

Studies on *Bacidia* (lichenized Ascomycota, *Ramalinaceae*) in temperate Australia, including Tasmania: saxicolous and terricolous species

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Abstract: Descriptions, illustrations, discussion and an identification key are presented for six saxicolous and terricolous species of the lichen genus *Bacidia* De Not. occurring in temperate Australia and Tasmania. Three species are described as new to science: *B. lithophila* Kantvilas from northern Tasmania, characterized by having only brown apothecial pigments and 3–5-septate, acicular ascospores, $23\text{--}35 \times 1.5\text{--}2.0 \mu\text{m}$; *B. littoralis* Kantvilas from Tasmania, South Australia (Kangaroo Island) and New South Wales, characterized by green and brown apothecial pigments and acicular, 3–7-septate ascospores, $24\text{--}48 \times 2.0\text{--}3.5 \mu\text{m}$; and *B. macCarthyi* Kantvilas from New South Wales, with pruinose apothecia and long, filiform, 17–25-septate ascospores, $65\text{--}115 \times 2.5\text{--}4.0 \mu\text{m}$. Three further species are reported for the region for the first time: *B. bagliettoana* (A. Massal. & de Not.) Jatta (Tasmania), *B. curvispora* Coppins & Fryday (Tasmania) and *B. scopulicola* (Nyl.) A. L. Sm. (Tasmania, Victoria).

Key words: Kangaroo Island, lichens, new records, New South Wales, new species, taxonomy, Victoria

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Introduction

The large “form genus” *Bacidia* De Not. represents one of the largest groups of lichens in the Australasian region that has yet to be subjected to focused collection, study and revision. McCarthy (2017) lists 33 names of *Bacidia* taxa occurring in Australia, most of which are based on Australian types and were described in the latter part of the 19th century, for example by Knight (1882) and Müller Argoviensis (1882, 1896). Since then, the genus has been largely neglected by lichenologists in the region. New species have been described by Coppins & Fryday (2007), Elix (2009) and Kantvilas (2017), and most major herbaria hold large numbers of specimens attributed to the genus, but which are largely unidentified or misidentified. A very preliminary account of 16 taxa occurring in New Zealand was published by Galloway (2007) who also

accounts for the numerous names based on New Zealand types (albeit often incorrectly).

Bacidia as interpreted by Zahlbruckner in his massive *Catalogus* (1921–1940) was essentially a place-holder for crustose lichens with a green, coccoid photobiont, biatorine or lecideine apothecial ascomata, 8-spored asci and hyaline, transversely multiseptate ascospores. Ekman (1996, 2001) outlined the history of the genus and traced the impact of the application of new characters in its taxonomy, notably ascus structure (Hafellner 1984), excipulum structure (Vězda 1990) and DNA-sequence data (Ekman & Wedin 2000; Ekman 2001). As a result, many ‘traditional’ Australian species of *Bacidia* are now accommodated in smaller, more natural genera; for example, *Arthrorhaphis* Th. Fr. (Obermayer 2001), *Bacidina* Vězda (Vězda 1990), *Bapalmuia* Sérus. (Kalb *et al.* 2000), *Jarmania* (Kantvilas 2008), *Sarrameana* Vězda & P. James (Kantvilas & Vězda 1996) and *Scoliciosporum* A. Massal. (Kantvilas 2008). Nevertheless, for practical reasons, the broad concept of *Bacidia* is still largely applied in many regional treatments of the genus, and Australia is no exception.

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For the last decade or so, the author has gradually accumulated data on the Australasian type specimens of many *Bacidia* species scattered throughout the world's herbaria and attempted to correlate these with modern collections, chiefly from Tasmania. *Bacidia* is highly species-rich in temperate Australia, particularly on wood, bark and leaves in forested habitats, although it appears to be notably absent from the alpine zone. A comprehensive account or revision of the genus is some way off but in this paper a preliminary treatment of saxicolous and terricolous species, a relatively small subset of taxa, is presented, offering some insights into the overlooked local diversity of the genus. It is significant that most saxicolous Australasian species are coastal, and even more so, that all but one of the coastal, saxicolous taxa described from New Zealand (Galloway 2007) have not been recorded for Australia.

Material and Methods

The study is based mainly on collections made by the author, housed in the Tasmanian Herbarium (HO), with additional material sourced from other herbaria as indicated in the text, chiefly the Australian National Herbarium (CANB). Anatomical and morphological observations were undertaken using light microscopy, with thin hand-cut sections mounted in water, 10% KOH (K), 50% HNO₃ (N), lactophenol cotton blue (LCB), ammoniacal erythrosin and Lugol's Iodine (with and without pretreatment with KOH). Ascospore measurements are based on 30–50 observations for each taxon and are presented in the format 5th percentile–average–95th percentile; outlying values are given in brackets. Chemical composition was investigated routinely by thin-layer chromatography using standard methods (Orange *et al.* 2001); solvent A was the preferred medium. Nomenclature of apothecial pigments follows Ekman (1996) and Meyer & Printzen (2000). The disposition of pigments is particularly important, and it is advisable to section both darkly pigmented and paler apothecia when examining a specimen. Pigments may also mask excipular anatomy but can usually be cleared with K, N, C or a combination of these prior to staining with LCB.

Key to the Species

- 1 Apothecia in section with greenish or greenish grey, N+ crimson-violet, K– pigments in the epithecium and/or excipulum; brownish or orange-brown pigments, ± intensifying in K or N, also present 2
Apothecia (even the darkest coloured ones) in section lacking greenish, N+ crimson-violet pigments; all pigments brownish 5
- 2(1) Ascospores fusiform, 1–3-septate, 3–5 µm wide **B. curvispora**
Ascospores filiform or acicular, at least 3–7-septate, <4 µm wide 3
- 3(2) Apothecia pruinose, weakly pigmented within, with greenish and brownish pigments restricted to the epithecium and outer edge of the excipulum; ascospores >17-septate, 65–115 µm long **B. maccarthyi**
Apothecia epruinose, usually intensely pigmented within, with the excipulum opaque or almost so; ascospores 3–7-septate, <50 µm long 4
- 4(3) On consolidated, often ± alkaline, exposed soil and pebbles; thallus granular; apothecia jet black **B. bagliettoana**
In sheltered microhabitats on littoral, siliceous rock outcrops and boulders; thallus rimose-areolate; apothecia ranging from pale to dark brown to black **B. littoralis**
- 5(1) Thallus coarsely granular-blastidiate **B. scopulicola**
Thallus smooth to rimose areolate or verruculose 6
- 6(5) Apothecia remaining ± plane; excipulum persistent, concolorous with the disc or paler, pruinose when young **B. lithophila**
Apothecia becoming markedly convex; excipulum becoming excluded, concolorous with the disc or darker, never pruinose **B. littoralis**

The Species

Bacidia bagliettoana (A. Massal. & de Not.) Jatta

Sylloge Lich. Ital.: 421 (1900); *Scoliciosporum bagliettoanum* A. Massal. & de Not. in A. Massal., *Mem. Lichenogr.*: 126 (1853).

(Figs 1A & 2A)

Thallus coarsely granular or warty, greyish white, lacking soredia and isidia, forming spreading, undelimited patches that form deep cracks as the soil substratum dries; individual granules mostly *c.* 0.12–0.25 mm wide, crowded together or overlapping, ecorticate. *Photobiont* a unicellular green alga with \pm globose cells, 5–15 \times 5–13 μ m.

