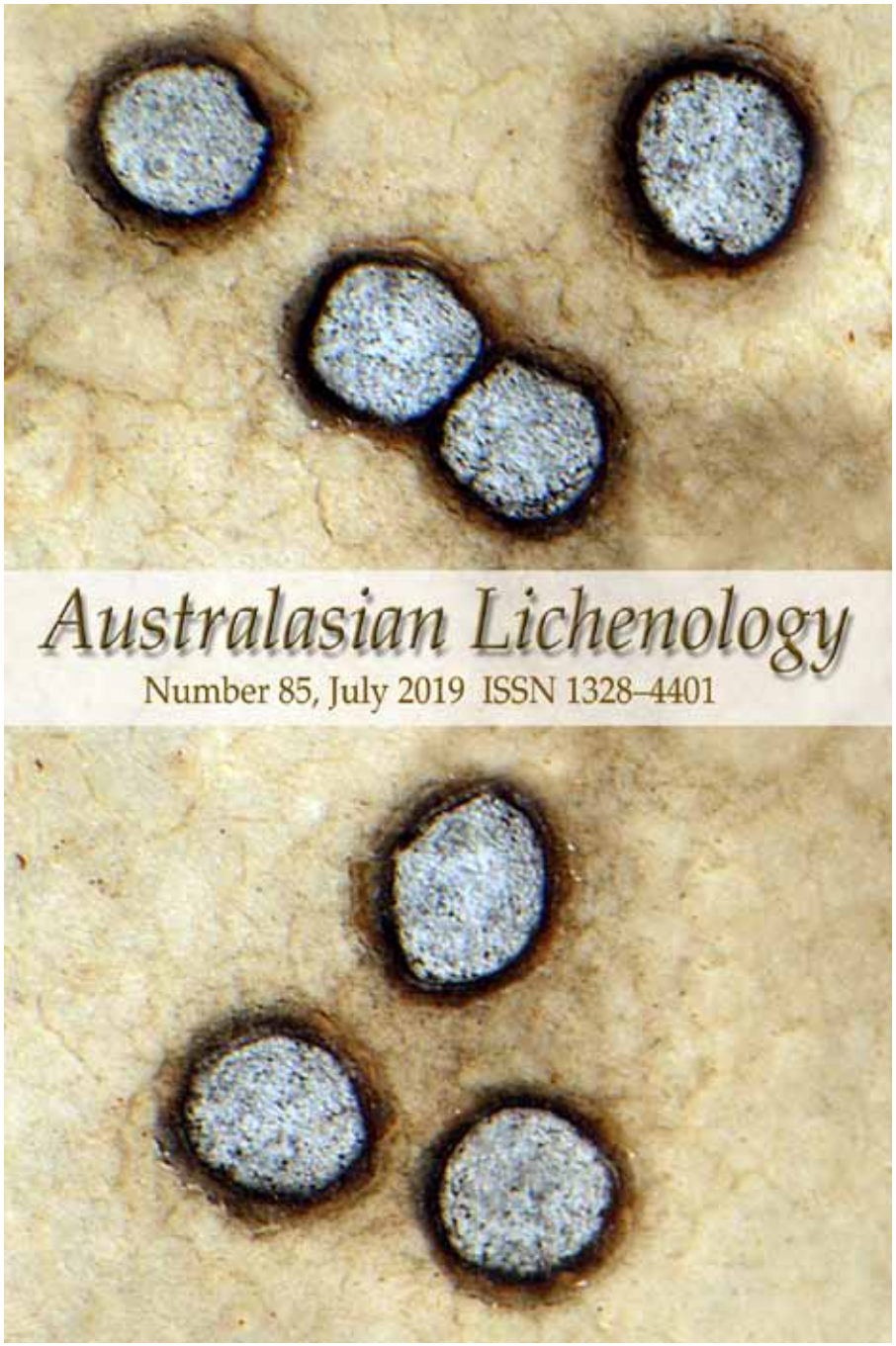

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Porpidia albocaerulescens is nearly cosmopolitan. In Australia and New Zealand, it's widespread on rock in lowland sites (often maritime), and is readily recognized by its thick creamy thallus and sunken apothecia with dark margins and strongly white-pruinose discs. The ascospores are large and one-celled, with a gelatinous halo. Two chemotypes are known. The major lichen substance is stictic acid in one of them (var. *albocaerulescens*) and norstictic acid in the other (var. *polycarpiza*).

