

# New taxa and combinations for *Oedogonium* and *Bulbochaete* (Oedogoniales, Chlorophyceae) in Australia

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## Abstract

Fifteen new taxa in the Oedogoniaceae, the species *Bulbochaete kakaduensis* [for *B. elatior* sensu Scott & Prescott (1958)] *B. rodwayi*, *Oedogonium bancroftii*, *Oe. capricornicum*, *Oe. cerasinum*, *Oe. cribbianum*, *Oe. hardyi* [for *Oe. monile* var. *victoriense* G.S.West] *Oe. moebiusii* [for *Oe. undulatum* var. *möbiusii* Schmidle] *Oe. pilbaranum* and *Oe. utrarium*, and the varieties *B. calospora* var. *murrayana*, *B. gigantea* var. *glabra*, *B. wuhanensis* var. *spechtii*, *Oe. kwangsiense* var. *playfairii* and *Oe. starmachii* var. *weetalibahense* are described. Two other taxa are new combinations: *Oe. undulatum* var. *wissmanii* for *Oe. wissmanii* Stephen Skinner and *Oe. uleanum* var. *continuum* for *Oe. platygynum* var. *continuum* Nordstedt ex Hirn.

## Introduction

Seventeen taxa (8 species and 4 varieties of *Oedogonium*, 2 species and 3 varieties of *Bulbochaete*) require taxonomic review in preparation for an account of the Oedogoniales (Chlorophyta) for the Algae of Australia series. Most are new taxa and require formal taxonomic recognition. A few require revision of status, although previously described. The taxa are arranged in systematic order following Mrozińska (1991, 2000).

The earliest mention of *Oedogonium* from Australia in the literature is Sonder (1852) but without description or illustration. Next comes Berkeley and Harvey's (1860) enthusiastic description of *Oe. monile*. It was Baron von Mueller who laid the Australian foundation for freshwater phycology generally and whose enthusiasm sparked the first local interest in the Oedogoniales. Mueller encouraged people in all parts of the continent to send him curious and unexpected plants, and so received quite a few freshwater algal samples including numerous Oedogoniales. F.M. Bailey in Brisbane made a major contribution in the late 19<sup>th</sup> and early 20<sup>th</sup> Century. All three Bailey papers (1893, 1895, 1898) include *Oedogonium* and *Bulbochaete* species.

Hirn's (1900) world monograph of the Oedogoniales, the starting point for nomenclatural priority in this order, used collections from the herbaria of Mueller and Bailey, sent to V.B. Wittrock, M. Möbius, W. Schmidle and C.F.O. Nordstedt. Although Hirn did not designate types as such, there are ten taxa based solely on Australian

collections. Four of these (and also numerous new desmid taxa) come from a single collection by T. Gulliver made 'between the Norman and Gilbert Rivers' in 1874. We have been able to find and view this collection, and some others from Australia, in LD, but not all Hirn 'types' could be located. In the absence of voucher material, we have relied on protologues and subsequent monographs and floras to define existing taxa.

Further records of Oedogoniales from parts of Australia can be found in Scott and Prescott (1958) for Arnhem Land, Skinner (1980) for the New England Tableland of New South Wales, and the many contributions of Cribb to the Queensland Naturalist (see Day et al. 1995 for a list). Cribb (1956) provides the only report of *Oedocladium* in Australia.

This paper uses material from historical collections in AD, MEL and BRI, as well as recent collections forwarded to us from collectors across the continent and our own recent collections.

## Methods

Recent collections were fixed in either 4% formaldehyde or 70% ethanol in the field, and sent to the National Herbarium of New South Wales where part of each sample was mounted in 40% Karo as semi-permanent slides, while the remainder of the specimen was stored in 70% ethanol and 5% glycerine. Slides were examined with a Leitz Dialux compound microscope and drawings made with a drawing tube. Collections from MEL, AD and BRI were also examined. Data sheets for each collection are also retained at NSW.

## Oedogonium Link

Mrozińska (1991) defined 20 informal groups for *Oedogonium*, based on phylogenetic analysis. Later she (Mrozińska 1999) presented a new subgeneric classification and allocated her informal groups to this new infrageneric system, which we follow here. Mrozińska (pers. comm.) kindly provided us with a list of how she has allocated taxa within this new system.

Subgenus *Archaeoedogonium* Mrozińska (1999)

Cell walls, possibly excepting antheridia, helically striped with finely granulate or punctate outer surface; basal cell globose or depressed globose, vertically plicate. Antheridia either intercalary with single spermatozooids or in globose, single-celled dwarf males.

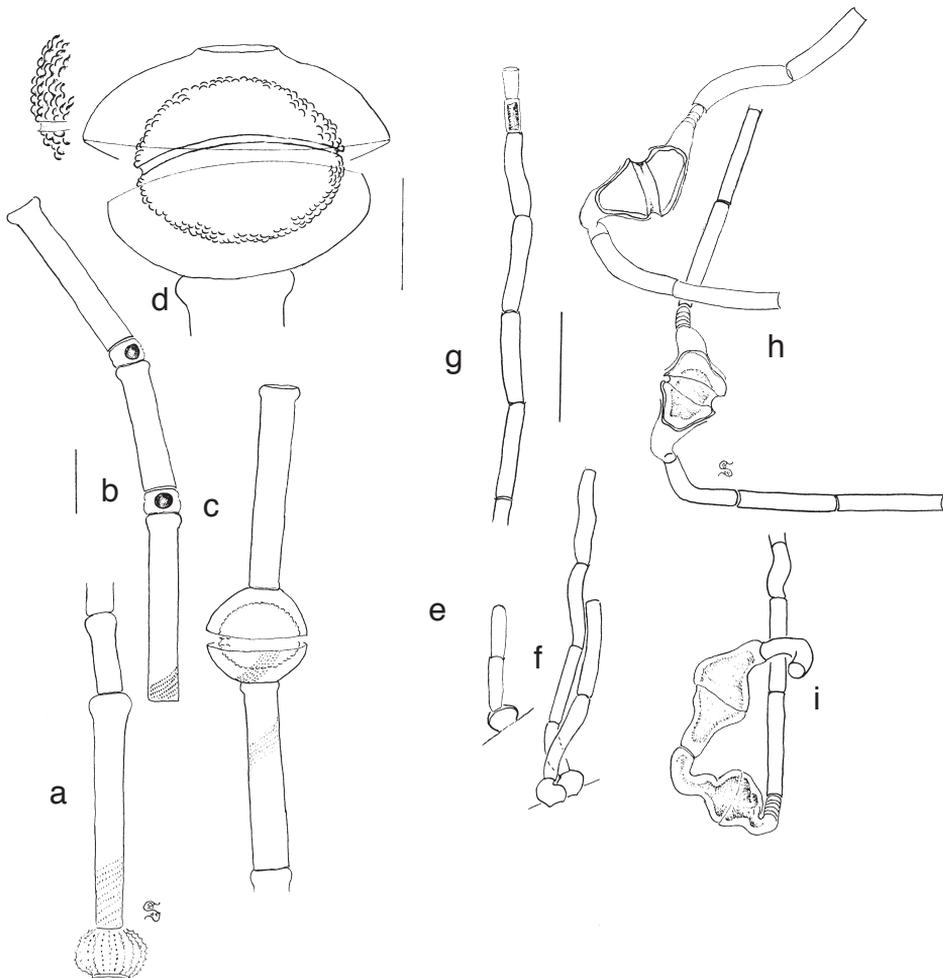
## Group A

Macrandrous taxa.

*Oedogonium cribbianum* Stephen Skinner & Entwisle *sp. nov.*

*Oe. punctato-striatum* sensu Cribb, *Lake Broadwater. The Natural History of an Inland Lake and its Environs*: 39 (1988)

Diagnosis: *Oedogonio fasciculato* simile, sed macrandro et oosporis globosis depressis dense verrucosisque.



**Fig. 1.** *Oedogonium cribbianum*: **a**, basal cell; **b**, intercalary antheridia; **c**, oogonium with oospore; **d**, enlargement of oospore, with sketch of sculpturing (Cribb 1090.4); *Oe. utrarium*: **e**, **f**, basal cells; **g**, antheridia; **h**, solitary oogonia, with oospores; **i**, pair of developing oogonia (Towler 283c & Wilson s.n.). (Scales = 20  $\mu$ m)

**Type:** Queensland: Surveyors Gully, Lake Broadwater (27° 21'S; 151° 06'E), Cribb 1090.4, 21 Feb 1987 (holo BRI).

**Illustration:** Fig. 1, a–d.

Macrandrous, monoecious or dioecious. *Vegetative cells* capitellate, finely helically punctate, L/D (3–)5–10, (14–)16–18  $\mu$ m diam., chloroplast reticulate, few pyrenoids; *basal cell* hemispherical, vertically plicate, 12–15  $\mu$ m long, 22–23  $\mu$ m diam.; *terminal cell* shallowly domed. *Oogonium* solitary, globose to depressed globose, punctate, intercalary or occasionally terminal (and then with a domed top), circumcission median, wide at one side, 34–41  $\mu$ m long, 40–44(–46)  $\mu$ m diam.; *oospore* depressed globose, not filling oogonium, golden to reddish golden, exospore banded verrucose, 29–32  $\mu$ m long, 35–38  $\mu$ m diam.; *suffultory cell* as vegetative cells, frequently L/D 3–4. *Antheridia* solitary

to triple, short (L/D c.1.5) same width as surrounding vegetative cells, top opening, in groups with vegetative cells between, either several cells above or below an oogonium or on separate filaments, with one spermatozoid.

