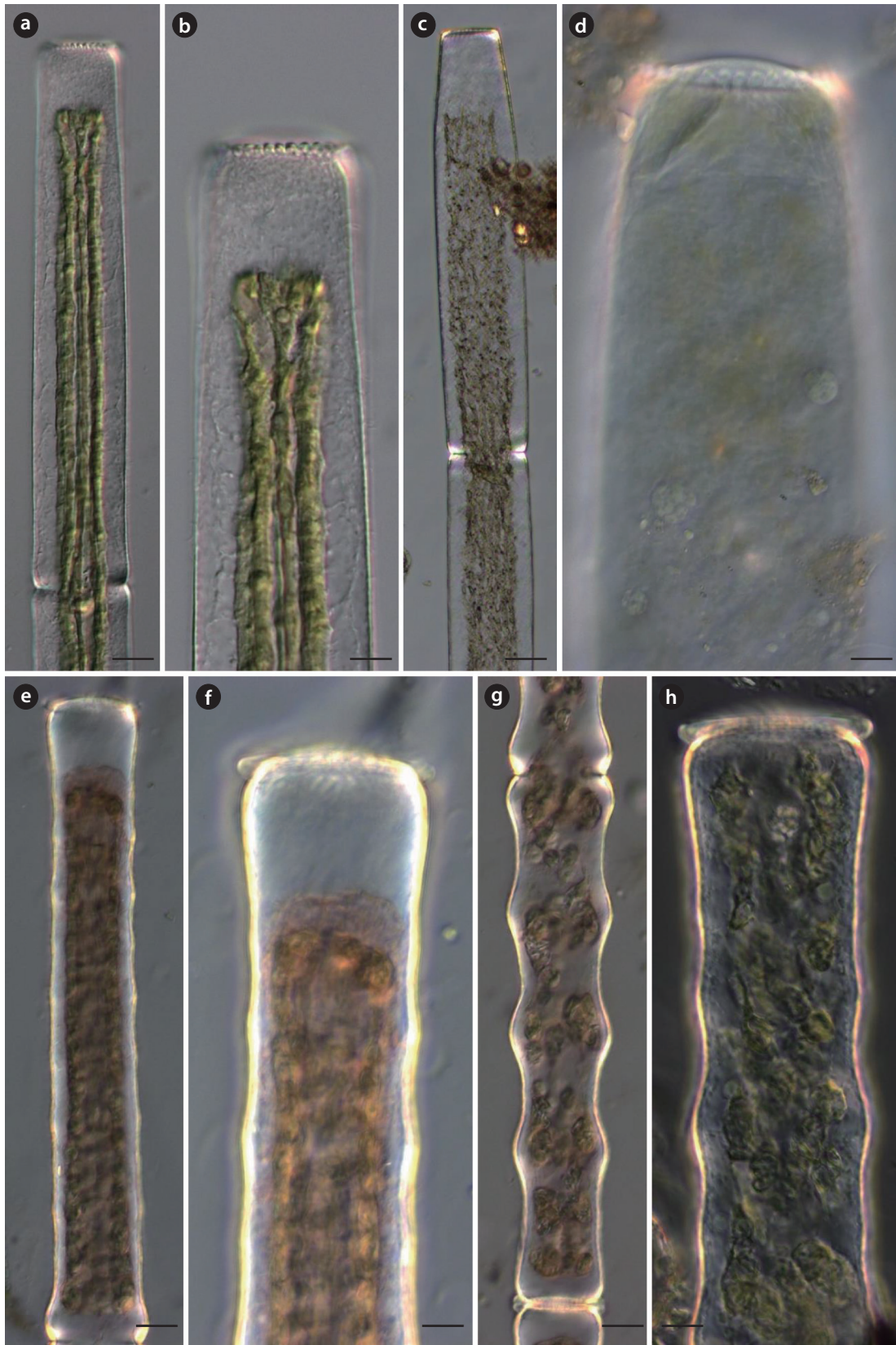


Fig. 2. (a, b) *Pleurotaenium cylindricum*, (c, d) *P. cylindricum* var. *stuhlmannii*, (e, f) *P. elatum*, and (g, h) *P. lagerheimii*. Scale bars represent 20 μm (a, c, e, and g) and 10 μm (b, d, f, and h).

al. 1975, p. 113, pl. 47, fig. 15.

Dist.: 5 (r), 7 (r), 9 (r); numbers indicate sampling sites in Fig. 1 and Table 1.

Description: Cells cylindrical, 7-13 times longer than broad, slightly constricted in the middle, lateral margins parallel; semicell with evident basal inflation, apices slightly broadened, with 10 to 20 tubercles; cells length 400-420 μm , breadth 25-27 μm .

In the present study, this species was rarely occurred from several lowland mesotrophic to eutrophic reservoirs.

***Pleurotaenium cylindricum* var. *stuhlmannii* (Hieronimus) Krieger (Fig. 2c and 2d)**

References: Krieger 1937, p. 420, pl. 45, fig. 3; Prescott et al. 1975, p. 114, pl. 47, figs. 16-17; Förster 1982, p. 117, pl. 14, fig. 8; Yamagishi and Akiyama 1998, p. 55.

Dist.: 9 (rr).

Description: Cells large, about 11-18 times longer than broad, very slightly constricted in the middle, lateral margins straight; semicells cylindrical throughout, apices rounded or truncate with 12-17 tubercles in front view; cells length 560-950 μm , breadth 46-75 μm . A variety differ from nominate by its larger size, greater length and in not being broader at the apex. This species very rarely occurred only at oligotrophic, shallow pond in Jeju Island.

***Pleurotaenium elatum* (Turner) Borge (Fig. 2e and 2f)**

References: Krieger 1937, p. 425, pl. 46, fig. 3; Hirose and Yamagishi 1977, p. 517, pl. 175, fig. 3; Yamagishi and Akiyama 1987a, p. 59.

Dist.: 3(r).

Description: Cells large, about 11-19 times longer than broad, slightly constricted in the middle, lateral margins with 7-10 undulations beyond the basal inflation to the apices; semicells cylindrical, conspicuously inflated at the base, not attenuated from base to apex, apex slightly dilated, with 13 to 15 rounded tubercles; cells length 520-900 μm , breadth 40-69 μm . It rarely occurred in mountainous oligotrophic, slightly acidic wetlands in this study.

***Pleurotaenium lagerheimii* NKrieger (Fig. 2g and 2h)**

References: Krieger 1937, p. 421, pl. 45, fig. 7; Yamagishi and Akiyama 1996, p. 62.

Dist.: 3(r).

Description: Cells large, cylindrical, about 10-14 times

longer than broad, slightly constricted in the middle; semicells typically with 4 large, equal prominent undulation, sometimes with small inflation between the large undulations, tapering slightly to the apex; apices rounded-truncate, with a crown of 11-15 conical tubercles; cells length 540-590 μm , breadth 56-62 μm . It rarely occurred in mountainous oligotrophic, slightly acidic wetlands in this study.

