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Contribution to the Desmid Flora of Papua New Guinea

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Abstract An investigation has been made into the desmid flora of Mt. Albert Edward and it's surroundings, Papua New Guinea. In 80 samples from different localities 80 taxa of 13 genera were revealed. For 23 of them this is a first finding in PNG. Zygospores of 8 species are recorded and illustrated, spores of *Staurastrum contectum* var. *aviceps* have not previously been reported in the literature. Two taxa, *Cosmarium porosum* Gontcharov et M. Watanabe sp. nov. and *S. capitulum* var. *spiniferum* Gontcharov et M. Watanabe var. nov., are described. The morphology of some species is discussed.

Key words: Desmids, flora, new records, Mt. Albert Edward, Papua New Guinea.

Although the number of papers dealing with the desmid algae from Papua New Guinea is relatively small, about 500 of taxa have been revealed there so far. The most extensive list of species including 427 taxa was presented by Vyverman (1991). His study covered a wide range of habitats and provides valuable information about desmid diversity of this part of the world.

Prior to his investigation considerable algal collections were made in Papua New Guinea by the members of four botanical and microbiological expeditions of the National Science Museum, Tokyo in 1969–1975. 345 samples of freshwater algae were collected by Dr. Takaaki Yamagishi in 1973–1974 and 231 samples by Masayuki Watanabe in 1975. Only part of this material was identified and the results published (Yamagishi, 1975; M. Watanabe *et al.*, 1979; M. M. Watanabe *et al.*, 1979; Yamagishi & M. Watanabe, 1979; Kumano, 1983; Kumano & M. Watanabe, 1983; Yamagishi & Kanetsuma, 1990).

Eighty samples used in the present study were collected by M. W. during an ascent of Mt. Albert Edward (3996 m a.s.l.; figs. 1–3) which is located about 60 km north of Port Moresby, the capital of Papua New Guinea. Although the samples were relatively poor regarding the desmids, some interesting species were revealed. Among them two taxa are believed to be new for science and two species are unidentified so far.

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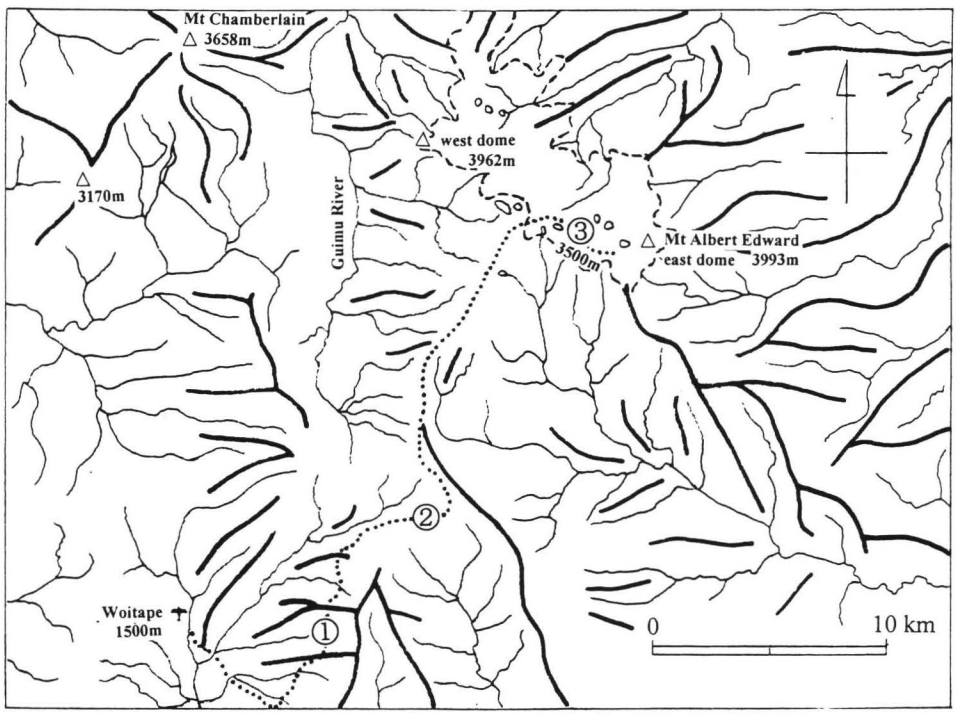

Fig. 1. Route map from Woitare to Mt. Albert Edward. A dotted line: route; thick line: mountain ridges; thin branching lines: river systems; a dashed line surrounding the mountain: a contour of 3500 m above sea level, 1, 2, 3: campsites.

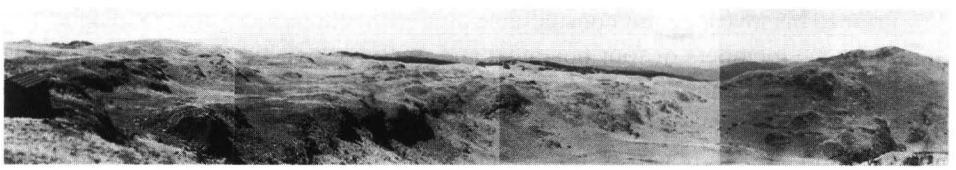

Fig. 2. A panoramic view from camp 3 shows the a glacial landform is gently sloping and covered with grasses.

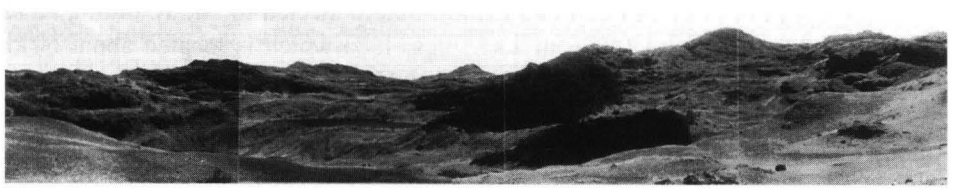

Fig. 3. A panoramic view from camp 3 shows the several forest patches are scattered among grassland.

Samples N51245–51252, Woitape, 1500 m a.s.l., Oct. 15–16, 1975, evergreen forest; N51253–51260, Woitape-camp 1, 2600 m a.s.l., Oct. 18–21, 1975, evergreen forest; N51261–51297, camps 1–2, 3100 m a.s.l., Oct. 22–26, 1975, arid grassland with tree-ferns scattered and some bogs; N51298–51315, camps 2–3, 3600 m–3800 m a.s.l., Oct. 27–29, 1975, grassland with numerous small lakes and some bogs.

The algae were collected by pipette from aquatics or taken manually from the upper sediment layer. Samples were examined under the Olympus BH-2 light microscope. Microphotographs were taken with Olympus C-35AD-4 camera. Drawings were made with a camera lucida.

For scanning electromicroscopy, algae were treated with 2% glutaraldehyde in cacodylate buffer for 2 h at room temperature and washed several times with distilled water. Thereafter, cells were post-fixed with 1% OsO_4 in the buffer for 1 h, rinsed with distilled water and dehydrated in the alcohol series. Finally cells were dried at critical-point in liquid CO_2. After coating with gold samples were examined with Hitachi Stereoscan S-4200.

The enumeration of the species is in accordance with the system of Růžička (1977) except the genus *Staurodesmus* Teil. The arrangement of the species within each genus is alphabetical. Taxa which had not previously been recorded from PNG are marked with an asterisk.

All dimensions are given in micrometers; the following abbreviations are used: L=length of cell, W=width of cell, T=thickness of cell, I=breadth of isthmus, csp=with spines, ssp=without spines, cpr=with processes, spr=without processes.

Species enumeration

Order **Desmidiales**

Family ***Peniaceae*** Haeckel

Penium Bréb. ex Ralfs

P. cylindrus Ehr. ex Ralfs — Pl. I, fig. 2.
L 32.5 μm, W 15 μm.

P. spirostriolatum Bark. — Pl. I, fig. 1.
L 155 μm, W 22.5 μm.

Penium sp. — Pl. I, fig. 3.
L 42.5 μm, W 17.5 μm.

Similar alga was reported in PNG by Vyverman (1991). He discussed it's possible affiliation but data on the zygospores morphology is needed for precise identification.

Family ***Closteriaceae*** Pritch.

Closterium Nitzsch ex Ralfs

Cl. abruptum W. West — Pl. I, fig. 10.

W 170–225 μm, W 15–22.5 μm, Ap 7.5–10 μm.

This taxon is very similar with *Cl. nilsonii* Borge and only the absence of striates differentiates it. Our specimens are characterised by smooth yellowish cell wall with girdle bands.

Cl. closterioides (Ralfs) Louis et Peeters Pl. I, fig. 4.
L 110–200 μm, W 25–35 μm.

Cl. dianae Ehr. ex Ralfs Pl. I, fig. 7.
L 175 μm, W 5–7.5 μm.