Apothecia abundant, biatorine, 0.4–1 mm wide, scattered or crowded together and sometimes fused, roundish, strongly basally constricted; *disc* black, epruinose, persistently plane or becoming undulate or a little convex; *proper excipulum* concolorous with the disc, persistent but becoming inconspicuous in more convex apothecia, in section 25–40(–50) μ m thick at the sides, with a mixture of greenish epithelial and brownish hypothecial pigments (see below) at the upper edge, increasingly brownish in lower parts, most intensely pigmented at the outer edges and dilute to almost colourless within, composed of radiating, densely packed, gelatinized hyphae with elongated lumina mostly 2–2.5 μ m wide. *Hypothecium* to 150 μ m thick, usually densely interspersed with oil droplets to 6–7 μ m diam., typically two-layered with a yellowish brown or reddish brown band 30–50 μ m wide in the upper part, intensifying reddish in both K (\pm) and N, the remainder dilute reddish brown to colourless. *Hymenium* 45–55(–60) μ m thick, highly coherent in water, K and N, colourless below, grey-green to green in the uppermost part, intensifying greenish in K, N+ violet, slowly fading and precipitating into minute, dark blue crystals. *Paraphyses* mostly simple, 1.5–2 μ m thick; apices usually expanded to 3–5 μ m wide. *Asci* narrowly clavate, 40–45 \times 8–10 μ m. *Ascospores* (25–)26.5–33.3–40 \times (1.5–)2–2.1–2.5 μ m, mostly side by side within the ascus, filiform to narrowly fusiform, \pm straight or bent, with apices typically

acute, sometimes a little attenuated at one end, 3–7-septate.

Pycnidia not found.

Chemistry. No substances detected by TLC, or containing traces of a terpene similar to zeorin that is possibly a contaminant from the substratum.

Remarks. The above description is based solely on the single Tasmanian specimen available but does not deviate significantly from other published descriptions (e.g. Ekman 2004; Coppins & Aptroot 2009; Stenroos *et al.* 2016). The two pigments present in the apothecium appear to concur with Bagliettoana-green and Laurocerasi-brown of Meyer & Printzen (2000). Impersion of the hypothecium is very conspicuous and consistent in the Tasmanian specimen but has been neither recorded by other authors nor observed in reference material examined from the Northern Hemisphere. The combination of terricolous habitat, whitish granular-warty thallus, black apothecia and greenish, N+ violet epihymenial pigment (Bagliettoana-green) is very distinctive and makes this species readily distinguishable among the complement of saxicolous or terricolous *Bacidia* species known from the study area. In the field, this species is more likely to be mistaken for a member of the *Lecideaceae* s. lat., all of which have different types of asci and simple, ellipsoid ascospores. Ekman (2001) suggests this species might be better accommodated in *Tominia* A. Massal.

An enigmatic collection from soil over limestone in New South Wales, mainland Australia (*Elix* 25543, CANB), was studied closely and compared to *B. bagliettoana*. Superficially this specimen, with a minutely granular, thinly dispersed thallus, plane, red-brown to brown-black apothecia, 3–7-septate, acicular ascospores 37–55(–60) \times 2–2.5(–3) μ m and capitate paraphyses, approximates *B. herbarum* (Stizenb.) Arnold as described in various flora accounts, for example Great Britain (Coppins & Aptroot 2009), Estonia (Randlane & Saag 2004) and Spain (Llop & Hladun (2002). Yet this single, small specimen consistently displays

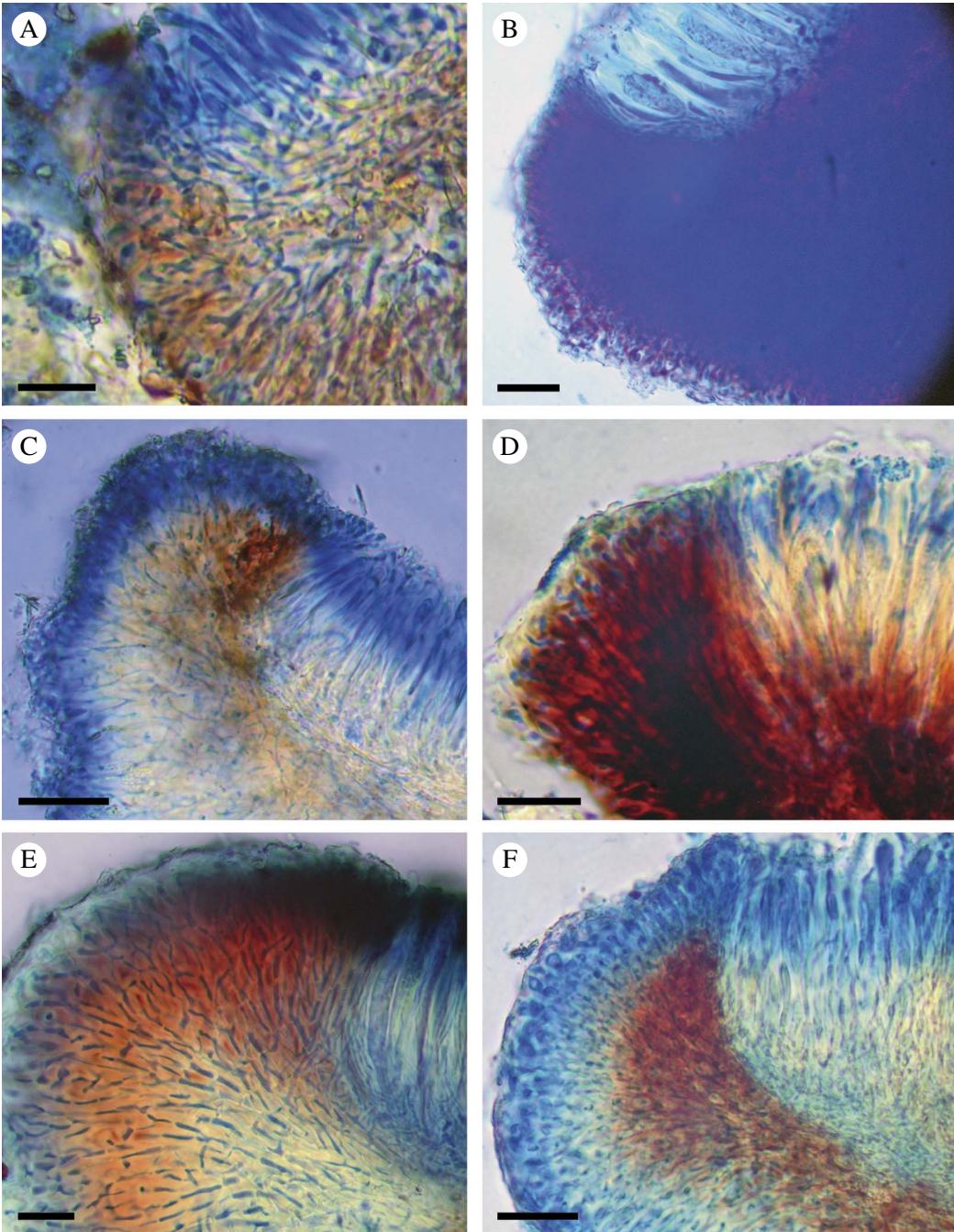


FIG. 1. Excipular structure in saxicolous *Bacidia* species, pretreated with N and stained with LCB. A, *B. bagliettoana*; B, *B. curvispora*; C, *B. lithophila*; D, *B. littoralis*; E, *B. macCarthyi*; F, *B. scopulicola*. Scales = 20 μ m.

traces of Bagliettoana-green pigment in the epithecium (N+ violet, forming dark blue crystals), a feature not noted by other workers. Nor can this specimen be shoe-horned into *B. bagliettoana* because although the apothecial pigments are consistent with that species, its ascospores are somewhat larger and, critically, the excipulum is distinctly pseudoparenchymatous at the outer edge, with several layers of cells up to 10 µm wide.

