

Algae of Australia
Batrachospermales, Thoreaales,
Oedogoniales and Zygnemaceae

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1. BATRACHOSPERMALES

Timothy J. Entwisle¹ & Helen J. Foard²

Batrachospermales Pueschel & K.M.Cole, *Amer. J. Bot.* 69: 717 (1982)

Type: Batrachospermaceae C.Agardh

Life history heteromorphic, triphasic. *Pit plugs* 2-layered. *Gametophyte* arising after somatic meiosis in an apical cell of chantransia phase, usually annual, uniaxial or multiaxial, with determinate laterals. *Carpogonial branches* often scarcely differentiated from vegetative fascicle. *Carpogonia* persistent; axillary cells absent; plastids parietal, discoid or plate-like. *Carpospores* giving rise to a chantransia phase that is perennial, uniseriate, branched, tufted, morphologically resembling species of *Audouinella* Bory, sometimes producing monosporangia (never tetrasporangia).

A worldwide order of three families, restricted to freshwater, predominantly in oligotrophic streams; two families, four genera and 25 species are known from Australia. The biogeographical relationships of the Australasian representatives have been discussed by Entwisle (2007). In Australia, the order is represented by the Batrachospermaceae and the Psilosiphonaceae; a third family, Lemaneaceae, is predominantly Northern Hemisphere in distribution, extending slightly into South America.

H.Kylin, *Nemalionales p.p., Die Gattungen der Rhodophyceen* 89–101 (1956); K.Starmach, *Rhodophyta-Krasnorosty p.p., Fl. Slodkowodna Polski* 14: 115–251, 384–404 (1977); C.M.Pueschel & K.M.Cole, *Rhodophycean pit plugs: an ultrastructural survey with taxonomic implications, Amer. J. Bot.* 69: 703–720 (1982); P.Bourelly, *Ordre des Némalionales, Les Algues d'Eau Douce* 3: 220–245, 541–544, pls 49–70 (1985); R.G.Sheath, *The biology of freshwater red algae, in F.E.Round & D.J.Chapman (eds), Progress in Phycological Research* 3: 89–158 (1984); T.J.Entwisle & O.Necchi Jr, *Phylogenetic systematics of the freshwater red algal order Batrachospermales, Jap. J. Phycol.* 40: 1–12 (1992); M.L.Vis, G.W.Saunders, R.G.Sheath, K.Duse & T.J.Entwisle, *Phylogeny of the Batrachospermales (Rhodophyta) inferred from rbcL and 18S ribosomal RNA gene sequences, J. Phycol.* 34: 341–350 (1998); M.L.Vis & T.J.Entwisle, *Insights into Batrachospermales (Rhodophyta) phylogeny from rbcL sequence data of Australian taxa, J. Phycol.* 36: 1175–1182 (2000); T.J.Entwisle, *Biogeography of freshwater macroalgae, Algae of Australia: Introduction* 566–579 (2007).

KEY TO FAMILIES

- Thallus cartilaginous, sparsely branched; fascicle structure obscure; outer cortex pseudoparenchymatous
..... 1. **PSILOSIPHONACEAE**
- Thallus flaccid to cartilaginous, much-branched; fascicles in regular whorls at each node; outer cortex loose or compact (but not pseudoparenchymatous)..... 2. **BATRACHOSPERMACEAE**

1. PSILOSIPHONACEAE

Psilosiphonaceae Entwisle, Sheath, K.M.Müll. & Vis, in R.G.Sheath, K.M.Müller, M.L.Vis, & T.J.Entwisle, *Phycol. Res.* 44: 245 (1996).

Type: *Psilosiphon* Entwisle

Gametophytes uniaxial with determinate laterals, cylindrical, without distinct nodes, cartilaginous, usually olive-green; axial filament thin, with 4 periaxial cells; medullary

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filaments ±evenly occupying the area between the axis and the cortex; cortex arising adventitiously from medullary filaments, pseudoparenchymatous, a few cells thick. *Sexual reproduction* poorly understood; putative spermatangia scattered on thallus surface; apparently asexual sporangia arising from apical cells of cortical filaments; adventitious plantlets produced vegetatively, apparently from indeterminate growth of some cortical filaments. *Chantransia phase* at first a prostrate compact mat, later tufty.

A monotypic family of one species in south-eastern Australia and northern New Zealand. Restricted to permanent, rocky streams in and around waterfalls.

Although originally referred to the family Lemnaceae, genetic comparisons show clearly that *Psilosiphon* is phylogenetically distinct from the two genera in that family, *Lemanea* Bory and *Paralemanea* Vis & Sheath.