Cl. jennerii Ralfs Pl. I, fig. 8.
L 87.5 μm, W 12.5 μm.

Cl. moniliferum (Bory) Ehr. ex Ralfs Pl. VIII, fig. 1.
W 235–270 μm, W 35–50 μm.

Cl. navicula (Bréb.) Lütkem. Pl. I, figs. 5, 6.
L 42.5–77.5 μm, W 10–12.5 μm. Zygospore 30 μm long, 25 μm width.

**Cl. ralfsii* Bréb. ex Ralfs var. *gracilius* (Mask.) Krieg. Pl. I, fig. 11.
L 177.5–232.5 μm, W 12.5–15 μm.

Vyverman (1991) reported the type variety of this species in PNG. Our alga differs from it in it's smaller dimensions.

Cl. striolatum Ehr. ex Ralfs Pl. I, fig. 12.
L 215–267 μm, W 25–30 μm, Ap 7.5–10 μm.

**Cl. tumidulum* Gay Pl. I, fig. 9.
L 107.5–117.5 μm, W 17.5 μm.

Family ***Desmidiaceae*** Ralfs

Haplotaenium Bando

H. minimum (Ralfs) Bando Pl. II, fig. 9.
L 112.5–117.5 μm, W 12.5–13.8 μm.

Actinotaenium Teil.

**?A. cruciferum* (De Bary) Teil. Pl. II, fig. 4; pl. IX, fig. 2.
L 12.5–15 μm, W 7.5 μm.

A large amount of this small alga was found in sample 51308. The outline of it's cell was somewhat different from that is typical in this species. All our specimens have cylindrical cells with truncate apexes; median constriction is very shallow but always evident. Despite this difference in cell morphology, it possesses stelloid chloroplasts with one or two perinoid per cell what as usual for the species. Its cell wall looked smooth under LM but has irregularly arranged small pores (SEM, pl. 9, fig. 2). This alga can be compared with *Cosmarium subtilissimum* G. S. West or *C. biobconicum* Brühl. et Biswas.

Earlie *A. cruciferum* var. *cruciferum* f. *latum* Teil. was reported in PNG (Yamagishi & Kanetsuma, 1990).

A. cucurbita (Bréb.) Teil. Pl. II, figs. 1, 2.

L 30–40 μm, W 15–25 μm, I 13.5–20 μm.

This alga was one of the most common species in the studied samples. Cells with bigger dimensions and subcircular semicells (pl. 2 : 1) were common in some samples from localities 2 and 3.

**A. obcuneatum* (W. West) Teil. var. *oravicum* Růžička Pl. II, fig. 3.

L 22.5 μm, W 12.5 μm.

This taxon is not rare at the Far East and SE Asia, however, it is reported for the first time in PNG.

Tetmemorus Ralfs ex Ralfs

T. laevis Kütz. ex Ralfs Pl. I, fig. 13.

L 112.5 μm, W 25 μm.

Euastrum Ehr. ex Ralfs

**E. ansatum* Ehr. ex Ralfs var. *triporum* Krieg. Pl. II, figs. 10–12; pl. IX, fig. 1.

L 80–90 μm, W 37.5–40 μm, I 12.5 μm, T 25 μm, Ap 22.5 μm.

Under LM only a median basal protrusion was seen in this alga, however, in a few specimens two very slight protrusions opposite the upper lateral lobes were detectable as well. The size of the lateral lobes was variable, sometimes the lateral sides were nearly straight. Such characters as one basal protrusion and three pores per semicell allow us to suppose affiliation of our specimens to *E. akaiense* Hinode (Hinode, 1955, p. 80, pl. 4: 1–6), however, they have somewhat bigger dimensions. Hinode (l. c.) mentioned the similarity of his alga with *E. sinuosum*, but from our point of view it is more similar to *E. ansatum* var. *triporum* and only one protrusion per semicell differs it from the latter taxon.

Study under the SEM revealed two small protrusions at the base of the semicell besides a prominent supraisthmal one and confirmed the presence of two protrusions on either side of the midregion (pl. 9, fig. 1). The pattern of cell wall decoration of our plant is similar to that reported in the type variety of the species, reticulate with pores of 1, 2, 3 and 4 types (Neuhaus & Kiermayer, 1982). In var. *triporum* this reticulation seems to be more prominent. Three large pores are present at the midregion of the semicell. The central pore is surrounded by a somewhat elongated smooth area and the same area is extended from the incision of the apical lobe. This feature is detectable under LM as well (pl. 2, fig. 10).

The outline of the cell, total number of protrusions and large pores per semicell in our alga correspond to those of *E. ansatum* var. *triporum*, whereas the four small lateral protrusions, sometimes almost undetectable, presence of smooth channel like areas, connected central pore and apical incision distinguished it from the mentioned taxon.

The variety under discussion is reported for the first time in PNG. Vyverman

(1991, pl. 47, fig. 3) illustrated a cell of *E. ansatum* var. *dideltiforme* Ducell. with three large pores per semicell what is not typical for this taxon but is a distinctive feature of var. *triporum*. However, the taxonomic importance of this character is questionable (Růžička , 1981). According to Neuhaus & Kiermayer (1982) the number of these pores in var. *ansatum* varies from 1 to 3.

E. bidentatum Näg. Pl. VIII, fig. 2.
L 55–57.5 μm, W 37.5–40 μm, I 12.5 μm.

**E. boldtii* Schmidle Pl. II, fig. 14.
L 22.5 μm, W 17.5 μm.

E. denticulatum (Kirchn.) Gay Pl. II, fig. 13.
L 22.5–25 μm, W 20–22.5 μm.

E. gayanum De Toni Pl. II, figs. 16, 17.
L 12.5–15 μm, W 10–12.5 μm.

The expression of cell wall ornamentation was a variable character in our material. This taxon displace transitions to *E. binale* (Turp.) Ehr. ex Ralfs and it's varieties and the difference between these algae seems to be not clear.

**E. insulare* (Wittr.) Roy Pl. II, fig. 7.
L 22.5–25 μm, W 17.5–22.5 μm.

**E. montanum* W. et G. S. West Pl. II, fig. 8.
L 22.5–27.5 μm, W 17.5–22.5 μm, I 5–7.5 μm.

**E. obesum* Josh. Pl. II, fig. 5.
L 107.5–120 μm, W 47.5–50 μm, I 17.5 μm, Ap 22.5 μm.

E. sinuosum Lenorm. ex Arch. Pl. II, fig. 6.
L 57.5 μm, W 30 μm, I 10 μm.

**E. subalpinum* Messik. var. *crassum* Messik. Pl. II, fig. 15.
L 17.5–22.5 μm, W 15–16 μm, T 10–12.5 μm.

Cells with long apical lobes typical for the type variety of the species were seen in sample 51318. According to Růžička (1981) this variability brings into the question the difference between these two varieties.

A similar algae has been reported in PNG by Yamagishi & Kanetsuma (1990) as *E. subalpinum* var. *granulosum* Grönbl.

Cosmarium Corda ex Ralfs

C. amoenum Bréb. ex Ralfs var. *mediolaeve* Nordst. Pl. V, figs. 5, 6.
L 47.5 μm, W 30 μm, I 10 μm.

C. caelatum Ralfs Pl. V, fig. 9.
L 42.5 μm, W 42.5 μm, I 17.5 μm.

C. connatum Bréb. ex Ralfs Pl. III, fig. 1.
L 47.5–57.5 μm, W 37.5–45 μm, I 30–35 μm.

C. contractum Kirhn. var. *ellipsoideum* (Elfv.) W. et G. S.West Pl. III, fig. 11.
L 27.5–35 μm, W 20–25 μm, I 7.5 μm.

C. crenatum Ralfs Pl. IV, figs. 17, 18.

L 27.5–30 μm, W 17.5–22.5 μm, I 7.5–12.5 μm.

C. decoratum W. et G. S.West Pl. V, figs. 3, 4

L 67.5–75 μm, W 52.5–60 μm, I 20 μm.

?*C. javanicum* Nordst. Pl. III, figs. 4, 5.

L 130–137.5 μm, W 82.5–87.5 μm, I 37.5–47.5 μm.

This alga was found in small amounts in sample 51270. Its morphology corresponds to the diagnosis (Nordstedt, 1880, p. 7, pl. 1: 10) but we question it because no cells with chloroplasts were observed. The taxon under discussion was similar to *C. ralfsii* Bréb. ex Ralfs var. *montanum* Racib. but this species distinguishes in the structure of chloroplasts.

Our plant is characterised in it's thick, obviously 2-layered, scrobiculate-punctate cell wall. A similar cell wall structure was recorded in the species by Skuja (1949).

C. laeve Rabenh. Pl. IV, fig. 12.

L 20–25 μm, W 15–15.5 μm, I 5–7.5 μm, T 12.5 μm. Zygospores 27.5×25 μm.