Distribution and habitat. *Bacidia bagliettoana* is a very widespread species that has been recorded from many regions of the world including Europe, North America, Asia and New Zealand. This is the first record of this species from Australia (Tasmania). The species was recorded from consolidated, dry soil and small dolerite pebbles in a gap in very sparse, eucalypt-dominated coastal woodland. Associated lichens included *Cladia aggregata* (Sw.) Nyl., *Diploschistes thumbergianus* Lumbsch & Vězda, *Lecidella sublaticida* (C. Knight) Hertel, *Paraporpidia glauca* (Taylor) Rambold, *Psora decipiens* (Hedw.) Hoffm. and *Trapelia crystallifera* Kantvilas & Elix.

Specimen examined. **Australia:** *Tasmania:* Hellfire Bluff, secondary peak, WSW of summit, 42°44'S, 147°55'E, 215 m, 2013, *G. Kantvilas* 167/13 (HO).

Comparative material examined. **Italy:** *Calabria:* Consenza, Saracena, Piano di Novacco, 1340 m, 1990, *D. Puntillo* (*A. Vězda: Lich. Sel. Exsicc.* 2456) (HO).—**USA:** *Nebraska:* Valley County, David Creek State Wildlife Management Area, 41°24'96"N, 98°46'57"W, 1960 ft, 2010, *M. K. Advaita* 9357 (*Lich. Eastern N. America Exsicc.* 9: 426) (CANB, HO).

***Bacidia curvispora* Coppins & Fryday**

Biblioth. Lichenol. 95: 156 (2007); type: New Zealand, Campbell Island, along shore at east side of Tucker Cove, 9 Jan. 1970, *H. A. Imshaug* 46738 (MSC—holotype; CANB!, HO!—isotypes).

(Figs 1B & 2B)

Thallus very variable, mostly very thin (to 120 µm thick), rimose-areolate, pale greyish brown, less commonly composed of grey-brown to grey-green, convex areoles 0.3–0.5 mm wide and to 0.5 mm thick, continuous, or patchy and interrupted by grains of the

substratum, usually lacking a prothallus and not delimited, lacking soredia and isidia, ecorticate. **Photobiont** a unicellular green alga with ellipsoid to ± globose cells, 6–18 × 5–12 µm.

Apothecia abundant, lecideine, 0.3–1 mm wide, usually scattered and roundish, less commonly clustered and misshapen, strongly basally constricted; **disc** grey-brown, black-brown to black, sometimes a little mottled, epruinose, plane at first, sometimes persistently so or becoming strongly convex; **proper excipulum** concolorous with or a little darker than the disc, persistent in plane apothecia or becoming inconspicuous and reflexed in the most convex apothecia, in section 50–80 µm thick at the sides, ± entirely opaque dark red-brown to black brown, K± purple-brown, N+ crimson to crimson-brown, composed of a reticulum of branched and anastomosing hyphae 1.5–2 µm thick, densely encased with pigment, terminal cells not enlarged. **Hypothecium** typically opaque and not differentiated from the opaque proper excipulum below, commonly greenish black to red-brown to black-brown, K± purple-brown, N+ crimson, together with the excipulum massive and to 200 µm thick, more rarely less intensely pigmented greenish grey, N+ violet, 60–75 µm thick, containing occasional oil droplets. **Hymenium** (50–)60–75(–80) µm thick, coherent in water and to a lesser extent in K, becoming lax in N, mostly colourless but usually with a patchy, dilute greyish green band in the upper part, K–, N+ violet, also commonly overlain by a patchy layer of minute, colourless crystals that very slowly turn N+ blue. **Paraphyses** simple, 1.5–2.5 µm thick; apices usually gradually expanded slightly to 2.5–4.0 µm wide. **Asci** narrowly clavate, 50–60 × 12–16 µm. **Ascospores** (13–)14–16.6–20 × 3–4.0–5 µm, spiralled within the ascus, narrowly ellipsoid to fusiform, bent or sigmoid, with apices rounded, (0–)1–3(–4)-septate.

Pycnidia immersed or semi-immersed and visible as blackish, perithecia-like specks to 0.12 mm wide; **conidia** filiform, typically very strongly bent, 15–25(–30) × 0.7 µm.

Chemistry. Traces of a zeorin-like terpene detected by TLC.

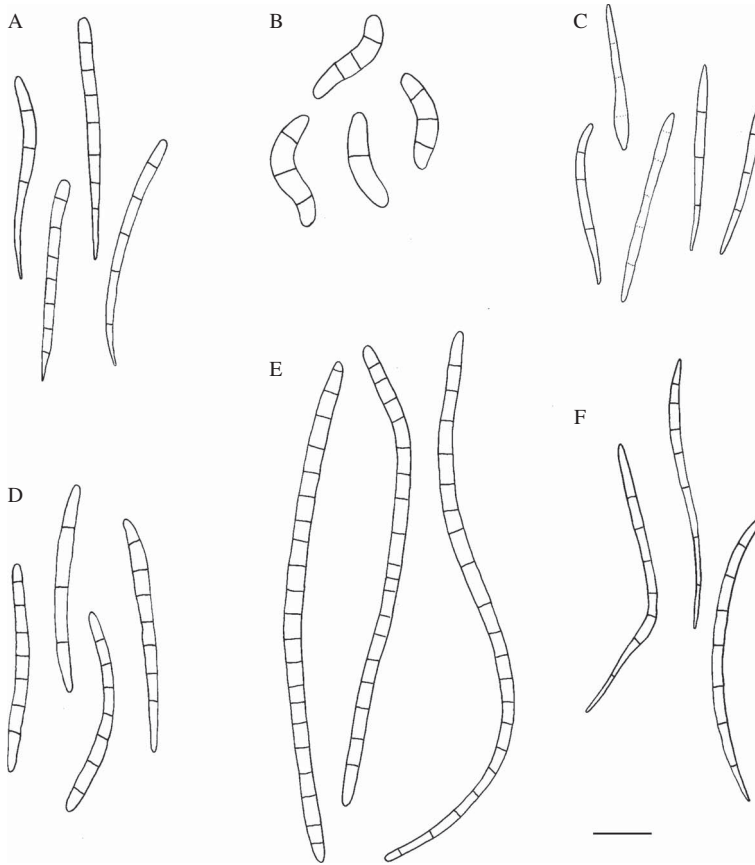


FIG. 2. Ascospores of saxicolous *Bacidia* species. A, *B. bagliettoana*; B, *B. curvispora*; C, *B. lithophila*; D, *B. littoralis*; E, *B. maccarthyi*; F, *B. scopulicola*. Scale = 10 μ m.

Remarks. The curved, 3-septate ascospores of this species readily distinguish it from all others in the study area although the suite of apothecial pigments is also found in some other species. Four saxicolous species with 3-septate ascospores were described from New Zealand by Zahlbruckner (1941) but all of these have different pigments and ascospores (also noted by Coppins & Fryday 2007). The Tasmanian populations of *B. curvispora* consistently display some subtle differences from the collections from Campbell Island on which the original description was based, viz. a taller hymenium (only 45–52 μ m in Coppins & Fryday 2007), wider ascospores (only 3–3.5 μ m; Coppins & Fryday 2007) and longer conidia (14–19 μ m; Coppins & Fryday 2007). These differences

were confirmed by checking type material but are not considered sufficient to warrant separate taxonomic recognition, at least not on the basis of available specimens.

