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ROYAL BOTANIC GARDENS VICTORIA

Noteworthy desmids (Desmidiales, Conjugatophyceae) from water supply reservoirs in south-east Queensland, Australia

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Introduction

Knowledge of freshwater algae in the state of Queensland is considered 'generally poor' (Bostock & Holland 2010). While desmids have gained more attention than other groups of algae, most published records concerning this group date back to the late 19th to early 20th centuries. Early literature includes: Möbius (1882, 1884), Bailey (1893, 1895, 1898), Borge (1896, 1911) and Schmidle (1896), with subsequent significant works by Mcleod (1975), Grimes (1988), Ling and Tyler (2000) and Dingley (2001a). The majority of the desmids catalogued in these works were sampled from south-east Queensland. Much of the state, such as the far north and central regions, remains scarcely surveyed (Coesel & Dingley 2005).

Constructed water storages for potable supplies are the most common, permanent lentic habitats in south-east Queensland (McGregor 2013), and their protected catchments provide ideal habitats for desmids (Entwisle et al. 1997). Previous studies from this type of environ from other regions within Australia have resulted in newly described species and varieties (e.g. West 1909; Playfair 1912). This paper documents eight

Abstract

Eight desmid taxa are presented herein, of which five are new records for Australia. One new species is proposed, *Euastrum planctonicum* A.Kenins, and the zygospore of a planktic *Staurastrum* Meyen ex Ralfs that defies certain identification is described. The taxa reported suggest south-east Queensland has elements of an Indo-Malaysian/North Australian desmid flora.

Key words: algae, plankton, Australia, Zygnematophyceae, new records

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desmids from south-east Queensland, including five new records and one new species.

Materials and methods

Site description: Sites in this survey were Baroon Pocket Dam (26°42′23.8″S, 152°52′14.1″E), Ewen Maddock Dam (26°46′53.8″S, 152°59′34.0″E), Hinze Dam (28°03′28.5″S, 153°16′55.8″E), Leslie Harrison Dam (27°32′10.3″S, 153°10′20.3″E), Lake Manchester Dam (27°28′57.1″S, 152°45′54.3″E) and Cooloolabin Dam (26°32′48.5″S, 152°52′51.2″E). These reservoirs lie within 200 km of the east coast of south-east Queensland and represent a subset of the many disconnected groups of small to medium sized catchments enclosed to the west by the Great Dividing Range. This south-east region only forms a small part of the state, but due to population pressures, much of the area has been developed for urban and agriculture enterprises resulting in numerous constructed water storages that regularly experience seasonal, cyanobacterial blooms during the Austral summer (McGregor 2013).

Analysis of material: The samples examined are part of an algal monitoring program from 2012 to 2015. Surface plankton grabs or, more often, five metre depth-integrated (three metres if the depth of the waterbody was too low) samples were taken throughout the study catchments for analysis. These samples were preserved on site with lugols iodine solution. Material was examined by brightfield and phase contrast microscopy with an Olympus BX51 compound microscope. Photomicrographs were taken of the preserved material using an Olympus SC30 Digital microscope camera at 400× magnification. Measurements of cellular dimensions (which are explained in Table 1) were taken from the digital images using Olympus cellSens software standard version 1.6. Means are provided when a sufficient number of measurements were taken. Presented focal-stacked images were created using FIJI (*Schindelin et al. 2012)*.

Taxonomic determinations and treatment: Whole-group treatments that encompassed the Australian desmid biogeographic regions as circumscribed by Coesel (1996) and Vyverman (1996) were primarily consulted for identification (i.e. Scott & Prescott 1961; Croasdale & Flint 1986, 1988; Vyverman 1991; Croasdale et al. 1994; Ling & Tyler 2000). Some additional monographs, floras and other publications were also consulted and are referenced herein. While the available dichotomous keys were utilised, 'comparative iconography' where examined specimens are compared to illustrations from the available literature and cross-checked with the descriptions, was largely employed. Identifications were then cross-checked again with the original descriptions when accessible.

Taxonomy

Mesotaeniaceae Oltmanns

1. ***Netrium oblongum*** var. ***cylindricum*** W.West & G.S.West

West & West (1903), *J. Bot. (London)* 41: 40, pl. 446: 10.

Brook & Williamson (2010) *A Monograph on some British Desmids* 57, pl: 22: 1–18 & 23: 1–8.

Dimensions: L. 36.9–63.2 µm, Br. 14.2–15.8 µm, L.:Br. 2.5–4.1. (Fig. 1A)

Description: *Chloroplast* composed of dissected ridges; notches observed in cells undergoing division.