***Pleurotaenium nodulosum* (Ralfs) de Bary (Fig. 3a and 3b)**

References: Prescott et al. 1977, p. 126, pl. 47, figs. 6, 8-11; Yamagishi and Akiyama 1997, p. 81; Coesel and Meesters 2007, p. 68, pl. 34, figs. 1-3; John et al. 2011, p. 696, pl. 170, fig. E.

Dist.: 5(r), 15(c).

Description: Cells medium, about 8-14 times longer than broad, slightly constricted in the middle; semicells with 5-9 undulated margins, apex smooth, rounded or truncately rounded; wall punctuate or scrobiculate; cells length 510-1,115 μm , breadth 59-85 μm .

***Tetmemorus laevis* Ralfs (Fig. 3c)**

References: West and West 1904, p. 222, pl. 32, figs. 11-16; Prescott et al. 1975, p. 149, pl. 56, figs. 1-3, 6-8; Růžička 1981, p. 366, pl. 56, figs. 9-15; Yamagishi and Akiyama 1986, p. 91; Coesel and Meesters 2007, p. 70, pl. 39, figs. 1-2.

Dist.: 11 (r).

Description: Cells cylindrical or subcylindrical, 4-6 times longer than broad, slightly constricted in the middle, lateral margins straight or slightly concave, towards the ends slightly attenuated; apices broadly rounded with a deep, conspicuous median incision; cell wall with clearly defined longitudinal rows of punctures; chloroplast star-shaped with 3-5 longitudinal ridges and 2-5 pyrenoids in each semicell; cells length 107-134 μm , breadth 22-26 μm . This species probably is acidophilic; mainly occurred in acidic peaty pools and *Sphagnum* bogs (pH 3.5-6.5) (John et al. 2011). It commonly occurred in mountainous oligotrophic, slightly acidic wetlands in this study.

***Triploceras gracile* Bailey (Fig. 3d-3f)**

References: Krieger 1937, p. 442, pl. 52, figs. 1-7; Prescott et al. 1975, p. 143, pl. 51, figs. 7-14; Hirose and Yamagishi 1977, p. 519, pl. 176, fig. 5; Růžička 1977, p. 288, pl. 44, figs. 9-13; Förster 1982, p. 131, pl. 16, figs. 1-3; Yamagishi and

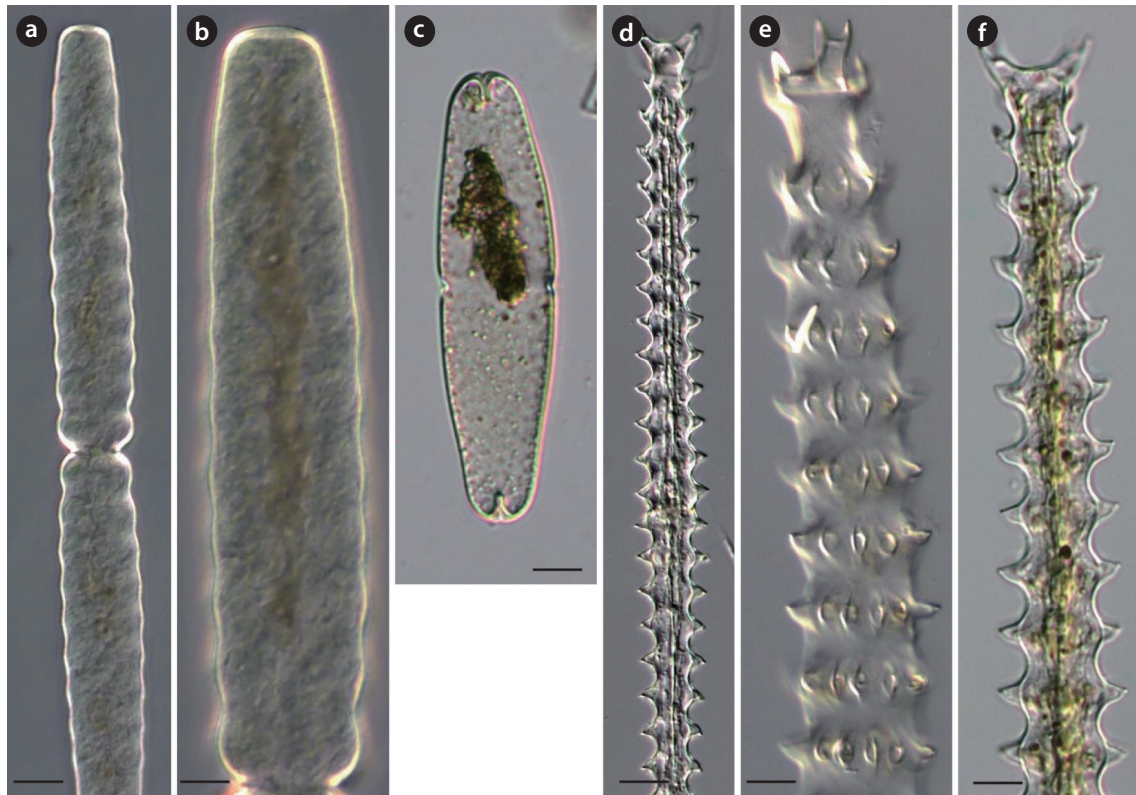


Fig. 3. (a, b) *Pleurotaenium nodulosum*, (c) *Tetmemorus laevis*, and (d-f) *Triploceras gracile*. Scale bars represent 20 μm (a and d) and 10 μm (b, c, e, and f).

Akiyama 1984, p. 96.

Dist.: 9(c).

Description: Cells medium size, subcylindrical, about 10-19 times longer than broad, slightly constricted in the middle; semicells slightly attenuated from base to apex, with 9-15 whorls of 10-14 low, each nodulation with a series of short spine; spines in lower whorls horizontal but spines in upper whorls directed upward; apex dilated and divided into two parts tipped with a pair of spines; cells length 190-230 μm , breadth 20-23 μm . It commonly occurred only at oligotrophic, shallow pond in Jeju Island.

***Euastrum ceylanicum* (W. & G. S. West) Krieger (Fig. 4a and 4b)**

References: Krieger 1937, p. 627, pl. 90, figs. 16-17; Prescott et al. 1977, p. 30, pl. 80, figs. 17-18; Hirose and Yamagishi 1977, p. 623, pl. 194, fig. 13; Yamagishi and Akiyama 1985a, p. 33.

Dist.: 11(r).

Description: Cells quadrate in outline, about 1.3 times longer than broader, deeply constricted in the middle, sinus acutely open outward; semicells 3-lobed, lateral

lobes broadly rounded and transversely extended; polar lobe rectangular, the margins slightly diverging or nearly parallel, apex slightly retuse or flat, apical angles broadly rounded or slightly swollen, the margins of the apical angles and the basal lobes with sharp short spines; the center above the isthmus with a prominent protuberance, provided with concentric series of granules, and with a small inflation disposed by the imperfectly concentric series of granules in both sides of the central protuberance; in vertical view narrowly elliptic, poles broadly rounded, with a group of spines; lateral view elongate rectangular with a prominent median granulated protuberances, apical angles rounded with a group of short spines; cells length 46-78 μm , breadth 39-63 μm , isthmus 11-16 μm .