1 mm

CONTENTS

A new saxicolous species of *Fellhanera* (lichenized Ascomycota, Pilocarpaceae) from eastern New South Wales, Australia

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Abstract
Fellhanera pluviosilvestris sp. nov. (Pilocarpaceae) is described from siliceous rock in cool-temperate rainforest in eastern New South Wales, Australia. It has a thin, continuous, greyish brown thallus that lacks lichen substances, medium-sized, sessile, biatorine apothecia with a dull blackish disc and a paler proper margin, a uniformly pale, paraplectenchymatous and cupulate excipulum, a dark brown, K+ orange-brown hypothecium and epihymenium, and (4–)8-spored, *Byssoloma*-type asci with ellipsoid to oblong, (1–)3-septate ascospores measuring 10–18 × 4.5–7.5 µm.

Introduction

Fellhanera Vězda (Pilocarpaceae), a genus of *c.* 75 species, is most diverse and predominantly foliicolous at tropical and subtropical latitudes (Vězda 1986; Sérusiaux 1996; Lücking 2008). It also occurs in temperate regions, where it is more likely to grow on bark or rock (van den Boom 2004; Aptroot *et al.* 2009; Harris & Lendemer 2009). The thallus is crustose, with a chlorococcoid photobiont, and the variously coloured, mostly sessile, biatorine apothecia have a paraplectenchymatous excipulum, mostly simple to sparingly branched paraphyses, *Byssoloma*-type asci and hyaline and transversely septate to muriform ascospores. Immersed to sessile pycnidia produce minute and usually pyriform to bacilliform conidia. Fifteen species are known from Australia (McCarthy 2018), all but four being obligately foliicolous. In this contribution, a new saxicolous species, *F. pluviosilvestris*, is described from siliceous rock in cool-temperate rainforest in eastern New South Wales.

Fellhanera pluviosilvestris P.M.McCarthy & Elix sp. nov. Figs 1, 2

MycoBank No.: **MB 830073**
Thallus thin, continuous, greyish brown, lacking lichen substances. Apothecia biatorine, sessile, 0.28–0.70 mm diam., with a dull blackish disc and a paler proper margin; proper excipulum uniformly pale in thin section, cupulate, paraplectenchymatous; hypothecium and epihymenium dark brown, K+ orange-brown; asci (4–)8-spored, *Byssoloma*-type, with ellipsoid to oblong, (1–)3-septate ascospores, 10–18 × 4.5–7.5 µm; pycnidia and conidia not seen.

Type: Australia. New South Wales, Central Tablelands, Jerusalem Creek Falls, Chichester State Forest, 19 km NNE of Dungog, 32°15'S, 151°44'E, 350 m alt., on siliceous rock on the ground in cool-temperate rainforest, *J.A. Elix 25047*, 27.iv.1990 (holotype — CANB).

Thallus crustose, epilithic, continuous to very sparingly rimose, forming discrete colonies to at least 5 cm wide, pale to medium greyish brown, to 80 µm thick, minutely and obscurely rugulose-verruculose, lacking isidia, soredia, blastidia and goniocysts. *Algae* green, globose, 8–13 µm diam., rather thick-walled. *Medulla* poorly delimited, not containing calcium oxalate (H_2SO_4–); hyphae 1.5–2(–3) µm wide, short-celled. *Thallus margin* thin, effuse; prothallus not apparent. *Apothecia* sparse and scattered at maturity (but very numerous as apothecial initials *c.* 50 µm wide), subsessile to sessile and constricted at the base, biatorine, usually