The shape of semicells varies from semicircular to subpiramidal but the notch at the apex was always evident.

**C. lapponicum* Borge Pl. III, fig. 2.

L 25 μm, W μm, T 12.5.

Vyverman (1991) reported var. *undulatum* Borge in PNG. The difference between these two taxa seems to be minor (Prescott *et al.*, 1981) and maintenance of latter variety is questionable.

C. minimum W. et G. S.West Pl. IV, fig. 15.

L 10–12.5 μm, W 10 μm, I 6 μm.

Characteristic specimens of this alga were rather common in many samples. However, cells with somewhat retuse lateral sides, which is typical for *C. norimbergense* Reinsch var. *depressum* (W. et G. S. West) Krieg. et Gerloff, were observed in the same localities.

**C. nasutum* Nordst. var. *nasutum* f. *granulata* Nordst. Pl. VI, figs. 1–3.

L 35–50 μm, W 25–40 μm, I 10–12.5 μm.

Few zygospores were seen in sample 51268. The zygospores were spherical, with swollen-based stout spines acute or bifurcate at the ends, about 9 of which can be seen at the periphery; 27.5 μm in diameter without spines, 47.5 μm with spines.

The dimension of the zygospores found were the same as described in this taxon (Förster, 1965). However, according to this author they have mamillate protuberances furnished with a short uncinate spine. In our alga these protuberances are much longer, like processes.

**C. nitidulum* De Not. Pl. IV, fig. 8.

L 47.5 μm, W 32.5 μm, I 20 μm.

The type variety of the species is reported for the first time in PNG. Earlier var. *javanicum* Krieg. et Gerloff was recorded there (Vyverman, 1991).

C. obliquum Nordst. Pl. VIII, fig. 10.

L 20 μm, W 15 μm, I 10 μm.

Cosmarium porosum Gontcharov et M. Watanabe sp. nov.

Pl. IV, figs. 9–11; pl. VIII, fig. 12.

Diagnosis: Cellulae parvae, latitudine longitudinem fere aequante, leviter constrictae, sinu maxime late aperto. Semicellulae obtrapeziformes; marginibus lateralibus rectis, apice lato et recto, angulis apiculibus attenuatis, anguste rotundatis. Semicellulae a latere visae obtrapeziformes, apice truncato, a vertice visae transverse hexagonales, extremis attenuatis. Membrana crassa, cum quinqui poris grandibus ad apicem, uno ad centrum, quatuor ad angulorum lateralium. Chloroplastus monocentricus.

Dimensions: Longitudo 15–17.5 μm, latitudo 17.5 μm, isthmi latitudo 12.5–15 μm, crassitudo 10 μm.

Holotype: Tab. 8, fig. 12.

Cell is quadrangular, as broad as long, slightly constricted, the sinus widely open. Semicells inversely trapeziform, apex broad, straight or slightly convex, lateral sides straight or nearly so, apical angles somewhat attenuate, narrowly rounded; in lateral view semicells inversely trapeziform, with truncate apex, in vertical view cell hexagonal, with attenuate ends. Cell wall rather thick, punctate, with a conspicuous pore at the apex and similar pores within the apical margins near the lateral ends, in total 5 large pores per semicell are present. Chloroplast with 1 pyrenoid. L 15–17.5 μm, W 17.5 μm, I 12.5–15 μm, T 10 μm.

This characteristic alga was found in small amount in the samples collected at locaity 3. The prominent pore pattern clearly differentiates it from other *Cosmarium* species. The number of taxa of the genus possessing such large pores is rather limited and there is no general tendency in these pores' arrangement.

C. pseudarctoum Nordst. Pl. II, fig. 18.

L 17.5–20 μm, W 10–12.5 μm, I 7.5–10 μm.

C. pseudoconnatum Nordst. Pl. VIII, fig. 3.

L 57.5–72.5 μm, W 45–52.5 μm, I 40–45 μm.

C. pseudoconnatum var. *subconstrictum* Jao Pl. III, fig. 2.

L 67.5–72.5 μm, W 40 μm, I 35 μm.

This alga has been reported in PNG by Kanetsuma & Yamagishi (1989a).

As a type variety of the species this taxon possesses four parietal chloroplasts in each semicell, each with one pyrenoid. However, the elongated semicells with the broadest part just above the isthmus distinguishes it from other infraspecific taxa of the species. Morphologically the plant under discussion is very similar to *C. westii* Bern., *C. thwaitesii* Ralfs and *Actinotaenium capax* (Josh.) Teil. var. *minus* (Schmidle) Teil., however, mentioned taxa are distinct in their chloroplasts structure.

**C. pseudonitidulum* Nordst. Pl. IV, figs. 6, 7.

L 45 μm, W 35 μm, I 20 μm.

In the specimens studied cell wall was distinctly but rather scarcely punctate. All other features conform to the original diagnosis (Nordstedt, 1873: 16, pl. 1: 4).

C. punctulatum Bréb. Pl. IV, fig. 14.

L 20–22.5 μm, W 22.5 μm, I 7.5 μm.

C. pyramidatum Bréb. ex Ralfs Pl. III, fig. 3.

60–80 μm, W 35–42.5 μm, I 15–17 μm, T 25 μm.

C. quadratulum (Gay) De Toni var. *applanum* Insam et Krieg. Pl. IV, fig. 16.

L 10–12.5 μm, W 10 μm, I 6 μm. The zygospores are spherical, with numerous short spines, about 12–14 of which can be seen at the periphery, 15 μm in diameter without spines, 20–22.5 μm with spines.

This taxon has been recorded in PNG (Kanetsuma & Yamagishi, 1989b). The morphology of vegetative cells and zygospores of the specimens studied corresponds well to their illustration of this taxon. It was very rare in our samples and only a few cells were seen. This alga occurred in the same samples as *C. minimum* and due to the morphological variability of the latter taxon their segregation was rather difficult.

C. quadratum Ralfs Pl. IV, fig. 1.

L 45–55 μm, W 25–30 μm, I 12.5–17.5 μm.

C. guadrifarium Lund. var. *octastichum* (Nordst.) Först. Pl. VI, figs. 4, 5, 12, 13.

L 37.5–45 μm, W 32.5–35 μm, I 10–12.5 μm. The zygospore was subspherical, black, with four produced subtruncate angles extended into the conjugating semicells, the angles of one end twisted into a plane at right angles to the other two, 45 μm in diameter.

This species is distinct in it's pattern of cell wall decoration. Usually it possesses 15 to 17 emarginate warts at the lateral margins of semicell in 2–3 intramarginal rows. The main portion of our alga is characterised by rows of flattened rather then emarginate granules. This pattern of cell wall ornamentation is illustrated in the same taxon by Thomasson (1963). This character seems to be very constant in the studied populations and only a few specimens with emarginate granules were seen. It distinguishes our specimens from the diagnosis but at the same time the pattern of decoration is typical for *C. guadrifarium*. Moreover, the morphology of the zygospores revealed in the samples corresponds to those reported in the species (Lundell, 1871; Allorge, 1930).

**C. raciborskii* (Racib.) Lagerh. Pl. IV, fig. 5.

L 47.5 μm, W 47.5 μm.

**C. reniforme* (Ralfs) Arch. var. *apertum* W. et G. S. West Pl. V, fig. 7, 8.

L 42.5 μm, W 45 μm, I 15 μm.

An open linear sinus was a constant feature of our plants and few specimens with a closed sinus were observed. Among other taxa *C. pseudobroomei* Wolle var. *apertum* Först. possesses the same character but it differs from our alga in cell outline and pattern of granulation.

In some specimens a hexagon punctata around each granule were seen. A simi-

lar pattern of cell wall decoration was depicted in the type variety of the species by Schulz (1930, fig. 30) and Williamson (1996, fig. 8: 3). On the SEM photographs of this species, presented by Couté & Tell (1981, p. 6: 1, 2) this character is absent. Punctulations around granules are typical for *C. margaritatum* (Lund.) Roy et Biss., however, the mentioned taxon has bigger dimensions and a different outline of semicells in face and vertical views. Croasdale & Flint (1988) stated that it always has convex sides in vertical view while alga from PNG has parallel sides.

C. sinostegos Schaarschm. Pl. VIII, fig. 8.

L 12.5–15 μm, W 15–17.5 μm, I 2.5–3.1 μm.

C. sublateriundatum W. et G. S.West Pl. IV, fig. 13.

L 30 μm, W 22.5 μm, I 10 μm.

C. tatricum Racib. Pl. III, figs. 6, 7.

L 37.5 μm, W 25 μm, I 17.5 μm.

C. tenue Arch. Pl. III, figs. 8, 9.

L 20–22.5 μm, W 17.5–20 μm, I 6–7.5 μm. Zygospores spherical, colourless, 25 μm in diametre.

Species is similar to *C. melanosporum* Arch. in morphology but distinguishes from it in the colourless zygospores.