***Euastrum didelta* var. *bengalicum* Lagerheim (Fig. 4c)**

References: Krieger 1937, p. 519, pl. 67, figs. 4-6; Yamagishi and Akiyama 1988, p. 42.

Dist.: 10(r).

Description: Cells medium size, narrowly oval in outline, about two times longer than broad, deeply constrict-

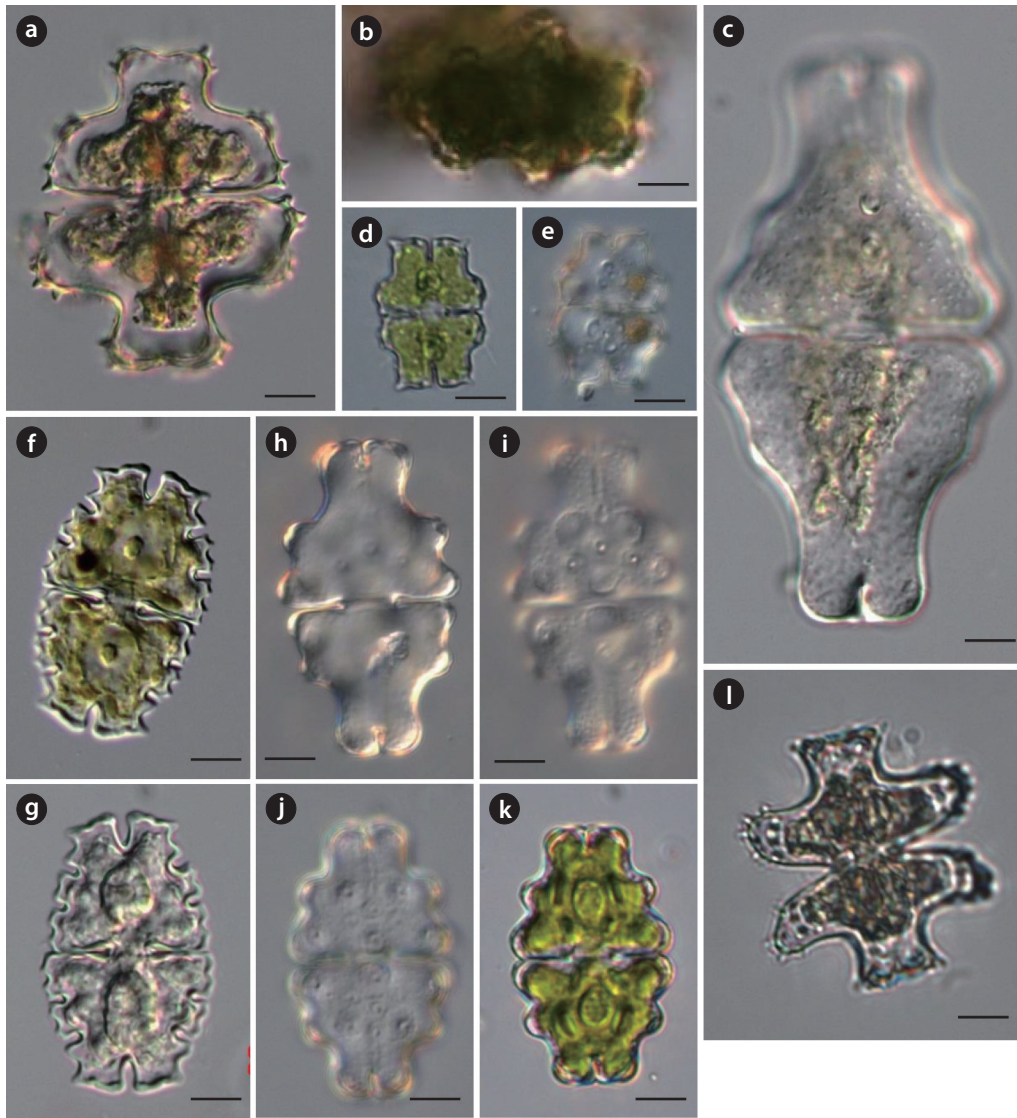


Fig. 4. (a, b) *Euastrum ceylanicum* and (b) its vertical view, (c) *E. didelta* var. *bengalicum*, (d, e) *E. pulchellum*, (f, g) *E. serratum*, (h, i) *E. sinuosum* var. *germanicum*, (j, k) *E. sinuosum* var. *scrobiculatum*, and (l) *E. substellatum*. Scale bars, 10 μ m.

ed in the middle, sinus linearly closed, slightly open at the extremity; semicells pyramidal with 5 protuberances; cell wall punctuate, with two mucilage pores vertically arranged at the center; lateral view narrowly pyramidal, basal margins with 2 inflations at the each side; cells length 116-122 μ m, breadth 56-61 μ m, isthmus 15-16 μ m.

***Euastrum pulchellum* Brebisson (Fig. 4d and 4e)**

References: Krieger 1937, p. 587, pl. 81, figs. 8-11; Prescott et al. 1977, p. 98, pl. 75, figs. 14-14b; Hirose and Yamagishi 1977, p. 667, pl. 205, fig. 6; Růžička 1981, p. 490, pl. 82, figs. 1-6. Yamagishi and Akiyama 1994, p 33; Coesel

and Meesters 2007, p. 81, pl. 47, figs. 4-5; John et al. 2011, p. 683, pl. 166, fig. F.

Dist.: 12(r).

Description: Cells small size, rectangular in outline, about 1.3-1.5 times longer than broad, deeply constricted in the middle, sinus linearly closed, slightly open at the extremity; semicells rectangular or trapeziform, basal angles broadly rounded with a minute spine; lateral margins retuse, apical angles with a short spine, apical margin elevated with a median incision; central protuberance with 3 large granules and a pair of mucilage pores, cell wall with granules within the margins of all lobes; vertical view elliptic; lateral view narrowly oval; cells length 26-41 μ m,

breadth 20-30 μm , isthmus 6.5-8 μm .

***Euastrum serratum* Joshua (Fig. 4f and 4g)**

References: Krieger 1937, p. 623, pl. 88, figs. 24-26; Hirose and Yamagishi 1977, p. 64, pl. 199, fig. 18; Yamagishi and Akiyama 1989a, p. 35.

Dist.: 12(c).

Description: Cells medium size, broadly oval in outline, about 1.6-1.7 times longer than broad, deeply constricted in the middle, sinus linearly closed, rounded at the extremity; semicells 5-lobed; lateral lobes divided into two lobules, the margins deeply retuse; polar lobe with deeply opened median incision and convex apex, apical angles with a short spine, incision between polar and lateral lobes deep and open; semicell with protuberance just above the isthmus and a pair of scrobiculations in the central region; in vertical view subrectangular, sides with a protrusion in the middle; lateral view ovate, apex narrowly rounded, sides inflated at the lower part, each side of the upper part with a large granule; cells length 40-50 μm , breadth 28-38 μm , isthmus 6.5-8 μm .