Table 1. Explanation of symbols and abbreviations

µm = micrometres	Br. = Breadth
L. = Length	Br. cpr. = Breadth with processes
L. cpr. = Length with processes	Br. spr. = Breadth without processes
L. spr. = Length without processes	Br. csp. = Breadth with spines
L. csp. = Length with spines	Br. ssp. = Breadth without spines
L. ssp. = Length without spines	Ap. = Breadth of apices
Isth. = Isthmus	L.:Br. = Ratio of length to breadth
Th. = Thickness of cell	(*X*; *n*=x) = Mean (*X*), followed by "*n*" which is the number of specimens measured (x)

Pyrenoid number unable to be determined due to lugols fixative darkening the central axis of said chloroplast.

Remarks: This taxon is regarded as tychoplanktic in lakes (Brook & Williamson 2010) and was found forming a considerable component of the plankton.

Location: Cooloolabin Dam.

Distribution: A new record for Queensland. This taxon has previously been observed by Dingley (1995) in a wheel rut subject to drying from New South Wales; the Australian freshwater algae census (Entwisle & Nairn 2016) is yet to cite this record.

Desmidiaceae Ralfs

2. *Cosmarium mikron* Skuja

Skuja (1949), *Nova Acta R. Soc. Sci. Upsal.,* ser. 4, 14(5): 129, pl. 27: 14.

Dimensions: L. 7.8–8.6 µm, Br. 10–11.5 µm, Isth. 2.7–3.1 µm, Th. 5.4–5.8 µm. (Fig. 1D)

Description: *Cells* small, broadly ellipsoid in outline; considerably constricted. *Apex* of semicell raised with a slight depression on both sides. *Sinus* narrowly open. *Lateral lobes* slightly swollen, terminating with mucros. *Semicell* depressed between the central axis and lateral lobes in apical view.

Remarks: The cells match the original description by Skuja *l.c.* but are ever so slightly larger in dimensions. Williamson (2006) proposed a variety *asymmetricum* on the basis of asymmetrical torsion of the lateral lobes, based on his specimens from Sri Lanka as well as figures provided by Vyverman (1991). Such torsion was not seen in the several cells observed in end-view in this survey. A feature not mentioned in Skuja's *l.c.* original description or shown in his figures was the presence of mucros or tiny spines at the end of the lateral lobes. Neither Vyverman (1991) nor Williamson (2006) mention this feature; but Williamson's *l.c.* central depiction in figure 5 seems to show somewhat pointed lateral lobes.

Location: Leslie Harrison Dam.

Distribution: A new record for Australia. A species presumably confined within the Indo-Malayasian/North Australian desmid biogeographic region. Originally described from Burma by Skuja (1949) with a separate variety *asymmetricum* subsequently recorded from Papua New Guinea by Vyverman (1991) and Sri Lanka by Williamson (2006).

3. *Euastrum planctonicum* A.Kenins, **sp. nov.**

Euastrum cuspidatum var. *goyazense sensu* Dingley (2003)

Dingley (2003), *The Victorian Naturalist* 120: 116 & 117, pl 1: I (as *Euastrum cuspidatum* var. *goyazense*).

Dimensions: L. 20.7–26.3 µm (*23.6 µm*; *n*=40), Br. 23.5–30.4 µm (*26.6 µm*; *n*=60), Isth. 4.1–5.9 µm (*5 µm*; *n*=45), Ap. 9.8–13.5 µm (*12 µm*; *n*=50). (Figs 1C, 2C)

Diagnosis: *Cells* generally broader than long. *Basal lobes* wing-like, comma-shaped, tapering and arising slightly divergently, with a hemispherical protuberance bearing tubercules in its centre. *Sinus* open, rhomboid in outline. *Semicell* in apical view depressed between the basal lobes and the central axis; protuberances bearing tubercules are positioned on the inflated portions of the cell outline.

Type: Figure I, Plate 1, p. 118 in Dingley (2003) Desmids (Chlorophyta) from two freshwater sites in Victoria with an emphasis on new records. *The Victorian Naturalist* 120, 116–120, under the misapplied name *Euastrum cuspidatum* var. *goyazense* (K.Förster & Eckert) K.Förster.

Due to insufficient material for adequate preservation and lodgement in a herbarium, Dingley's figure *l.c.* has been designated as the holotype as the examined cells were illustrated at much greater magnification, detailing the finer aspects of cell wall ornamentation. The species epithet was chosen due to this species being present in the plankton, where cells were frequently observed in mid-division.