Two main pigments are present in this species. The brownish one that dominates the excipulum is Laurocerasi-brown and reacts a purplish brown in K and reddish brown to crimson in N. The greenish grey pigment appears to be Bagliettoana-green; it reacts N+ violet but is \pm unchanged in K. With pretreatment in N, it reacts grubby brown in K and subsequently crimson-brown in HCl. Its characterization can be tricky because it is usually mixed in most parts of the apothecium (except the epihymenium where it is very dilute) with Laurocerasi-brown. The N+ blue crystals can

be easily overlooked as they take several minutes to develop. They occur commonly in the epihymenium and in the thalline tissue surrounding the apothecium. Colourless crystals may be present elsewhere in the thallus but do not react in N. Both Ekman (1996) and Meyer & Printzen (2000) attribute N+ blue crystals to Bagliettoana-green, the former author considering their occurrence variable and inconsistent. The concentration of this pigment appears to depend on habitat and is greatest in thalli exposed to direct sunlight; one Tasmanian specimen lacked any greenish pigments. In the same way, the thallus is highly variable and best developed in more exposed habitats.

Distribution and ecology. This species has been recorded from the relatively high-rainfall, exposed southern and western coasts of Tasmania where it occurs on the sheltered faces of littoral boulders. These are habitats where there would be intermittent influences of sea water, from splashing or direct inundation during storm surges. Lichens with which it has been recorded include *Amandinea otagoensis* (Zahlbr.) Blaha & H. Mayrhofer, *Caloplaca* sp., *Catillaria glaucogrisea* Fryday, *Halecama* sp., *Hydropunctaria maura* (Wahlenb.) C. Keller et al., *Megalaria grossa* (Pers. ex Nyl.) Hafellner and *Verrucaria aucklandica* Zahlbr.

Specimens examined. **Australia:** *Tasmania:* Lion Rock, 43°36'S, 146°49'E, 1 m, 2013, *G. Kantvilas* 27/13, 29/13 (HO); between mouths of Italian and Lagoon Rivers (Dago Plains vicinity), 41°30'S, 144°49'E, 3 m, 2015, *G. Kantvilas* 108/15 (HO); Lime Bay Nature Reserve, c. 1 km N of Plunkett Point, 42°59'S, 147°43'E, 1 m, 2016, *G. Kantvilas* 124/16, 257/16 (HO).

***Bacidia lithophila* Kantvilas sp. nov.**

Mycobank No.: MB 824761

Thallo effuso, rimoso-areolato, apotheciis brunneis, margine persistenti, saepe pruinoso, disco plano, pigmentosis virellis N+ carmesinis destitutis, ascosporis acicularibus, 23–35 µm longis, 1.5–2 µm latis, indistincte 3–5-septatis, et conidiis filiformibus curvatisque, 15–20 µm longis recognita.

Typus: Australia, Tasmania, Bakers Beach, at foot of Archers Knob, 41°08'S, 146°37'E, 5 m elev., on somewhat sheltered, inclined surfaces of large boulders in coastal scrubby woodland, 6 May 2017, *G. Kantvilas* 86/17 (holotypus—HO).

(Figs 1C, 2C, 3A)

Thallus effuse, rather scurfy and very thin, becoming rimose-areolate and to 250 µm thick where best developed, grey-green to green, undelimited, mostly rather patchy and interrupted by areas of uncolonized substratum, lacking soredia or isidia, ecorticate. *Photobiont* a unicellular green alga with roundish to globose cells, 5–15 × 6–12 µm.

Apothecia biatorine, 0.2–0.6 mm wide, roundish, scattered or occasionally crowded together, basally constricted; *disc* pale pinkish brown to brown, epruinose, mostly persistently plane, only occasionally becoming undulate to convex; *proper excipulum* concolorous with the disc or a little paler, but usually with a thin dark brown inner edge immediately surrounding the disc, mostly distinct and persistent and becoming inconspicuous and reflexed only in the most convex apothecia, often with a thin, coarse, pale grey pruina, in section 35–60 µm thick at the sides, colourless except for a pale to dark brown inner band, K+ grubby olive-brown, unchanged in N, composed of a rather loose reticulum of radiating, branched and anastomosing hyphae c. 2 µm wide with narrow, elongate lumina, the outermost cells in older apothecia typically becoming pseudo-parenchymatous and up to 4–7 µm wide. *Hypothecium* 30–100 µm thick, pale brown to brown (as in the excipulum), not interspersed. *Hymenium* 48–55 µm thick, colourless, typically coherent in water, K and N. *Paraphyses* mostly simple, 1–1.5 µm thick; apices gradually expanded to 2–4 µm wide. *Asci* narrowly clavate, 42–48 × 7–10 µm. *Ascospores* 23–28.3–34(–35) × 1.5–1.8–2 µm, mostly side by side within the ascus, acicular, with apices blunt or acute, attenuated at the distal end, very obscurely 3–5-septate.

Pycnidia pale brownish, sunken into the upper surface of the thallus and resembling apothecial initials; *conidia* filiform, non-septate, mostly strongly bent, 15–20 × 0.5 µm.

Chemistry. No substances detected by TLC.

Etymology. The specific epithet is derived from the Greek 'lithos' (λίθος, meaning rock) and 'philo' (φιλο, meaning loving) and alludes to the habitat of this lichen.

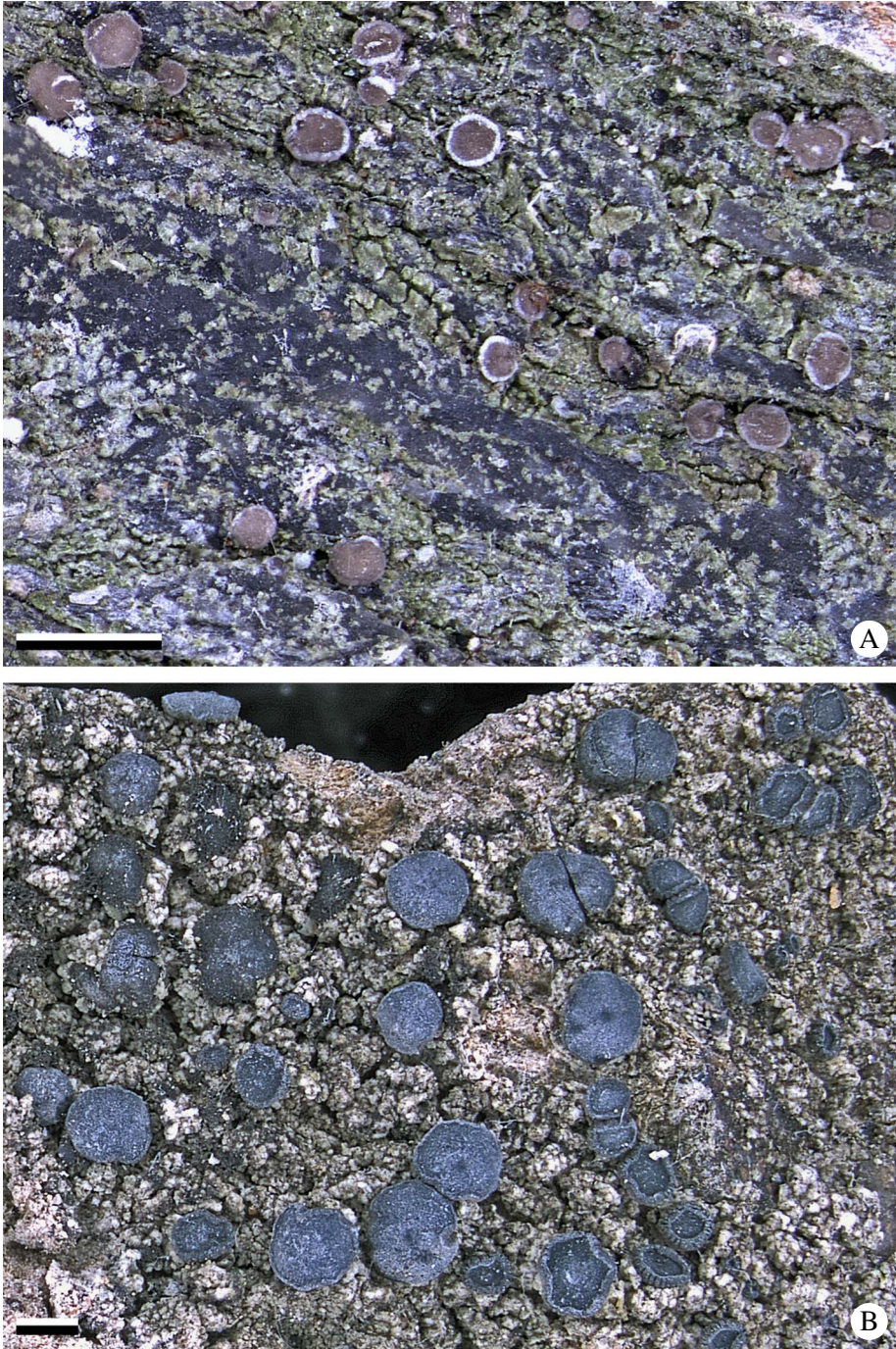


FIG. 3. Habit of new *Bacidia* species. A, *B. lithophila*; note the apothecia with a pale grey, pruinose margin. B, *B. macCarthyi*. Scales = 1 mm.