***Euastrum sinuosum* var. *germanicum* (Raciborski) Krieger (Fig. 4h and 4i)**

References: Krieger 1937, p. 502, pl. 63, fig. 1; Prescott et al. 1977, p. 104, pl. 61, figs. 1-2; Hirose and Yamagishi 1977, p. 627, pl. 195, fig. 2; Růžička 1981, p. 425, pl. 69, fig. 8; Yamagishi and Akiyama 1985a, p. 38.

Dist.: 3(c), 6(c), 11(c).

Description: Cells medium size, broadly oval in outline, about 2 times longer than broad, deeply constricted in the middle, sinus linearly closed; semicells truncate-pyramidal, 3-lobed; polar lobe elongate rectangular with concave lateral margins and apex truncate, apex truncate and convex with deep closed incision, angles rounded; basal part of semicell rectangular, lateral margin slightly retuse; incision between polar and upper lateral lobes concave; lateral view of semicell elongate truncate-pyramidal with two inflation at the lower part, apex convex; vertical view elliptic; cells length 60-67 μm , breadth 30-34 μm , isthmus 8.5-10 μm .

***Euastrum sinuosum* var. *scrobiculatum* Nordstedt (Fig. 4j and 4k)**

References: Krieger 1937, p. 503, pl. 63, figs. 2-3; Prescott et al. 1977, p. 105, pl. 60, fig. 15; Hirose and Yamagishi 1977, p. 627, pl. 195, fig. 4; Růžička 1981, p. 426, pl.

69, figs. 11-12; Förster 1982, p. 339, pl. 44, fig. 2.

Dist.: 3(c), 6(c), 11(c).

Description: Cells medium size, broadly oval in outline, about 1.5 times longer than broad, deeply constricted in the middle, sinus linearly closed; semicells truncate-pyramidal, 3-lobed; polar lobe elongate rectangular with concave lateral margins and apex truncate, apex truncate and convex with deep closed incision, angles rounded; basal part of semicell rectangular, lateral margin slightly retuse; incision between polar and upper lateral lobes concave; lateral view of semicell elongate truncate-pyramidal with two inflation at the lower part, apex convex; vertical view elliptic; cells length 60-67 μm , breadth 30-34 μm , isthmus 8.5-10 μm .

***Euastrum substellatum* Nordstedt (Fig. 4l)**

References: Krieger 1937, p. 629, pl. 90, figs. 21-24; Hirose and Yamagishi 1977, p. 622, pl. 194, fig. 8.

Dist.: 13(r).

Description: Cells medium size, slightly longer than broad, deeply constricted at the middle, sinus acutely opened; semicells 3-lobed; polar lobe rectangular with retuse apex and parallel sides, angles with a few small spines and within margin with 2-3 small spines; lateral lobes horizontally extended, lateral margins convex and slightly divergent and furnished with a number of spines; central part above the isthmus with a concentric series of wart-like granules, in both sides of the central granule-group with a few small spines inside the lateral lobes; lateral view ovate, with a granular protuberance on each side; cells length 47-60 μm , breadth 41-53 μm , isthmus 11-14 μm .

***Cosmarium cyclicum* P. Lundell (Fig. 5a-5c)**

References: West and West 1905, p. 145, pl. 63, figs. 8-9; Prescott et al. 1981, p. 116, pl. 166, figs. 2-4; Coesel and Meesters 2007, p. 113, pl. 68, fig. 27.

Dist.: 1(r).

Description: Cells medium size, circular in outline, as long as broad or slightly broader than long, deeply constricted in the middle, sinus narrow linear and slightly open at the extremity; semicells semicircular, with about a dozen crenations, and 2 or 3 concentric series of undulations within the margin, basal angles slightly rounded; in vertical view of semicell fusiform, undulate toward the sharp poles; cells length 46-56 μm , breadth 50-58 μm , isthmus 16-28 μm .