C. tinctum Ralfs Pl. VIII, fig. 4.

L 15–22.5 μm, W 12.5–15 μm, I 7.5–10 μm.

C. variolatum Lund. var. *skujae* Croasd. Pl. IV, figs. 2–4.

L 42.5–57.5 μm, W 27.5–32.5 μm, I 12.5 μm.

Williamson (1994) pointed out that the scrobiculated cell wall clearly differentiates the alga under discussion from *C. pseudopyramidatum* Lund. which has a comparable appearance. However, in PNG material transitional forms between these two taxa were seen (pl. 4: 4). The same range of morphology has been mentioned in this speciees by Yamagishi & Kanetsuma (1990).

Cosmarium sp. Pl. V, figs. 1–2; pl. IX, figs. 3, 4.

L 102.5–105 μm, W 62.5–65 μm, I 20–25 μm, T 45–50 μm.

This large alga was present in large numbers in sample 51269. It is very similar to *C. amoenum* var. *mediolaeve* in appearance and pattern of cell wall ornementation but distinguishes in much bigger size. It has subrectangular semicells with narrowly rounded basal angles, convex lateral sides and broadly rounded apexes. The cell wall is granulated with large somewhat elongated rounded granules disposed in 18–20 oblique and 12 horizontal rows, with punctata betwen the granules. In the central part of semicells granules are reduced in size or sometimes only punctata are present. The semicells are ovate in lateeral view, broadly elliptic in vertical view.

Among large-celled *Cosmarium* species with granulated cell walls *C. amplum* Nordst. resembles our alga but it clearly segregates from it in the shape of the semicell in face and lateral views and in the uniformly granulated cell walls.

Staurodesmus Teil.

**S. boergesenii* (Messik.) Croasd. Pl. VI, fig. 8.

L 15–17.5 μm, Wssp 12.5–15 μm, Wcsp 17.5–20 μm, I 7.5 μm.

There are a number of small-sized species in the genus that our specimens resemble. However, inversely-trapeziform semicells with straight or slightly convex apexes and relatively long parallel spines are more typical for *S. boergsenii*.

**S. isthmosus* (Heimerl) Croasd. Pl. VI, fig. 7.

L 17.5 μm, Wssp 12.5–15 μm, Wcsp 20–30 μm, I 4–5 μm.

S. omearii (Arch.) Teil. Pl. VIII, fig. 9.

Lssp 17.5 μm, Lcsp 30 μm, Wssp 12.5 μm, Wcsp 25 μm, I 7.5 μm.

S. pachyrhynchus (Nordst.) Teil. Pl. VI, fig. 6.

L 25 μm, W 17 μm, I 6 μm.

Staurastrum Meyen ex Ralfs

**S. capitulum* Bréb. ex Ralfs var. *dimidio-minor* Grönbl.

Pl. VII, fig. 9; Pl. VIII, fig. 7.

L 17.5 μm, W 17.5 μm.

This smaller variety of the species seems to be reported for the first time outside N. America. It is characterised by smaller dimensions and a cell wall ornamented by a few rows of small granules around the processes and the isthmus. Croasdale & Grönblad (1964, pl. 17: 17) illustrated these granules in a circle around the isthmus but in our specimens 4–6 granules were disposed only under the processes with a clear break between them.

Staurastrum var. *spiniferum* Gontcharov et M. Watanabe var. nov.

Pl. VI, figs. 17, 18; pl. VIII, fig. 6.

Diagnosis: Varietas angulis apiculibus spiniferis a varietate nominata differt.

Dimensions: Longitudo 37.5 μm, latitudo sine processibus 15 μm, latitudo cum processibus 25–32.5 μm, isthmi latitudo 10 μm.

Holotype: Tab. 8, fig. 6

This alga was found in relatively large amounts in the samples 51268–51271. The outline of the cells and the pattern of cell wall ornamentation allow us to suppose it's affiliation to *S. capitulum*. However, this species is characterised by rounded apical angles with a series of granules across them. In the specimens studied each angle was tipped with a stout spine and had the same rows of acute granules or spines as reported in the species. No plants of any other morphology were observed. L 37.5 μm, Wspr 15 μm, Wcpr 25–32.5 μm, I 10 μm.

S. contectum Turner var. *aviceps* Krieg. Pl. VI, fig. 14–16.

Lcsp 20–25 μm, Wcsp 20–25 μm, I 7.5 μm. Zygospores spherical, with short rounded spines, 9–12 of which can be seen at the periphery, 22.5 μm in diameter without spines, 30 μm with spines.

Among algae recorded from PNG *S. guadricornutum* Roy et Biss. var. *simplex*

Vyverman resembles our plant. Vyverman (1991) mentioned a similarity between these two taxa but listed them separately in his paper. In our samples dichotypic cells similar to those reported by this author also were observed. From our point of view it links *S. contectum* var. *aviceps* with *S. quadrangulare* (Bréb.) Ralfs.

S. dilatatum Ehr. ex Ralfs Pl. VI, figs. 9, 10.

L 20–25 μm, W 20–25 μm, I 7.5 μm.

?*S. forficulatum* Lund. Pl. VII, figs. 3, 4.

Lspr 25–27.5 μm, Wspr 30–32.5 μm, I 7.5–10 μm.

We question this epithet because the morphology of our specimens does not completely agree with the diagnosis. The apical processes are placed very close to the secondary processes at the lateral sides and these four processes and the simple spines at the ventral margins of the semicells form a circle around them.

Vyverman (1991) mentioned some morphological variability of the species under discussion and it's intermediate forms with *S. furcatum* (Ehr. ex Ralfs) Bréb., *S. gutwinskii* Bernard and their varieties. Perhaps *S. senarium* Ehr. ex Ralfs is also a closely related taxon and practical definition of these taxa is always difficult.

S. furcigerum (Bréb. ex Ralfs) Arch. Pl. VII, fig. 2.

Lspr 35–37.5 μm, Lcpr 45–55 μm, Wcpr 45–55 μm, I 12.5–15 μm.

S. inconspicuum Nordst. Pl. VI, fig. 11.

Lcpr 12.5 μm, Wcpr 12.5 μm, I 6 μm.

S. margaritaceum (Ehr.) Menegh. ex Ralfs Pl. VII, figs. 7, 8.

L 27.5–40 μm, Wcpr 30–42.5 μm, I 7.5–17.5 μm.

**S. muelleri* Först., morphae Pl. VII, figs. 10, 11; pl. VIII, fig. 13.

Lcpr 27.5 μm, Wcpr 27.5 μm, T 12.5 μm, I 10 μm.

This remarkable alga was found in sample 51306. The cells are small, about as long as broad, slightly constricted and the sinus is rounded at the apex. The semicells are companulate, with a row of spines supraisthmally and the apex straight and smooth. The processes are short, attenuate, tipped with 3–4 small teeth, with undulate margins and 3–4 transverse series of granules, the proximal granules are usually emarginate. In vertical view semicell is fusiform with undulate margins, and is smooth at the centre.

The dimensions of the specimens from PNG are somewhat bigger than indicated in the diagnosis (Förster, 1964, p. 234, pl. 1: 36, 37, pl. 2: 20, 21) and the semicells have longer basal parts. However, the appearance of our alga and the pattern of it's cell wall ornamentation are almost the same as described in the species under discussion. It seems to be the first report of this taxon outside Africa.

S. punctulatum Bréb. ex Ralfs Pl. VII, figs. 5, 6.

L 30–32.5 μm, W 30 μm, I 10 μm.

**S. sexcostatum* Bréb. ex Ralfs Pl. VII, fig. 1.

L 40–45 μm, Wcpr 42.5–47.5 μm, I 17.5 μm.

**S. spongiosum* Bréb. ex Ralfs Pl. VIII, fig. 11.

Lcpr 47.5–52.5 μm, Wcpr 47.5–55 μm, I 12.5 μm.

S. teliferum Ralfs Pl. VIII, fig. 5

Lssp 42.5 μm, Wssp 32.5 μm, Wcsp 42.5 μm, I 15 μm.

Bambusina Kütz. ex Kütz.

B. borreri (Ralfs) Cleve Pl. VII, fig. 15

L 22.5–27.5 μm, W 12.5–17.5 μm.

Hyalotheca Ehr. ex Ralfs

H. dissiliens (Smith) Bréb. ex Ralfs Pl. VII, figs. 13, 14.

L 12.5–15 μm, W 20–25 μm.

The zygospores were seen in the majority of samples where this species was revealed.

Spondylosium Bréb. ex Kütz.

S. planum (Wolle) W. et G. S. West Pl. VII, fig. 12.

L 10–12.5 μm, W 12.5–15 μm, I 5 μm.

Teilingia Bourr.

T. granulata (Roy et Biss.) Bourr. Pl. VIII, fig. 14

L 10–12.5 μm, W 10–12.5 μm.