T.J.Entwisle, *Psilosiphon scoparium* gen. et sp. nov. (Lemnaceae), a new red alga from south-eastern Australian streams, *Phycologia* 28: 469–475 (1989); R.G.Sheath, K.M.Müller, M.L.Vis, & T.J.Entwisle, A re-examination of the morphology, ultrastructure and classification of genera in the Lemnaceae (Batrachospermales, Rhodophyta), *Phycol. Res.* 44: 233–246 (1996); T.J.Entwisle, M.L.Vis & H.J.Foard, Biogeography of *Psilosiphon* (Batrachospermales, Rhodophyta) in Australia and New Zealand, *Cryptog. Algol.* 21: 133–148 (2000).

PSILOSIPHON

Psilosiphon Entwisle, *Phycologia* 28: 469 (1989); from the Greek *psilo* (smooth) and *siphon* (a tube), in reference to the gametophyte which lacks the regular nodulation of the superficially similar *Lemanea* and *Paralemanea*.

Type: *P. scoparius* Entwisle

Gametophyte anodulate. *Medullary filaments* ±evenly occupying the regions between the axial filament and the cortex. *Cortical filaments* arising from medullary filaments, unbranched, with cells similar in size and shape throughout (at least when young), at least some eventually producing an occasionally branched series of ellipsoidal cells.

Psilosiphon scoparius Entwisle, *Phycologia* 28: 470 (1989), as *scoparium*

T: Barren Grounds Nature Reserve, Lyrebird Ck (Lamonds Ck), between Robertson and Jamberoo, N.S.W., 11 Nov. 1988, T.J.Entwisle 1565 & R.A.Andersen; holo: MEL; iso: KIRI, MELU, MICH, NSW.

Illustrations: T.J.Entwisle, *op. cit.* 471–474, figs 1–15.

Gametophytes in clumps of 10–20, erect, rarely branched, cylindrical to fusiform, 1–5 (–9) cm long, 0.5–3.0 mm diam. *Axial filament* thick-walled. *Medullary filaments* forming an open tangled mass (up to several hundred cut in a transverse section of the thallus), 7–15 µm diam. *Cortical filaments* arising laterally from medullary cells, radial, compact and cohesive, branched, initially of 4 or 5 cells, 7–10 µm diam., sometimes terminated by a unicellular hair to 60 µm long; in older thalli at least some cortical filaments extending up to 12 cells; terminal cells becoming ellipsoidal and sometimes inflated, 12–20 µm diam., some apparently producing adventitious plantlets. *Chantransia phase* a firm basal cushion of sparingly branched uniseriate filaments; cells cylindrical, 30–60 µm long, 10–15 µm diam. *Little Water Besom*. Fig. 1.

Known from a few catchments in south-western Tas., and one locality south-west of Wollongong, N.S.W. Locally common in humic streams on sandstone or quartzite. Also at the northern tip of the North Island, New Zealand. Map 1.

Tas.: Peak 25, near West Portal, Western Arthurs [not Frankland Ra. as on original herbarium label], D.A.Ashton 3783 (MELU); headwaters of Frankland R., 2.5 km WSW of Franklands Peak, N.G.Walsh 3489 (MEL).