Description: A relatively small species of *Euastrum* Ehrenberg ex Ralfs that is usually slightly broader than long. *Semicells* consist of morphologically elaborate, wing-like basal lobes that extend horizontally with a single, prominent spine terminating at the very end. *Apical margin* of the polar lobe flat with an open notch. *Polar lobe* short, with sub-parallel margins, the angles furnished with a slightly diverging spine on each corner with a single subapical granule positioned nearby. Additional *granules* are found on the upper and lower margins of the basal lobes; the remainder of the cell wall apparently smooth. *Sinus* very widely open, acutely angled from the isthmus then narrowing and opening again. Three hemispherical *facial protuberances* bearing tubercules can be seen in faceview; one directly above the isthmus with the other two positioned on each of the basal lobes beside the aforementioned central one.

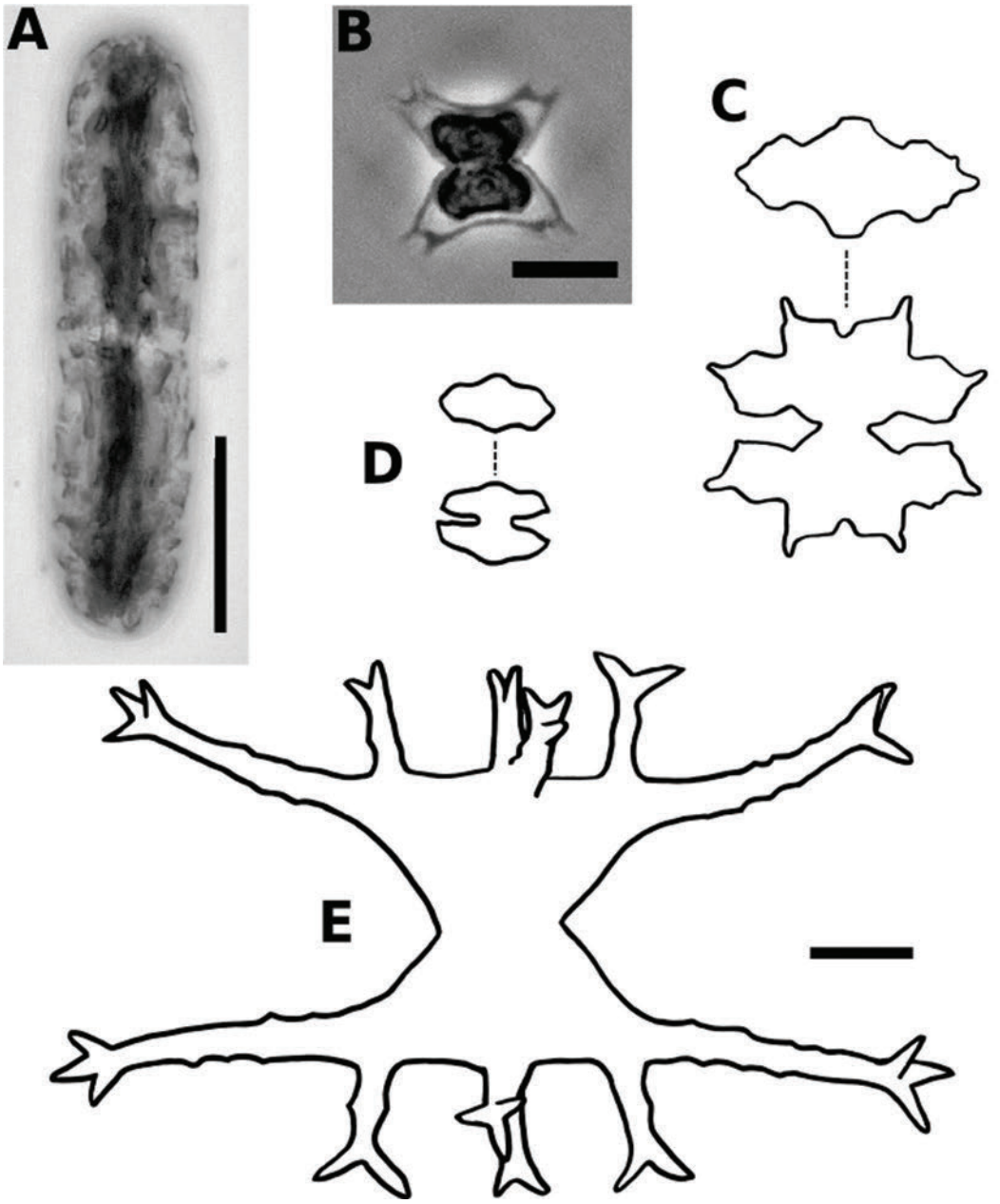

Figure 1. A. *Netrium oblongum* var. *cylindricum*, 400× mag. Focus-stacked, Brightfield. Scale Bar = 20 µm; **B.** *Xanthidium bifidum,* 400× mag. Brightfield. Scale Bar = 10 µm; **C.** *Euastrum planctonicum,* line drawing of apical and faceview; **D.** *Cosmarium mikron*, apical and faceview; **E.** *Staurastrum biwaense.* Scale bar for illustratraions = 10 µm.