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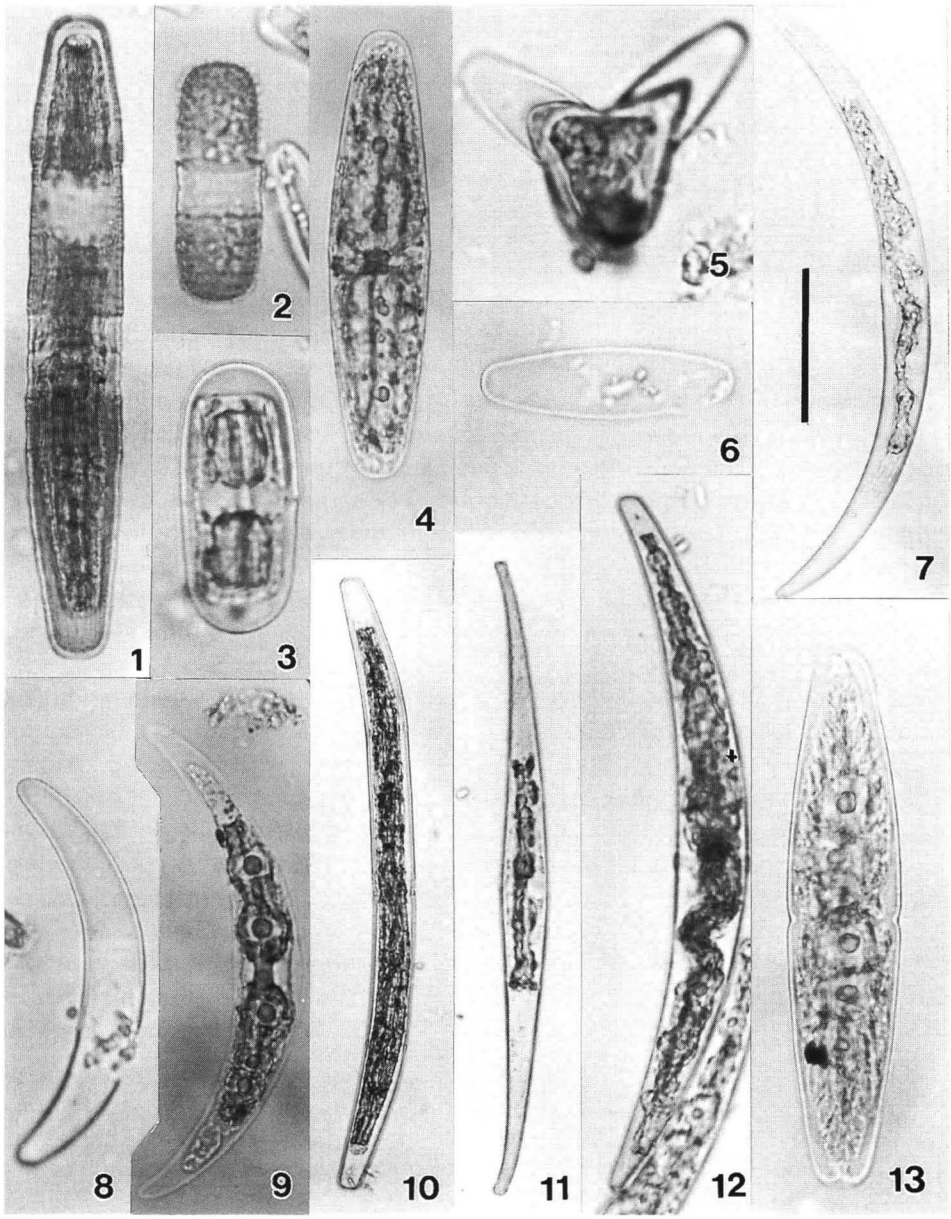

Plate I. 1. *Penium spirostriolatum*; 2. *P. cylindrus*; 3. *Penium* sp.; 4. *Closterium closterioides*; 5–6. *Cl. navicula*; 7. *Cl. dianae*; 8. *Cl. jennerii*; 9. *Cl. tumidulum*; 10. *Cl. abruptum*; 11. *Cl. ralfsii* var. *gracilius*; 12. *Cl. striolatum*; 13. *Tetmemorus laevis*. Scale bar 1, 4–7, 9–11=40 μm, 2, 3=20 μm, 8, 13=30 μm, 12=60 μm.

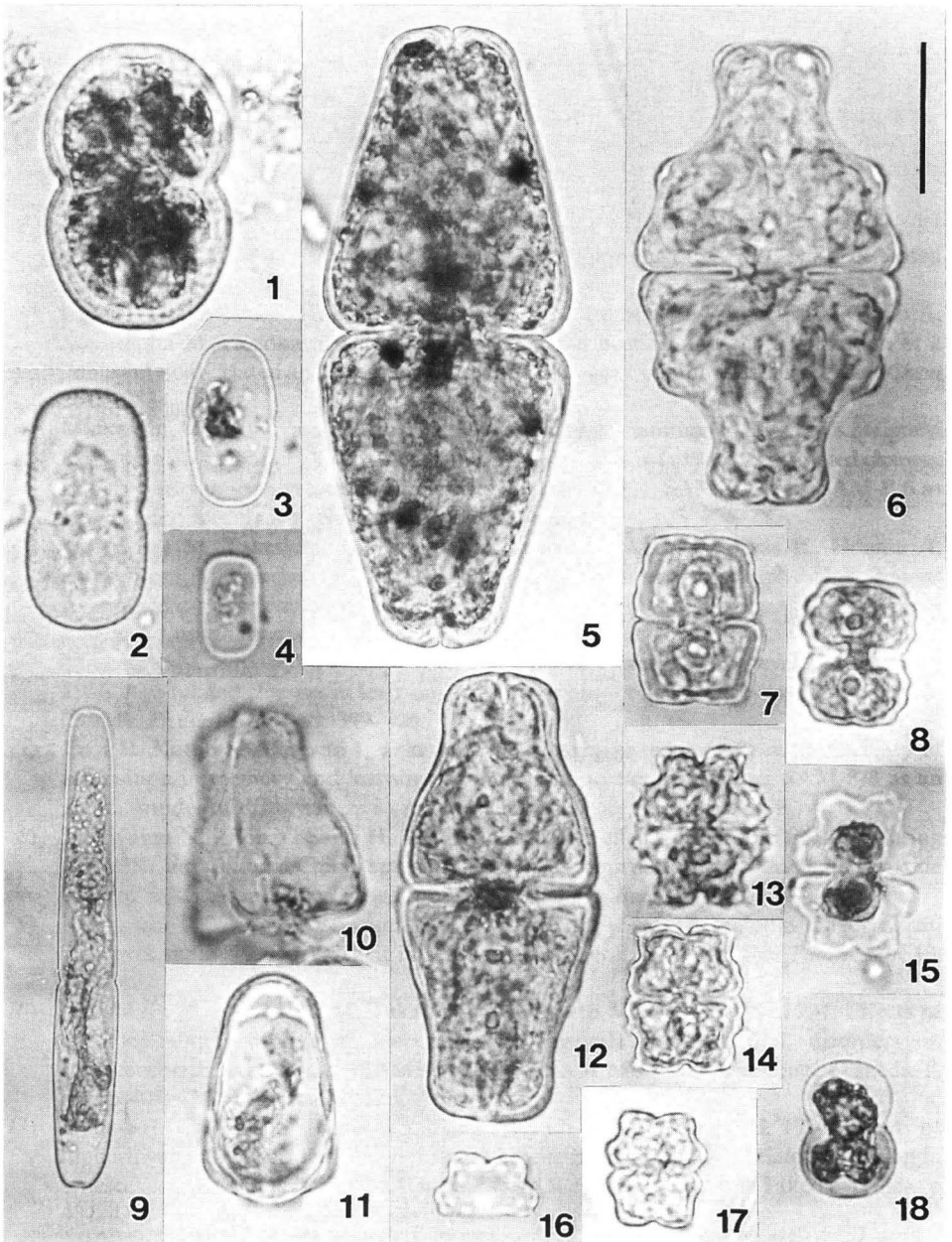

Plate II. 1–2. *Actinotaenium cucurbita*; 3. *A. obcuneatum* var. *oravicum*; 4. ?*A. cruciferum*; 5. *Euastrum obesum*; 6. *E. sinuosum*; 7. *E. insulare*; 8. *E. montanum*; 9. *Haplotaenium minimum*; 10–12. *Euastrum ansatum* var. *triporum*; 13. *E. denticulatum*; 14. *E. boldtii*; 15. *E. subalpinum* var. *crassum*; 16, 17. *E. gayanum*; 18. *Cosmarium pseudarctoum*. Scale bar 1–4, 6–8, 13–18=20 μm, 5, 10–12=30 μm, 9=40 μm.