**Etymology:** named in honour of Professor Alan B. Cribb who has done so much to alert people to the fascination of freshwater algae.

**Distribution:** known from type locality in Queensland, on *Vallisneria* sp. and northern New South Wales on *Myriophyllum* sp.

Very similar to *Oe. fasciculum* Zhu (1964) from China but differs in not being nannandrous, and in having slightly more depressed oospores with more regular and dense cover of verrucae. Cribb's (1988) determination of *Oe. punctato-striatum* de Bary ex Hirn is superficially similar to the type, but that taxon has smooth oospores.

**Specimens examined:** Queensland: Surveyors Gully, Lake Broadwater, *Cribb 1090* subsamples, 21 Feb 1987 (BRI). New South Wales: North Western Slopes: quarry, 1 km W of township, Howell Rd, Tingha, *Skinner 0801, McPherson & Towler*, 13 Oct 2004 (NSW).

Subgenus ***Prooedogonium*** Mrozińska (1999)

Cell walls smooth; basal cells globose to depressed globose, hemispherical or if vase-like then a short goblet, L/D no more than 3. Antheridia with single spermatozoid, macrandrous or nannandrous, and then internal.

### Section C

Macrandrous; basal cell hemispherical, occasionally short vase-like; oogonium usually depressed globose, oospore smooth walled.

***Oedogonium utrarium*** Stephen Skinner & Entwisle *sp. nov.*

Diagnosis: species bene distincta, cellula suffultoria reflexa, oogonio asymmetrico gleboso utriculoide, oospora quoque biconica sulcoque medio.

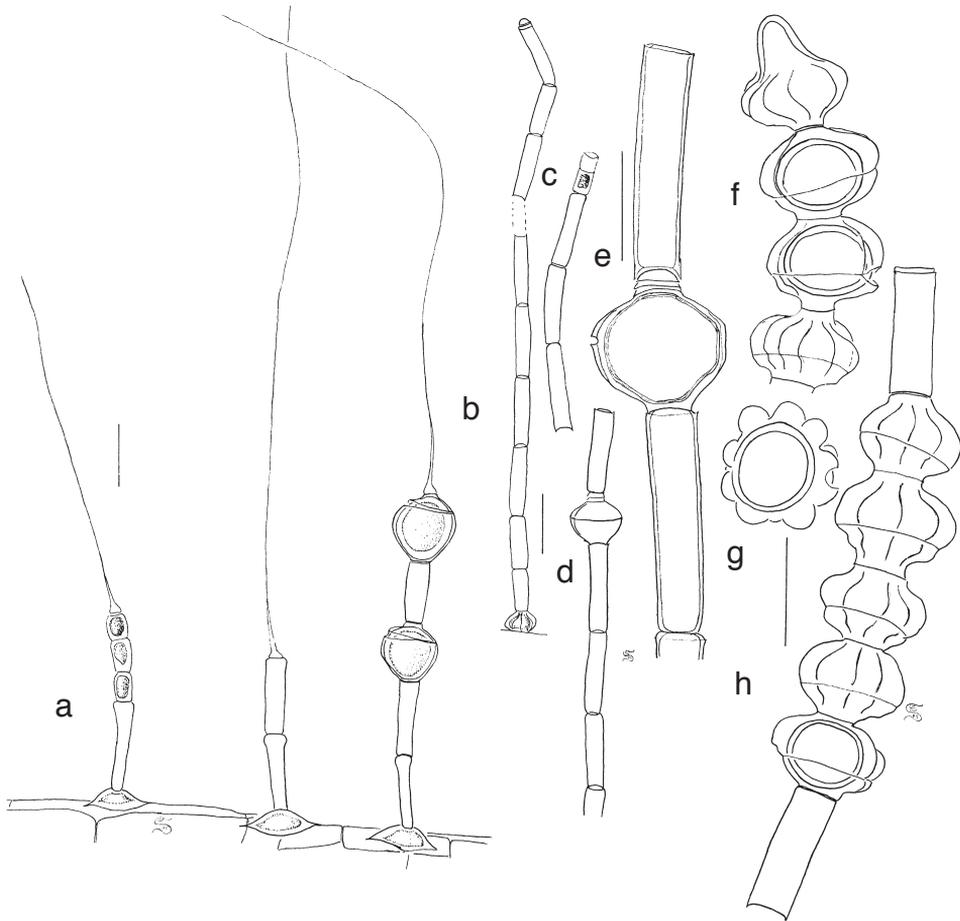
**Type:** Western Australia: pool in bed of tributary of Hammersley R., Fitzgerald River Nat. Pk (33° 46'S; 119° 43'E), *Towler 283c & Wilson*, 10 Aug 2003 (holo NSW).

Illustration: Fig. 1, e–i.

Macrandrous, dioecious. *Vegetative cells* narrow cylindrical, L/D 4–6, 2.5–3.5 µm diam.; *basal cell* irregular depressed globose, 4–5.5 µm high, 5–5.5 µm diam.; *terminal cell* truncated. *Oogonium* solitary or paired, irregularly saccate, 23–28 µm long, 10–12 µm diam., circumcission median, wide; *oospore* irregular bi-conical, with median furrow, wall smooth but lumpy, not filling the chamber but forcing the circumcission open, 14–19 µm long, 10–12 µm diam.; *suffultory cell* as vegetative cell but reflexed, so that the filament is curled through 90–180°. *Antheridia* solitary or paired, terminal on separate filament, 5.5 µm long, 2–3 µm diam., single spermatozoid.

**Etymology:** from *utrarius* (Latin) a water-bag carrier in the Roman army. These water-bags were frequently made from whole goat or other animal skins, like wineskins, and the oogonia of this taxon are similar in shape.

**Distribution:** known only from the type locality, Western Australia, in a deep riverine pool on granite with aquatic grass, apparently forming a greenish layer close to the gravel.



**Fig. 2.** *Oedogonium cerasinum*. **a**, individual antheridial, vegetative and oogonial thalli (Cherry 446); *Oe. pilbaranum*. **b**, vegetative filament; **c**, antheridia; **d**, oogonium; **e**, oogonium with mature oospore (Edinger 3516); *Oe. uleanum* var. *continuum*: **f**, terminal series of oogonia; **g**, top view of oogonium; **h**, intercalary series of oogonia (Cribb 496.9). (Scales = 20  $\mu$ m)

While sharing vegetative characters with the rest of Group C, this taxon is distinctive in possessing the bent suffultory cell and the lumpy, irregular, wineskin-shaped oogonium as well as the bi-conical oospore with a median furrow. There are no other taxa with similar oogonia.

***Oedogonium cerasinum*** Stephen Skinner & Entwisle *sp. nov.*

**Diagnosis:** *Oedogonio fremyi* simile sed oogonio pyriformi angulari et cellularibus vegetativis capitellatibus celluloque basi hemispherico.

**Type:** Western Australia: Brixton Street wetland, Kenwick, Perth (32° 22'S; 115° 56'E), Cherry 446, 9 Sept 2002 (holo NSW).

**Illustration:** Fig. 2, a.

Dioecious, macrandrous. *Vegetative cells* capitellate, 15–23(–26)  $\mu\text{m}$  long, (3–)6–6.5  $\mu\text{m}$  diam., three to seven or eight in a whole plant; *basal cell* shallow hemispherical, 3–5  $\mu\text{m}$  high, 35–50  $\mu\text{m}$  diam.; both male and female plants terminate in a very long, (up to three or four times the length of the rest of the thallus) fine seta. *Oogonium* pyriform to angular pyriform, 15–21  $\mu\text{m}$  long, 17–20  $\mu\text{m}$  diam., often acropetal, opening by a supreme hinged pore (or partial circumcission); *oospore* closefitting oogonium, pyriform to angular pyriform, wall smooth, thick, laminated, mesospore yellowish to cherry red, 14–20.5  $\mu\text{m}$  long, c.17–20  $\mu\text{m}$  diam. *Antheridia* paired, below seta on male plant, chambers 6–8.5  $\mu\text{m}$  long, 6  $\mu\text{m}$  diam, single spermatozoid.

**Etymology:** as the oogonia are cherry-shaped, the mesospore cherry red in colour and the collector was Wayne Cherry, *cerasinum* (Latin) for cherry-like seems appropriate.

**Distribution:** known only from the type locality, Western Australia, where it is epiphytic on fine, terete stems of water plants in both still and moving water.

*Oedogonium cerasinum* is one of a number of species with few-celled filaments, including *Oe. mirpurensense* Islam, *Oe. fremyi* Gauth.-Lièvre, *Oe. nanum* Wittr. ex Hirn, *Oe. capitellatum* Wittr. ex Hirn, *Oe. sphaerandrium* Wittr. & Lundell ex Hirn, and *Oe. longipilum* Jao. *Oe. cerasinum* is distinctive in the following combination of characters: dioecious, distinctly angular pyriform oogonia, and a shallowly hemispherical basal cell. It is closest to *Oe. longipilum* and *Oe. fremyi*. It shares a terminal seta and supreme circumcission with *Oe. longipilum*, but that species has a short, vase-shaped basal cell, and ovoid oogonia, sometimes in pairs. *Oe. fremyi* has a suprmedian circumcission, the oogonium is globose, the basal cell is diffuse and the vegetative cells are less consistently capitellate than *Oe. cerasinum*.

