BATRACHOSPERMUM ANTIPODITES SP. NOV. (BATRACHOSPERMACEAE): A WIDESPREAD FRESHWATER RED ALGA IN EASTERN AUSTRALIA AND NEW ZEALAND

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ABSTRACT

Entwisle, Timothy J. *Batrachospermum antipodites* sp. nov. (Batrachospermaceae, Rhodophyta): a widespread freshwater red alga in eastern Australia and New Zealand. **Muelleria 8(3): 291–298 (1995).** — *Batrachospermum antipodites* is a widespread red alga in mountain streams of New Zealand and eastern Australia. It differs from all other members of the section *Batrachospermum* in having primary fascicles consisting entirely of cylindrical cells with an apical dilation; carpogonia 19–39 μm long, borne on a branch consisting of cells similar to (but shorter than) those in fascicles, and with a sessile and club-shaped trichogyne; and with gonimoblasts sparse, 1 (rarely 2) per whorl and 70–200 μm in diameter. Comparisons with various type materials and published accounts show this to be a unique combination of characters in the section. The sectional classification of *Batrachospermum* is again challenged, and further refinements are suggested.

INTRODUCTION

This is the fifth paper in a series on the freshwater red algae of the Australian region, comprising a reconnaissance survey of south-eastern Australia (Entwisle & Kraft 1984), the description of a new genus from eastern Australia (Entwisle 1989), a re-evaluation of the *Batrachospermum atrum* complex including the description of a new species (Entwisle 1992), and an historical review of the discovery of Batrachospermalean taxa in Australia and New Zealand (Entwisle 1993). Considerable collections of *Batrachospermum* have been located in Australian and New Zealand herbaria, stimulating an appraisal of species concepts (see also Entwisle 1993) and necessitating the establishment of a number of new taxa. As with the recent description of *B. diatyches* Entwisle (1992), the recognition of new taxa follows detailed comparison with existing type materials where possible and with all relevant published or unpublished data.

A distinctive taxon widespread in Australia and New Zealand has had a chequered nomenclatural history and in this paper it is finally given a legitimate and appropriate name.

MATERIALS AND METHODS

Procedures for preservation and examination of material are as in Entwisle (1992). Data for most taxa have been stored in DELTA format (Dallwitz 1980; Dallwitz *et al.* 1986) and comparisons with other Australian and New Zealand taxa as well as types were made using the INTKEY program.

SPECIES ACCOUNT

Batrachospermum antipodites Entwisle *sp. nov.*

MISAPPLIED NAMES:

Batrachospermum ectocarpum auct. non Sirodot: Entwisle & Kraft, *Aust. J. Mar. Freshw. Res.* 35: 228 (1984).

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Batrachospermum boryanum auct. non Sirodot: Entwisle, *Proc. Roy. Soc. Victoria* 101: 42 (1989); see also Entwisle & Kraft, *Aust. J. Mar. Freshw. Res.* 35: 254 (note added in proof) (1984).

MANUSCRIPT NAME:
Batrachospermum novae-zealandiae ined. Skuja (see Entwisle 1993).

In sectio *Batrachospermo*, ad *B. gelatinoso* similis sed combinatione sequente characterum: fasciculi secondarii absentes (interdum presentes et ferentes antheridia in thallis veteribus); cellulae fasciculorum primariorum cylindricae delatatione apicali (parietes laterales plerumque, interdum leniter convexi), cellula distalis cylindrica apice rotundato, anguste obovata; rami-cellulae carpogoniales cellulis fasciculis ceteris similes sed breviores; carpogonium 19–30 µm longum, trichogynium sessile clavatum; gonimoblasti rari, 1 raro 2 per verticillum, 70–200 µm diametro.

HOLOTYPUS: In cracks below ledge of large pool in Kondalilla Falls, Skene Creek, Kondalilla National Park, Qld, 26°40′S 152°52′E., 6 Sep. 1993, *T.J. Entwisle 2236* [MEL 2020014 (air & silica-gel dried, spirit, microscope slide); ISOTYPI: BRI (dried)].