Chloroplast axile with a centrally placed pyrenoid in each semicell. *Zygospore* unknown.

Remarks: On the basis of similarity of sinus shape and comparable dimensions, Viyakornvilas (1974) recorded the present form from Australia under the name *Euastrum cuspidatum* var. *goyazense* (Förster & Eckert) Förster & Eckert (synonym *Euastrum subtile* var. *goyazense* Förster & Eckert), originally described from South America. However, Viyakornvilas (1974) noted differences such as three pyrenoids (there may be confusion here where Viyakornvilas may have meant the term tubercule) per semicell instead of one and the polar lobes bearing a lesser number of spines. Dingley (2003) remarks that the specimens encountered are in agreement with Viyakornvilas (1974) and observed a single long spine with a sub-apical granule adjacent to it on each angle of the polar lobes. The cells in this survey agree with the previous authors' plants from Australia. Aside from the previously noted differences, *E. planctonicum* A.Kenins also differs from *E. cuspidatum* var. *goyazense* by having a more elaborate, arced, wing-like basal lobe instead of a cylindrical one and each lobe is beset with a tubercule; *E. cuspidatum* var. *goyazense* is not described nor figured to have any on its lobes (see Förster 1964 & 1969). The differences between the two taxa are even more apparent when compared in endview, where *E. planctonicum* is much more angular and pointed with respect to the cell margins as well as being depressed between the central axis of the cell and basal lobes. The aforementioned protuberances bearing tubercules are also prominent from this view. *Euastrum planctonicum* and *E. cuspidatum* var. *goyazense* are quite unique species in that they differ from other Euastra with horizontally extending basal lobes by having a sinus that is considerably open rather than tending to be closed. *Euastrum planctonicum* is a very morphologically distinct species which has considerable differences from *E. cuspidatum* var. *goyazense* and other Euastra and warrants recognition at species rank.

Location: Leslie Harrison Dam.

Distribution: *Euastrum planctonicum* is newly recorded from Queensland. Australian reports were previously misidentified as *E. cuspidatum* var. *goyazense*, as by Viyakornvilas (1974), who included records from Lakes Hume and Mulwala (Victoria); Dingley (2003), who subsequently recorded it in Victoria from a shallow stream flowing into Lake Nillahcootie; and Viyakornvilas (1974) and Brook (1981), based on personal communication by P.A. Tyler, who recorded it in Lakes Sorell and Crescent (Tasmania).

4. ***Haplotaenium minutum*** var. ***elongatum*** (W.West) Bando

Croasdale & Flint (1986), *Flora of New Zealand. Freshwater Algae, Chlorophyta, Desmids*, vol. I 73, pl. 14:2–4.

Synonym: *Pleurotaenium minutum* var. *elongatum* (W.West), Cedergren (1932), *Ark. f. Bot.* 25A(4): 13.

Dimensions: L. 233.69–317.72 µm (*266.7 µm*; *n*=34), Br. 9.73–11.36 µm (*10.5 µm*; *n*=34), Isth. 8.66–10.4 µm (*9.6 µm*; *n*=34), L.:Br. 21.2–30.3. (Fig. 2A)

Description: *Cells* elongate, cylindrical; *basal swelling* very slight. *Apex* smooth,varying from truncated to very slightly indented; *vacuoles* absent. *Chloroplast* axile, ribbon-like with 12 to 22 pyrenoids; its centre often contorted to accommodate for the nucleus.

Location: Ewen Maddock Dam.

Distribution: A new record for Australia. Considered widespread, found on most continents.

5. ***Sphaerozosma aubertianum*** var. ***indicum*** (W.B.Turner) Coesel & Ngearnpat

Coesel, Ngearnpat & Peerapornisal (2009), *Algol. Stud.* 131: 17, fig. 4.

Basionym: *Sphaerozosma vertebratum* var. *indicum* W.B.Turner (1893), *Kongl. Svenska Vet.-Akad. Handl.* 25(5): 140, fig. 18.

Dimensions: L. spr. 13.6–15.4 µm, Br. 16.3–20.6 µm, Isth. 4.5–5.9 µm. (Fig. 2B)

Description: *Semicells* elliptic; *sinus* open, cuneate; *isthmus* slightly elongate. A pair of *pores* giving a granule-like appearance were visible on the lateral sides of the cell wall.

Remarks: The open sinus and elliptic semicells differentiate *Sphaerozosma aubertianum* West from *S. vertebratum* Brébisson ex Ralfs (Coesel & Van Westen 2013). The variety *indicum* differs from the nominate in that the sinus is more open and cuneate, making the isthmus more elongate and distinct. The pores of the nominate variety of this species have been observed to cross each other in an 'x' fashion (Coesel & Van Westen 2013). Unfortunately, due to the lack of empty semicells in the material available, this feature was not discernible.