solitary, rounded to irregular, sometimes with undulate or shallowly lobate margins, (0.28–) 0.51(–0.70) mm diam. [*n* = 31], occasionally proliferating as irregular, convex clusters up to 1.3 mm wide, consisting of 5–10(–15) apothecia that are distorted by mutual pressure; proper margin ± concolorous with or a little darker than the thallus, smooth, dull to slightly glossy, entire or unevenly flexuose, 30–60 µm thick in surface view, persistent, slightly prominent; disc dull brownish or greyish black, smooth, usually plane, otherwise slightly convex, epruinose. *Thalline margin* absent. *Proper excipulum* well-developed, uniformly colourless to pale yellowish brown in thin section, cupulate, paraplectenchymatous, K–, N–, I– or I+ pale lilac, not containing calcium oxalate crystals (H_2SO_4–), 25–50(–60) µm thick laterally, 40–70 µm thick at the base; cells of the lateral excipulum ± uniform, rounded and comparatively thick-walled, 4–8 µm wide; cells of the excipular base, thinner-walled, rectangular and vertically elongate, 7–13 × 5–10 µm. *Epihymenium* 5–8(–10) µm thick, dark brown, not inspersed, K+ orange-brown, N+ deep rust-brown. *Hypothecium* dark brown, 45–60 µm thick, ± paraplectenchymatous, the cells 2–3 µm wide, K+ orange-brown, I–, N+ deep rust-brown; base sharply delimited from the excipulum, merging more gradually with the hymenium above. *Hymenium* 50–65 µm thick, uniformly pale greenish brown or with darker vertical streaks extending from the epihymenium or hypothecium, not inspersed with granules or oil globules, KI+ blue. *Paraphyses* tightly conglutinate in water, loosening in K, mostly unbranched, although sparingly branched and with sparse anastomoses below the apices, long-celled, 1–2 µm thick; apices not or scarcely swollen, not pigmented or pale brown. *Asci* narrowly to broadly clavate or cylindroclavate, 44–60 × 10–14 µm, 8-spored or with 4 spores aborting early, *Byssoloma*-type (Hafellner 1984). *Ascospores* colourless, irregularly biseriate or overlapping-uniseriate in the ascus, (1–)3-septate at maturity, narrowly or broadly ellipsoid to oblong-ellipsoid or narrowly ovoid, usually straight, occasionally a little bent, often slightly constricted at the septa, occasionally markedly constricted at the primary septum, (10–)14(–18) × (4.5–)6(–7.5) µm [*n* = 35], thin- to rather-thick-walled, often with a perispore *c.* 1 µm when 1-septate, perispore not or scarcely apparent when 3-septate; apices rounded to subacute; contents clear. *Pycnidia* absent.

Chemistry: No lichen substances detected by TLC.

Etymology: From the Latin *pluvius* (rainy) and *silvestris* (of the forest), in reference to the habitat of the new species.

Remarks

Other exclusively or predominantly saxicolous species of *Fellhanera* with transversely 3-septate ascospores include *F. nashii* van den Boom from northern Mexico (van den Boom 2004) and *F. granulosa* R.C.Harris & Lendemer from eastern U.S.A. (Harris & Lendemer 2009). Both taxa have blastidiate thalli; the former contains atranorin and probably divaricatic acid (van den Boom 2004), and the hypothecium is yellowish brown to reddish brown and up to 30 µm thick, while *F. granulosa* lacks lichen substances but produces smaller apothecia than those of *F. pluviosilvestris*, with blackish discs and more-or-less concolorous margins (Harris & Lendemer 2009). Apothecia of similar size and external colour are also seen in the eastern North American *F. silicis* R.C.Harris & Ladd and *F. fallax* R.C.Harris & Lendemer, both of which, like the new Australian species, lack asexual propagules. However, the hypothecium and epihymenium of *F. silicis* are K+ purple, while these tissues are K– in *F. fallax* and K+ orange-brown in *F. pluviosilvestris*. The two American species have comparatively narrow, fusiform ascospores mostly 4–5 µm wide.