Remarks. This new species is characterized by an effuse to rimose-areolate thallus, brown apothecia with a persistent, often pruinose margin and plane disc, the absence of any greenish, N+ crimson-violet pigments (Bagliettoana-green), relatively short, acicular ascospores and filiform, simple conidia. These characters readily separate it from the other species known from the study area. For example, whereas it may occur together with *B. littoralis* (even on the same rock surface), that species is easily distinguished by soon developing convex apothecia in which the margin is excluded, by lacking pruina and by containing Bagliettoana-green (albeit sometimes in dilute concentrations). The same pigment, as well as significantly longer ascospores, distinguish *B. macCarthyi* from the new species. *Bacidia scopulicola*, which also occurs in similar habitats to *B. lithophila* and *B. littoralis*, has a distinctly blastidiate-granular thallus as well as a very characteristic disposition of apothecial pigmentation. I have been unable to match the new taxon with any species cited in literature accounts of *Bacidia*, nor with any reference specimens seen in various herbaria.

The brown pigment in the new species occurs in rather dilute concentrations but appears to approximate Arnoldiana-brown of Ekman (1996) and Meyer & Printzen (2000). It turns a grubby olive-brown in K, is unchanged in N, but is brown in K after pretreatment with N. The pigment is certainly not Laurocerasi-brown which predominates in most of the species studied. Arnoldiana-brown is not widely distributed in the genus; for example, Ekman (1996) records it in only three corticolous species in his North American study. In some respects, the new species shares some features with *Bacidina arnoldiana* (Körb.) V. Wirth & Vězda (e.g. brown apothecia with occasionally pruinose margins, disposition of pigments, dimensions of ascospores) but the latter differs unequivocally in that it has a *Bacidina*-type, pseudoparenchymatous exciple. In contrast, the excipulum of *B. lithophila* consists of a loose reticulum of thin hyphae in a gel matrix; the hyphae become very lax in both K and N. The outermost cells (or several layers of cells),

particularly on the lower, outer edge of the exciple of older apothecia, may become expanded but in no way approach a *Bacidina*-type exciple.

The new species was also compared to the *B. rubella* group but taxa of this group differ chiefly by the presence of *rubella*-orange pigment and by often having crystals in the excipulum (Llop *et al.* 2007). Interestingly, clusters of minute, rod-shaped crystals to 2 µm long were sometimes observed in the excipulum and hypothecium of *B. lithophila* but these neither refract polarized light nor dissolve in K.

Distribution and ecology. The new species is known only from the type collection and, given the extent of field surveys in Tasmania in search of *Bacidia* species, it appears to be rather uncommon. At the type locality, it was observed on just a few large boulders of a Precambrian, schistose quartzwacke beneath a rather dense, shady, low closed canopy of *Pomaderris apetala* (*Rhamnaceae*) and *Melaleuca ericifolia* (*Myrtaceae*) that formed a low, moist scrub behind coastal sand dunes. The species grew on the inclined, overhanging faces of rocks in a rather pure colony, uninterrupted by other lichens but with fragments of a *Lepraria* species nearby. *Bacidia littoralis* also grew on the same boulders and the fact that the two species grew side by side facilitated the recognition of this new taxon.

***Bacidia littoralis* Kantvilas sp. nov.**

Mycobank No.: MB 824762

Thallo plerumque aequato rimosoque vel verruculoso, interdum ad marginem prothallo griseo byssoido, apotheciis variabilibus, pallide subroseobrunneis vel griseobrunneis vel atris, mox valde convexis et margine excluso, typice epithecio pigmentum griseoviridem, N+ carmesinum continenti, et ascosporis acicularibus, 3–7-septatis, 24–48 µm longis, 2–3.5 µm latis recognita.

Typus: Australia, Tasmania, Bonnet Island, Macquarie Harbour, 42°13'S, 145°13'E, 1 m elev., in damp sheltered underhangs on quartzitic littoral boulders, 14 May 2013, G. Kantvilas 139/13 (holotypus—HO).

(Figs 1D, 2D, 4)

Thallus smooth and rather waxy, or rimose, or scurfy, lumpy-verruculose, mostly rather patchy and reflecting the contours of the