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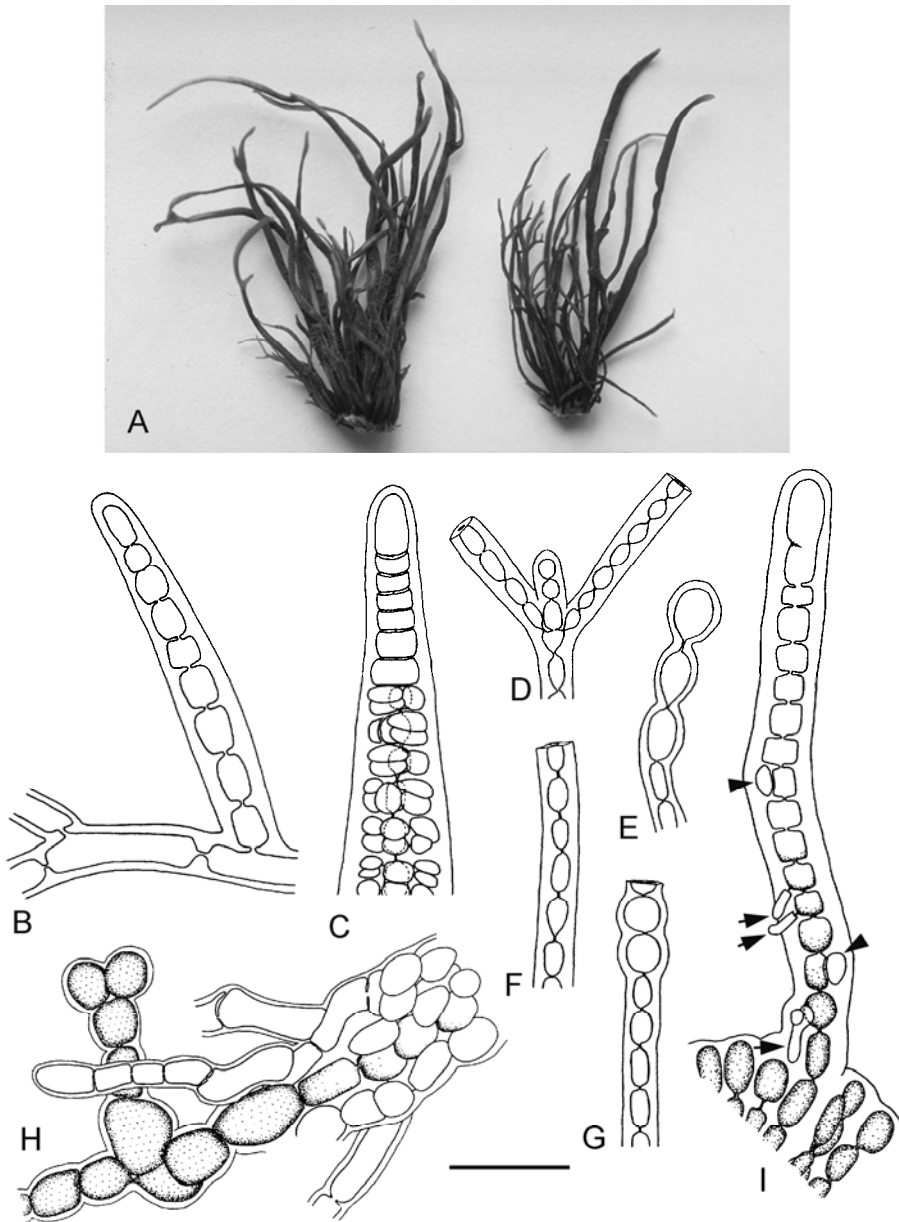


Figure 1. *Psilosiphon scoparius*. **A**, Habit (T.J.Entwisle 2543, MELU). **B**, Prostrate, rhizoid-like filament of basal cushion giving rise to erect filament (T.J.Entwisle 717, MELU). **C**, Apex of plant showing development of periaxial cells from axial filament (dotted lines) (T.J.Entwisle 717, MELU). **D–G**, Exogenous filaments extending from the outer cortical layer in an older thallus. **D**, Branched filament. **E**, Swollen cells. **F**, Unbranched filament of non-inflated cells. **G**, Transition from non-inflated to inflated cells (T.J.Entwisle 3783, MELU). **H**, Plantlet developing from a detached exogenous filament (shaded). **I**, Cortical filament at an early stage of conversion into a new plantlet *in situ* by the initiation of basal rhizoids (arrows) and the first periaxial cells (arrowheads) (T.J.Entwisle 1565, MELU). Scales: B–I = 30 µm. B–I © 1989 International Phycological Society. From *Phycologia*, by T.J.Entwisle. Reprinted by permission of Alliance Communications Group, a division of Allen Press Inc.

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Three 'genetic races' have been recognised (Entwisle *et al.*, 2000), one in New Zealand, a second in New South Wales and the third in Tasmania. No morphological characters were found to support these well-circumscribed genetic groups.

2. BATRACHOSPERMACEAE

Batrachospermaceae C.Agardh, *Syst. Alg.* xxiii (1824)

Type: *Batrachospermum* Roth

Gametophyte uniaxial with regular whorls of branched determinate laterals (fascicles), cylindrical to moniliform in outline, flaccid to cartilaginous, olive-green, brown or red, rarely grass-green. *Axial filaments* broad; periaxial cells usually 4–6; rhizoidal filaments usually adhering to axial filament, giving rise to 'secondary' fascicles laterally. *Spermatangia* terminal on fascicles or on specialised filaments. *Carpogonial branches* variously differentiated (or not) from vegetative fascicles; trichogyne swollen, generally broader than base of carpogonium. *Carposporophytes* usually borne within thallus, often of definite shape; gonimoblast filaments determinate and/or indeterminate; carposporangia single from a terminal cell. *Chantransia phase* not always evident, forming a tufty cushion; monosporangia sometimes present.