Three other species of *Fellhanera* are known from siliceous rocks in Australia. The almost cosmopolitan *F. bouteillei* (Desm.) Vězda, which usually grows on leaves, has a bluish grey or bluish green, granulose thallus containing usnic and isousnic acids, pale yellowish to orange-brown or pale brown apothecia 0.1–0.4 mm diam. and 1-septate ascospores (van den Boom 2004; Lücking 2008; Aptroot *et al.* 2009), while the recently described *F. robusta* P.M.McCarthy & Elix, from coastal rock in southern New South Wales, also has 1-septate ascospores; it is characterized by its thick, variously verrucose, bullate or contorted, whitish thallus containing atranorin and norgangaleoidin and concolorous apothecia that are heavily impregnated with calcium oxalate (McCarthy & Elix 2017). The third Australian taxon, the endemic *F. tropica* Elix from the Northern Territory, has a pale green, granulose thallus containing 4,5-dichlorolichexanthone (major) and zeorin (major), pale to dark brown apothecia and 3–5-septate ascospores, 15–20 × 4–6 µm (Elix 2008).

Fellhanera pluviosilvestris is known only from the type locality in eastern New South Wales, where it grows on siliceous rock in cool-temperate rainforest. Associated species include *Chiodecton leptosporum* Müll.Arg., *Cladia aggregata* (Sm.) Nyl., *Heterodermia koyana* (Kurok.) Elix, *Paraporpidia* sp., *Parmeliella* sp. and *Trapelia coarctata* (Sm.) M.Choisy.

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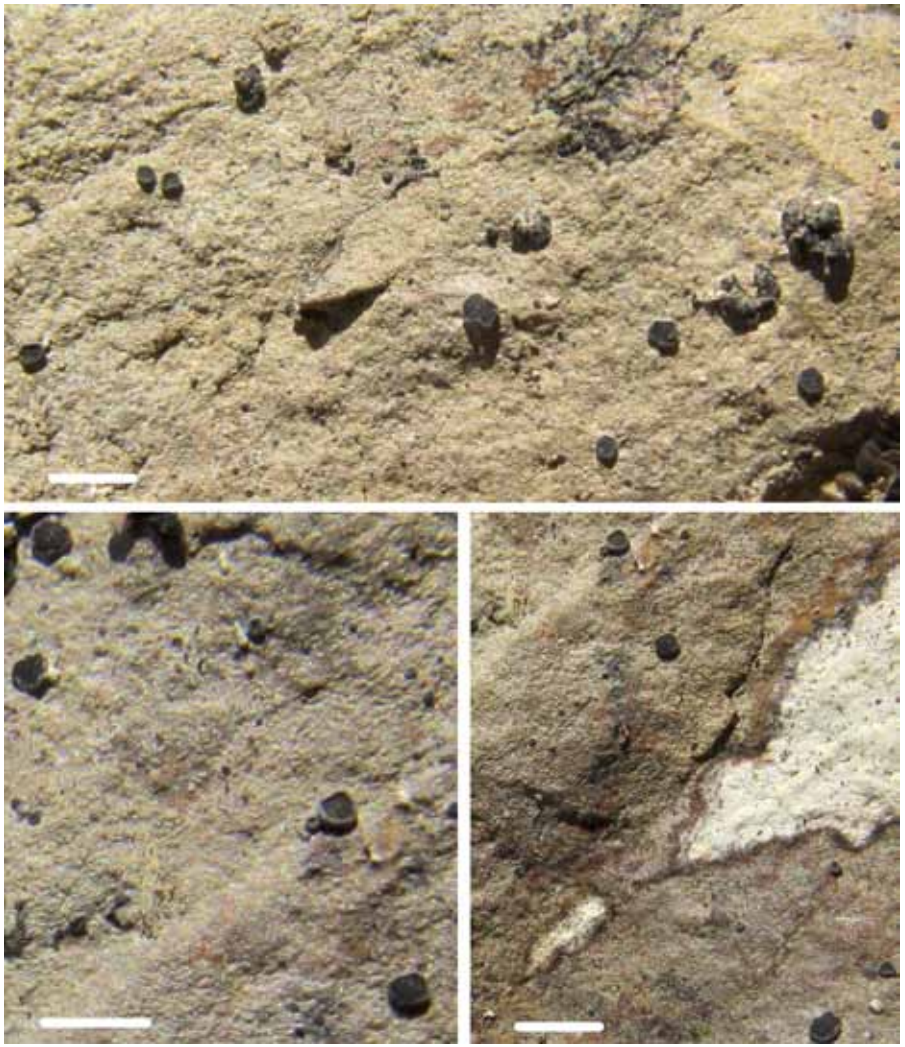