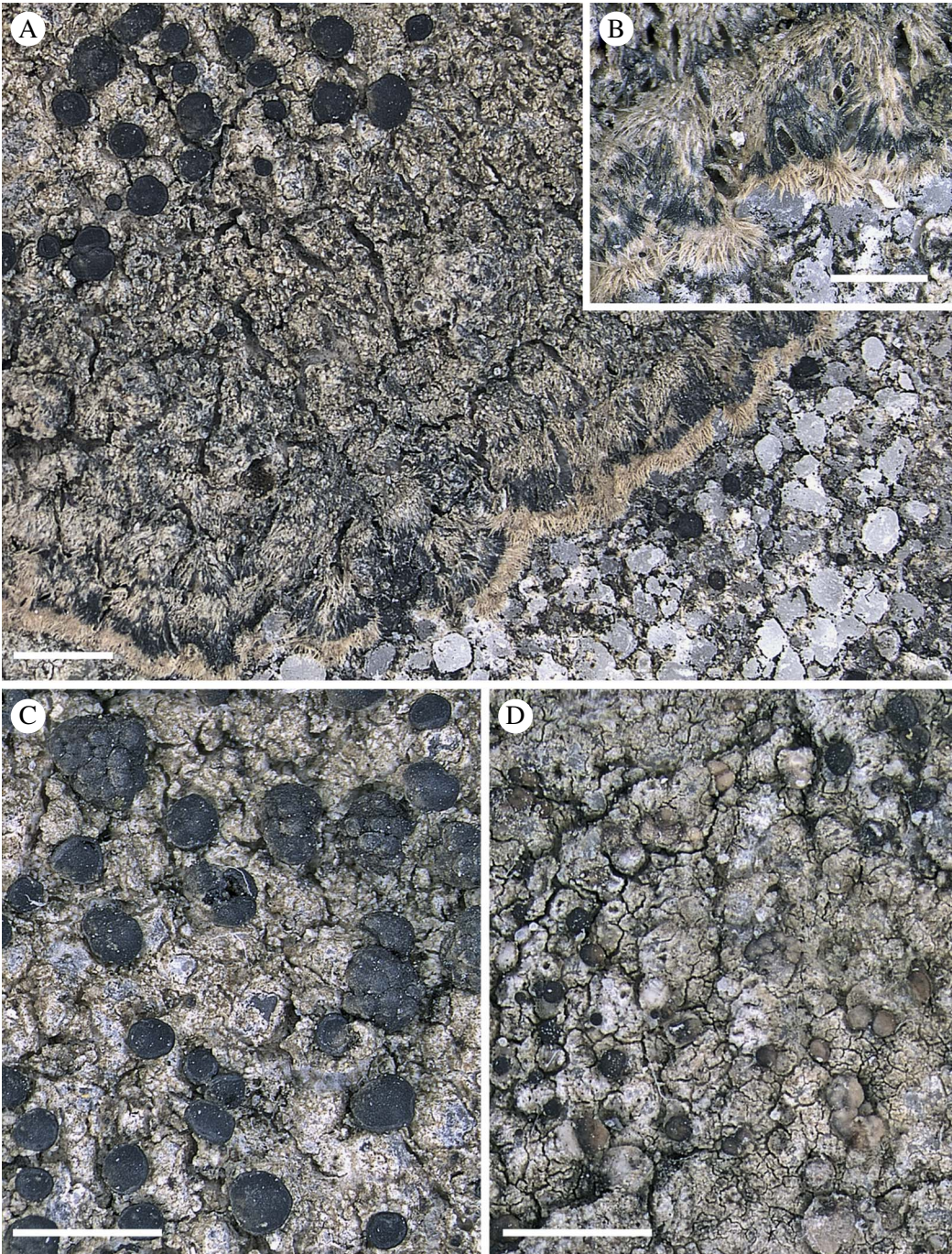


FIG. 4. *Bacidia littoralis* habit, showing variation in thalli from a single population (Bonnet Island, Tasmania). A, coarsely scurfy thallus with black apothecia and a byssoid, marginal prothallus; B, detail of prothallus; C, typical brown-black apothecia; D, piebald or pallid apothecia. Scales: A, C & D = 2 mm; B = 1 mm.

substratum, very thin or to 200 µm thick (or more) when lumpy, pale grey-green to pale olive-brownish, mostly undelimited but occasionally with a greyish, ± byssoid-arachnoid prothallus to 0.2 mm wide at the leading edge, lacking soredia or isidia, ecorticate. *Photobiont* a unicellular green alga with ± globose cells, 5–15 × 5–13 µm.

Apothecia typically very abundant, biatorine to lecideine, 0.3–0.9(–1) mm wide, usually scattered and roundish, less commonly crowded together and contorted, strongly basally constricted; *disc* pale pinkish brown to mottled pink-grey, to greyish brown, brown-black or entirely black, epruinose, plane at first but usually soon becoming strongly convex; *proper excipulum* typically darker than the disc, dark brown to black, becoming inconspicuous, reflexed or ± excluded in the most convex apothecia, in section (30–)50–80 µm thick at the sides, red-brown at the edges, or intensely red-brown with a somewhat paler edge, or entirely opaque dark red-brown, composed of radiating, branched and anastomosing hyphae 2.5–3.5 µm wide, with the outermost cells not expanded, or at most with lumina ellipsoid to rectangular and sometimes to 4(–7) µm wide, excipular pigment K± purple-brown, N+ intensifying orange-brown, sometimes also with grey-green, K–, N+ crimson-violet pigment at the edges. *Hypothecium* 60–100 µm thick, dilute red-brown (sometimes darkest adjacent to the hymenium) in paler coloured apothecia, or becoming massive, to 220 µm thick, opaque dark red-brown throughout and indistinguishable from the excipulum; hypothecial pigments as in the excipulum. *Hymenium* 50–70 µm thick, typically coherent in water and to a lesser extent in K, becoming more lax in N, ± colourless or, more commonly, with a dilute to rather intense greyish green, K–, N+ crimson-violet pigment forming an epithecium, or diffusing in bands through the entire hymenium or concentrated in the lower part, in paler apothecia with the N+ crimson pigment dilute to absent, and the epithecium with a dilute brownish pigment, N+ weakly orange and dissolving. *Paraphyses* simple or

sparsely branched, 1.5–2.5 µm thick; apices slightly expanded or sometimes markedly capitate and with a ± globose terminal cell to 4.5–6 µm wide. *Asci* narrowly clavate, (35–)40–62 × (8–)10–15 µm. *Ascospores* (24–)26–33.4–40(–48) × 2–2.6–3(–3.5) µm, spiralled or side by side within the ascus, acicular to very narrowly fusiform, ± straight or bent, with apices typically acute, sometimes a little attenuated at one end, 3–7(–8)-septate.

Pycnidia typically common and scattered, 0.1–0.2 mm wide, immersed in the thallus or sunken into the upper surface, visible as a dark, N+ crimson-purple (in section) rim and a flesh-coloured centre. *Conidia* filiform, typically very strongly bent, of two types: 15–28 × 0.5–0.8 µm (typically) or 7–15 × 0.5–1.0 µm.

Chemistry. No substances detected by TLC.

Etymology. The specific epithet refers to the seashore habitat of the new species.

Remarks. Superficially the new species displays some similarities to the widespread Northern Hemisphere taxon, *Bacidina inundata* (Fr.) Vězda, at least as depicted, for example, by Stenroos *et al.* (2016). Beyond that, however, the two taxa have little in common. One major difference between the two is the pigmentation of the excipulum and hypothecium. In *B. inundata*, these tissues are hyaline or at most only weakly pigmented, whereas in *B. littoralis* they are usually intensely pigmented and opaque. Furthermore, the greenish pigment appears to be absent or extremely dilute in *B. inundata*. More critically, *B. inundata* has a *Bacidina*-type excipulum where the outermost cells become expanded and ± pseudoparenchymatous. Macroscopically, the apothecial margin in *B. inundata* is generally paler than (or concolorous with) the disc, whereas in *B. littoralis* it is concolorous or darker. In *B. littoralis*, the excipulum is often opaque in section and so its structure can be difficult to observe, but pretreatment in N or C and subsequent staining with LCB revealed only thin hyphae with narrow lumina. To some extent the two species occupy somewhat analogous

ecological niches (see below), although *B. inundata* is associated with fresh water and has been recorded from wood as well as rock, whereas *B. littoralis* is exclusively saxicolous along the seashore or nearby. Also occurring in similar habitats are the New Zealand species *B. subcerina* Zahlbr. and *B. tholera* Zahlbr. (type specimens in W and CHR examined), both of which have narrowly fusiform ascospores wider than 3.5 µm; the former differs further by having pale, flesh-coloured apothecia lacking any dark pigments.

Bacidia littoralis is a remarkably variable species with respect to thallus morphology, external coloration and internal pigmentation of the apothecia, ascospore septation and conidial length. So great is the variation that, were there not numerous large herbarium collections available, often with multiple gatherings from the same localities accompanied by field observations, one could easily conclude that several (or certainly at least two) taxa are involved.

The texture of the thallus of *B. littoralis* depends to a large extent on the texture of the substratum. On smooth surfaces, the thallus is usually relatively even and rimose. On very uneven, coarse, highly crystalline rock surfaces (and most specimens are from such substrata), the thallus becomes extremely scurfy and lumpy. The thallus is probably also influenced by habitat and specimens from coarse rocks, collected in very damp underhangs, have the lumpiest, thickest thallus. Also variable is the development of a prothallus, with some specimens or parts of specimens showing a very obvious, byssoid prothallus whereas others have no hint of this feature at all. Such a prothallus is found also in *B. inundata* (as illustrated by Stenroos *et al.* 2016) and in the type specimen of the New Zealand species *B. albozonata* Zahlbr. (a synonym of *B. subcerina*).