A cosmopolitan family of four genera and more than 100 species; three genera and 24 species reported from Australia (*Tuomeya* Harv. is restricted to the Northern Hemisphere). Common in pristine streams and in some lakes and swamps.

Three genera have been reported from Australia: the widespread *Batrachospermum* and *Sirodotia*, and the Southern Hemisphere *Nothocladus*. Necchi & Entwisle (1991) have argued that, on practical as well as presumed phylogenetic grounds, only one genus should be recognised in the Batrachospermaceae. However, phylogenies derived from molecular data (Vis *et al.*, 1998) imply that the family, and therefore *Batrachospermum s. lat.*, is paraphyletic. Pending a complete reassessment of the family, the traditional generic classification is revived here.

T.J.Entwisle & G.T.Kraft, Survey of freshwater red algae (Rhodophyta) of south-eastern Australia, *Austral. J. Mar. Freshwater Res.* 35: 213–259 (1984); T.J.Entwisle, Macroalgae in the Yarra River basin: flora and distribution, *Proc. Roy. Soc. Victoria* 101: 1–76 (1989); O.Necchi Jr & T.J.Entwisle, A reappraisal of generic and subgeneric classification in the Batrachospermaceae (Rhodophyta), *Phycologia* 29: 478–488 (1990); S.Kumano, Taxonomy of the family Batrachospermaceae (Batrachospermales, Rhodophyta), *Jap. J. Phycol.* 41: 253–274 (1993).

KEY TO GENERA

- 1 Carposporophytes globose or semi-globose (rarely diffuse and ill-defined); most or all gonimoblast filaments determinate; base of carpogonium \pm symmetrical (never protuberant) **1. BATRACHOSPERMUM**
- 1: Carposporophytes diffuse; gonimoblast filaments indeterminate 2
- 2 Thallus flaccid; whorls separated or confluent; base of carpogonium protuberant (*l.*) **2. SIRODOTIA**
- 2: Thallus jelly-like or cartilaginous; whorls confluent; base of carpogonium \pm symmetrical (never protuberant) **3. NOTHOCLADUS**

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1. BATRACHOSPERMUM

Batrachospermum Roth, *Bemerk. Crypt. Wassergew.* 3(2): 36 (1797); from the Greek *batrachos* (a frog) and *sperma* (a seed), alluding to the resemblance of the habit of some species to a mass of frogs' eggs.

Type: *B. gelatinosum* (L.) DC.

Thallus flaccid to cartilaginous; whorls conical to globose; secondary fascicles absent to common. *Carpogonial branches* arising from periaxial or fascicle cells, straight or curved to twisted, slightly to (in Australian species) substantially modified from vegetative fascicles, 3–31-celled; base of carpogonium \pm symmetrical, never protuberant. *Carposporophytes* globose or semi-globose (rarely diffuse and ill-defined; see *B. watsii*); gonimoblast filaments usually determinate, occasionally some indeterminate.

A worldwide genus of over 100 species. Twenty species are known in Australia; 12 are endemic, and three are restricted to Australia and New Zealand.

Although *Batrachospermum s. str.* is usually divided into six or seven sections (Necchi & Entwisle, 1990; Sheath & Vis, 1995), these groupings do not readily accommodate taxa from Australia and have no demonstrated phylogenetic basis. Until the subgeneric taxa are better resolved, there is no practical benefit in using sections here.