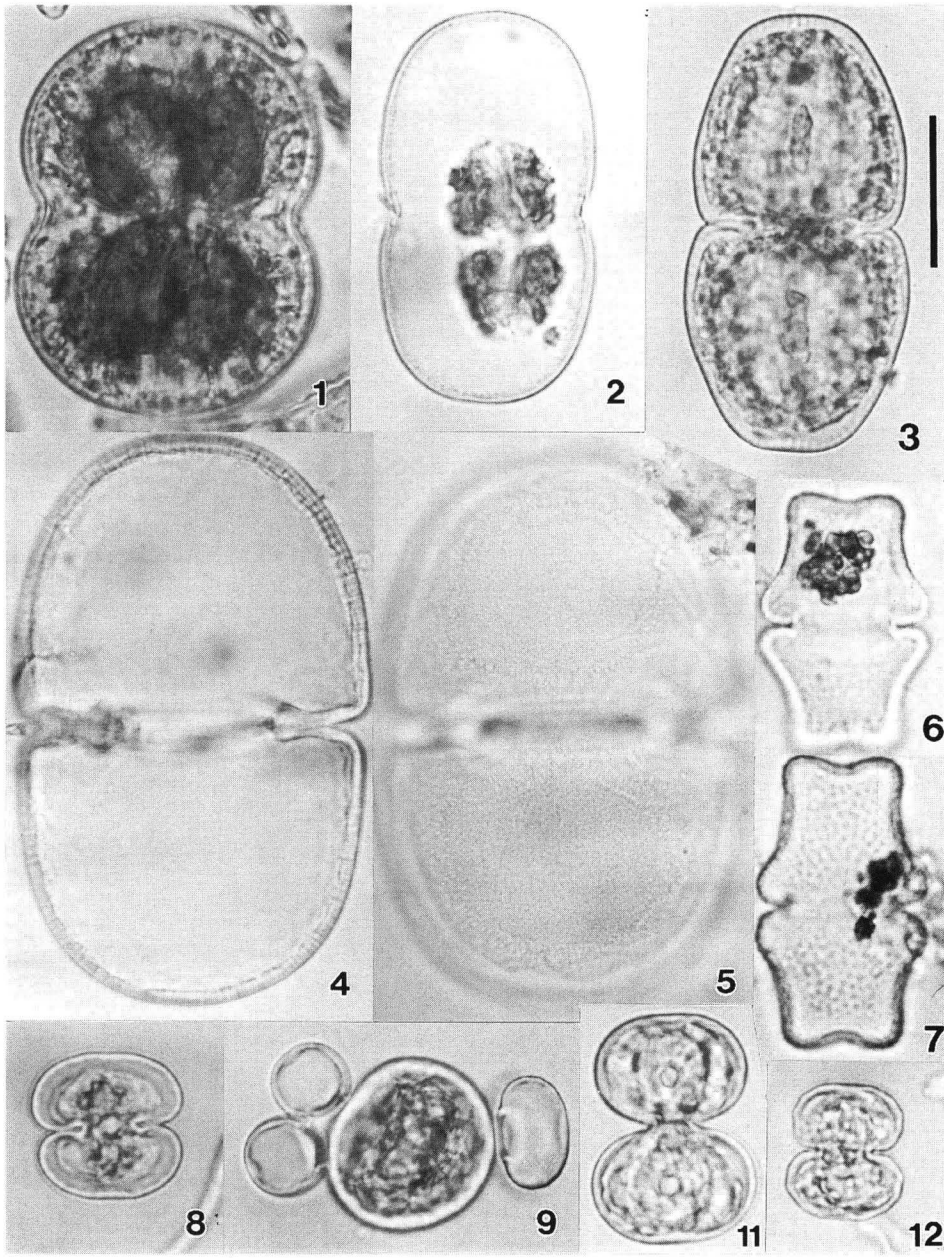

Plate III. 1. *Cosmarium connatum*; 2. *C. pseudoconnatum* var. *subconstrictum*; 3. *C. pyramidatum*; 4–5. ?*C. javanicum*; 6–7. *C. tatricum*; 8–9. *C. tenue*; 10. *C. contractum* var. *ellipsoideum*; 11. *C. lapponicum*. Scale bar 1, 3, 6–11=20 μm, 2=30 μm, 4, 5=40 μm.

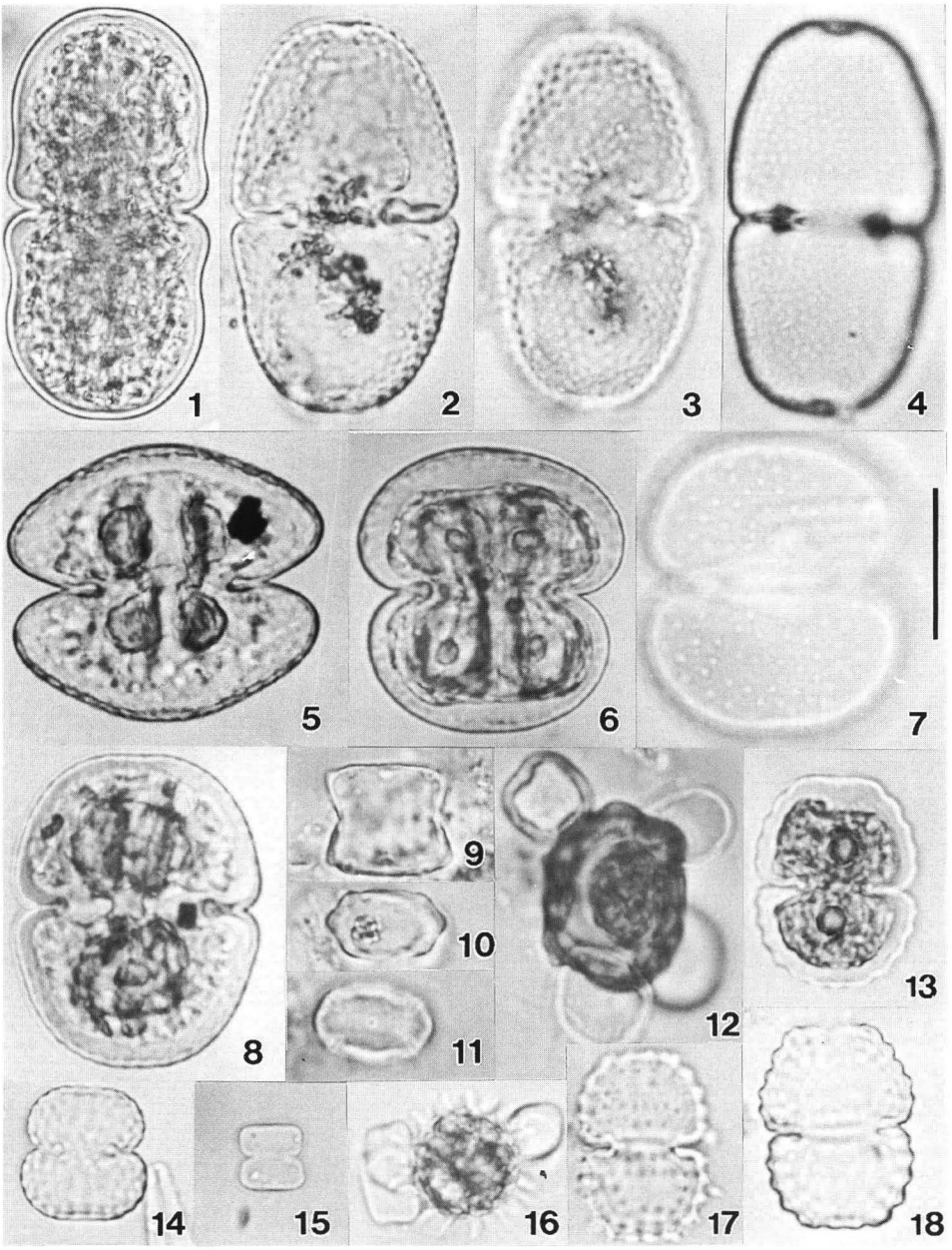

Plate IV. 1. *Cosmarium quadratum*; 2–4. *C. variolatum* var. *skujae*; 5. *C. raciborskii*; 6–7. *C. pseudonitidulum*; 8. *C. nitidulum*; 9–11. *Cosmarium porosum*, sp. nov.; 12. *C. laeve*; 13. *C. sublateriundatum*; 14. *C. punctulatum*; 15. *C. minimum*; 16. *C. quadratulum* var. *applanum*; 17–18. *C. crenatum*. Scale bar 1–4, 8–18=20 μm, 5–7=30 μm.