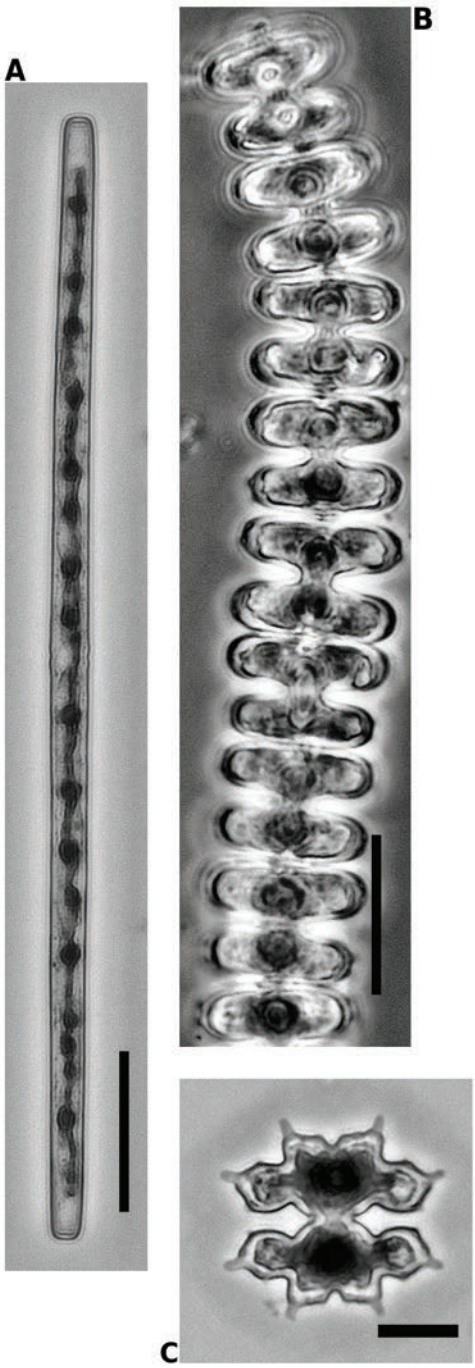

Figure 2. A. *Haplotaenium minutum* var. *elongatum*, 200× mag. Brightfield. Scale Bar = 40 µm; **B.** *Sphaerozosma aubertianum* var. *indicum*, 400× mag. Phase contrast. Scale Bar = 20 µm; **C.** *Euastrum planctonicum*, faceview, 400× mag. Brightfield. Scale Bar = 10 µm.

Location: Ewen Maddock Dam.

Distribution: New record for Australia; previously reported from India and Thailand. The nominate variety has been previously recorded from Victoria.

6. *Staurastrum biwaense* Hirano

Yamaguchi & Hirano (1953), *Acta Phytotax. et. Geobot.* 15: 56, figs. 7–9.

Hirano (1959), *Flora Desmidiarum Japonicum* VI 373, pl. 49:12–14.

Dimensions: L. cpr. 45.4–64.3 µm, L. spr. 28.5–32.1 µm, Br. cpr. 75–94.8 µm, Br. spr. 24.6–28.2 µm, Isth. 9.5–10.8 µm. (Fig. 1E)

Description: *Cells* triradiate, very rarely biradiate. *Cell body* slightly longer than broad, deeply constricted. *Semicell body* in face view triangular and cup-shaped, lacking any ornamentation or granulation. *Processes* dentate, extend horizontally then arise divergently, terminating with 3 robust, sharply-pointed spines. *Secondary vertical process* occasionally found above the base of each of the aforementioned processes which in comparison are much shorter, and terminate with 2 spines. The cells in endview are triangular with slightly concave sides, with the main, basal processes appearing to be slightly curved in an anticlockwise direction. *Chloroplast* furcoid, extending about two-thirds of the way into both the primary and secondary processes.

Remarks: The dimensions and description match well with Hirano (1959) except for the short apical process being described as *'trispinatus'* rather than bispinate. However, figure 13 provided by Hirano (1959) clearly shows them as bispinate like the cells observed in this survey. This desmid has morphological affinities with *Staurastrum rosei* Playfair and the *S. sexangulare* complex.

Location: Baroon Pocket Dam and Hinze Dam.

Distribution: New record for Australia, originally described from Japan.