S.Sirodot, *Batrachospermes*. Paris (1884); O.Necchi Jr, Revision of the genus *Batrachospermum* Roth (Rhodophyta, Batrachospermales) in Brazil, *Biblioth. Phycol.* 84: 1–201 (1990); M.L.Vis, R.G.Sheath & T.J.Entwisle, Morphometric analysis of *Batrachospermum* section *Batrachospermum* (Batrachospermales, Rhodophyta) type specimens, *Eur. J. Phycol.* 30: 35–55 (1995); R.G.Sheath & M.L.Vis, Distribution and systematics of *Batrachospermum* (Batrachospermales, Rhodophyta) in North America, 7. Section *Hybrida*, *Phycologia* 35: 431–438 (1995); T.J.Entwisle & H.J.Foard, *Batrachospermum* (Batrachospermales, Rhodophyta) in Australia and New Zealand: new taxa and emended circumscriptions in sections *Aristata*, *Batrachospermum*, *Turfosa* and *Virescentia*, *Austral. Syst. Bot.* 10: 331–380 (1997); T.J.Entwisle & H.J.Foard, *Batrachospermum latericium* sp. nov. (Batrachospermales, Rhodophyta) from Tasmania, Australia, with new observations on *B. atrum* and a discussion of their relationships, *Muelleria* 11: 27–40 (1998); T.J.Entwisle & H.J.Foard (1999), *Batrachospermum* (Batrachospermales, Rhodophyta) in Australia and New Zealand: sections *Contorta* and *Hybrida*, *Austral. Syst. Bot.* 12: 615–633; T.J.Entwisle, M.L.Vis & H.Macpherson, *Batrachospermum pseudogelatinosum* (Batrachospermales, Rhodophyta), a polyecious paraspecies from Australia and New Zealand, *Austral. Syst. Bot.* 17: 17–28 (2004); Corrigendum, *Austral. Syst. Bot.* 17: 113 (2004); M.L.Vis, T.J.Entwisle, J.A.West & F.D.Ott, *Ptilothamnion richardsii* (Rhodophyta) is a chantransia stage of *Batrachospermum*, *Eur. J. Phycol.* 41: 125–130 (2006a); T.J.Entwisle, The true story of *Sirodotia goebelii*, *Austral. Syst. Bot. Soc. Newsletter* 128: 13–15 (2006b).

Old thalli with denuded axes may be impossible to identify to species level. However, careful examination will usually reveal at least some younger branches or thalli in the sample.

- 1 Carpogonial branches straight or sometimes slightly curved 2
- 1: Carpogonial branches twisted or contorted (in *B. virgatodecaisneanum* some carpogonial branches on an individual may be curved or \pm straight)..... 16
 - 2 Fascicles 3–26 cells long, not appressed to main axis; carposporophyte within or slightly protruding from whorl; carpogonial branches 4–18 cells long (*1*) 3
 - 2: Fascicles up to 6 cells long, usually closely appressed to main axis; carposporophyte protruding from whorl; carpogonial branches 4–6 cells long 14
- 3 Carposporophytes semi-globose (rarely globose) or diffuse; centre adjacent to thallus axis (rarely distant from axis and then carposporophyte always semi-globose); carpogonial branches of 3–8 modified cells (*2*) .
 4
- 3: Carposporophytes globose (rarely some semi-globose); centre not (or rarely, within a specimen) adjacent to thallus axis; carpogonial branches of 3–18 modified or unmodified cells 6