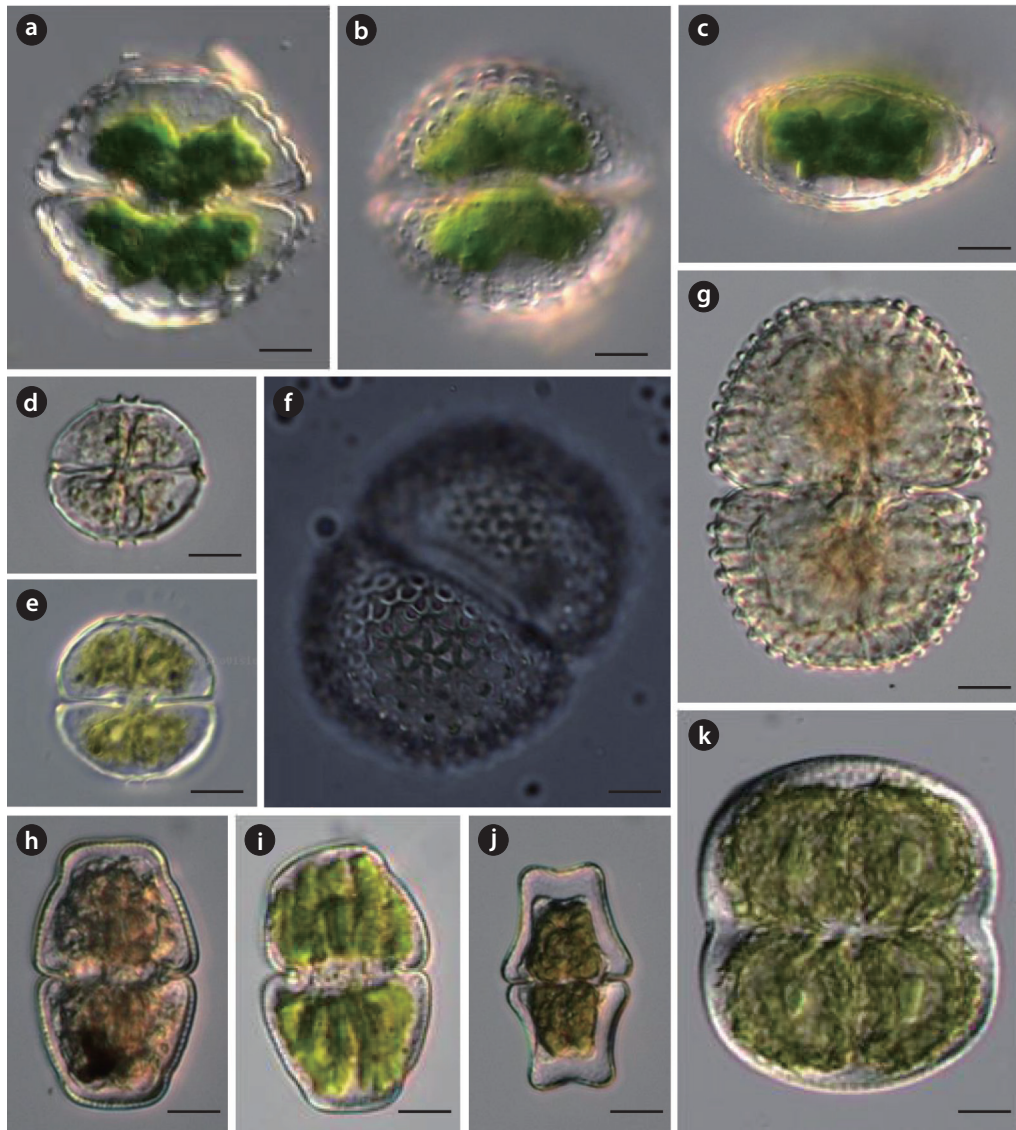


Fig. 5. (a-c) *Cosmarium cyclicum* and (c) its vertical view, (d, e) *C. decachondrum*, (f, g) *C. decoratum*, (h, i) *C. holmiens* var. *attenuatum/integrum*, (j) *C. taticum* var. *novizelandicum*, (k) *C. pseudoconnatum* var. *pluriadians*. Scale bars, 10 µm.

***Cosmarium decachondrum* Roy et Bisset (Fig. 5d and 5e)**

References: Prescott et al. 1981, p. 120, pl. 224, fig. 8; Yamagishi and Akiyama 1985a, p. 19.

Dist.: 10(r).

Description: Cells medium size, slightly broader than long, deeply constricted in the middle, sinus linear but open, and slightly widening outwards; semicells semicircular, each basal angles rectangular with a small papilla, lateral margins undulate, undulations 4 to 5 on either side, apical margin slightly convex, with intramarginal

of 4 small teeth; in vertical view of semicell elliptic, poles truncate, with 3 slight prominences in the mid-region of both side and with 10 minute teeth arranged in an oval around the center; cells length 25-32 µm, breadth 26-32 µm, isthmus 6-9 µm.

***Cosmarium decoratum* W. et West (Fig. 5f and 5g)**

References: Prescott et al. 1977, p. 121, pl. 267, fig. 11; Hirose and Yamagishi 1977, p. 601, pl. 190, fig. 2; Förster 1982, p. 192, pl. 32, fig. 9; Yamagishi and Akiyama 1984, p. 11.

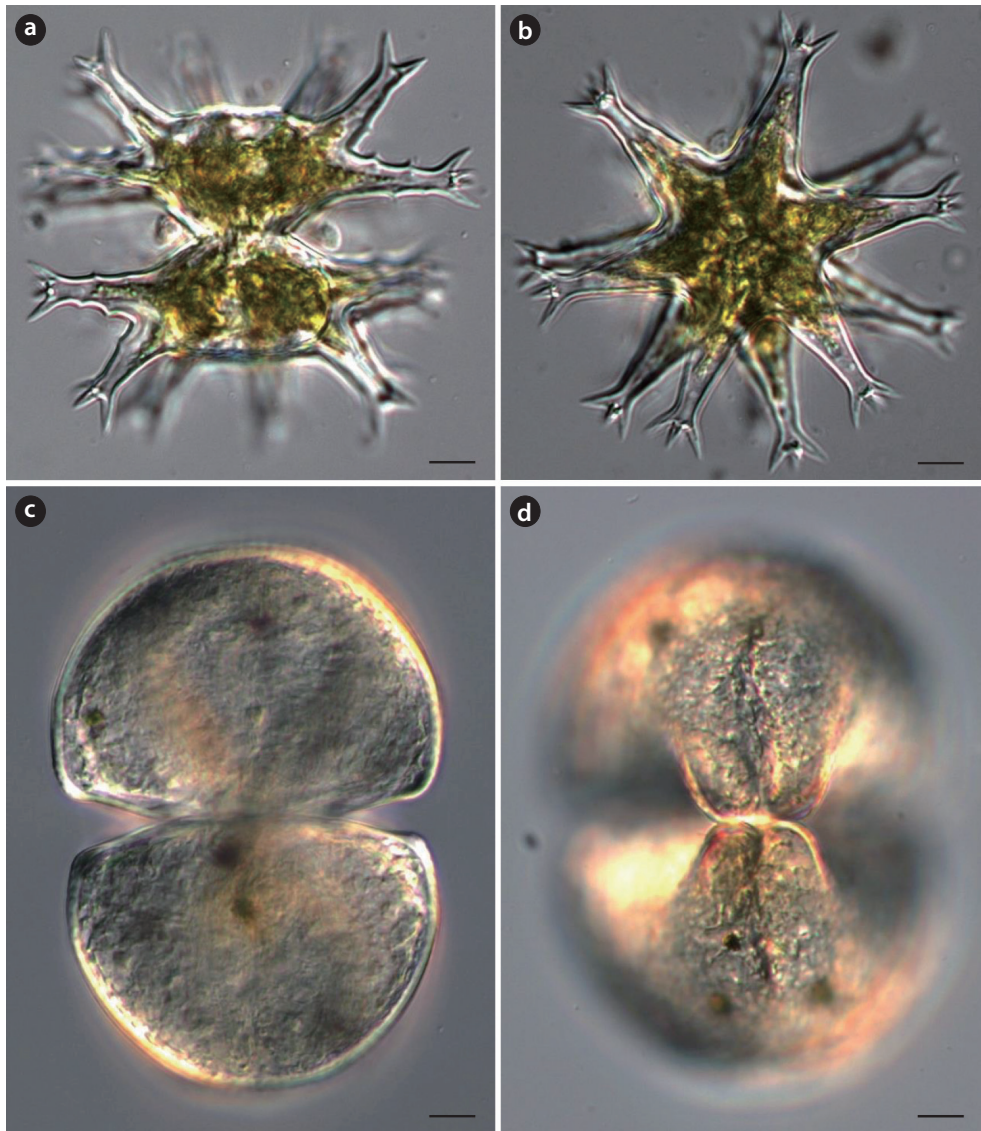


Fig. 6. (a, b) *Staurastrum arctiscon* and (b) its vertical view, and (c, d) *S. zahlbruckneri*. Scale bars, 10 μ m.

Dist.: 12(r), 14(r).

Description: Cells large, about 1.3 times longer than broad, deeply constricted in the middle, sinus narrowly linear, a slightly dilated extremity; semicells truncate-pyramidal, basal angles rounded, lateral margins convex and upwardly convergent, upper angles obtusely rounded, apex nearly straight; cell wall uniformly granules disposed in oblique decussating series as well as in vertical and horizontal rows, each granules surrounded by 6 triangular pits throughout the surface of the semicell, the pits diminishing in size toward the margins of the cell; in vertical view of semicell elliptic, with a slight but conspicuous

inflation in the mid-region on both side, and with a punctuate area destitute of granules in the center; cells length 64-86 μ m, breadth 47-63 μ m, isthmus 22-33 μ m.