### Group G

Macrandrous; basal cell shortly vase-like; oogonium opening through a median to superior pore, or pore and slit; oospore smooth.

***Oedogonium pilbaranum*** Stephen Skinner & Entwisle *sp. nov.*

Diagnosis: *Oedogonio rufescente* simile sed in dimensiones minore atque circumcissione oogonii rostrato.

**Type:** Western Australia: 28 km SSW of Turee Creek Station (23° 52'S; 118° 32'E), *Edinger 3516*, 9 May 2003 (holo NSW).

Illustration: Fig. 2, b–e.

Macrandrous, dioecious. *Vegetative cells* cylindrical or slightly capitellate, L/D 3–10, 7–8  $\mu\text{m}$  diam.; *basal cell* depressed globose, slightly undulate, c.10  $\mu\text{m}$  tall, 13–14  $\mu\text{m}$  diam.; terminal cell ending in a shallow cap. *Oogonium* solitary or paired, depressed globose to spindle-like, 20–26  $\mu\text{m}$  long, 20–23 (–25)  $\mu\text{m}$  diam., opening a suprmedian pore or short slit; *oospore* depressed globose, smooth walled, filling chamber, mesospore brown, 18–19  $\mu\text{m}$  long, 20  $\mu\text{m}$  diam.; *suffultory cell* as vegetative cells. *Antheridia* intercalary or acropetal, in pairs, 7–10  $\mu\text{m}$  long, c.7  $\mu\text{m}$  diam.; single spermatozoid.

**Etymology:** from Pilbara, the region of Western Australia from which the sole collection was made.

**Distribution:** known only from the type locality, Western Australia, in a permanent seepage.

Although very close to the cosmopolitan *Oe. rufescens* Witttr. ex Hirn, this specimen shows a globose basal cell, more similar to those of *Oe. inversum* Witttr. ex Hirn and *Oe. infirmum* Tiffany, and the oospore is more nearly globose, not tending to be laterally ovoid/elliptical. The oospore fills the chamber and conforms to its shape to some extent, exhibiting a slight dome below the terminal dome of the oogonial chamber.

Subgenus **Oedogonium** Mrozińska (1999)

Cell walls smooth; basal cell short to elongate vase-shaped, usually with a basal disc which may be clawed.

Supersection *Monospermatozoidiae*

Antheridia with single spermatozoid; in nannandrous species either internal in goblet-like dwarf male, or extruded from the body cell, with diffuse antheridial walls.

### Group E

Macrandrous or nannandrous; dwarf males with internal antheridia; basal cell shortly vaselike; oogonia with median whorl of projections or ribs.

**Oedogonium uleanum** Hirn, *Acta Soc. Sci. Fenn.* 27: 311 (1900).var. **continuum** (Nordstedt) Stephen Skinner & Entwisle **comb.nov.**

*Oedogonium platygynum* var. *continuum* Nordstedt, *Bot. Not.*: 153 (1887).

*Oe. platygynum* var. *continuum* Nordstedt ex Hirn (1900).

**Type:** New Zealand: Ohaeawai, (35° 21'S; 173° 53'E), *Berggren*(64): Herb Nordstedt, (LD n.v.).

Illustration: Nordstedt op cit: Pl. 1, figs 16, 17; hic Fig. 2, f–h.

Dioecious, macrandrous. *Vegetative cells* cylindrical to slightly capitellate, L/D 2.5–3.5, 7–8 µm diam.; *basal cell* not seen; *terminal cell* obtusely capped. *Oogonia* solitary, in pairs, threes, fours (common) or fives, depressed globose, 13.5–23 µm long, 18–25 µm diam., flanges prominent rounded mamillate, circumcision submedian; *oospore* depressed globose to spherical, not filling the chamber, 14–18 µm diam.; *suffultory cells* similar to vegetative cells. *Androsporangia*, dwarf males or antheridia not observed.

**Distribution:** Queensland in seepage on upper shelf near entrance of cave, and in New Zealand.

The Queensland and New Zealand collections are of the same taxon. Nordstedt (1887, 1888) described the New Zealand taxon as a variety of *Oe. platygynum* Witttr. ex Hirn. However *Oe. platygynum* var. *platygynum* is described as nannandrous and figured with dwarf males, and the flanges are rounded. Nordstedt (1887) contains the six word protologue for *Oe. platygynum* var. *continuum* Nordstedt, while the illustrations, including the antheridia/androsporangia, are in Nordstedt (1888). This taxon is clearly a macrandrous taxon, and the flanges are often slightly truncated. Although the oogonia and oospores are rather smaller than *Oe. uleanum* as described

in Hirn (1900) (oogonia 28–32  $\mu\text{m}$  diam., 21–26  $\mu\text{m}$  long) the Queensland and New Zealand collections have oogonia in series and otherwise fit closer to *Oe. uleanum* than *Oe. platygynum*. Interestingly Hirn (1900, p. 279) queried the position of *Oe. platygynum* var. *continuum* and expressed the desire for more information. “Für die Var. *continuum*, die leider noch wenig bekannt ist, sind die reihenständigen Oogonien und die abgestutzte Form der Oogoniumvorsprünge hervortretende Merkmale.” [As for the var. *continuum*, unfortunately we do not know as yet if having oogonia in series and truncated oogonial wall flanges are characteristic enough to make it distinct.] This record from Queensland was not included in Cribb (1965).

**Specimens examined:** Queensland: Paradise Cave, Noosa Heads, Cribb 496.9, 13 Oct 1962 (BRI).

### Group P

Nannandrous; dwarf males with a basal cell and internal antheridia later extruded; vegetative cells may have undulate walls; oogonia with inframedian to supramedian circumcission; oospore smooth or variously sculptured.

When establishing this group Mrozińska (1991) allowed only *Oe. undulatum* and *Oe. croasdaleae* Jao as examples, and later listed *Oe. undulatum* var. *undulatum* f. *undulatum* and f. *senegalense*, *Oe. undulatum* var. *americanum* Transeau f. *americanum* and f. *serriatum* (Prescott) Mrozińska, *Oe. mirificum* Zhu and var. *minus* Jao, *Oe. croasdaleae* and f. *goczalkowiczensis* Mroz. Webb in the group (Mrozińska, pers. comm.). We have adopted a much wider definition here, based on comparison of the dwarf male structures in *Oe. undulatum* with those in *Oe. hians* Nordstedt & Hirn in Hirn, *Oe. monile* and similar taxa, where the antheridial cell appears to be extruded from the body cell and to contain only a single spermatozoid at a time. The fine structure of dwarf males of members of this group requires examination similar to Leonardi et al. (1998) for *Oe. pluviale* Nordst. ex Hirn.

***Oedogonium moebiusii*** Stephen Skinner & Entwisle *sp. nov.*

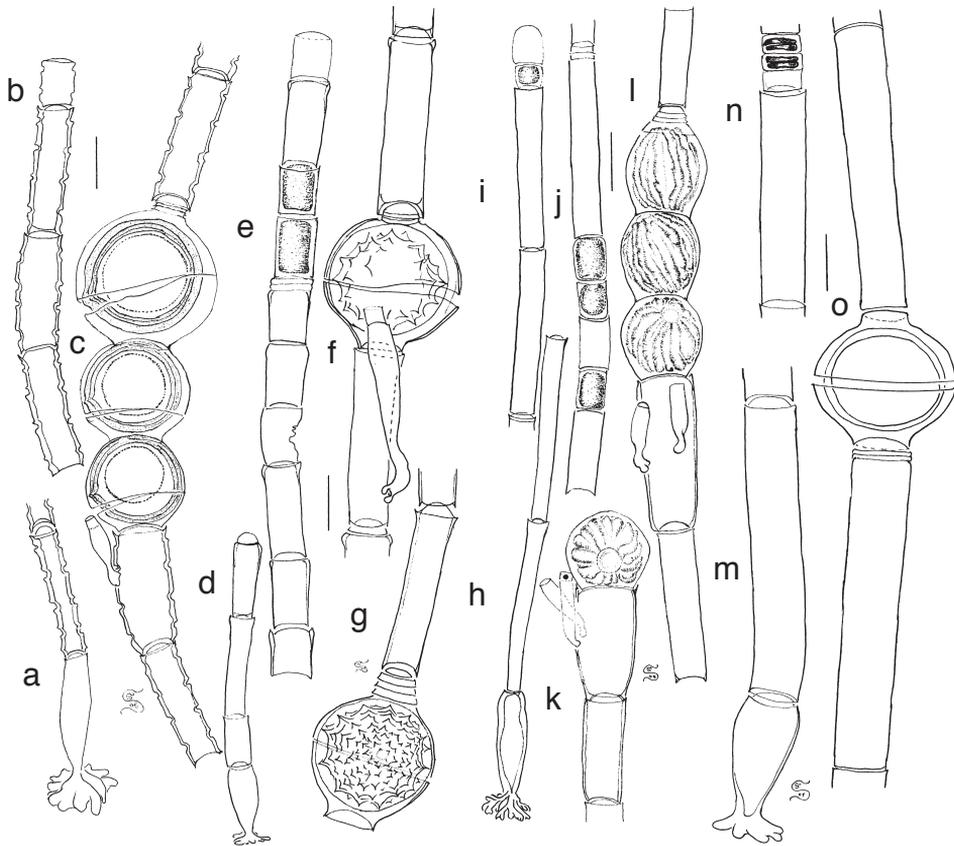
*Oedogonium undulatum* var. *möbiusii* Schmidle, *Flora* 82: 297, fig.1 (1896). Type: Burpengary, Bancroft; 1894?: Herb. Schmidle (B probably lost, n.v.).