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- 4 Thallus somewhat rigid; axial cells 9–23 μm diam.; rhizoidal filaments inflated, 6–34 μm diam.; distal cells globose or conical-globose (3) **11. B. wattsii**
- 4: Thallus flaccid; axial cells 18–80 μm diam.; rhizoidal filaments cylindrical, 4–14 μm diam.; distal cells not globose 5
- 5 Trichogynes clavate (sometimes narrowly so), 6–15 μm diam.; carposporangia always terminal on gonimoblast filaments, 17–33 μm long, 10–18 μm diam. (4:) **8. B. theaquum**
- 5: Trichogynes linear, 3–5 μm diam.; carposporangia arising in a lateral series from gonimoblast filaments, 10–16 μm long, 7–9 μm diam. **9. B. debile**
- 6 Fascicle cells cylindrical with distal expansion; fascicle branching unilateral; secondary fascicles absent (rarely present and then sparse in overmature thalli); trichogynes clavate (3:) **3. B. antipodites**
- 6: Fascicle cells and branching otherwise; secondary fascicles present or absent; trichogynes variously shaped 7
- 7 Fascicles in conical whorls (at least in some parts of thallus); carpogonial branches 9–18 cells long; trichogynes pedicellate (6:) **1. B. cayennense**
- 7: Fascicles in globose, barrel-shaped or disc-shaped whorls; carpogonial branches 4–15 cells long; trichogynes pedicellate or sessile 8
- 8 Trichogynes bilaterally asymmetrical (check a few trichogynes to ensure correct orientation) (7:) 9
- 8: Trichogynes symmetrical (occasionally distorted or lumpy) 11
- 9 Trichogynes oblique-ellipsoidal to scimitar-shaped; carposporangia < 30 μm long (8) **4. B. kraftii**
- 9: Trichogynes foot- or sausage-shaped; carposporangia > 30 μm long 10
- 10 Trichogynes curved sausage-shaped, 8–10 μm diam.; whorls dense (9) **5. B. ranuliferum**
- 10: Trichogynes foot-shaped, 10–16 μm diam.; whorls relatively open **6. B. antiquum**
- 11 Inner cells of fascicle quite different in size and shape from outer cells (without graduation between the two layers); rhizoidal filaments 7–26 μm diam., consisting of cylindrical and inflated cells; carposporangia 8–11 μm diam. (8:) **2. B. discors**
- 11: Fascicles without clearly defined inner and outer layers of cells; rhizoidal filaments 2–14 μm diam., consisting of cylindrical cells; carposporangia 6–34 μm diam. 12
- 12 Whorls less than 300 μm diam.; carposporophytes 2 or more times as broad as whorl radius; trichogynes ellipsoidal (11:) **10. B. prominens**
- 12: Whorls usually more than 300 μm diam.; carposporophytes up to 1.6 times (rarely to 2.3 times) as broad as whorl radius; trichogynes rarely ellipsoidal 13
- 13 Base of carpogonia 2–6 μm diam.; carposporophytes variously positioned but never overlapping axis, 80–190 μm diam., 0.2–0.5 times the whorl radius; fascicles branching 5–8 times (12:) **7. B. pseudogelatinosum**
- 13: Base of carpogonia 5–11 μm diam.; carposporophytes always adjacent to or overlapping the axis, 115–350 μm diam., 0.3–2.3 times the whorl radius; fascicles branching 2–5 times **8. B. theaquum**
- 14 Axial filament more than 2.5 times as broad as rhizoidal filaments; apical cell less than 10 μm diam.; widespread in mainland Australia and Tas. (2:) **12. B. atrum**
- 14: Axial filament usually less than 2.5 times as broad as rhizoidal filaments; apical cell more than 10 μm diam.; Tas. only 15
- 15 Apex of thallus tapering; apical cell protruding from whorled branchlets; primary laterals c. 2 cells long (14:) **13. B. latericum**
- 15: Apex of thallus blunt; apical cell embedded in whorled branchlets; primary laterals 4–6 cells long **14. B. diatyches**
- 16 Fascicles with 4–7 storeys of cells 8–11 μm long; carposporophytes always exerted from whorls; carposporangia 7–13 μm long (1:) **20. B. deminutum**
- 16: Fascicles with 6–15 storeys of cells mostly 8–52 μm long; carposporophytes rarely exerted from whorls; carposporangia 11–26 μm long 17
- 17 Carpogonial branches coiled through 3 loops, 11–26 cells long; N.T. only (16:) **19. B. australicum**
- 17: Carpogonial branches curved or coiled (rarely some straight), but never coiled through more than 2 loops, 5–10 (–13) cells long 18
- 18 Spermatangia never on involucrel filaments, usually terminal on fascicles; involucrel filaments curled and compactly wrapped around carpogonial branch (17:) **16. B. ambiguum**
- 18: Spermatangia on involucrel filaments and/or in a longitudinal mid-whorl band; involucrel filaments spreading 19

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- 19 At least some carpogonial branches within any individual \pm straight or slightly curved; southern Australia (18:) **15. B. virgatodecaisneanum**
- 19: All carpogonial branches contorted or spiralled; northern Australia 20
- 20 Spermatangia in a longitudinal mid-whorl band; carposporophytes compact; N.T. (19:) **17. B. vittatum**
- 20: Spermatangia distributed throughout whorl; carposporophytes loose; southern Qld **18. B. globosporum**

1. *Batrachospermum cayennense* Mont. ex Kütz., *Sp. Alg.* 537 (1849)

Batrachospermum moniliforme Roth var. *guyanense* Mont., *Ann. Sci. Nat. Bot.*, sér. 2, 13: 200 (1840). T: in rivulis montanis circa Cayennam lectum [Cayenne, French Guiana], *C. Leprieur* 348; holo: PC; iso: PC.

Illustrations: O. Necchi Jr, *Biblioth. Phycol.* 84: 29, figs 30–38 (1990); R.G. Sheath, M.L. Vis & K.M. Cole, *Phycologia* 33: 410, figs 16–19 (1994).

Monoecious. *Thallus* flaccid, olive-green to purplish; apices obtuse, sometimes uncinata; apical cell elongate; whorls confluent or separated, conical, 240–600 μ m diam.; axial cells 45–60 μ m diam.; rhizoidal filaments cylindrical, 5–6 μ m diam.; secondary fascicles abundant. *Primary fascicles* with 6–14 cell storeys, branching 2–5 times; cells fusiform, ellipsoidal or obovoid, 14–70 μ m long, 6–14 μ m diam.; distal cells 6–10 μ m long, 3–4 μ m diam.; hairs absent. *Carpogonial branches* \pm straight, (9–) 12–18-celled; carpogonium \pm straight, 25–44 μ m long; base 3–4 μ m diam.; trichogyne pedicellate (rarely almost sessile), clavate to cylindrical, 4–10 μ m diam. *Carposporophytes* 1–3 per whorl, in outer cortex or exerted, the centre 170–270 μ m from node, globose, 69–125 μ m diam., 0.1–0.4 times whorl radius; gonimoblast filaments with c. 2–3 cell storeys; carposporangia obovoid, 11–18 μ m long, 7–14 μ m diam. Figs 2F, 4A.