Chantransia-stage not seen. *Thallus* 1–5 cm long, red to dark greyish (purple when dry), flaccid, monopodial, apices obtuse; apical cell more or less flush with primary fascicles; old axes often denuded of fascicles; fascicle whorls 330–800 µm in diameter, globose to barrel- or disc-shaped, confluent or separated; internodes 230–400 µm long; axial cells 34–120 µm in diameter; rhizoidal filaments 5–8 µm in diameter, covering entire surface of axial cell; secondary fascicles absent (or rarely present in overmature, mostly denuded axes). *Primary fascicles* 2 or 3 per axial cell, somewhat audouinelloid, with more or less straight distal ends, without any clearly defined outer and inner cell layers, of 8–13 cell storeys; branching lateral, dichotomous or (sometimes) trichotomous, 3–7 times. Periaxial cell ovoid to cylindrical; proximal cell cylindrical with apical dilation at lateral branch insertion, 16–30 µm long, 3–5 µm in diameter; intermediate cells similar in shape to proximal cells (lateral walls rarely slightly convex), 11–32 µm long, 2–5 µm in diameter; fascicle distal cells cylindrical to obovoid (apex rounded), 6–9 µm long, 3–4 µm in diameter; hairs absent. *Monoecious. Spermatangia* borne on primary or rarely (in overmature thalli) on secondary fascicles, spherical, 5–8 µm in diameter. *Carpogonia* borne on (or in place of) primary fascicles (terminating percurrent branch of lateral); carpogonial branch more or less straight; carpogonium 5–8 cells from periaxial cell, subtended by 4–7 modified cells; modified cells barrel-shaped to ellipsoid, 6–7 µm long, 4–7 µm in diameter; involucral bracts arising from all (modified) cells subtending carpogonium, 1–2 cells long. *Carpogonium* more or less straight, 19–39 µm long; base symmetric, 3–5 µm in diameter; trichogyne sessile, club-shaped, 4–8 µm in diameter at broadest part. *Gonimoblasts* pedicellate, 1 or (rarely) 2 per whorl, in inner or outer cortex, centre 70–110 µm from node, globose, 70–200 µm in diameter, 0.5–1 times the whorl radius; filaments determinate, 4–5 cells long; post-fertilisation cells of carpogonial branch globose to barrel-shaped, or slightly constricted in middle; carposporangia obovoid, 10–18 µm long, 6–12 µm in diameter.

ILLUSTRATIONS
Figs 1–2; Entwisle & Kraft (1984), fig. 6 (as *B. ectocarpum*); Entwisle (1989), fig. 6E-G (as *B. boryanum*).

DIAGNOSTIC FEATURES
Secondary fascicles absent (rarely present and bearing spermatia in old thalli); cells of primary fascicles cylindrical with apical dilation (lateral walls usually parallel, occasionally slightly convex), distal cell cylindrical with rounded apex to narrowly obovate; carpogonial branch cells similar to other fascicle cells but shorter; carpogonium 19–39 µm long, trichogyne sessile and club-shaped; gonimoblasts uncommon, 1 or rarely 2 per whorl, 70–200 µm in diameter.