Variation in the pigmentation of the apothecia is remarkable but a wide range, from pale, flesh-coloured apothecia through piebald, greyish ones to grey-black to jet black, can be seen in a single population (for example amongst the Bonnet Island specimens; Fig. 4) or even in a single large specimen. In section, at one extreme, are

lightly pigmented apothecia with a relatively weakly reddish brown excipulum, especially at the outer edge, an unpigmented or only weakly red-brown pigmented hypothecium, and an almost unpigmented hymenium with just traces of a greenish grey epithelial pigment (detected by the N⁺ reaction). At the other extreme, and again displayed within a single collection or population, are black or dark grey apothecia where the excipulum and hypothecium together form a uniformly opaque, red-brown tissue, and the hymenium contains a large amount of the greyish, N⁺ crimson-violet pigment, either in the epithelial layer, in the lower hymenium or in vertical bands throughout the hymenium. The orange-brown pigment is Laurocerasi-brown whereas the green or greenish grey epithelial pigment is probably Bagliettoana-green. The greenish hue depends on its concentration: it barely intensifies in K whereas in N it turns a crimson to crimson-violet, again depending on the overall intensity. Using the method described by Meyer & Printzen (2000), after pretreatment with N, the pigment turns greenish in KOH and then crimson following application of HCl. The precipitation of blue crystals following application of N was observed in only very few sections.

With respect to ascospore septation, most spores are either 3-septate or 7-septate and spores with an intermediate number of septa are rarely encountered. Some specimens or apothecia are predominantly either 3- or 7-septate, but both 3- and 7-septate spores may be observed in the same apothecial section. The number of septa does not appear to be related to ascospore size as some of the longer spores may be only 3-septate whereas some of the shorter ones may be 7-septate.

The variation in conidial length is curious. Specimens from western and southern Tasmania (including the type) all have long conidia (15–28 µm). The specimens from Kangaroo Island, New South Wales, Bakers Beach in northern Tasmania, and from Lime Bay, south-eastern Tasmania, all consistently show shorter conidia (7–15 µm). Interestingly these are also specimens where the greyish green epithelial pigment is most dilute or absent, even in the outwardly

darkest apothecia. However, no additional anatomical or morphological characters could be found that correlate with the conical size difference. The problem requires further investigation, especially with additional collections from other areas, but the complete allopatry of the two forms and their discrete geographical distribution suggest that a cryptic taxon might be lurking within what is included here under the one taxon. The Lime Bay specimen (*Kantvilas* 249/16) is even more curious in that it has jet black apothecia that anatomically concur with the most intensely pigmented examples of *B. littoralis*, but its thallus consists of highly dispersed, yellowish green, bullate areoles, 0.2–0.4 mm wide and to 0.25–0.35 mm thick.

Distribution and habitat. This species is locally abundant along the high-rainfall southern, western and northern coasts of Tasmania, with disjunct collections from south-eastern Tasmania, southern New South Wales and Kangaroo Island, South Australia. It occurs on a range of non-calcareous rock types (dolerite, basalt, granite, quartzite, serpentinite). Most collections are from along the seashore, usually in damp, sheltered, shaded underhangs but well within the splash zone of the sea, especially when the waters are rough. In Tasmania, lichens that have been recorded growing with this species include *Bacidia curvispora*, *Buellia stellulata* (Taylor) Mudd, *Enterographa* sp., *Ochrolechia apiculata* Versegny, *Porina corrugata* Müll. Arg., *P. whinrayi* P. M. McCarthy, *Thelenella tasmanica* H. Mayrhofer & P. M. McCarthy, species of *Verrucaria* s. lat. and *Xanthoria ligulata* (Körb.) P. James. On Kangaroo Island, it occurs a little inland but nevertheless near the coast where some marine influences prevail. Here it was recorded with *Caloplaca gallowayi* S. Y. Kondr. et al., *Fuscopannaria decipiens* (P. M. Jørg. & D. J. Galloway) P. M. Jørg., *Lecidella sublapicida* (C. Knight) Hertel, *Megalaria grossa* (C. Knight) Hertel, *Porina guentheri* (Flot.) Zahlbr., *Pseudocyphellaria neglecta* (Müll. Arg.) H. Magn., *Rinodina oxydata* (A. Massal.) A. Massal. and *Verrucaria fusconigrescens* Nyl.

Specimens examined. **Australia:** *Tasmania:* Couta Rocks, 41°10'S, 144°41'E, 1 m, 1993, *G. Kantvilas* 301/93 & *J. A. Elix* (HO); Granville Harbour, 41°48'S, 145°03'E, 3 m, 2013, *G. Kantvilas* 117/13, 118/13 (BM, HO, UPS); Bonnet Island, 42°13'S, 145°13'E, 1 m, 2013, *G. Kantvilas* 122/13, 137/13, 140/13 (HO); Trial Harbour, 41°56'S, 145°10'E, 2 m, 2014, *G. Kantvilas* 421/14 (HO); mouth of Interview River, 41°35'S, 144°53'E, 3 m, 2015, *G. Kantvilas* 141/15, 145/15 (HO); Interview River, upstream from mouth, 41°35'S, 144°53'E, 3 m, 2015, *G. Kantvilas* 154/15 (HO); Stony Point, 40°45'S, 144°59'E, 2 m, 2016, *G. Kantvilas* 290/16 (HO); Lime Bay, c. 1 km N of Plunkett Point, 42°59'S, 147°43'E, 2 m, 2016, *G. Kantvilas* 249/16 (HO); Snake Point, Recherche Bay, 43°34'S, 146°54'E, 1 m, 2017, *G. Kantvilas* 14/17, 15/17 (HO); Bakers Beach, at foot of Archers Knob, 41°08'S, 146°37'E, 5 m, 2017, *G. Kantvilas* 56/17, 85/17, 87/17, 88/17 (HO). *South Australia, Kangaroo Island:* Billygoat Falls, 35°42'S, 136°55'E, 200 m, 2012, *G. Kantvilas* 785/12 (HO). *New South Wales:* Barling Beach, 1 m, 2016, *P. M. McCarthy* 4552 (HO).

Bacidia maccarthyi Kantvilas sp. nov.

MycoBank No.: MB 824763

Apotheciis leviter pruinosis, 0.5–1.5 mm latis, pigmenta laurocerasi-brunneum et bagliettoana-viridem continentibus et igitur *B. septosiori* (Nyl.) Zahlbr. similis sed excipulo crystallis non-insperso et ascosporis aliquantum angustioribus, 65–115 µm longis, 3–4 µm latis, 17–25-septatis differt.

Typus: Australia, New South Wales, South Coast, Barlings Beach, on sheltered shale on seashore, 1 m elev., 19 November 2016, *P. M. McCarthy* 4539 (HO—holotypus).

(Figs 1E, 2E, 3B)

Thallus composed of rather scurfy granules, 0.07–0.15 mm wide, that coalesce tightly into a coarse, undelimited, loosely attached, uneven, dull greyish green crust c. 1 mm thick; prothallus absent. *Photobiont* chlorococcoid, with cells globose, 5–12 µm diam.

Apothecia biatorine, 0.5–1.5 mm diam., scattered, rather urceolate when young, soon becoming disciform, basally constricted; *disc* persistently plane or becoming undulate or a little convex, brown-black to black, matt, lightly grey pruinose; *proper excipulum* persistent, pale red-brown, rather inrolled, crenulate and radially striate when young, later becoming brown-black to black, mostly pruinose around the rim, in section 90–140 µm thick, at the upper edge red-brown to brown,

K \pm purple-brown, N $+$ orange, elsewhere \pm colourless, composed of radiating, branched and anastomosing, rather stout hyphae 2–5(–8) μ m thick with mostly elongate cells. *Hypothecium* 70–140 μ m thick, pale yellowish, intensifying yellowish in K and N in the upper part, colourless below. *Hymenium* 100–130 μ m thick, colourless, not interspersed, overlain by a grey-green epithelial layer *c.* 5–10 μ m thick, K \pm intensifying greenish, N $+$ purple, sometimes rather fleetingly so and then fading to pale orange and forming a precipitate of minute, dark blue crystals. *Paraphyses* 1.5–2 μ m thick; apices usually expanded to *c.* 4 μ m, remaining conglutinated in epithelial pigment. *Asci* narrowly cylindrical, 78–95 \times 12–15 μ m. *Ascospores* arranged side by side or loosely coiled in the ascus, filiform to acicular, with apices rounded or attenuated at the distal end, easily fractured, (65–)70–83–100(–115) \times (2.5–)3–3.4–4 μ m, 17–25 + -septate.