Disjunctly distributed in permanent streams through northern and eastern Australia (N.T., far-north Qld, south-eastern Qld and N.S.W.); also in Malaysia and northern South America. Map 2.

N.T.: Wangi Falls, Litchfield Natl Park, *T.J. Entwisle* 2692 (MEL). Qld: Jardine R. above Elliot R., Cape York, *A.B. Cribb* 1038.1 (BRI); wallum stream near Paradise Cave, Noosa Heads, *A.B. Cribb* 682.1 (BRI); Cold Spring, Myora, Stradbroke Is., 9 July 1995, *G.T. Kraft* (MEL, MELU, NSW). N.S.W.: Salvation Ck, West Head Rd, Ku-Ring-Gai Natl Park, *T.J. Entwisle* 2989 (NSW).

2. *Batrachospermum discors* Entwisle & Foard, *Austral. Syst. Bot.* 10: 341 (1997), as *discorum*

T: Canungra Ck, Box Forest Circuit, Green Mtns, Lamington Natl Park, Qld, 4 Oct. 1993, *T.J. Entwisle* 2208; holo: MEL; iso: NSW.

Illustration: T.J. Entwisle & H.J. Foard, *op. cit.* 342, fig. 5.

Dioecious. *Thallus* flaccid or firm, yellow-green when dry; apices obtuse; whorls confluent, barrel- to disc-shaped, 620–1080 μ m diam.; axial cells 28–32 μ m diam.; rhizoidal filaments cylindrical or inflated, 7–26 μ m diam.; secondary fascicles common. *Primary fascicles* with a \pm abrupt change from inner to outer cells, with 12–22 cell storeys, branching 6–11 times; cells fusiform to obovoid or globose, 10–64 μ m long, 4–10 μ m diam.; distal cells 6–15 μ m long, 5–12 μ m diam.; hairs sometimes present. *Carpogonial branches* arising from rhizoidal filaments as well as primary fascicles, \pm curved, 6–15-celled; involucre filaments sometimes bearing carpogonia; carpogonium \pm straight, (?30–) 44–60 μ m long; base 5–8 μ m diam.; trichogyne sessile, clavate, ellipsoidal or fusiform, 8–14 μ m diam. *Carposporophytes* 1 or 2 per whorl, in inner cortex, the centre 120–230 μ m from node, globose, 120–185 μ m diam., 0.2–0.4 times whorl radius; gonimoblast filaments with c. 4 or 5 cell storeys; carposporangia obovoid, 17–22 μ m long, 8–11 μ m diam. Figs 3B, 4B.

Disjunctly distributed in eastern Australia (north-eastern and south-eastern Qld and north-eastern N.S.W.); also in New Zealand. Grows in permanent mountain streams. Map 3.

Qld: Dirran Ck, Atherton Tableland, 1995, *S. Bunn* (MEL). N.S.W.: Mullumbimby, Mar. 1981, *A.B. Cribb* (MEL).

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3. *Batrachospermum antipodites* Entwisle, *Muelleria* 8: 291 (1995)

T: Kondalilla Falls, Skene Ck, Kondalilla Natl Park, Qld, 6 Sept. 1993, *T.J.Entwisle 2236*; holotype: MEL; isotype: BRI.
[*Batrachospermum ectocarpum* auct. non Sirodot: T.J.Entwisle & G.T.Kraft, *Austral. J. Mar. Freshwater Res.* 35: 228 (1984)]

[*Batrachospermum boryanum* auct. non Sirodot: T.J.Entwisle, *Proc. Roy. Soc. Victoria* 101: 42 (1989)]

Illustrations: T.J.Entwisle & G.T.Kraft, *op. cit.* 229, fig. 6, as *B. ectocarpum*; T.J.Entwisle, *Proc. Roy. Soc. Victoria* 101: 41, fig. 6E–G (1989), as *B. boryanum*; T.J.Entwisle, *op. cit.* 293, fig. 1; 294, fig. 2 (1995).