***Cosmarium holmiens* var. *attenuatum* Gutw. (Fig. 5h and 5i)**

References: West and West 1908, p. 4, pl. 65, fig. 6.

Dist.: 11(c).

Description: Cells moderate, about 1.6-1.8 times longer than broad, slightly constricted in the middle, sinus narrowly linear, a slightly dilated extremity; semicells

broadly pyramidal, apical and basal angles rounded, apex slightly convex, upper lateral margins just below the apex concave; in lateral and vertical view of semicell broadly elliptic; cell wall finely punctuate; cells length 47-55 μm , breadth 31-33 μm , isthmus 15-17 μm .

***Cosmarium pseudoconnatum* var. *pluriadians*
Scott et Grönblad (Fig. 5k)**

References: Prescott et al. 1981, p. 237, pl. 203, figs. 8, 12-13; Yamagishi and Akiyama 1987b, p. 24.

Dist.: 9(r).

Description: Cells large, about 1.1-1.2 times longer than broad, median constriction very shallow; semicells semielliptic; chloroplast with 4-7 longitudinal ridges in semicell, each with 2-3 pyrenoids; in vertical view, semicell circular or nearly so; cells length 65-70 μm , breadth 59-65 μm , isthmus 50-53 μm .

***Cosmarium taticum* var. *novizelandicum* Nordstedt (Fig. 5j)**

References: West and West 1908, p. 46, pl. 64, figs. 11-12; Yamagishi and Akiyama 1989b, p. 20.

Dist.: 6(c), 11(c).

Description: Cells medium in size, about 1.7-1.8 times longer than broad, median constriction deep, sinus narrowly linear, a slightly dilated extremity; semicells trapeziform, lateral margins and apex concave, basal angles slightly protrude; cell wall punctuate; in vertical and lateral view, semicell elliptic; cells length 40-50 μm , breadth 24-28 μm , isthmus 14-15 μm .

***Staurastrum articon* (Ehrenb.) Lundell (2012),
(Fig. 6a and 6b)**

References: West and West 1923, p. 193, pl. 157, fig. 5; Hirose and Yamagishi 1977, p. 749, pl. 221, fig. 1; Prescott et al. 1982, p. 129, pl. 410, fig. 6; Yamagishi and Akiyama 1986, p. 78; Coesel and Meesters 2013, p. 174, pl. 101, fig. 2.

Dist.: 5(r), 12(r).

Description: Cells large, about 1.5 times longer than broad without processes, deeply constricted in the middle, sinus acutely open; semicells subelliptic to subspherical, and with two superimposed whorls of processes, lower whorl consisted of 9 processes horizontally disposed, upper whorl consisted of 6 upwardly divergent processes, all the processes nodulated and tipped with 3 sharp teeth; in vertical view showing 2 whorls of processes, with a marginal series of 9 processes and intramarginal

series of 6 processes; cells length 50-96 μm without processes, 86-155 μm long with processes, broad 36-68 μm without processes, 77-160 μm breadth with processes, isthmus 24-33 μm .

***Staurastrum bifidum* (Ehrenb.) Brébisson (Fig. 7a-7d)**

References: West and West 1923, p. 32, pl. 134, fig. 4; Hirose and Yamagishi 1977, p. 686, pl. 208, fig. 12; Prescott et al. 1982, p. 142, pl. 363, fig. 13; Yamagishi and Akiyama 1987b, p. 69; Coesel and Meesters 2013, p. 72, pl. 39, figs. 1-2.

Dist.: 4(c), 9(c).

Description: Cells medium size, about as broad as long, deeply constricted in the middle, sinus obtuse at the extremity, widely open; semicells subelliptic or subcuneate, lateral margins convex, apical angles slightly produced, with a pair of long, sharp superimposed spines, spines long and strongly downturned and sometimes recurved, apical margins flat, truncate or broadly convex; cell wall smooth; in vertical view of semicell triangular, the margins flat or slightly concave, the poles bifurcate and furnished with two stout spines; cells length 26-33 μm , breadth 29-33 μm without spines, 48-56 μm with spines, isthmus 9-14 μm .

***Staurastrum louisianicum* Scott et Grönblad (Fig. 7e-7h)**

References: Prescott et al. 1982, p. 243, pl. 363, fig. 15; Yamagishi and Akiyama 1987a, p. 76.

Dist.: 3(r).

Description: Cells medium size, about as long as broad with spines, deeply constricted in the middle, sinus obtuse at the extremity and widely open; semicells suboviform or trapeziform, lateral and apical margins convex, angles with 2-3 spines; in vertical view of semicell triangular, the margins flat or slightly convex, the poles with 2-3 spines; cell wall smooth; cells length 32-35 μm , breadth 29-34 μm without spines, isthmus 11-14 μm .

***Staurastrum spongiosum* var. *perbifidum* West
(Fig. 7i-7k)**

References: Prescott et al. 1982, p. 316, pl. 345, figs. 10, 13; Yamagishi and Akiyama 1998, p. 72.

Dist.: 3(c), 6(c), 11(c)

Description: Cells medium size, about as broad as long, deeply constricted in the middle, sinus acutely open out-