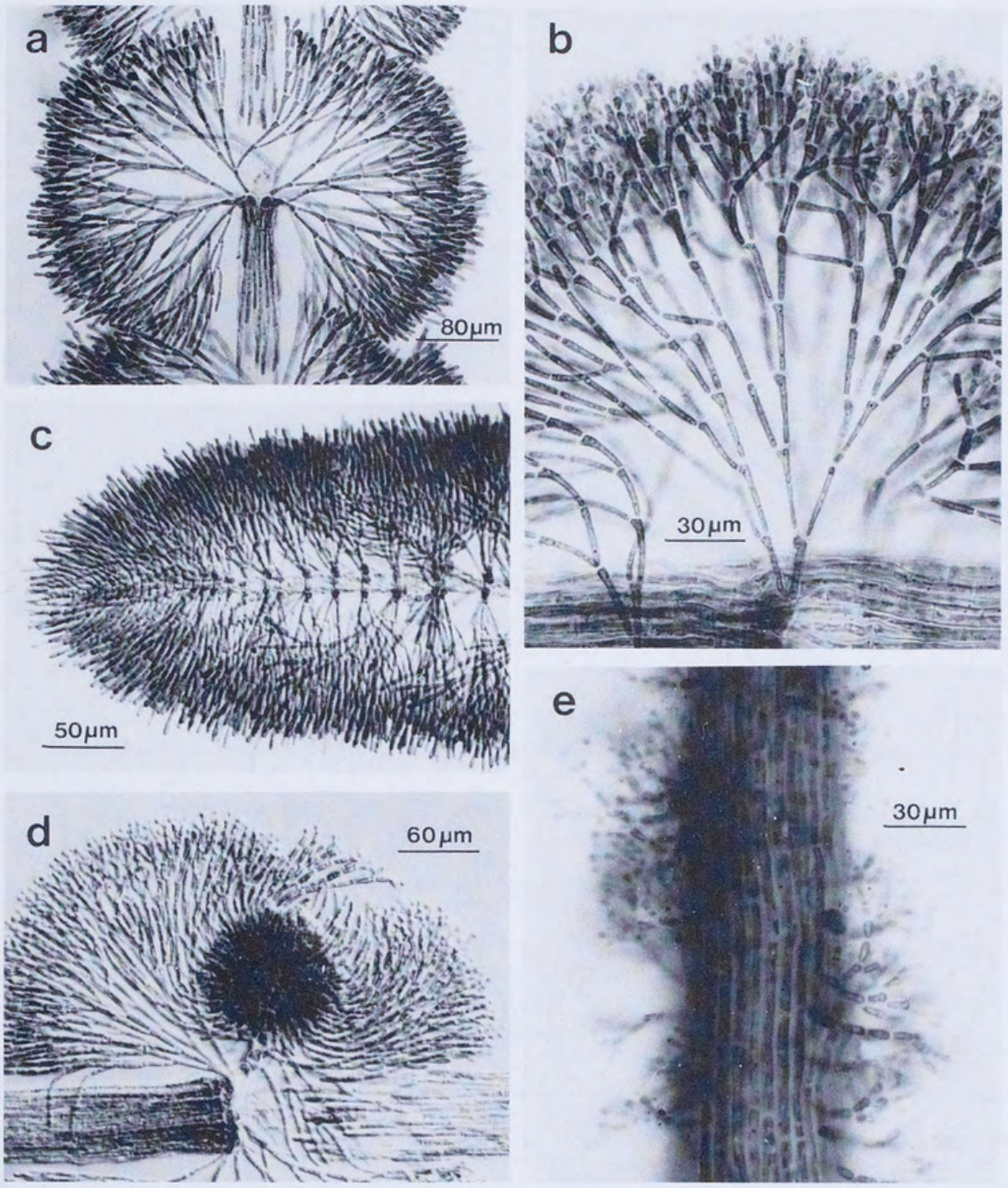

Fig. 1. Photomicrographs of *Batrachospermum antipodites*. a — whorl of fascicles. b — fascicle terminated by antheridia. c — apex of thallus. d — gonimoblast in whorl. e — secondary fascicles bearing antheridia in overmature thallus.

Distribution & Habitat

Widespread in mountain streams of eastern Australia (Qld, NSW, Vic. and Tas.) and New Zealand (North and South Islands), known thus far from 17–42°S and 145–175°E (Fig. 3). Usually growing in heavily-shaded gullies or in shaded parts of stream.