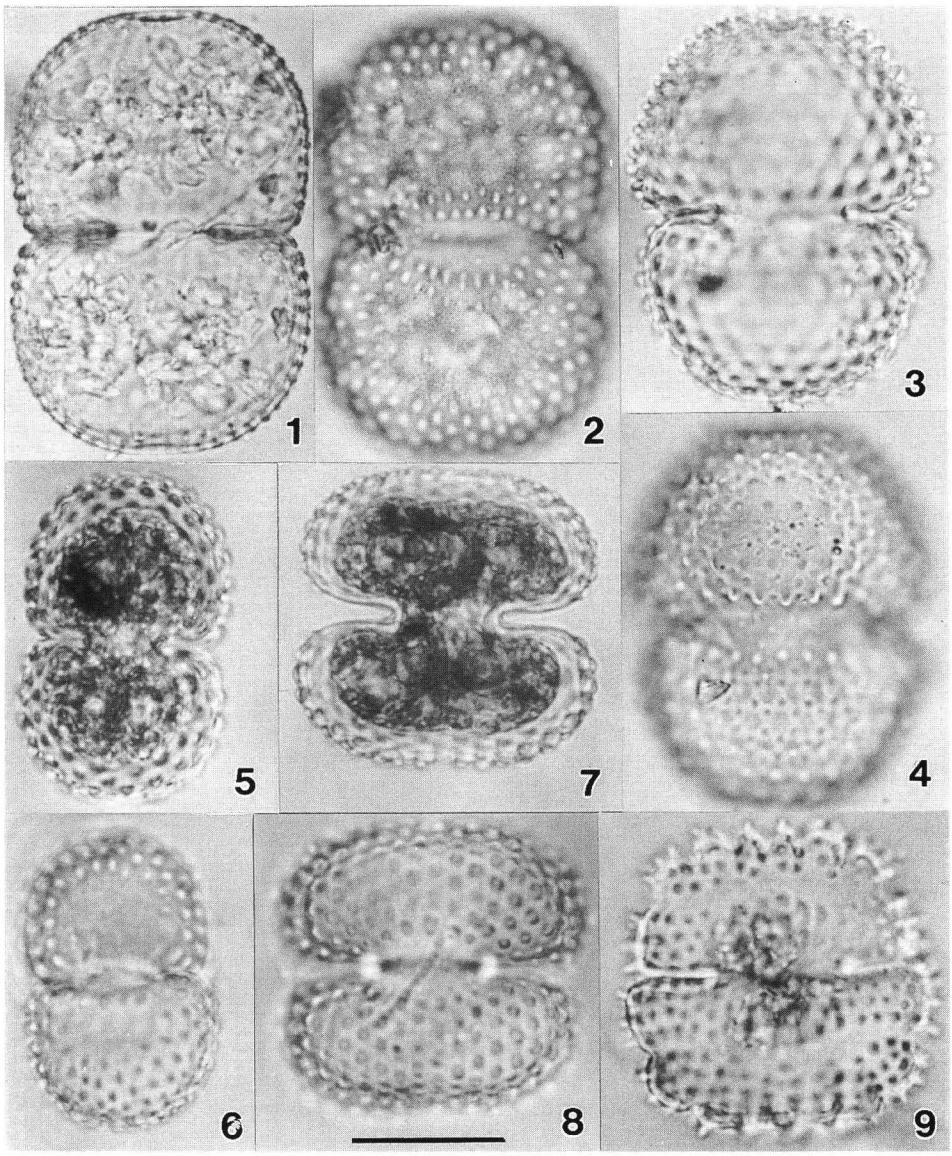

Plate V. 1–2. *Cosmarium* sp.; 3–4. *C. decoratum*; 5–6. *C. amoenum* var. *mediolaeve*; 7–8. *C. reniforme* var. *apertum*; 9. *C. caelatum*. Scale bar 1–4=30 μm, 5–9=20 μm.

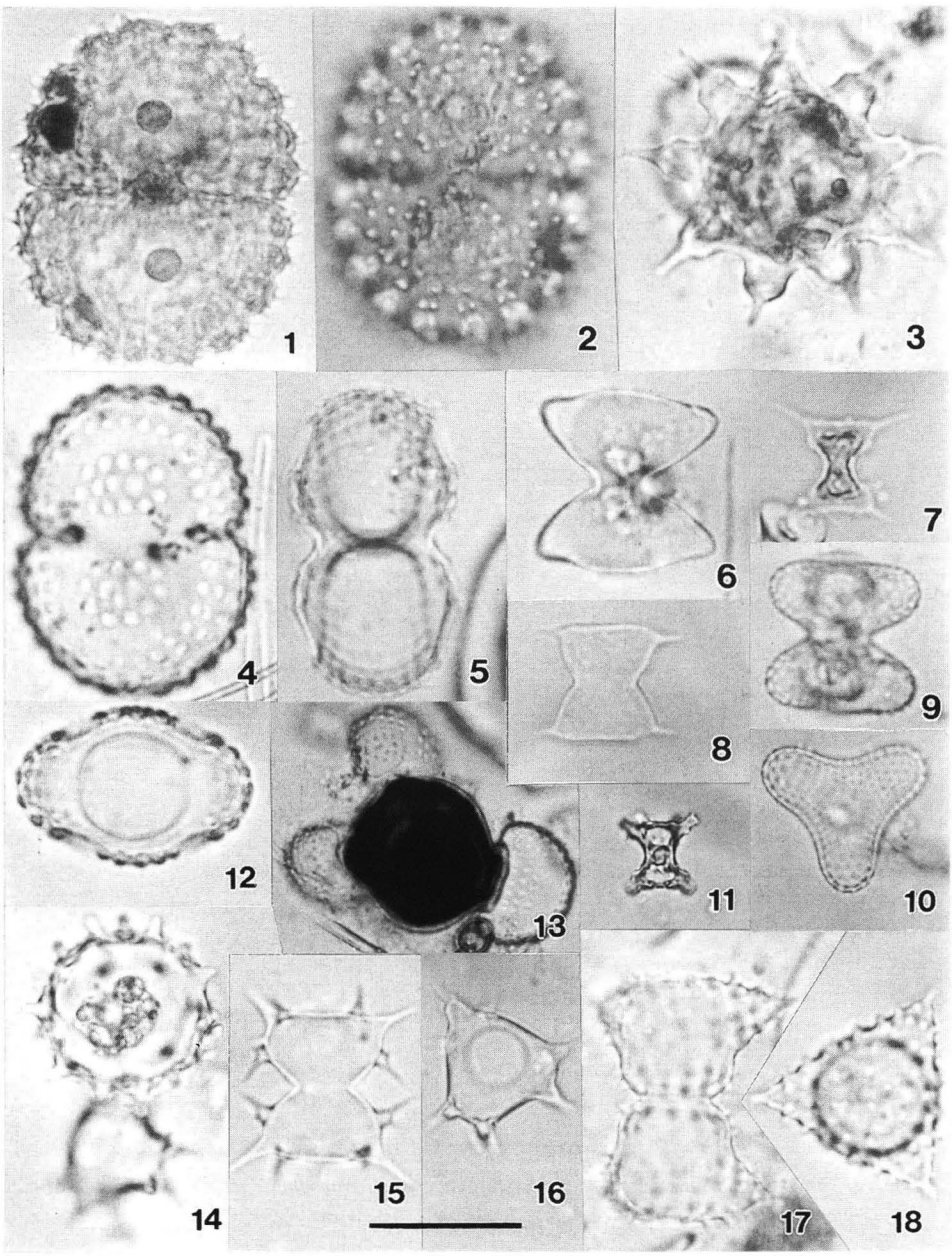

Plate VI. 1–3. *Cosmarium nasutum* var. *nasutum* f. *granulat*; 4, 5, 12, 13. *C. guadrifarium* var. *octastichum*; 6. *Staurodesmus pachyrhynchus*; 7. *S. isthmosus*; 8. *S. boergesenii*; 9–10. *Staurastrum dilatatum*; 11. *S. inconspicuum*; 14–16. *S. contectum* var. *aviceps*; 17, 18. *S. capitulum* var. *spiniferum* var. nov. Scale bar 1–18=20 μm.