Diagnosis: a *Oedogonio undulato* parietium tholis concavis in ambobus cellulibus vegetabilis androsporangiisque differt.

**Type:** Queensland: Peregian Beach (26 30'S; 153° 06'E), *Peberdy s.n.*, Sept 1973: (holo BRI).

Illustration: Fig. 3, a–d.

Nannandrous, gyn- or more frequently idioandrosporous. *Vegetative cells* undulate with 4 invaginations, 3 complete, 2 short, flat to concave vaults, L/D 3–4(–5), 15–22  $\mu\text{m}$  diam.; *basal cell* vase-shaped, smooth walled; *terminal cell* with domed cap (sometimes as terminal oogonium). *Oogonium* spherical, inframedian hinged pore becoming circumcission, solitary, paired or up to 6 in a row, 46–75(–87)  $\mu\text{m}$  long, 44–64(–75)  $\mu\text{m}$  diam.; *oospore* spherical, 44–58(–67)  $\mu\text{m}$  diam., thick walled, lamellate and occasionally with faint denticulations below outer wall, chinese-red mesospore, almost filling oogonium; *suffultory cell* similar to vegetative cells, but at the broad end



**Fig. 3.** *Oedogonium moebiusii*: **a**, basal cell; **b**, androsporangium; **c**, series of oogonia with oospores and dwarf male (*Peberdy s.n.* BRI704656); *Oe. hardyi*: **d**, new thallus with basal cell and terminal cap; **e**, intercalary androsporangia; **f**, oogonium with oospore and dwarf male; **g**, mature oospore (*Towler 283a & Wilson*); *Oe. kwangsiense* var. *playfairii*: **h**, basal cell; **i, j**, androsporangia; **k**, terminal oogonium; **l**, series of oogonia with oospores (*Cherry 447*); *Oe. capricornicum*: **m**, basal cell; **n**, intercalary antheridia; **o**, oogonium with oospore (*Reid 270103.04*). (Scales = 20  $\mu$ m)

of sizes, 19–23  $\mu$ m diam.. *Androsporangia* undulate walled, 1–3(–4), often below the groups of oogonia, c. 15  $\mu$ m long, c. 12  $\mu$ m diam.; dwarf male on suffultory cell, curved vase-shaped body cell, 28–44  $\mu$ m long, 8–12  $\mu$ m diam., upper internal antheridium, 6–9  $\mu$ m long, 6  $\mu$ m diam. (body cell as lower antheridium), single spermatozoid.

**Distribution:** fertile material from Western Australia, South Australia, New South Wales and Queensland, with vegetative material noted for Victoria, in still or slow flowing habitats; Argentina, probably widespread (sometimes reported as *f. incisum* Hansg. or *f. senegalense* Nordst.).

Schmidle's iconotype is of a poorly sketched vegetative fragment, and Bancroft's specimen appears to have been lost. We have used the Schmidle epithet to describe a new species rather than make a new combination based on inadequate material.

*Peberdy s.n.* has all reproductive structures, and is from coastal south-eastern Queensland like the Bancroft collection. Hirn (1900), in a long and strongly worded discussion of the variation in *Oe. undulatum* sens. lat., insists that he found no consistency in the vaulting of undulations of cells even within the same filament. There is no distinction made between ‘*integrus*’ and ‘*repandis*’ cell kinds in the Hirn (1900) protologue until you get to the various forms: ‘*integrus*’ referring to those forms with the evenly undulate wall outline, and ‘*repandis* (= bent back)’ to those with the concave wavytops. Formae  $\delta$  and  $\epsilon$  of *Oe. undulatum* and the subforma below *Oe. undulatum* f. *senegalense* (Nordstedt) Hirn all show what Hirn called repand waves. Hirn (1900) quotes Hansgirg as being of the same opinion, even though forma  $\beta$  *incisum* Hansg. is Hansgirg’s (1886) published interpretation, and he was confident enough to distribute exsiccatae under that name. Herring (1914) illustrated reproductive material of forma  $\epsilon$  and contended that it was the common forma in Schleswig-Holstein. A clear illustration of both wall forms is given in Fig. 5c in Vélez (1995).

Hirn’s observation has not been the experience with Australian material examined for this study. Communities of filaments with either smoothly undulate cells or with concave vaulting have been the norm, all cells in any filament being similar in wall form. Intergrading forms, if present at all, are extremely rare. There are three known sites (Brixton St wetland, Ham Common, and Collector) where both forms of filaments may be found in the same sample, but the cells are consistent within each filament. Vélez (1995) pointed out that culture studies of filaments of various forms of *Oe. undulatum* sensu lato should clear up this problem once and for all, a sentiment with which we concur. Preliminary results indicate that culture strains are morphologically consistent (Vélez, pers. comm.). Culture studies may also demonstrate the worth of Hirn’s other subgeneric character in *Oedogonium undulatum*, number of oogonia in sequence, which in Australian material of both *Oe. moebiusii* and *Oe. undulatum* varies widely within any one sample. With significant vegetative and reproductive differences, there is strong support for the distinction between these two varieties of *Oe. undulatum*. Collections of sterile filaments fitting *Oe. moebiusii* in Australia can be separated readily from filaments of *Oe. undulatum* (4 inflexions and 3 domes with 2 half-domes).

**Specimens examined:** Queensland: Peregian Beach, *Peberdy s.n.*, Sep 1973 (BRI). New South Wales: Southern Tablelands: Collector Ck, Collector, *Skinner 0543*, 4 Jan 2002 (NSW). Central Coast: Centennial Park, *Lucas s.n.*, – Sep 1915 (NSW); Lake Nadumgamba, Mt Annan Bot. Gdn, *Ling s.n.*, 22 Oct 2001, and *Coveny 18980*, 22 Nov 2001 (NSW). Northern Tablelands: Barleyfields Lagoon, TSR paddock, near Uralla, *Brock s.n.*, 6 Feb 2002 (NSW). North Western Slopes: quarry, Howell Rd 1km W of Tingha, *Skinner 0801*, *McPherson & Towler*, 13 Oct 2004 (NSW). South Australia: 6 km NW Beachport, towards Robe, *Skinner 0556*, 14 Nov 1978 (NSW); transient pool, main pond, Piccaninnie Ponds Cons. P., *Skinner 0446*, *Arnold & Towler*, 1 Oct 2001 (NSW). Western Australia: Fernbrook Falls, Deep R., Mt Franklin N.P., *Entwisle 2392*, 5 Jan 1994 (MEL); Brixton St wetland, Kenwick, *Cherry 447*, 9 Sep 2002 (NSW); Lake Gillon, Gillon St, Karawarra, *Skinner 0577*, *Casanova, Garcia & Novis*, 3 Oct 2002 (NSW).

***Oedogonium undulatum*** (Bréb.) A.Braun ex Hirn, *Acta Soc. Sci. Fenn* 27: 257 (1900)  
var. ***wissmanii*** (Stephen Skinner) Stephen Skinner & Entwisle **comb. et stat. nov.**

*Oedogonium wissmanii* Stephen Skinner, *Proc. Linn. Soc. N.S.W.* 104: 261 (1980).

Type: New South Wales: Northern Tablelands: Bullock Ck (30° 07’S; 152° 15’E), *Skinner s.n.*, Dec 1974 (NSW!).

Illustration: Skinner, op.cit.: fig. 3.3a–c.

Nannandrous, idioandrosporous. *Vegetative cells* evenly undulate with four grooves and five domes, L/D 2.5–4, 15–27(–30)  $\mu\text{m}$  diam., few large pyrenoids; *basal cell* tall, waisted vase shaped with digitoid holdfast; *terminal cell* (sometimes oogonium) with domed cap. *Oogonium* solitary or in series 2–6, globose, 57–88  $\mu\text{m}$  long, 45–72  $\mu\text{m}$  diam., inframedian hinged circumcision; *oospore* globose, 56–67  $\mu\text{m}$  diam., outer wall thick, opaque, often with a pinch opposite the opening of the circumcision, mesospore chinese-red; *suffultory cell* variable, from as vegetative cells to tumid, 18–28  $\mu\text{m}$  diam. *Androsporangia* solitary or in series 3–5, two undulations, 16–23  $\mu\text{m}$  long, 11–16  $\mu\text{m}$  diam.; dwarf male narrow clavate, 45–54  $\mu\text{m}$  long, 9–11  $\mu\text{m}$  diam., antheridia internal, single spermatozoid.

**Distribution:** Western Australia, Northern Territory, New South Wales and Queensland, in both still and running water.