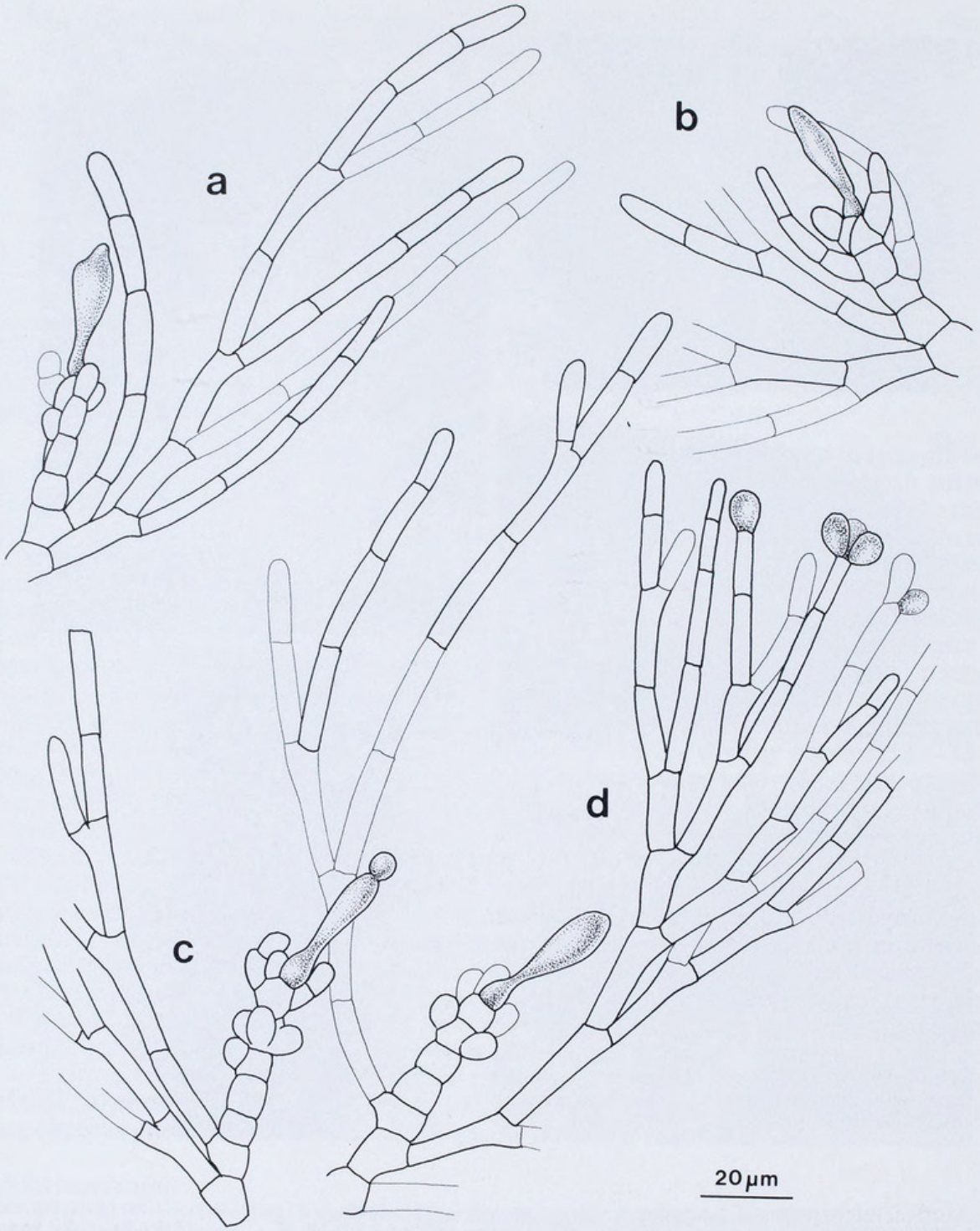

Fig. 2. Illustrations of *Batrachospermum antipodites* by H. Skuja (copied by Mali Moir). a — fascicle bearing carpogonium (shaded). b — carpogonial branch with carpogonium (shaded). c — carpogonial branch with spermatium attached to carpogonium (both shaded). d — fascicle bearing terminal antheridia (shaded) and a carpogonial branch with carpogonium (shaded).