7. *Staurastrum* sp. 'SE Queensland'

Dimensions: L. cpr. 40.5–88.6 µm (*71.3 µm*; *n*=26), L. spr. 35.9–51.3 µm (*41.8 µm*; *n*=29), Br. cpr. 68.6–112.8 µm (*88.8 µm*; *n*=26), Br. spr. 17.7–30.8 µm (*23.3 µm*; *n*=30), Isth. 8.6–13.3 µm (*10.4 µm*; *n*=32). (Figs 3 A–D; 4 A–C)

Description: *Cells* triradiate, the occasional biradiate/triradiate janus forms are very rarely encountered. *Cell*

body cup-shaped with a slightly swollen base above the isthmus which can on occasions be reduced and not apparent. *Processes* arising divergently, corrugated and ending with 4 robust spines. Below each process is a group of granules on the basal swelling. *Cell margin* in endview triangular in outline with several apical verrucae of the same size, arranged in an intramarginal arc, with the first and last verrucae projecting beyond said margins. *Annulus*, in endview, spherical with the aforementioned basal granules visible in line with each of the three processes. *Chloroplast* furcoid with a single, centrally placed pyrenoid in each semicell. *Zygospore*, L. cpr: 65.4–75.4 µm and L. spr: 31.3–37.1 µm, angularly globose to isohedral, sides flat with angles producing into processes that fork dichotomously three times.

Remarks: The species described has clear morphological affinities with the *Staurastrum pingue/planktonicum* complex and matches what Thosmasson and Tyler (1971) designated as *S. pingue* Teiling from the plankton of Tasmanian lakes. However, there are marked differences which separate it from this complex in the strict sense, such as the ornamentation of the body and apex and the presence of four distinct spines that terminate the end of the processes rather than three as discussed by Kusber and Scharf (2009). These characters share similarities with *S. manfeldtii* var. *fluminense* (Deplonte) Schumacher, but the semicell body of the Australian populations is granulate rather than spinulate when compared to the original illustration by Schumacher and Whitford (1961). Furthermore, the supraisthmal granules, referred to as "teeth" in Schumacher and Whitford (1961) had combinations of three + four or two + three whereas the cells observed in this survey were much more variable and reduced

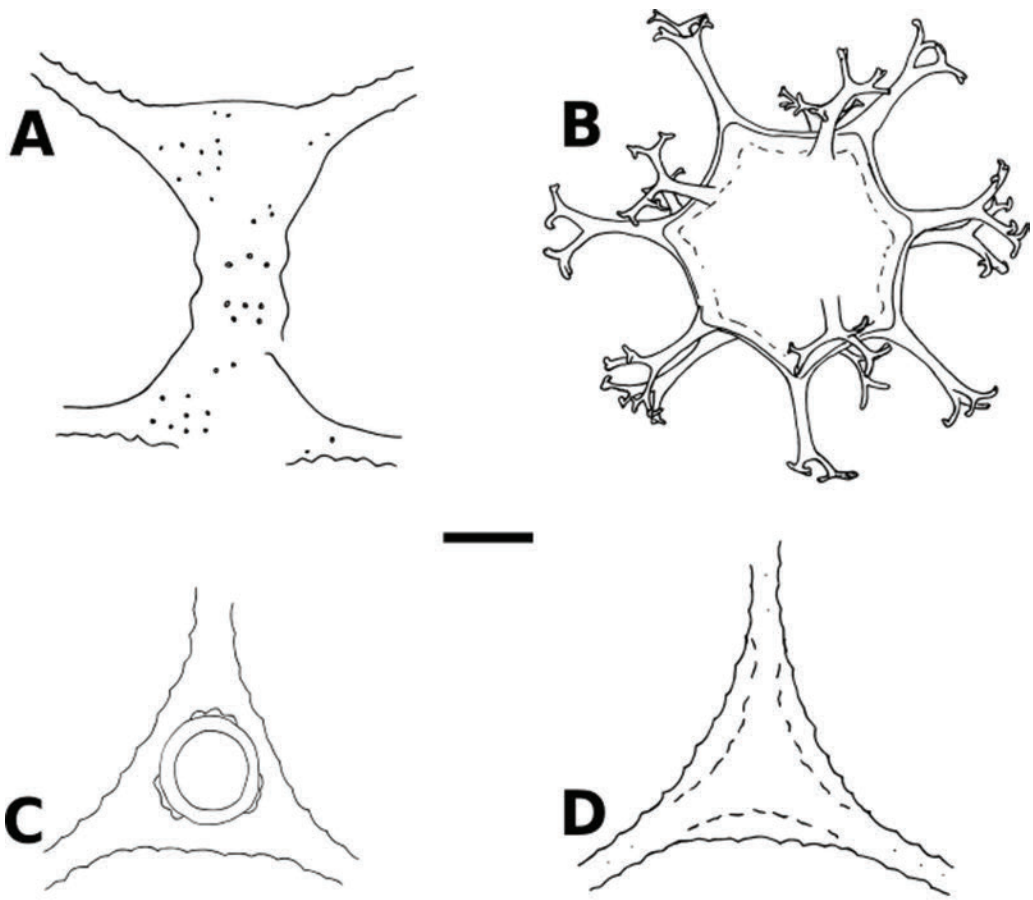

Figure 3. Line drawings of *Staurastrum* sp. from Baroon Pocket Dam. **A.** Ornamentation of basal inflation; **B.** Zygospore; **C.** Annulus, showing shape and ornamentation; **D.** Apex, showing intramarginal verrucae. Scale Bar = 10 µm.