We have submerged the Skinner (1980) taxon in *Oe. undulatum* as var. *wissmanii*, for Australian material, because the undulate androsporangia which distinguish this variety from *Oe. undulatum* var. *undulatum*, were previously mistakenly described as antheridia in Skinner (1980). The type slides of *Oe. wissmanii* show 1) *Oe. undulatum* var. *undulatum*-like vegetative cells, 2) androsporangia with the undulate walls, and 3) no dwarf males on the oogonium. More recent collections confirm the presence of dwarf males similar to those of the type variety. The width of cells in the same filament in wild populations may vary by a factor of two in a distance of ten or fewer cells.

Novis (2003) appears to have a similar taxon, cited as *Oedogonium* sp. aff. *Oe. wissmanii*, from Chatham Island, New Zealand.

**Specimens examined:** Queensland: Sir John Chandler Park, Brisbane, *Peberty s.n.*, 17 Jul 1964 (BRI). New South Wales: Northern Tableland: Bullock Ck, *Skinner s.n.*, Dec 1974 (NSW). Central Coast: Nepean R., Yarramundi Bridge, Agnes Banks, *Skinner 0335 & McPherson*, 9 Aug 2001 (NSW); The Driftway, Richmond, watermeadow, *Skinner 0337 & McPherson*, 9 Aug 2001 (NSW); Ham Common, Richmond, watermeadow, *Skinner 0338 & McPherson*, 9 Aug 2001 (NSW). Northern Territory: Douglas R., u/s Douglas Hot Springs, *Padovan & Mecalfé A129*, 20 Aug 2003 (NSW). Western Australia: Brixton Street wetland, Kenwick, *Cherry 447*, 9 Sep 2002 (NSW).

***Oedogonium hardyi* Stephen Skinner & Entwisle *sp. nov.***

*Oe. monile* Berkeley & Harvey ex Hirn f. *victoriense* G.S.West, *J. Linn. Soc.* 39: 45 (1909). Type: Victoria: Yan Yean Reservoir, macrophytic benthos, *A.D. Hardy s.n.*, 2 Dec 1905 (BM, reported dried out 2004).

Diagnosis: Aut grande aut grandiore *Oedogonio monile* var. *eminente*, sed circumcissione oogonii medio, strato medio exosporae stellato spiraleque, stipa nannandrii longissima et gracile.

**Type:** Western Australia: tributary Hammersley R., Fitzgerald River Nat. Pk (33° 46'S; 119° 42'E), *Towler 283a & Wilson* 10 Aug 2003 (holo NSW).

Illustration: Fig. 3, e–g.

Nannandrous, gyn- or more often idioandrosporous. *Vegetative cells* regular cylindrical, L/D 4–7(–8), 11–15(–20)  $\mu\text{m}$  diam.,  $\sigma^7$  usually finer; *basal cell* tall vase-like, 70–75  $\mu\text{m}$  long, 15–16  $\mu\text{m}$  diam.; *terminal cell* with domed cap. *Oogonium* solitary or paired (the upper one slightly larger than the lower one), globose, 58–81  $\mu\text{m}$  long, 52–61  $\mu\text{m}$  diam., circumcission median or submedian; *oospore* globose, 38–45(–51)  $\mu\text{m}$  diam., outer exospore smooth, inner exospore tightly spiraled serrations, mesospore red; *suffultory cell* slightly tumid, to 20  $\mu\text{m}$  diam. *Androsporangia* intercalary, solitary or paired, if gynandrosporous then well above oogonia, 23–25  $\mu\text{m}$  long, 18  $\mu\text{m}$  diam.; dwarf males long narrow clavate, 91–104(–113)  $\mu\text{m}$  long, 8–11  $\mu\text{m}$  diam., two spermatozoids formed one above the other in tip, faintly septate.

**Etymology:** commemorates Alfred Douglas Hardy, the Victorian botanist who sent numerous specimens to G.S. West in the 1900's and 1910's and continued to study phytoplankton in Victorian reservoirs until the 1950's (Entwisle 1990). The name *Oe. victoriense* West has been used for a different taxon.

**Distribution:** Western Australia and Victoria, in ponds and river pools.

The description in West (1909) is extremely brief, highlighting the length of the dwarf males, but the iconotype shows the spore wall with evenly spaced teeth. As the inner exospore wall of *Oe. monile* has longitudinal serrated ribs, and that of *Oe. hardyi* has a tight spiral of teeth, West's (1909) figure 6a–b appears to fit the latter more closely.

The suffultory cell develops first, upon which dwarf males mature before the oogonia are initiated. The form of the dwarf males with internal antheridia, the morphology of the oospore, with a wide exospore sculptured below the outer layer, and general aspect similar to *Oe. undulatum* and *Oe. monile* suggest a position in Group P. The presence of a few short rhizoids on the base of the dwarf males may also indicate affinities with Group Q.

**Specimens examined:** Victoria: pond opposite Phillip Island Information Centre, New Haven, Entwisle 3133, 29 Dec 2001 (NSW). Western Australia: tributary of Hammersley R., pool in river bed, Fitzgerald River Nat. Pk, Towler 283a & Wilson, 10 Aug 2003 (NSW); Brixton Street wetland, Kenwick, Cherry 448, 9 Sep 2002 (NSW).

***Oedogonium kwangsiense*** Jao, Bot. Bull. Acad. Sin. 1: 85 (1947) var. ***playfairii*** Stephen Skinner & Entwisle var. **nov.**

**Diagnosis:** *Oedogonio kwangsiensi* var. *kwangsiensi* simile sed costis undulatis levigatisque in oospore.

**Type:** Western Australia: Brixton Street wetland, Kenwick (32° 01'S; 115° 58'E), Cherry 447, 9 Sep 2002, (holo NSW).

**Illustration:** Fig. 3, i–l.

Nannandrous, idioandrosporous. *Vegetative cells* regular cylindrical, L/D 5–8, 40–74  $\mu\text{m}$  long, (7–)10–19  $\mu\text{m}$  diam.,  $\sigma^7$  frequently narrow, 6–8 quite large pyrenoids; *basal cell* tall, narrow vase-like, 50–55  $\mu\text{m}$  long, 10–12  $\mu\text{m}$  diam., sometimes flattened on one side, holdfast digitoid; *terminal cell* (often oogonium) with rounded or shallowly peaked cap. *Oogonium* solitary to 3 in series, globose to ovoid, 32–44(–50)  $\mu\text{m}$  long, 32–36(–41)  $\mu\text{m}$  diam., (pore and) circumcission superior; *oospore* globose to barrel-shaped, top and bottom inset, oblique in the chamber, 35–39  $\mu\text{m}$  long, 33–35  $\mu\text{m}$  diam., inner exospore with broad, deep, undulate costae, mesospore ruby red; *suffultory*

cell 48–70 µm long, 25–29 µm diam. *Androsporangium* intercalary, single or paired, in groups, 11–16 µm long, 10–13 µm diam.; dwarf males clavate, on suffultory cell, body cell 29–35 µm long, 4.5–6 µm diam., antheridium with single spermatozoid extruded at maturity.

**Etymology:** commemorates George Israel Playfair, the honorary freshwater phycologist associated with the National Herbarium of New South Wales from 1902 to 1923. In the draft manuscript of his Census (Playfair 1917) Playfair notes ‘*Oedogonium* sp. long corrugate spore’ from Broughton Island, but did not complete the determination or include this collection (*Bottle* 29) in the Census or any other publication.

**Distribution:** Western Australia and New South Wales, in coastal wetlands.

The Brixton Street wetland sample contains numerous filaments with terminal solitary oogonia and the general aspect of the cosmopolitan *Oe. acrosporum* de Bary, but the equally common occurrence of intercalary series of oogonia and the pronounced depth of the costae favour inclusion in *Oe. kwangsiense* from China. The Australian material comes close to the type form of *Oe. kwangsiense* but has cylindrical cells, the costae are broad and smooth, and the basal cells are tall vase-shaped with a digitoid holdfast. This taxon is idioandrosporous, and the antheridium, while the fragile wall is persistent, appears to be extruded from the body cell of the dwarf male, rather than being a separate cell of a small plant as in both *Oe. acrosporum* de Bary ex Hirn and *Oe. tentoriale* Nordstedt & Hirn in Hirn.

**Specimens examined:** New South Wales: North Coast: Broughton Island, *Dr E. Stokes* (Playfair 29, 30), –1903? (NSW). Western Australia: Brixton Street wetland, Kenwick, *Cherry* 447, 9 Sep 2002 (NSW).

#### Supersection *Dispermatozoidiae*

Antheridia with paired spermatozoids. In macrandrous species the spermatozoids may be horizontal, that is lying in the antheridium one on top of the other, or vertical, where the spermatozoids are found side by side. In nannandrous species the dwarf male plantlet consists of a persistent body cell, sometimes a narrow vegetative cell, and above one or a series of discrete, external antheridia, each with two spermatozoids.

### Group L

Macrandrous; spermatozoids one above the other in intercalary antheridia; oogonium opening a circumcission.