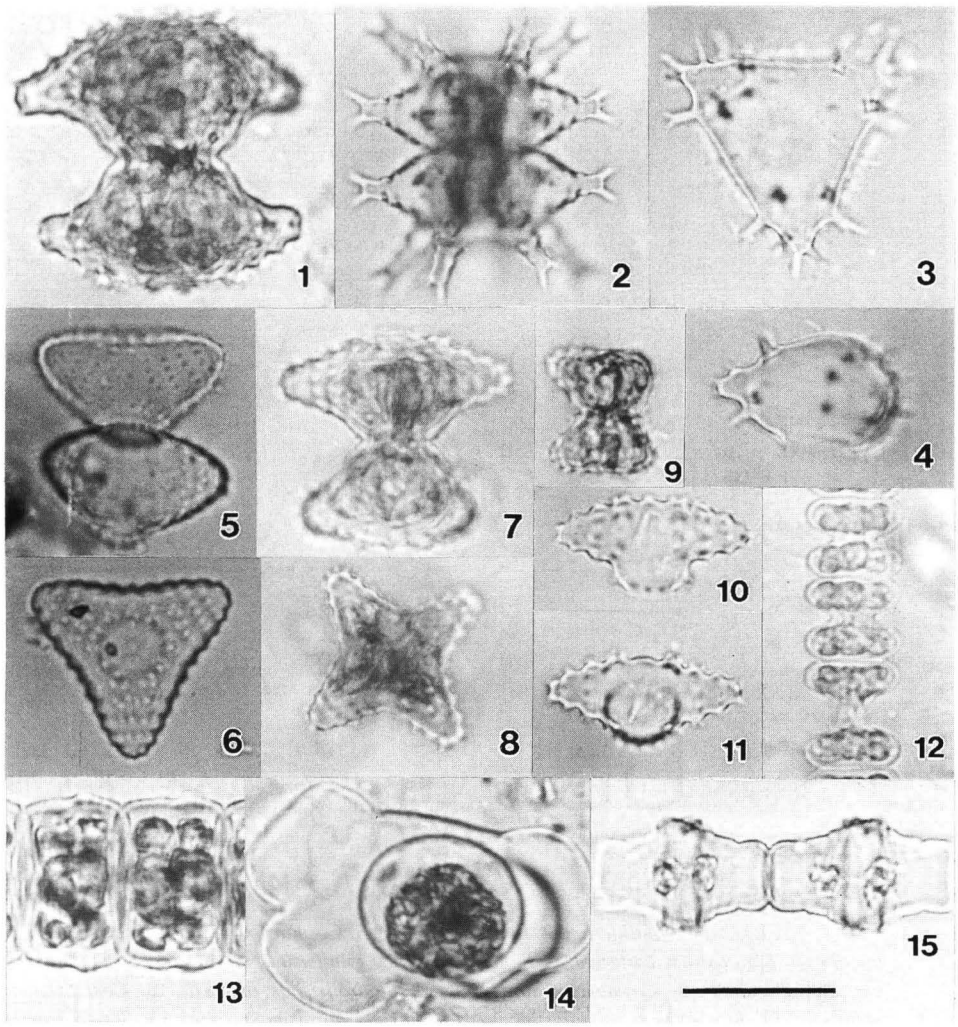

Plate VII. 1. *Staurastrum sexcostatum*; 2. *S. furcigerum*; 3, 4. ?*S. forficulatum*; 5, 6. *S. punctulatum*; 7, 8. *S. margaritaceum*; 9. *S. capitulum* var. *dimidio-minor*; 10, 11. *S. muelleri*; 12. *Spondylosium planum*; 13, 14. *Hyalotheca dissiliens*; 15. *Bambusina borreri*. Scale bar 1–15=20 μm.

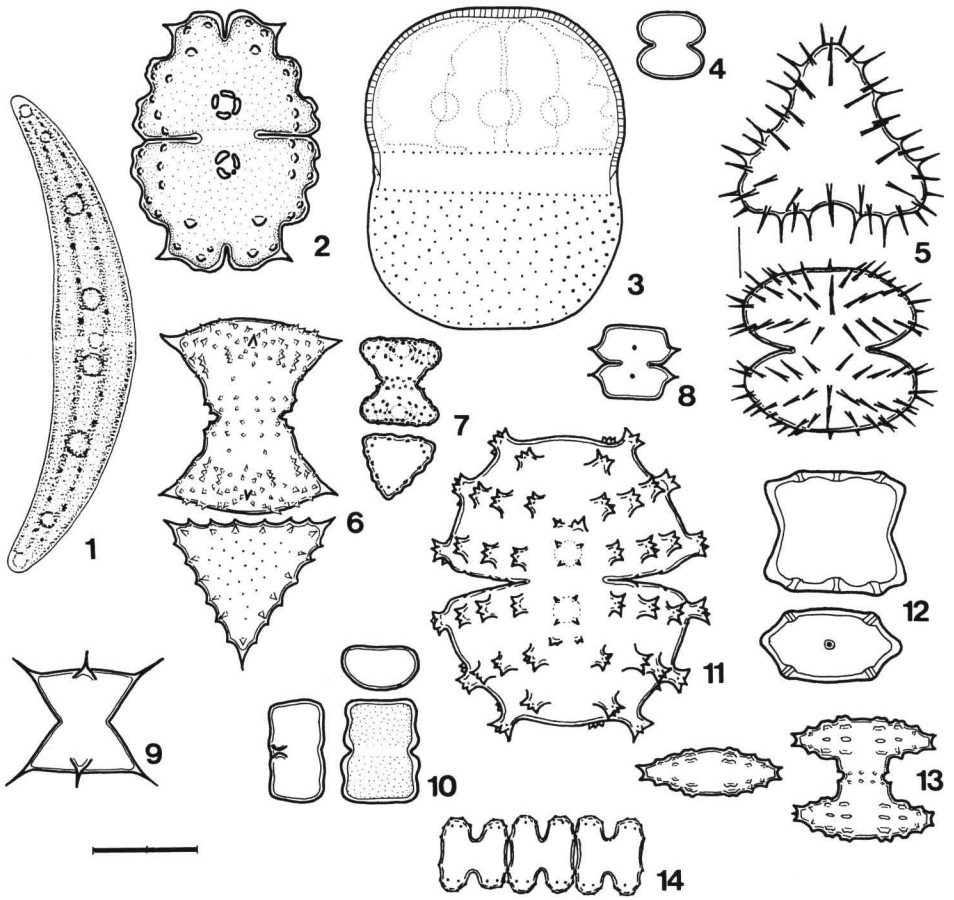

Plate VIII. 1. *Closterium moniliferum*; 2. *Euastrum binale*; 3. *Cosmarium pseudoconnatum*; 4. *C. tinctum*; 5. *Staurastrum teliferum*; 6. *S. capitulum* var. *spiniferum*, var. nov.; 7. *S. capitulum* var. *dimidio-minor*; 8. *Cosmarium sinostegos*; 9. *Staurodesmus omearii*; 10. *Cosmarium obliquum*; 11. *Staurastrum spongiosum*; 12. *Cosmarium porosum* sp. nov.; 13. *Staurastrum muelleri*; 14. *Teilingia granulata*. Scale bar 1=60 μm, 2–11, 13, 14=20 μm, 12=15 μm.

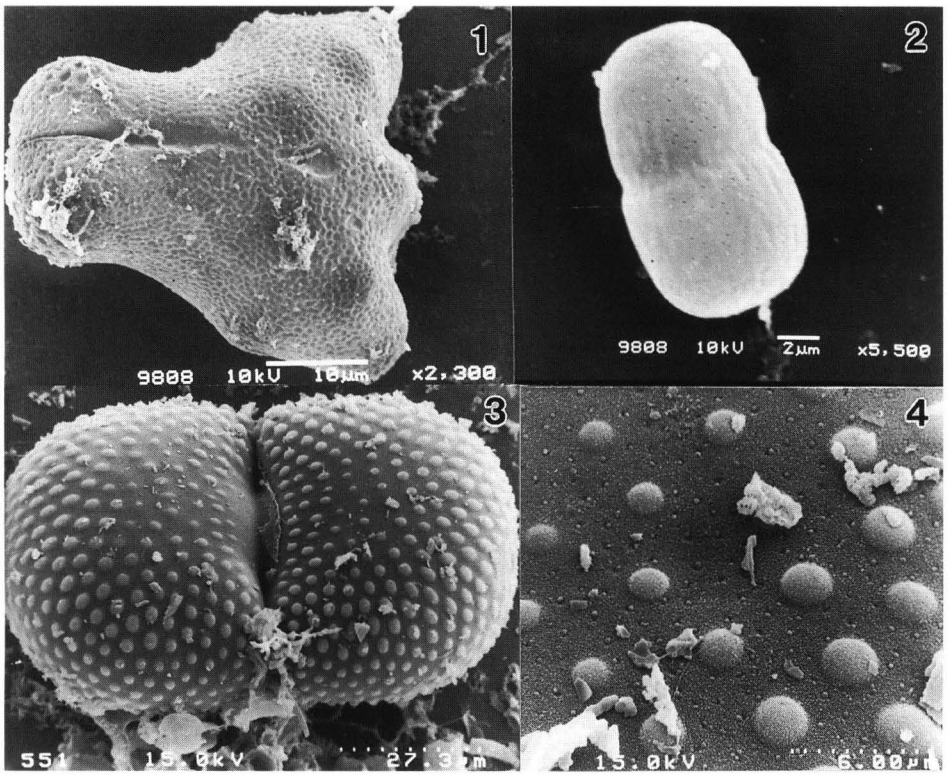

Plate IX. 1. *Euastrum ansatum* var. *triporum*; 2. ?*Actinotaenium cruciferum*; 3, 4. *Cosmarium* sp.