Selected Specimens Examined (total examined = 40)

Australia. *South Australia* — Bones Ponds, near Mount Gambier, Oct.1988, *M. Thurgate s.n.* (MEL). *Queensland* — Wallacha Falls, North Johnstone River tributary, 10 Sep. 1993, *T. Entwisle 2269* (MEL); Sunday Creek, Jimma State Forest, 16 June 1974, *A.B. Cribb 793.7* (BRI); Burnett Creek, Mt Barney area, 4 Sep. 1993, *T. Entwisle 2216* (MEL). *New South Wales* — Cowdroy Creek, Bodala State Forest, 5 Feb. 1991, *T. Entwisle 1866* (MEL); Red Ceder Creek, 9 Feb. 1991, *T. Entwisle 1951* (MEL). *Victoria* — trib. of Martins

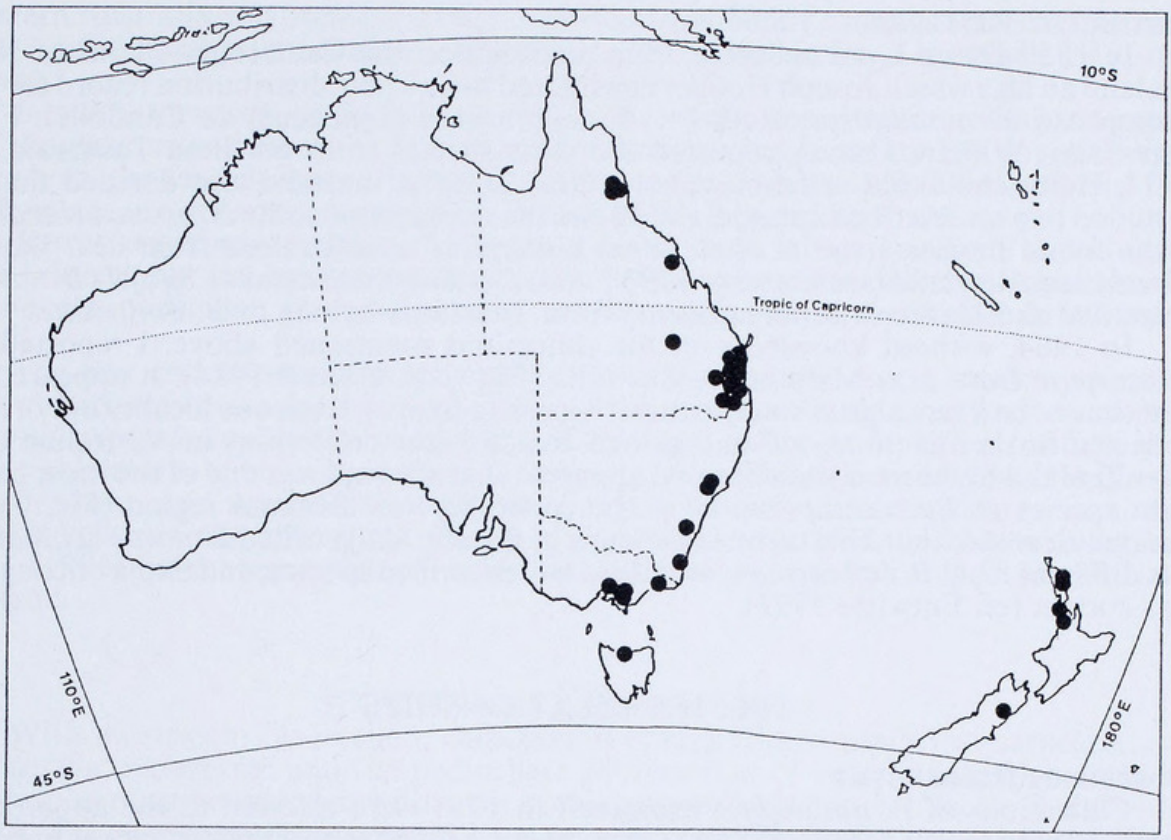

Fig. 3. Australia-New Zealand region showing the distribution of *Batrachospermum antipodites*.