Figure 1. *Fellhanera pluviosilvestris* (holotype). Scales: 2 mm.

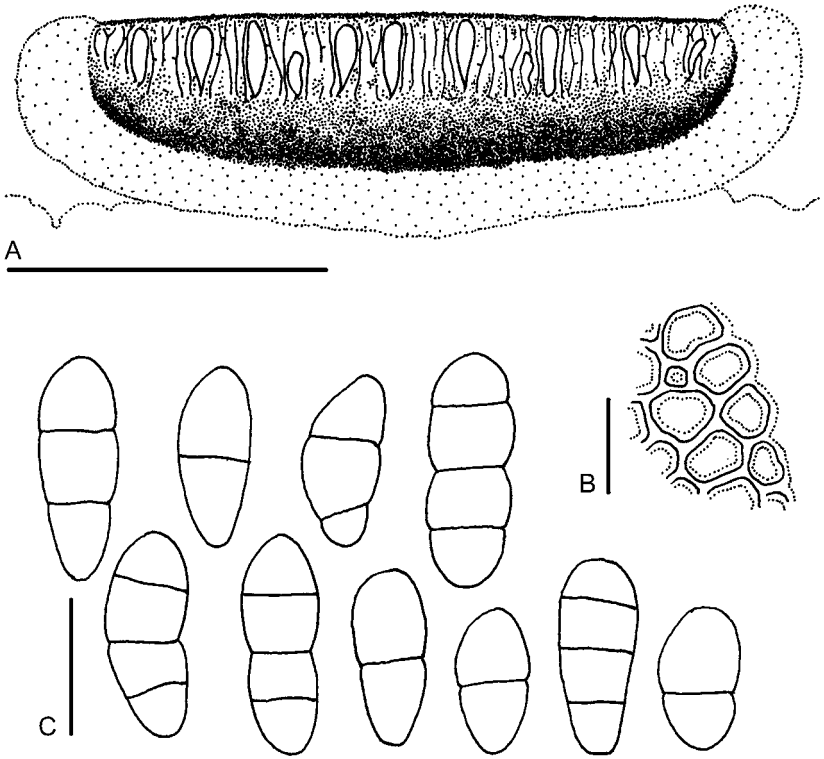

Figure 2. *Fellhanera pluviosilvestris* (holotype). A, Vertical section of an apothecium (semi-schematic); B, Outer cells of the lateral excipulum; C, Ascospores. Scales: A = 0.2 mm; B, C = 10 µm.

Arthonia cryptica (Arthoniaceae), a new lichen species from coastal rock in southern New South Wales, Australia

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Abstract
Arthonia cryptica sp. nov. (Arthoniaceae) is described from coastal siliceous rock in southern New South Wales. The dull whitish thallus is effuse and patchy, containing a trentepohlioid photobiont, and it lacks lichen substances. Ascomata are blackish, rounded, immarginate and 0.18–0.52 mm wide; the hypothecium is thin, hyaline and inspersed with granules; paraphysoids anastomosing; asci (6–)8-spored, broadly clavate to obpyriform; ascospores colourless, 3-septate, 12–16 × 4–6.5 µm. Pycnidia are black and minutely punctiform, producing ellipsoid or oblong to oblong-obovoid conidia 2.5–6 × 1–2.5 µm.