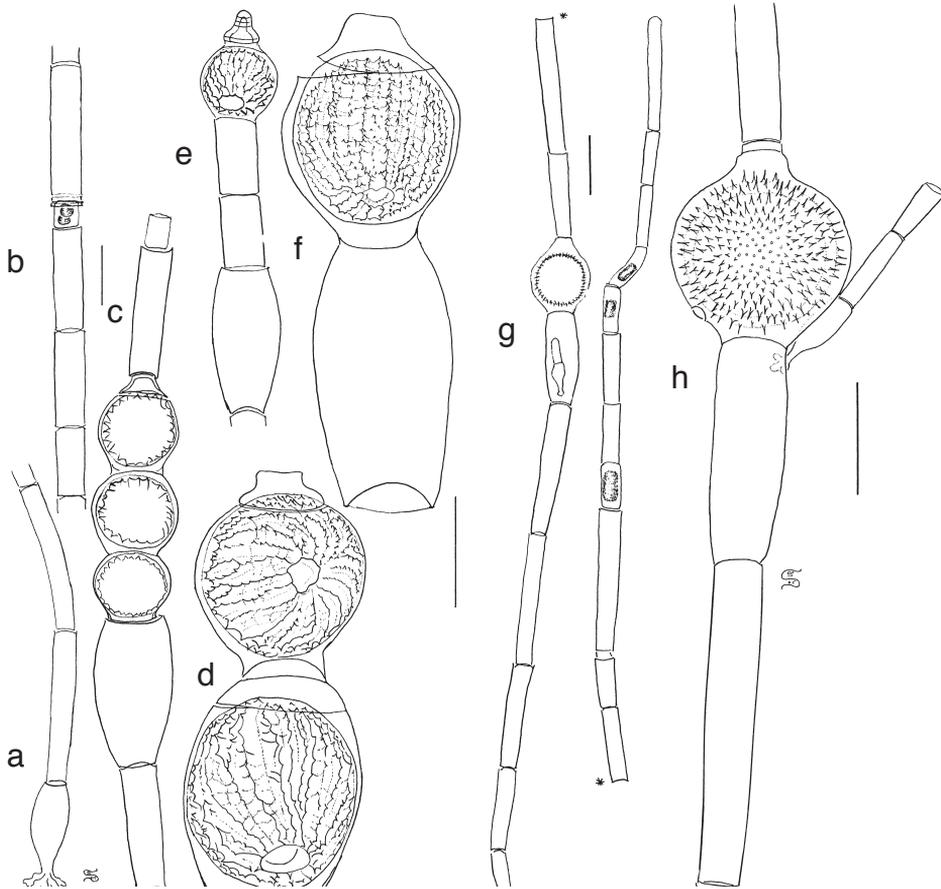
***Oedogonium capricornicum*** Stephen Skinner & Entwisle *sp. nov.*

Diagnosis: *Oedogonium* oogonio collari cylindrico aut terminale aut basale, circumcissione oogonii medio.

**Type:** Queensland: Burdekin River, downstream from Highway crossing, near Ayr (19° 37'S; 147° 24'E), *Reid* 270103.04, 27 Jan 2003 (holo NSW).

Illustration: Fig. 3, m–o.

Dioecious, macrandrous. *Vegetative cells* cylindrical, chloroplast reticulate, many small pyrenoids, slight sexual dimorphism, L/D (5–)8–12, (20 ♂)23–32 µm diam.; *basal cell* elongate goblet-shaped, ridged disc, c. 80 µm long, c. 32 µm diam.; *terminal cell* domed.



**Fig. 4.** *Oedogonium bancroftii*: **a**, basal cell; **b**, intercalary antheridium; **c**, empty antheridium above series of oogonia and suffultory cell; **d**, oospores in intercalary oogonia; **e**, terminal oogonium at a distance from suffultory cell; **f**, oospore in terminal oogonium (Cribb 587.1); *Oe. starmachii* var. *weetalibahense*: **g**, oogonium with dwarf male and suffultory cell, and androsporangia above, in same filament; **h**, oogonium with mature oospore, and multicellular dwarf male (Dingley 050603.4a/b). (Scales = 20  $\mu$ m)

*Oogonium* globose to slightly depressed globose, (63–)68–82  $\mu$ m long, (68–)77–84  $\mu$ m diam., with collar top and/or bottom, stained with tannin, median circumcision, narrowly open, internal pore; *oospore* globose to depressed globose, 59–61  $\mu$ m long, 59–65  $\mu$ m diam., smooth exospore, red mesospore; suffultory cell as vegetative cells. *Antheridia* solitary to groups of 4–8, 8–14  $\mu$ m long, 16–20  $\mu$ m diam., with a short supporting cell at least in initial stages, spermatozoids paired, horizontally separated.

**Etymology:** from the Tropic of Capricorn which covers the northern third of Australia, where this taxon is encountered.

**Distribution:** Tropical Australia.

A distinctive taxon and difficult to place. It has a lantern-shaped oogonium with a well defined median circumcission and thickened wall, which would place it close to *Oe. pratense* Transeau (1914) in subgenus *Prooedogonium*, or the nanandrous *Oe. confertum* Hirn and *Oe. perspicum* Hirn in Supersection *Monospermatozoidiae*. Paired spermatozoids in antheridia in small belts, a vase-shaped basal cell and dimensions and general vegetative form that agree with larger members of the subgenus *Oedogonium*, suggest its placement there, in Group L.

**Specimens examined:** Queensland: Type and Burdekin R., downstream from highway crossing, near Ayr, *Reid 270103.05*, 27 Jan 2003 (NSW). Western Australia: Camp Ck, Mitchell Plateau, *Kenneally 11765a*, 18 Jun 2002 (NSW);

***Oedogonium bancroftii*** Stephen Skinner & Entwisle *sp. nov.*

Diagnosis: *Oedogonio areolato-costato* simile sed oosporibus globosis vel subglobosis et proportionibus minoribus.

**Type:** Queensland: Lake Weyba, near Noosa (26° 27'S; 153° 05'E), *Cribb 587.1*, 26 Jul 1964 (holo BRI 704657).

Illustration: Fig. 4, a–f.

Monoecious/dioecious macrandrous. *Vegetative cells* narrow cylindrical, at first slightly capitellate near basal cell, L/D (5–)6–9(–10), (8–)9–11 µm diam.; *basal cell* elongate vase-like, basal pad deeply costate; *terminal cell* usually with blunt peaked cap. *Oogonium* spherical to ovoid, (27–)34–45 µm long, (29–)34–36 µm diam., circumcission superior, solitary, paired, triples and fours common, five in a row occasional; *oospore* spherical to subglobose, top and bottom inset, 31–34 µm diam., smooth on very outside, longitudinally denticulate-costate from basal and apical rings, some forking and anastomosis, inside, mesospore red?; *suffultory cell* terminally widely tumid, 27–32 µm upper diam. *Antheridium* solitary, either subepigynous or intercalary, 12–14 µm long, c. 9 µm diam.; spermatozoids 2, horizontally displaced.

**Etymology:** commemorated Dr Thomas Lane Bancroft, prominent epidemiologist and assiduous collector of natural history specimens throughout Queensland from the late 19<sup>th</sup> Century to WWI.

**Distribution:** known only from Queensland, associated with *Oe. varians* among stoneworts in coastal tidal lake (Cribb's notes state 'highly saline').

As the oogonia appear to develop sequentially, one or two short cylindrical cells may be found between the tumid suffultory cell and the developed oogonia above. It is close to the description of North African specimens attributed to *Oe. paloense* Britton in Gauthier-Lièvre (1964), but Britton's (1949) protologue based on Philippine material has solitary ovoid to ellipsoid oospores in similar shaped oogonia, a suffultory cell similar to vegetative cells, and antheridia in long series. *Oe. bancroftii* also resembles *Oe. areolato-costatum* Jao in Mrozińska (1985), but the dimensions of the Australian specimen are all half the size of the Chinese taxon, and the oospores are spherical rather than ovoid.

### Group T

Nannandrous; dwarf males multicellular, antheridia external; oogonia opening through a pore.

***Oedogonium starmachii*** Mrozińska, *Frag. Flor. Geobot.* 4:252 (1958) var. ***weetalibahense*** Stephen Skinner & Entwisle **var. nov.**

Diagnosis: *Oedogonium starmarchio* var. *starmarchio* simile sed cellulo suffultorio inflate.

**Type:** New South Wales: North Western Plains: Weetalibah Waterholes (29°19'S, 147°50'E) *Dingley 050603.4*, 5 Jun 2003 (holo NSW).

Illustration: Fig. 4, g, h.