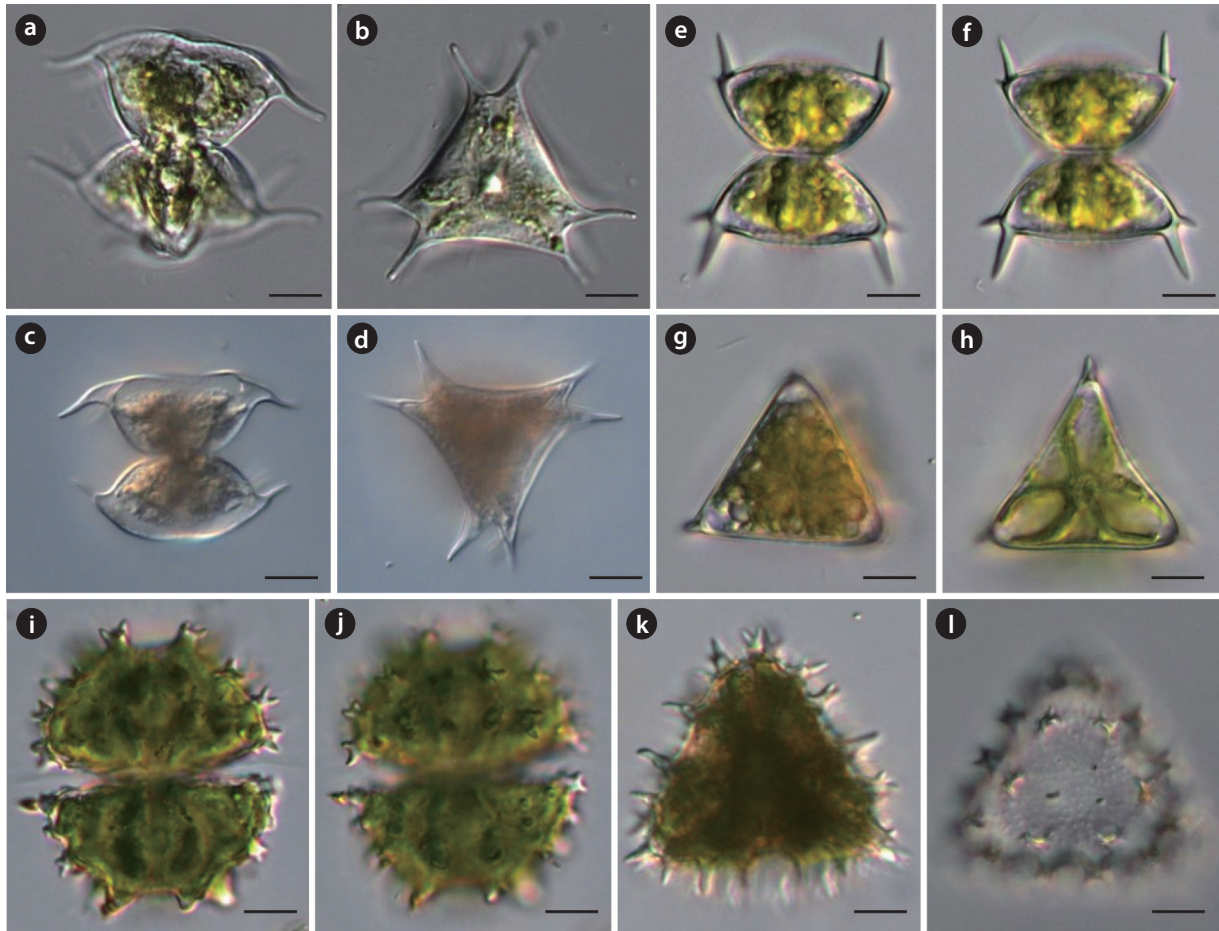


Fig. 7. (a-d) *Staurastrum bifidum*, (e, h) *S. louisianicum*, (i-l) *S. spongiosum* var. *perbifidum*. (a), (c), (e), (f), (i) and (j) are front view; (b), (d), (g), (h), (j), and (k) are vertical view. Scale bars, 10 μ m.

wardly; semicells subtrapeziform, apical and basal angles with bispinate verruca, with a transverse series of 6 verrucae across the midregion of semicell; in vertical view of semicell triangular, the margins slightly convex, with a stout bi- or trispinate verruca at the angles, and with 4-6 bi-spinate verrucae at the margins; within the margin 2 concentric circles of verrucae; cells length 45-53 μ m, breadth 42-50 μ m, isthmus 12-13 μ m.

***Staurastrum zahlbruckneri* Lütkemüller (Fig. 6c and 6d)**

References: Yamagishi and Akiyama 1985b, p. 85.

Dist.: 12(r).

Description: Cells large, broadly elliptic, slightly longer than broad, deeply constricted in the middle, sinus slightly open like narrow fusiform but acuminate at the extremity; semicells semicircular, basal angles slightly produced

toward obliquely downward and slightly thickened; in vertical view of semicell triangular, the margins straight, angles truncate and forked; cell wall minutely granulated; cells length 105-125 μ m, breadth 88-100 μ m, isthmus 22-36 μ m.

***Xanthidium superbum* Elfving (Fig. 8a-8c)**

References: Hu and Wei 2006, p. 894, pl. XIV-85, figs. 1-3; Scott and Prescott 1961, p. 5, pl. 37, fig. 5.

Dist.: 6(r).

Description: Cells large, about 1.2-1.5 times longer than broad without spines, deeply constricted in the middle, sinus narrowly linear; semicells semicircular, apical margin rounded or slightly straight, basal angles with 1-2 papillae or short spine, margins of semicells with 15-16 equidistant pairs of long stout spines, apex with 3-4 pairs of conical short spines; vertical view of semicells elliptic,

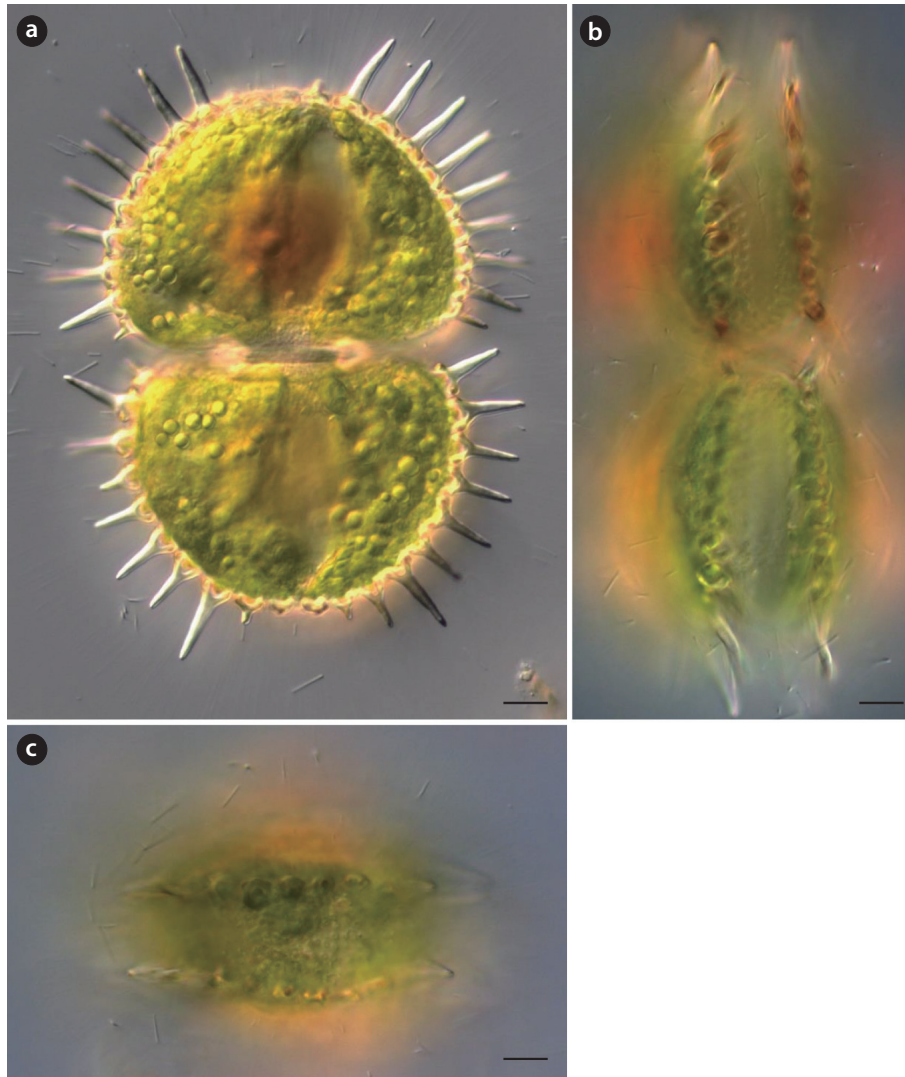


Fig. 8. *Xanthidium superbum*, (a) front view, (b) lateral view, and (c) vertical view. Scale bars, 10 μ m.

with two low of spines; cells length 110-130 μ m without spines, breadth 75-80 μ m without spines, spine 15-20 μ m. It rarely occurred in mountainous oligotrophic, slightly acidic wetlands in this study.