in number, having at most the aforementioned two + three combination. Both Viyakornvilas (1974) and Ling and Tyler (2000) also reported a very similar looking *Staurastrum* from Australia under *S. pseudosebaldi* var. *planctonicum* Teiling and *S. pseudosebaldi* Wille respectively. *Staurastrum pseudsebaldi* is considered an artificial species due to taxonomically ill-defined morphological characters, so much so that Coesel and Meesters (2013) transferred it as a mere variety of *S. manfeldtii* and therefore many records under this name are likely to be other, unrelated Staurastra. Viyakornvilas (1974) considered *S. manfeldtii* var. *fluminense* (Deplonte) Schumacher but was not able to observe the ornamentation of the cell body, which was obscured by the chloroplast. Ling and Tyler's (2000) *l.c.* depictions of many of the *S. pseudosebaldii* forms have the characteristic supraisthmal granulation, especially on Pl. 143 figs 3–5. Whether the other depictions under the same name form a series of morphological continuity for a single species requires further investigation. The material from Queensland is also similar to *S. multispiniceps* A.M.Scott & G.W.Prescott from Indonesia but that species has an apparently smooth body with a convex apex bearing several small conical spines.

This study observed what could be best described as a mass-spawning event that occurred throughout the Baroon Pocket Dam catchment where seven different sample sites (some of which were kilometres apart) had 'blooms' of this *Staurastrum*. In these blooms cells were observed paired up, positioned perpendicular to one another within a common mucilaginous envelope. There were empty cells adjacent to the resultant zygospores.

Location: Baroon Pocket Dam, Leslie Harrison Dam and Hinze Dam.

8. ***Xanthidium bifidum*** (Brébisson) Deflandre

Deflandre (1929), *Bull. Soc. Bot. France* 76: 137.

Croasdale & Flint (1988), *Flora of New Zealand. Freshwater Algae, Chlorophyta, Desmids*, vol. II 120, pl. 58: 5 & 6.

Basionym: *Arthrodesmus bifidus* Brébisson (1856), *Mém. Soc. Imp. Sc. Nat. Cherbourg* 4: 135, pl. 1: 19.

Synonym: *Octacanthium bifidum* (Brébisson) Compère (1996), *Nova Hedwigia* 112: 503, fig. 3.

Dimensions: L. csp. 16.7–19.2 µm, Br. csp. 16.3–18.2 µm, Isth. 5.8–6.5 µm. (Fig. 1B)

Description: *Semicells* semi-lunate with the emerging lateral angles bifurcate. *Sinus* open, slightly notched.

Remarks: The plants most closely resemble those depicted by Scott and Prescott (1961) under the synonym *Arthrodesmus bifidus*.

Location: Lake Manchester.

Distribution: New record for Australia. This species is putatively cosmopolitan.

Conclusion and discussion

Despite the low number of taxa reported here, their geographic distributions are of interest. *Cosmarium mikron* Skuja and *Sphaerozosma auberitianum* var. *indicum* (W.B.Turner) Coesel & Ngearnpat have thus far been recorded solely from what is known as the Indo-Malaysian/North Australian region (IMNAR) (Coesel 1996; Vyverman 1996). The presence of these taxa suggest that south-eastern Queensland has elements of an IMNAR desmid flora and supports the assumption that the yet to be catalogued parts of northern Queensland encompass this biogeographic region (Vyverman 1996; Coesel & Dingley 2005). Conversely, *Euastrum planctonicum* A.Kenins has thus far only been reported from south-eastern Australia which coincides with similar distributions of desmids known solely from southern Australia and/or New Zealand (Coesel 1996). The assemblage of taxa from the two bioregions found in this study correlates with a previous survey of freshwater algae from north-eastern New South Wales by Skinner (1979) who notes the desmid flora as having both elements of the IMNAR and temperate Australia-New Zealand flora, and suggests northern New South Wales may be part of the interface between the two floras. Such an interface would match patterns detected for higher plants. Far south-east Queensland and far north-eastern New South Wales comprise a floristic zone in higher plants known as the Mcpherson-Macleay overlap (Burbidge 1960); and much the same region is included in the eastern Queensland phytogeographical region developed by González-Orozco et al. (2014). As noted by previous Australian studies on desmids, such as Tyler (1970) and Dingley (2001b), records are scant and patchy, and further studies are required in order to synthesise a better understanding of distribution patterns for this group of algae, comparable to the knowledge of higher plant patterns.