Creek, Bonang Highway, 15 July 1990, *K. Thiele (T. Entwisle 1664)* (MEL); Sassafras Creek, Monbulk-Emerald Road, 24 Mar. 1987, *T. Entwisle 1139* (MEL). *Tasmania* — Cheshunt near Deloraine, Feb. 1855, *D. Lyall s.n.* (BM,NSW).

New Zealand. *North Island* — Maunu, near Whangerai, North Is., 7 Dec. 1934, *L. Cranwell s.n.* (AKU). South Island — Canterbury Plain, South Is., Dec. 1850, *D. Lyall s.n.* (BM).

Many types and representative collections were examined, and the following from the section *Batrachospermum* have relevance to this paper:

B. anatinum Sirodot, *Batrachospermes* 249 (1884). Ruisseau de Vau-de Meu, au patis Saint-Lazare, Monfort, 10.iv.1872, *Sirodot s.n.* (PC; lectotype).

B. anatinum Sirodot, *Batrachospermes* 249 (1884). Ruisseau de Vau-de Meu, au patis Saint-Lazare, Monfort, 10.iv.1872, *Sirodot s.n.* (PC; lectotype).

B. boryanum Sirodot, *C. R. Acac. Sci.* 79: 1366. Caniveau de la Trottinais, 12.v.1877, *Sirodot* (PC; lectotype); Brazil, 10.vii.1993, *M.R.A. Braga s.n.* (SP; representative collection).

B. cylindrocellulare Kumano, *Bot. Mag. Tokyo* 91: 100 (1978). Fort Iskander, Tasek Bera, Pehang, Malaysia, *S. Kumano s.n.*, 16.iv.1971 (Kobe University Herbarium; type).

B. ectocarpum Sirodot, *Batrachospermes* 222 (1884), *nom. illeg.* St Germain Rivière d'Ille, 12.vii.1877, *S. Sirodot s.n.* (PC; representative collection).

B. fluitans Kerner, *Bot. Centralb.* 10: 362 (1882). Mühlau in ditione Oenipontana, Austria, *A. Kerner s.n.* (BM; syntype).

B. fruticulosum Drew, *Ann. Bot.*, new ser., 10: 10: 340 (1946). Chee Dale, Derbyshire, England, 20.vi.1942, *Drew 1610b* (BM; isotype).

B. ludibundum var. *stagnale* Bory de St-Vincent, *Ann. Mus. Hist. Nat.* 12: 325 (1808), "*Batrachosperma ludibunda stagnale*". Marais des ouvrais de Bordeaux, Talence, an V, *Bory de St-Vincent s.n.* (PC; holotype).

Etymology

From Middle English *antipodites* = an inhabitant of the antipodes (places directly opposite on the surface of the earth). The reference point is Europe, nomenclatural birthplace of the genus *Batrachospermum* and more or less opposite eastern Australia and New Zealand. This name was chosen to maintain the geographical spirit of Skuja's manuscript name for this taxon, 'novae-zelandiae' (now a somewhat misleading epithet).

Historical Remarks

In 1850 David Lyall collected from a stream on the Canterbury Plains of New Zealand an alga which Joseph Hooker considered to be a new distribution record for the widespread *B. moniliforme* Roth (= *B. gelatinosum* (Linnaeus) de Candolle). Five years later, William Harvey reported the same species from northern Tasmania. In 1937, Heinrichs Skuja re-examined the New Zealand material and decided that it included two undescribed species, giving one the manuscript name *B. novae-zelandiae*. Skuja found further material of *B. novae-zealandiae* in collections from near Bay of Islands and Auckland (see Entwisle 1993 for further historical details). Skuja's *B. novae-zelandiae* and Harvey's *B. moniliforme* from Tasmania belong to *B. antipodites*.