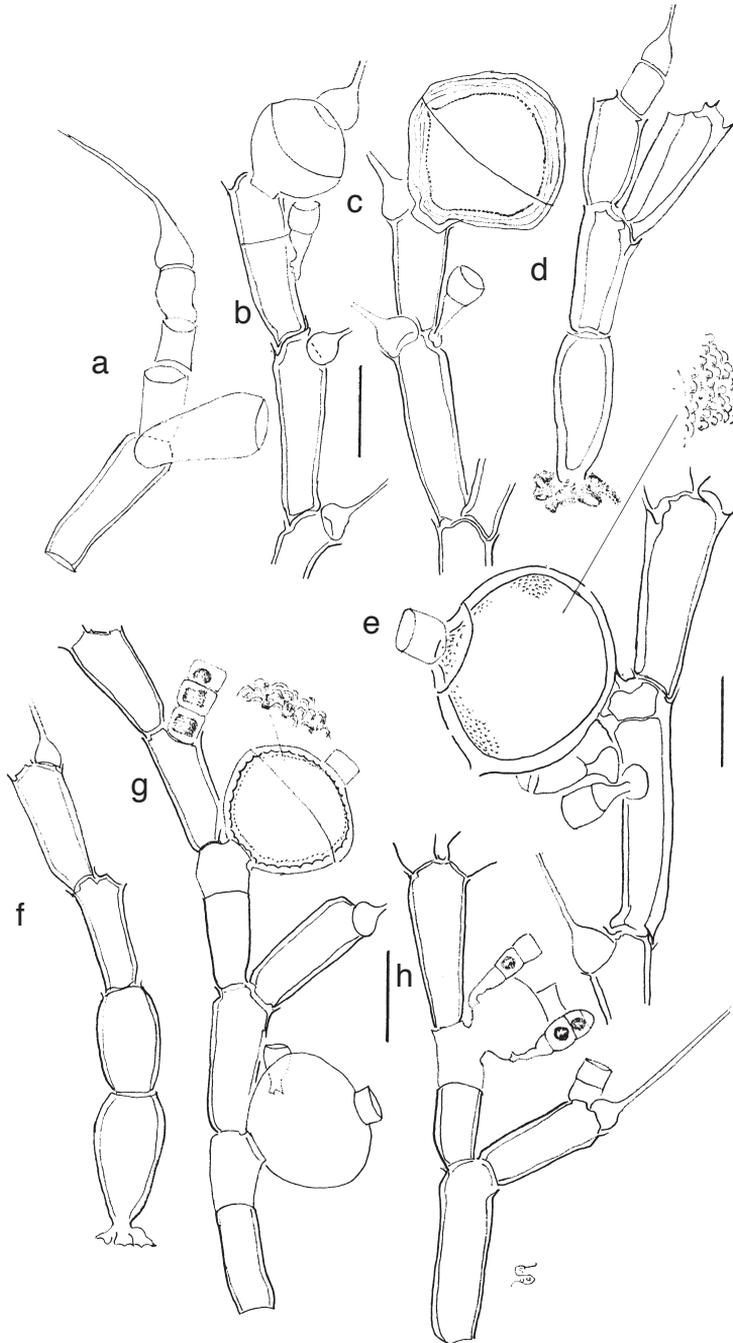
Nannandrous, gynandrosporous. *Vegetative cells* regular cylindrical, 40–120 µm long, 7–9 µm diam.; *basal cell* short vase, 20–23 µm long, c. 8 µm diam.; *terminal cell* truncated. *Oogonium* intercalary, solitary, obpyriform, 32–34 µm long, 24–30 µm diam., pore inframedian to inferior; *oospore* globose, filling chamber, covered in fine spines, mesospore red, 23–25 µm without spines (spines add c. 1 µm to radius); suffultory cell usually inflated, 39–50 µm long, 9–12 µm diam. *Androsporangia* intercalary, in upper filament, 23–27 µm long, 8 µm diam.; dwarf males on *suffultory cell*, with slightly inflated body cell (18–20 µm long, 8–9 µm diam.), one or two vegetative cells (18–20 µm long, 4.5 µm diam.) and one or more antheridial cells (7 µm long, 4.5–5 µm diam.), solitary? spermatozoid.

**Etymology:** for Weetalibah Waterholes in north-western New South Wales, from where the taxon was first recognized.

**Distribution:** known from South Australia, in a transient roadside swamp in limestone country, and New South Wales, on *Najas tenuifolia* in caustic (pH 9.5) artesian spring, and on *Chara* sp. in coastal creek.

There are a number of closely similar taxa with spiniferous spores and inferior pores to the oogonium. The Weetalibah specimen shows some characters in common with both *Oe. inframediale* Jao and *Oe. starmachii* Mroz., both of which occur in China (Jao 1979). While *Oe. inframediale* has an inflated suffultory cell, it has regular dwarf males, and the cells are 13–21 µm in diameter. *Oe. starmachii* as described by Mrozińska (1958) and Jao (1979) lacks the inflated suffultory cell but does have the multicellular dwarf males, and vegetative cells 9–14 µm in diameter. *Oe. excentriporum* (Jao) Tiffany is similar in dimensions, and has an inflated suffultory cell, but has a distinctly superior pore. Australian collections are the same as *Oe. starmachii* as described by Mrozińska (1985) in all aspects except the suffultory cell. We therefore recognize this taxon as a new variety of *Oe. starmachii*.

Specimens examined: New South Wales: North Western Plains: Weetalibah Waterholes, between Lightning Ridge and New Angledool, *Dingley 050603.4 a & b*, 5 Jun 2003 (NSW). South Coast: Stony Ck, 3 km S of Bodalla, *Skinner 0497*, 27 Dec 2001 (NSW). South Australia: Beachport–Robe road, *Skinner 556*, 14 Nov 1978 (NSW).



**Fig. 5.** *Bulbochaete rodwayi*: **a**, androsporangia and zooidangium; **b**, immature oogonium and dwarf male; **c**, mature oospore in oogonium; **d**, basal cell (Entwisle 2497); *B. wuhanense* var. *spechtii*: **e**, oogonium with androsporangium, dwarf males and oospore, with sketch of sculpturing (Specht A30); *B. calospora* var. *murrayana*: **f**, basal cell; **g**, branch with androsporangia and mature oospore, with sketch of sculpturing; **h**, immature oogonium with two dwarf males (Skinner 0401, Arnold & Towler). (Scales = 20  $\mu$ m)

## Bulbochaete C. Agardh

***Bulbochaete rodwayi*** Stephen Skinner & Entwisle *sp. nov.*

Diagnosis: *Bulbochaete* nannandriata oosporis quadriglobosis et glabris, nannandriis camelliformibus antheridiisque interne.

**Type:** Tasmania: pool in Melaleuca Ck, below Alexandra Ck junction, Port Davey Track, South West National Park (43° 25'S; 146° 08'E), *Entwisle* 2497, 3 May 1996 (holo MEL).

Illustration: Fig. 5, a–d.

Nannandrous, idioandrosporous? Thallus a densely intertwined cushion, visible to the naked eye. *Vegetative cells* subcylindrical, 48–56 µm long, 16–18 µm diam.: *basal cell* vase shaped, 18–20 µm diam. *Oogonium* squared globose, c.52 µm long and diam., median circumscision; *oospore* filling chamber, smooth, laminated thick exospore, mesospore red; suture in *suffultory cell* median, faint. *Androsporangia* in short lateral or terminal series, subtending a seta, c.16 µm long, 10–12 µm diam.; dwarf male goblet shaped, 23–25 µm long, c.10 µm diam., upper half antheridium, lower half rhizoidal, on suffultory cell.

**Etymology:** commemorates Leonard Rodway, botanist and natural history collector in Tasmania in the first half of the 20<sup>th</sup> Century.

**Distribution:** Tasmania, known only from the type locality, as free living cushions among mosses and leafy liverworts in high latitude stream.

A distinctive nannandrous *Bulbochaete* with squared globose smooth-walled oospores, and goblet-shaped dwarf males with internal antheridia. Unlike any reported *Bulbochaete* species both *B. rodwayi* and at least one population of *B. wuhanensis* var. *wuhanensis*, from Litchfield National Park in the Northern Territory, form dense masses of filaments and appear to be free living rather than epiphytes.

***Bulbochaete wuhanensis*** Jao, *Monograpica Oedogoniales Sinicae*: 377 (1979) var. *spechtii* Stephen Skinner & Entwisle *var. nov.*

Diagnosis: *Bulbochaetae wuhanense* var. *wuhanense* similis, sed gynandrospora, antheridiis epigynis atque lateralibus, oosporis verrucosis.