Introduction

Arthonia, a cosmopolitan genus of more than 300 species, includes lichenized taxa on all substrata, as well as non-lichenized fungi, lichenicolous parasites and other lichen-associated entities. Thirty-eight lichenized species are included in the most recent Australian checklist (McCarthy 2018). However, many reports are doubtful, most taxa require a thorough re-assessment, with many others awaiting identification among herbarium holdings. Globally, only a small minority of *Arthonia* species are saxicolous, with just one, *A. lapidicola* (Taylor) Branth & Rostrup, having been confirmed from Australia (McCarthy & Elix 2017). In this paper, a second saxicolous species, *A. cryptica*, is described as new from siliceous seashore rocks on the south coast of New South Wales.

Arthonia cryptica P.M.McCarthy & Elix, sp. nov. Figs 1, 2
MycoBank No.: **MB 830074**

Thallus crustose, dull whitish, effuse and patchy, to 100(–200) µm thick, with a trentepohlioid photobiont, lacking lichen substances. Ascomata innate to semi-immersed, dull black, ± rounded, with a vestigial excipulum, 0.18–0.52 mm wide; epihymenium dark olive-brown; hypothecium 40–80 µm thick, hyaline, inspersed with granules; paraphysoids anastomosing; asci (6–)8-spored, broadly clavate to obpyriform, 29–42 × 15–21 µm; ascospores colourless, 3-septate, narrowly ellipsoid to oblong, 12–16 × 4–6.5 µm. Pycnidia black above, punctiform, 50–70 µm wide; conidia ellipsoid or oblong to oblong-obovoid, 2.5–6 × 1–2.5 µm.

Type: Australia: New South Wales, South Coast, Ben Boyd National Park, Green Cape Peninsula, Bittangabee Bay, 37°13'00"S, 150°01'04"E, *c.* 1.5 m alt., on sheltered, vertical, coarse sandstone, south-facing with overhanging trees, adjacent to high-water mark on a sandy beach, *P.M. McCarthy 4749*, 21.iii.2018 (holotype – CANB).

Thallus crustose, epilithic, effuse and patchy between projecting crystals, dull whitish, to 100(–200) µm thick, ecorticate. *Algal layer* to 50 µm thick, continuous or not beneath the ascomata; cells trentepohlioid, globose to broadly ellipsoid, 6–13 × 6–11 µm, scarcely forming filaments; interstitial hyphae a loose weft, short-celled, 2–3 µm wide. *Medulla* loose, impregnated with rock fragments and crystals, I–, not containing calcium oxalate (H_2SO_4–). *Prothallus* not apparent. *Ascomata* numerous, innate to semi-immersed in the thallus, resembling apothecia, outwardly immarginate at all stages of development, usually solitary or in 2s or 3s, rounded, broadly ellipsoid or more irregular in outline, (0.18–)0.37(–0.52) mm in maximum extent [*n* = 30]; disc dull black, plane to slightly or moderately convex, smooth to slightly uneven, epruinose. *Proper excipulum* vestigial, narrowly annular, 8–12 µm thick laterally and greenish brown to dark brown, of elongate-periclinal hyphae 1–2 µm wide, hyaline to dark brown below and 10–15 µm thick, K+ greenish grey, N+ orange-brown. *Hypothecium* hyaline, inspersed with minute granules, 40–80 µm thick in the centre of the ascoma, consisting of downwardly directed, anastomosing hyphae 1–1.5 µm thick, K–, N–. *Hymenium* hyaline or very pale greenish, 40–50 µm thick, not inspersed with granules or oil globules; hymenial gel KI+ blue. *Epihymenium* dark olive-brown, 10–15 µm thick, K+ greenish grey, N+ orange-brown. *Paraphysoids* with abundant anastomoses, forming a compact reticulum about the asci, 0.7–1.2 µm wide, short-celled; apices not or only very slightly swollen. *Asci* (6–)8-spored, broadly clavate to obpyriform, 29–42 × 15–21 µm [*n* = 10]; stalk with an abruptly swollen base 4–5 µm wide; apex rounded, with a thick, weakly amyloid tholus when submature (usually scarcely apparent at maturity) and a bluntly conical ocular chamber. *Ascospores* colourless, 3-septate, massed in the ascus, narrowly ellipsoid to oblong, then sometimes with a broader distal end, not or slightly constricted at the septa (especially the primary septum), with rounded ends, or the proximal end subacute, thin-walled, lacking a perispore, (12–)14(–16) × (4–)5.5(–6.5) µm [*n* = 50]; locules similar in size; contents commonly guttulate (guttules clearing in K). *Pycnidia* sparse, solitary, immersed in the thallus, greenish black, punctiform and 50–70 µm wide above, hyaline below; conidiophores simple or furcate, 10–17 × 1.5–2 µm; conidia narrowly to broadly ellipsoid or oblong to oblong-obovoid, 2.5–5(–6) × 1–2(–2.5) µm.
Chemistry: No substances detected by TLC.