Pycnidia very rare, immersed; *conidia* filiform, strongly curved, simple, 15–25 \times 0.5 μ m.

Chemistry. No substances detected by TLC.

Etymology. Named in honour of my friend and colleague, Patrick McCarthy, who collected and generously provided me with the type specimen.

Remarks. With its relatively large apothecia that are rather urceolate when young and having a pale brown proper margin, the lightly grey-pruinose disc, Bagliettoana-green pigmented epithecium, essentially unpigmented excipulum (apart from Laurocerasi-brown at the upper edge) and long, filiform, multi-septate ascospores, *B. macCarthyi* is reminiscent of the coastal, southern Australian, corticolous species, *B. septosior* (Nyl.) Zahlbr. (see Kantvilas 2017 for description and illustrations). There the similarities end, however, and the two taxa display critical differences (in addition to their choice of substratum). Most significant is the structure of the excipulum which, in *B. septosior*, is comprised of rather slender hyphae, 1–1.5 μ m thick, in a gel matrix, interspersed with bands of angular crystals, whereas in *B. macCarthyi* the

excipulum is striking in that the hyphae are packed together (without an obvious matrix) and have stout, rectangular to rhomboidal cells. Furthermore, the ascospores are distinctly broader in *B. septosior* (4–6 μ m). In both species the spores are extremely fragile and fracture easily, and, as a result, locating intact examples for measuring is difficult. Consequently, the spore measurements given for *B. macCarthyi* may well be an underestimate as it is the longest spores that are most easily broken. Macroscopically, the two species also differ in the disposition of the apothecial pruina. In the new species, the pruina are a very fine, almost cobweb-like, light ‘dusting’ across the entire upper surface of the apothecium, whereas in *B. septosior* the pruina are coarser and eventually restricted to the inner edge of the excipulum.

Distribution and habitat. The single specimen was collected from a sheltered aspect on coastal shale outcrops. Also collected at the site was *B. littoralis*. No further details are known.

***Bacidia scopulicola* (Nyl.) A. L. Sm.**

Monogr. Br. Lich. 2: 156 (1911); *Lecidea scopulicola* Nyl., *Flora* 57: 312 (1874).

(Figs 1F & 2F)

Thallus entirely coarsely granular or blastidiate, pale greenish when fresh, later becoming pale fawn-brown, forming a thick, patchy or continuous, loosely attached, undelimited crust; individual granules mostly *c.* 30–60 μ m wide. *Photobiont* a unicellular green alga with \pm globose cells, 4–15 \times 4–11 μ m.

Apothecia biatorine, 0.4–0.7 mm wide, scattered, superficial or nestled amongst the thallus granules; *disc* pale to dark reddish brown, or a little greyish brown when older, epruinose, plane to undulate; *proper excipulum* pale brown, \pm concolorous with the disc or a little paler, persistent or becoming inconspicuous in older apothecia, in section 45–60 μ m thick at the sides, 120–190 μ m at the base, \pm two-layered with the inner part deep orange-brown, intensifying in K and N, and an

outer, colourless or weakly yellowish brown outer layer, 10–50 µm thick, composed of radiating, densely packed, gelatinized hyphae with elongated lumina mostly 2–2.5 µm wide, but with the outermost cells frequently expanded to 5–7 µm. *Hypothecium* poorly differentiated from the excipulum, to c. 20–50 µm thick, orange-brown, not inspersed. *Hymenium* 55–65 µm thick, highly coherent in water, K and N, mostly colourless, or pale orange-brown in the uppermost and lowermost parts, not inspersed. *Paraphyses* simple, 1–2 µm thick; apices mostly capitate, to 2.5–5.0 µm wide, not pigmented. *Asci* narrowly cylindrical, 44–60 × 6–10 µm. *Ascospores* (30–)32–40.1–51 (–52) × 1.5–1.9–2(–2.5) µm, side by side (mostly) or coiled within the ascus, acicular, ± straight or bent, with apices acute, usually attenuated at the distal end, 3–7-septate.

Pycnidia immersed, reddish brown; *conidia* thread-like, strongly curved, 15–25 × 0.7 µm.

Chemistry. No substances detected by TLC.

Remarks. This is the first Australasian report of a species that is widespread in coastal areas of Europe, North America and the Azores (Coppins & Aptroot 2009). Australian specimens were compared to published descriptions (Brand *et al.* 2009; Coppins & Aptroot 2009) and to reference material from the British Isles. The Australian material differs chiefly by having an entirely granular-blastidiate thallus (with no thick, areolate areas); nor does it develop a wispy prothallus as seen at the margins of some European specimens. Although with abundant apothecia, few mature ascospores free of their asci could be located, and many apothecia were eroded or contaminated with the brown hyphae of an unidentified fungus. *Bacidia scopulicola* is easily recognized in the study area by its granular thallus, reddish brown apothecia, filiform ascospores and complete absence of Bagliettoana-green, N+ crimson or violet pigment. In younger, well-formed, reddish brown apothecia, the dominant orange-brown pigment intensifies somewhat in K and N and appears to accord with Rubella-orange, which has been

reported in Northern Hemisphere material (Brand *et al.* 2009). However, in older, darker apothecia with some greyish tones, there is also a hint of a K+ dull reddish reaction, suggesting that additional Laurocerasi-brown might also be present. This was also seen in older apothecia in specimens from Britain. The New Zealand species, *B. subcerina*, also has red-brown apothecia with Rubella-orange but there the pigment is diffused throughout the excipulum (not disposed in layers) and the ascospores are fusiform and 3-septate.

Distribution and habitat. The Victorian collections are from coastal rocks and are not accompanied by further label information regarding their ecology. In Tasmania, the species is known from a single general area where it is occasional and highly localized on coarse sandstone on low cliffs with a shaded, southerly aspect. The locality is remarkable in that *Bacidia scopulicola* grows together with a very unusual suite of species that includes some which are unknown elsewhere in Tasmania: species of *Catillaria* and *Gliostomum* (both presumed to be undescribed), *Opegrapha conferta* auct., *Caloplaca kilcundaensis* S. Y. Kondr. & Kärnefelt, *Lecidea ochroleuca* Pers., *Paraporpidia leptocarpa* (C. Bab. & Mitt.) Rambold & Hertel and *Xanthoparmelia verrucella* (Essl.) O. Blanco *et al.* Furthermore, similarly unusual taxa occurred nearby.

Specimens examined. **Australia:** *Tasmania:* Frogmore Peninsula, 1 km NW of Midway Point, 42°47'S, 147°31'E, 5 m alt., 1986, *A. Moscal* 11492 (HO); same locality, 2 m alt., 2017, *G. Kantvilas* 125/17 (HO). *Victoria:* East Gippsland, Quarry Beach, 6 km SW of Mallacoota, 37°36'03"S, 149°43'41"E, 1–3 m alt., 2016, *J. A. Elix* 46258, 46259 (CANB, HO).

Comparative material examined. **Great Britain:** *Scotland:* V.C. 112, Shetland, Sumburgh, 2011, *A. M. Coppins* 23628 (E). V.C. 104, Isle of Skye, Trotternich, Drium an Rumm, 1991, *A. Fryday* 2429 (E); North Ebuades, Raasay, headland 6 km S of Oskraig, 2009, *B. J. Coppins* & *A. M. Coppins* 23362 (E).

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