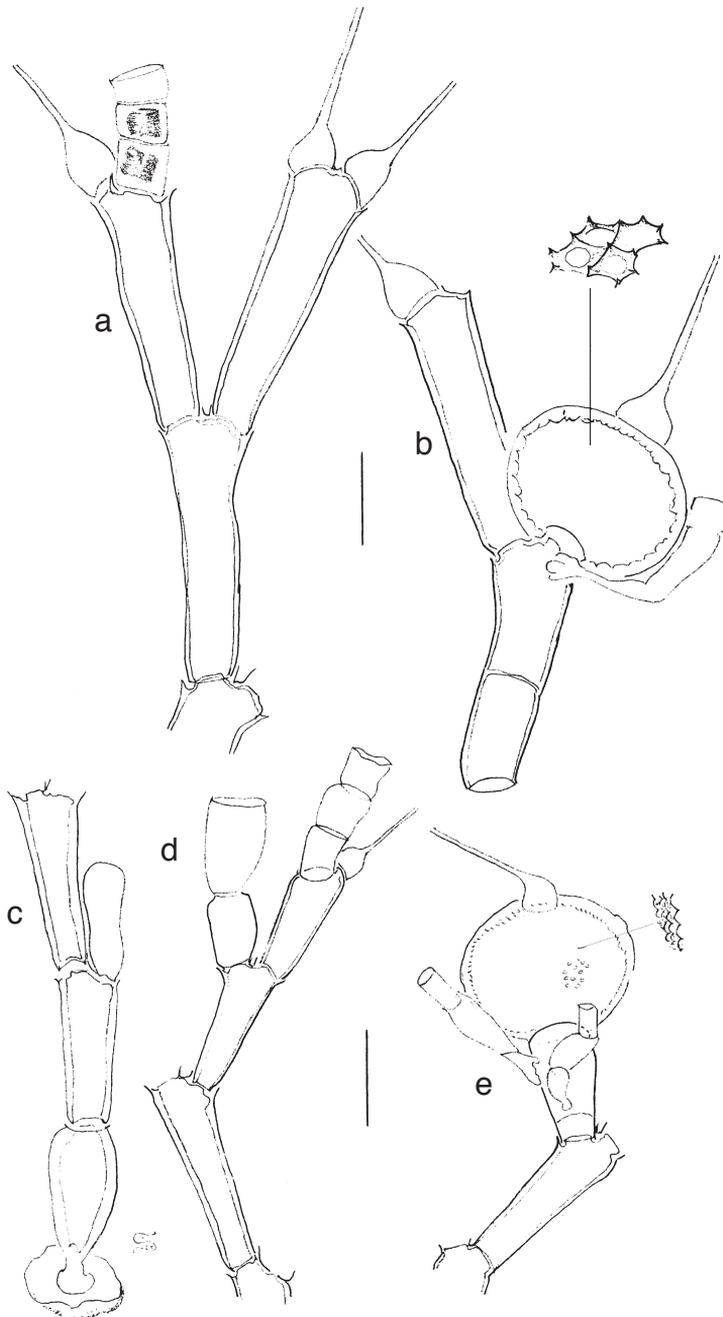
**Type:** Northern Territory: freshwater pool, South Bay, Bickerton Island (13° 46'S; 136° 13'E), *Specht* A30, 7 Jun 1948 (holo AD).

Illustration: Fig. 5, e.

Gynandrosporous. *Oogonium* 48–56 µm long, 59–88 µm diam.; *oospore* sculpturing very fine warts. *Androsporangia* epigynous or lateral, 11–14 µm long, 12–14 µm diam.

**Etymology:** commemorates Raymond Louis Specht, Australian ecologist and member of the American-Australian Expedition to Arnhem Land in 1948.

**Distribution:** Northern Territory, on aquatic vegetation in tropical seasonal waterways.



**Fig. 6.** *Bulbochaete Gigantea* var. *glabra*: **a**, androsporangia; **b**, oogonium with dwarf male, sketch of sculpturing (*Divola s.n.*(*Skinner 0039*)); *B. kakaduensis*: **c**, basal cell; **d**, androsporangia and zooidandium; **e**, mature oogonium with dwarf males, oospore, and sketch of sculpturing (*Dostine, Metcalfe & Padovan A104*). (Scales = 20  $\mu$ m)

Differs from *B. wuhanensis* var. *wuhanensis* from China in being gynandrosporous, and the sculpturing of the oospore being very finely warty.

**Specimens examined:** Northern Territory: freshwater pool, South Bay, Bickerton Island, *Specht A30*, 7 Jun 1948 (AD); East Charlotte R., *Dingley 110903.2*, 11 Sept 2003 (NSW).

***Bulbochaete calospora*** Jao, *Sinensia* 10: 147 (1939) var. ***murrayana*** Stephen Skinner & Entwisle **var. nov.**

Diagnosis: *Bulbochaetae calosporae* var. *calosporae* similis sed in dimensionibus brevior.

**Type:** New South Wales: South West Slopes: Corowa–Mulwala road (36° 00'S; 146° 16'E), *Skinner 0401*, *Arnold & Towler*, 27 Sep 2001 (holo NSW).

Illustration: Fig. 5, f–h.

Dioecious gynandrosporous. Thallus moderately large, open but infrequently branching. *Vegetative cells* subcylindrical, 36–45(–48) µm long, 11–14(–18) µm diam., finely spirally spinose; basal cell vase-like, 48 µm long, 20 µm diam., base ridged, spreading. *Oogonium* depressed globo-pyriform, 36–39 µm long, 43–45 µm diam., cingulum, opening supramedian (closed at maturity); *oospore* filling chamber, exospore with large, sharp edged scrobiculae, mesospore yellow; suture in *suffultory cell* supramedian to superior. *Androsporangia* epigynous or lateral, solitary or in series 2–4, 9–11 µm long, c. 9 µm diam.; dwarf males shortly clavate, 25–27 µm long, 7–9 µm diam., antheridia internal, two chambers, single spermatozoid each.

**Etymology:** named for the Murray River valley, in which floodplain the collection was made.

**Distribution:** New South Wales/Victoria Border: riverine system, on filamentous algae and stoneworts.

This taxon is close to cosmopolitan *B. intermedia* de Bary in size of features and has similar position of suffultory suture, but, with the finely spinose cells, and large scrobiculae, appears to be a small variety of *B. calospora* from China.

***Bulbochaete gigantea*** Pringsh. ex Hirn, *Acta Soc. Sci. Fenn* 27: 347 (1900) var. ***glabra*** Stephen Skinner & Entwisle **var. nov.**

Diagnosis: *Bulbochaetae giganteae* var. *giganteae* similis sed parietibus glabris, oosporis areolatis scrobiculis.

**Type:** New South Wales: Northern Tablelands: Barleyfields Lagoon, near Uralla (30° 37'S; 151° 30'E), *Divola s.n.* [*Skinner 0039*], 30 May 1996 (holo NSW).

Illustration: Fig. 6, a, b.

*Vegetative cells*, 60–75(–80) µm long, 19–25 µm diam., smooth walled; *basal cell* vase like. *Oogonium* depressed globose, 43–45(–48) µm long, 58–68 µm diam.; *oospore* sculpturing of large, areolate scrobiculae, mesospore yellow; suture in suffultory cell

median to suprmedian. *Androsporangia* in series 1–4, c. 12 µm long, c. 14 µm diam., subtending seta; dwarf males clavate to vermiform, 57–60 µm long, c. 12 µm diam., antheridia internal.

**Etymology:** from *glaber*, *ra*, *rum* (Latin) smooth.

**Distribution:** New South Wales: transient swamp and creek pondages.

Differs from the widespread type variety in having cell walls smooth rather than finely helically spinose, and large open areolate scrobiculations on oospores. The report of *B. gigantea* in Skinner (1980) may refer to this taxon, as spinose cell walls were not reported. The specimen is missing, although other slides from the collection (Bullock Ck, Skinner NED002, Dec 1974(NE)) contain sterile fragments of a large *Bulbochaete* with smooth cell walls.

**Specimen examined:** New South Wales: Northern Tablelands: on stoneworts, Barleyfields Lagoon, near Uralla, Skinner 0036, Cooper & Divola, 29 Feb 1996, and Divola (Skinner 0039), 30 May 1996 (NSW); Central Coast: on rushes in pond of Porters Ck, Wyong, Gartenstein s.n., 7 Dec 2001 (NSW).

***Bulbochaete kakaduensis*** Stephen Skinner & Entwisle *sp. nov.*

*Bulbochaete elatior* sensu Scott & Prescott, *Record of the American–Australian expedition to Arnhem Land*, 3: 19 (1958).

Diagnosis: *Bulbochaetae scrobiculatae* similis sed idioandrospora nannandriisque clavatis, stipa 22–23 µm, antheridio 9–16 µm longo.

**Type:** Northern Territory: Howard R., upstream of Pioneer Dr. (12° 33'S; 131° 08'E), Dostine, Metcalfe & Padovan A104, 30 May 2003 (holo NSW).

Illustration: Fig. 6, c–e.

Dioecious, idioandrosporous. Thallus moderate, open branching. *Vegetative cells* subcylindrical, L/D 3.5–6, 12.5–14 µm diam.; *basal cell* short vase-like, 16–18 µm diam., rhizoidal base. *Oogonium* depressed globose, 37–42 µm long, 42–50 µm diam., cingulum, pore superior; *oospore* filling chamber, exospore very finely scrobiculate, mesospore yellow; suture in suffultory cell basal. *Androsporangia* lateral in series 1–4, 9–14 µm long, 11 µm diam.; dwarf male body cell stalked goblet, 22–23 µm long, 10 µm diam., antheridium single, 9–16 µm long, 7–8 µm diam.

**Etymology:** named for the Kakadu region of the Northern Territory over which the American–Australian expedition to Arnhem Land travelled and collected.

**Distribution:** Northern Territory, in still and flowing water.

Scott and Prescott (1958) described and figured the Bickerton Island specimen as *Bulbochaete elatior* Prings., illustrating clearly the fine scrobiculae. *B. elatior*, a cosmopolitan species, has smooth exospores. Scott and Prescott failed to mention if androsporangia were present. The Arnhem Land collections, and the Howard R. collection are idioandrosporous, and have dwarf males with almost clavate rather than goblet shaped body cells (as in *B. elatior*), and along with the fine scrobiculae on the oospore, make this a distinctive species.

**Specimens examined:** Northern Territory: freshwater pool, South Bay, Bickerton Is., *Specht A30*, 7 Jun 1948 (AD); freshwater marsh, behind dunes, Yirrkalla, *Specht A80*, 27 Aug 1948 (AD); Howard R., upstream of Pioneer Dr., *Dostine, Metcalfe & Padovan A104*, 30 May 2003 (NSW).

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