In 1984, without knowledge of the collections mentioned above, I reported *B. ectocarpum* from near Melbourne, Australia (Entwisle & Kraft 1984). It appeared at that time to be a rare alga in south-eastern Australia (known from one locality only). As I collected further afield myself and gained access to the collections in Australian and New Zealand herbaria it soon became apparent that the alga was one of the most common species of *Batrachospermum* in the Australia-New Zealand region (Fig. 3). It became clear also that: this taxon is the same as the one Skuja called *B. novae-zelandiae*; it is different from *B. ectocarpum*, or indeed any described species; and Skuja once again was correct (cf. Entwisle 1992).

SPECIES RELATIONSHIPS

Northern Hemisphere

Collections of *B. antipodites* examined in 1981 were referred to the apparently cosmopolitan *B. ectocarpum* Sirodot (*nom. illeg.*), a taxon with a tangled recent history. Sheath & Burkholder (1983) subsumed *B. ectocarpum* within *B. boryanum*, a change accepted in Entwisle & Kraft (1984; as a note added in proof) and Entwisle (1989). Compère (1991), however, considered these two taxa distinct, pointing out that *B. ectocarpum* was a later synonym of *B. stagnale* (Bory de St-Vincent) Hassall. More recently Vis *et al.* (1995) referred representative collections of *B. ectocarpum* to *B. anatinum*, a taxon distinct from *B. boryanum* and *B. stagnale*. *Batrachospermum stagnale* was included by Vis *et al.* (1995) in the apparently cosmopolitan *B. gelatinosum*. *Batrachospermum antipodites* also falls within the circumscription of *B. gelatinosum sensu* Vis *et al.* (1995), although the gonimoblasts are generally larger (70–200 μm cf. 40–139 μm in diam.). However *B. antipodites* has a vegetative structure which could never be confused with *B. boryanum*, *B. stagnale*, *B. anatinum*, *B. gelatinosum*, *B. ectocarpum*, or indeed any of the taxa circumscribed in Bory de St-Vincent (1808) or Sirodot (1884). Vegetative cell morphology was not used in the analysis of Vis *et al.* (1995) but the cylindrical fascicle cells of *B. antipodites* are consistent (and distinctive) throughout its range in Australia and New Zealand.

Within the section *Batrachospermum*, *B. cylindrocellulare* from Malaysia is the most similar in fascicle-cell morphology but it has abundant secondary fascicles, spermatia on shortened branchlets (these may be comparable with the spermatia on secondary fascicles of older thalli of *B. antipodites*) and pedicellate, ovoid to ellipsoid trichogynes. *Batrachospermum fluitans* Kerner from Austria has a fascicle structure somewhat reminiscent of *B. antipodites* but that species has broader (6–14 μm diam.) fascicle cells which are more ellipsoid or obovoid than cylindrical, and longer (42–65 μm) carpogonia subtended a branch of longer (11–38 μm) cells. The type of *B. fruticulosum* Drew (= *B. confusum* (Bory de St-Vincent) Hassall *emend.* Vis *et al.* 1995), from England, is also vegetatively similar to *B. antipodites*, but has narrower (10–30 μm diam.) axial cells, irregularly inflated rhizoidal filaments, spermatia on involucral bracts, and once again broader (6–14 μm diam.) fascicle cells.

Southern Hemisphere

Batrachospermum antipodites appears to be restricted to eastern Australia and New Zealand. No plants of this morphology were found in a reconnaissance survey of

Western Australia and none have been reported from South America (Necchi 1990) or from initial forays in southern Africa (e.g. by M.-A. Joska, University of Cape Town).

Batrachospermum boryanum sensu Necchi (1990), from Brazil, is similar in general dimensions and has no or few secondary fascicles, but there are 1–4 gonimoblasts per whorl, the fascicle cells are cylindrical to elliptical (distal cells elliptical) and the trichogynes are generally smaller (13–25 μm cf 18–39 μm long).

Batrachospermum breutelii Rabenhorst from South Africa has some cylindrical-celled fascicles at the base of the thallus but is otherwise quite different from *B. antipodites* (in particular, in its distinctive tetrads of carpospores; Sheath & Whittick 1995).