***Hyalotheca disciliensis* f. *bidentula* Nordstedt (Fig. 9a and 9b)**

References: West and West 1923, p. 232, pl. 161, figs. 20, 26; Croasdale et al. 1983, p. 28, pl. 460, fig. 13.

Dist.: 2(r), 3(r).

Description: Cells small, slightly broader than long, transversely rectangular, slightly constricted in the middle, sinus depressed and widely open; semicell subtrapeziform, later margins convex; vertical view of semicell

circular with a slight papilla in opposite disposition; cells length 14-33 μ m, breadth 17-36 μ m, isthmus 14-30 μ m. This variety differs from nominate variety by having vertical view of semicell with a slight papilla in opposite disposition. It rarely occurred in mountainous oligotrophic, slightly acidic wetlands in this study.

***Hyalotheca disciliensis* f. *tridentula* Nordstedt (Fig. 9c and 9d)**

References: West and West 1923, p. 233, pl. 161, figs. 21; Croasdale et al. 1983, p. 28, pl. 461, fig. 1.

Dist.: 11(r).

Description: Cells small, slightly broader than long, transversely rectangular, slightly constricted in the mid-

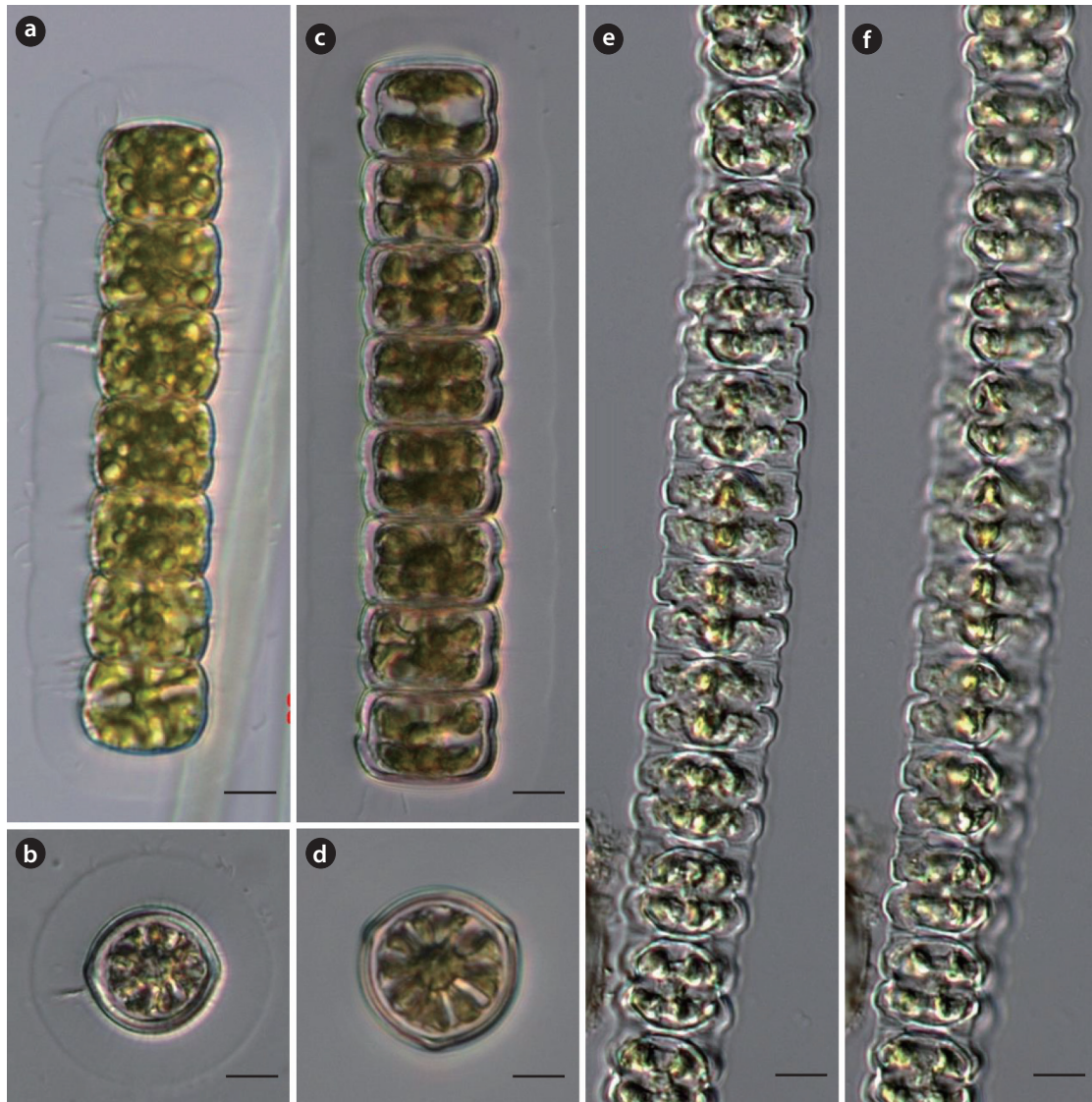


Fig. 9. (a, b) *Hyalotheca disciliensis* f. *bidentula*, (c, d) *H. disciliensis* f. *tridentula*, and (e, f) *Desmidium aptogonum* var. *constrictum*. (b) and (d) are vertical view. Scale bars, 10 μ m.

dle, sinus depressed and widely open; This variety differs from nominate variety in that vertical view of semicell contains three tiny mamillates equidistant around the periphery of the circle; cells length 18-24 μ m, breadth 26-37 μ m, isthmus 23-33 μ m. It rarely occurred in mountainous oligotrophic, slightly acidic wetlands in this study.

***Desmidium aptogonum* var. *constrictum* Nordstedt (Fig. 9e and 9f)**

References: Croasdale et al. 1983, p. 39, pl. 463, fig. 9.

Dist.: 9(r).

Description: Cells medium size, about 1.5 times broad-

er than long, moderately constricted in the middle, sinus acute and linear; semicells transversely narrowly oblong, lateral angles broadly rounded, later margins convergent to the apex, with a small basal inflation on either side of the isthmus; apex concave in the middle, with a cavity between the adjacent cells; vertical view of semicells triangular, sometimes quadrangular, angles broadly rounded, sides concave; This variety differs from the nominate variety in that the sinus is much deeper and linear, with a slightly dilated extremity; cells length 15-16 μ m with processes, breadth 21-23 μ m, isthmus 15-16 μ m. It rarely occurred in mountainous oligotrophic, slightly acidic wetlands in this study.

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