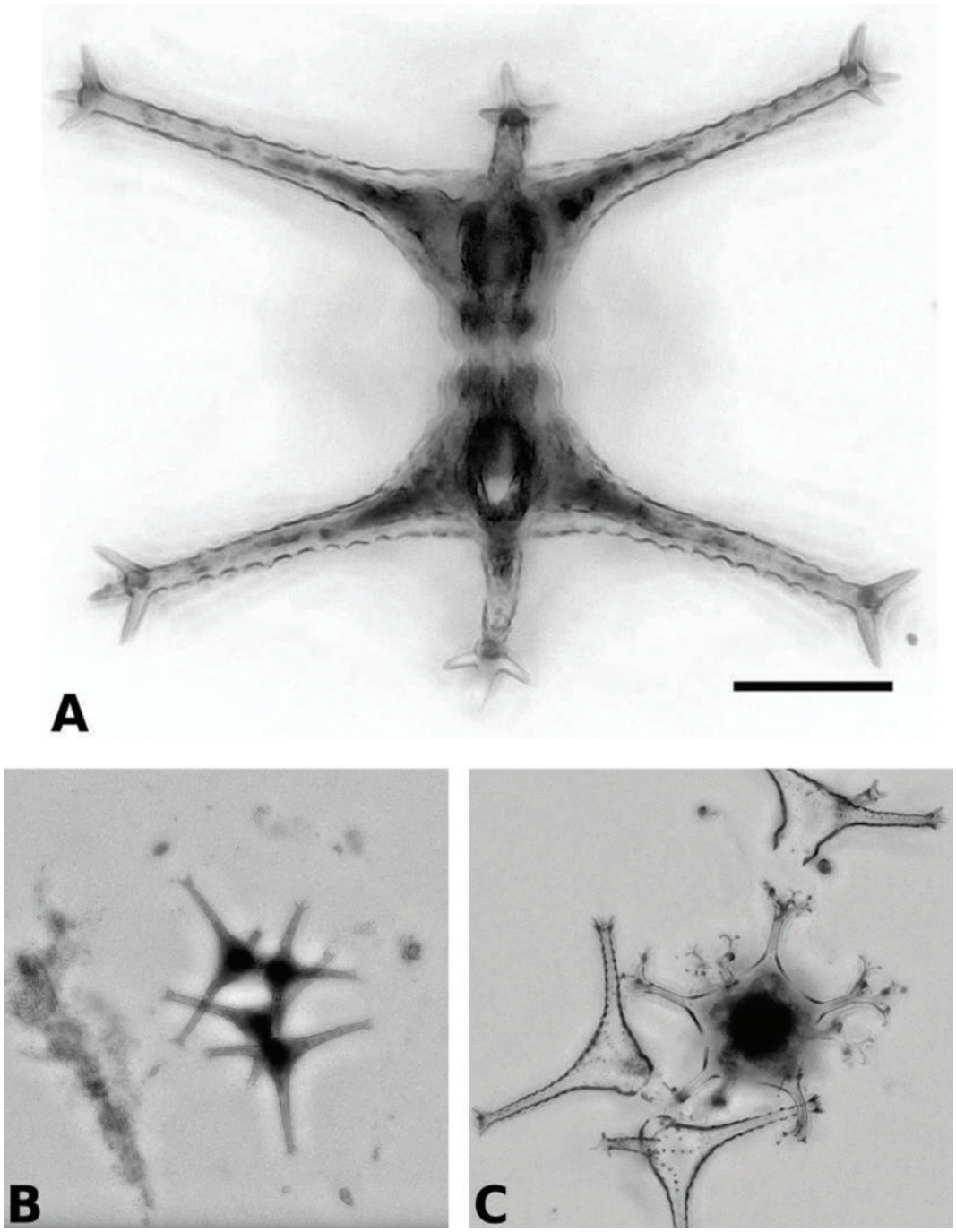

Figure 4. *Staurastrum* sp. from Leslie Harrison Dam. **A.** Faceview, 400× mag. Focus-stacked, Brightfield. Scale Bar = 20 µm; **B.** Pair initiating conjugation within common mucilaginous envelope, 200× mag. Focus-stacked, Brightfield; **C.** Empty semicells adjacent to resultant zygospore post conjugation, 400× mag. Focus-stacked, Brightfield.

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