Monoecious. *Thallus* flaccid, red to greyish; apices obtuse; whorls confluent or separated, globose to barrel- or disc-shaped, 330–800 µm diam.; axial cells 34–120 µm diam.; rhizoidal filaments cylindrical, 5–8 µm diam.; secondary fascicles generally absent. *Primary fascicles* somewhat audouinelloid, with 8–13 cell storeys, branching 3–7 times; cells mostly cylindrical with apical dilation at lateral branch insertion, 16–32 µm long, 2–5 µm diam.; distal cells 6–9 µm long, 3–4 µm diam.; hairs absent. *Carpogonial branches* ±straight, 6–9-celled; carpogonium ±straight, 19–39 µm long; base 3–5 µm diam.; trichogyne sessile, clavate, 4–8 µm diam. *Carposporophytes* 1 (rarely 2) per whorl, in inner or outer cortex, the centre 70–110 µm from node, globose, 70–200 µm diam., 0.5–1 times whorl radius; gonimoblast filaments with 4 or 5 cell storeys; carposporangia obovoid, 10–18 µm long, 6–12 µm diam. Figs 2B, 4C.

Widespread in the hinterland areas of eastern and south-eastern Australia, from the Atherton Tableland, Qld, to northern Tas. and south-eastern S.A.; also in New Zealand. In permanent mountain streams, usually in deeply shaded gullies. Map 4.

S.A.: Bones Ponds, near Mt Gambier, Oct. 1988, *M.Thurgate* (MEL). Qld: Wallacha Falls, tributary of North Johnstone R., *T.J.Entwisle 2269* (MEL). N.S.W.: Red Cedar Ck, W of Craven, *T.J.Entwisle 1951* (MEL). Vic.: Sassafras Ck, Monbulk–Emerald road, *T.J.Entwisle 1139* (MEL). Tas.: Cheshunt, near Deloraine, Feb. 1855, *D.Lyall* (BM, NSW).

Old thalli are often denuded of primary fascicles, but sometimes produce stunted secondary fascicles or specialised, spermatangia-bearing filaments. A *chantransia* phase of this species, growing in creeks in northern New South Wales and southern Queensland, has recently been described as a form species, *Chantransia richardsii* (Skuja) Vis, Entwisle, J.A.West & F.Ott (Vis *et al.*, 2006). This taxon was previously thought to be an independent species in the order Ceramiales.

4. *Batrachospermum kraftii* Entwisle & Foard, *Austral. Syst. Bot.* 10: 344 (1997)

T: Arve R., Hartz Mtns, Tas., 27 Dec. 1992, *G.T.Kraft*; holotype: MEL; isotype: MELU, NSW.

[*Batrachospermum gelatinosum* auct. non (L.) DC.: T.J.Entwisle, *Proc. Roy. Soc. Victoria* 101: 42 (1989), *p.p.*]

Illustrations: T.J.Entwisle, *op. cit.* 44, fig. 8E–N, as *B. gelatinosum*; T.J.Entwisle & H.J.Foard, *op. cit.* 345, fig. 7.

Dioecious (rarely monoecious). *Thallus* flaccid or firm, olive-green or brown; apices obtuse; whorls confluent, barrel- to disc-shaped, 420–1300 µm diam.; axial cells 23–52 µm diam.; rhizoidal filaments cylindrical, 4–9 µm diam.; secondary fascicles absent or few. *Primary fascicles* with 11–20 cell storeys, branching 4–8 times; cells bone-shaped, fusiform or obovoid, 6–90 µm long, 2–7 µm diam.; distal cells 5–12 µm long, 3–4 µm diam.; hairs sometimes present. *Carpogonial branches* ±slightly curved, 6–10-celled; involucre filaments profuse, short; carpogonium straight or curved, 20–40 µm long; base 3–5 µm diam.; trichogyne sessile or pedicellate, oblique-ellipsoidal (with or without an apical pimple) to scimitar-shaped, 6–10 µm diam. *Carposporophytes* 1 or 2 (or 3) per whorl, in inner cortex (rarely extending into outer cortex), the centre 90–180 µm from node, globose, 85–260 µm diam., 0.1–0.9 times whorl radius; gonimoblast filaments with 2–4 cell storeys; carpo-sporangia obovoid or tadpole-shaped, 18–26 µm long, 7–14 µm diam. Figs 3D, 4D.

Restricted to central Vic. and Tas; also in New Zealand. Grows in fast-flowing, permanent streams through tall, wet forest. Map 5.

Vic.: Watts River Falls, Watts R., Maroondah Reservoir catchment, *T.J.Entwisle 970* (MEL). Tas.: Hatfield R., Murchison Hwy crossing, *T.J.Entwisle 2586* (MEL).