The first collection of *B. antipodites* from New Zealand (see historical remarks above) also included material of another species, to which Skuja gave the manuscript name *B. campyloclonum* (Entwisle 1993). This taxon will be dealt with more fully in a later publication, but like *B. antipodites* it has sparse gonimoblasts. Unlike *B. antipodites*, however, and in common with most taxa in the section *Batrachospermum*, the fascicle cells are not cylindrical. Plants probably referable to *B. anatinum sensu* Vis *et al.* (1995) have been collected in the 'antipodean' region, but only from the New Zealand.

SECTIONAL CLASSIFICATION

With its straight, 4–7-celled, carpogonial branch, the symmetrical carpogonium and sessile trichogyne, and the pedicellate gonimoblast of determinate filaments, *B. antipodites* must be included within the section *Batrachospermum* (Necchi & Entwisle 1990). The only generally accepted character of this section that it lacks, is the 'numerous' gonimoblasts per whorl (see e.g. Bourrelly 1985, Mori 1975, Kumano 1993): *B. antipodites* (and '*B. campyloclonum* Skuja *ined.*' as mentioned above) has only one, or rarely two, gonimoblasts per whorl. Kumano (1979) apparently drew attention to the lack of correlation between frequency and position of gonimoblasts in a whorl, but he has continued to use gonimoblast frequency to define the section *Batrachospermum* (Kumano 1993). The interpretations of Sirodot (1884) and Israelson (1942), that the number of gonimoblasts per whorl is 'variable' or 'usually numerous', respectively, seem more appropriate.

Trichogyne shape and attachment partly characterize the section *Batrachospermum* (Kumano 1993). Trichogynes of this section are sessile (see Sheath *et al.* 1986 for definition of 'sessile' vs 'pedicellate') and vary in shape from ovoid or urn-shaped, to ellipsoid, to club-shaped. Sections *Hybrida*, *Turfosa* and *Virescentia*, which like section *Batrachospermum* have straight or curved carpogonial branches bearing carpogonia without a basal protuberance, have trichogynes either pedicellate or sessile, and conical, cylindrical or ellipsoid in shape. While there is obviously some overlap, trichogyne shape and attachment may be sufficient to correctly place a specimen in the section *Batrachospermum*. *Batrachospermum antipodites*, with its sessile, club-shaped trichogynes, nestles comfortably within the section *Batrachospermum*.

Many authors (Sirodot 1884, Israelson 1942, Bourrelly 1985, Kumano 1993) use the relative size of the gonimoblast — small vs large — to help separate section *Batrachospermum* from the sections *Hybrida*, *Turfosa* and *Virescentia*. However there is considerable overlap in this feature. To use as an example the published data summarized by Necchi (1990), gonimoblasts of section *Batrachospermum* are 210 μm or less in diameter while those of the latter group are 90 μm or more. The gonimoblasts of *B. antipodites*, at 70–200 μm in diameter, fall almost entirely within the overlap zone. Gonimoblast size clearly has limited use as a diagnostic character for the section *Batrachospermum*.

An additional problem encountered during this study was the distinction between section *Batrachospermum* and section *Aristata*. Although the monophyly of section *Batrachospermum* is yet to be tested, most authors (except e.g. Kumano 1993 who retains the section *Helminthoidea*) accept the definition recounted by Necchi & Ent-

wisle (1990). However, the circumscription of section *Aristata*, based largely on the presence of a 'long', 'differentiated' filament subtending the carpogonium, needs refinement. A species such as *B. equisetifolium* Montagne with carpogonia borne on branches similar in length to those of *B. antipodites*, and hardly more 'differentiated', is unquestionably included in the section *Aristata* by most authors (e.g. Kumano 1993, Sheath *et al.* 1994). Because *B. equisetifolium* also produces 'rosette-like, hypogynous cells', Kumano (1993) has further segregated it into the subsection *Macrosporum*. This arrangement is not particularly satisfying, but I am reticent to tinker further with the infrageneric classification of *Batrachospermum* before morphological and molecular phylogenies have been tested.

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