Etymology: From the Greek *kryptos* (hidden, secret), in reference to the effuse thallus and ascomata that are almost completely obscured by minute rock fragments and crystals.

Remarks

The type specimen of the very inconspicuous *Arthonia cryptica* was collected purely by chance. Other saxicolous species include *A. atlantica* P.James, known from coastal siliceous rocks in north-western Europe. It has a similar thallus and broadly similar ascomata to those of *A. cryptica* (although the latter are usually elongate or stellate), but the ascospores are 16–24 × 6–7 µm, the upper cell enlarged and old ascospores becoming brown, while two chemosyndromes contain either confluentic acid or stictic acid (Coppins & Aptroot 2009). *Arthonia phaeobaea* (Norman) Norman, occurs on coastal siliceous rocks in western Europe and North America. It has a brownish thallus with a chlorococcoid photobiont and 3–5-septate spores of 17–30 × 5–7 µm (Coppins & Aptroot 2009). *Arthonia arthonioides* (Ach.) A.L.Sm., from siliceous rock and bark in Europe and North America, has a rather thick, whitish thallus, rounded, convex ascomata and ascospores rather similar to those of *A. cryptica*. Critically, however, the hypothecium is dark brown and 100–300 µm (Coppins & Aptroot 2009).

Arthonia madreana Egea & Torrente, known from coastal rocks in southern California, has a similarly effuse, white thallus, but it is thicker than *A. cryptica* and contains confluentic acid. The ascomata are immersed and up to 1.2 mm wide, and while the ascospores are rather similar to those of the new Australian species in terms of size and septation, the conidia are very different, being filiform and 14–20 × 1 µm (Egea & Torrente 1995; Grube 2007). Another New World species, the Brazilian *A. saxistellata* Aptroot & M.Cáceres, has a pale ochraceous to pale orange thallus, apothecia in confluent groups, and clavate, 3-septate spores 12–13 × 3–4.5 µm (Aptroot & Cáceres 2018).

One other saxicolous species, *A. lapidicola* (Taylor) Branth & Rostrup, is known from Australia. While it usually grows on limestone or at least on base-rich rocks, mainly in the northern temperate to boreal latitudes, it was also found on shale on a sheltered seashore cliff in southern New South Wales (McCarthy & Elix 2017). It has a chlorococcoid photobiont, small, blackish apothecia on a thin and rather nondescript thallus, a thick, dark brown hypothecium, mostly soleiform, 1-septate ascospores and bacilliform conidia.

The new species is known only from sheltered, coarse-grained, siliceous seashore rocks in Ben Boyd National Park, southern New South Wales, Australia. Associated lichens in-

clude *Bacidia* sp., *Bapalmuia rotatilis* P.M.McCarthy & Elix (previously known only as a corticole), *Caloplaca* sp., *Ochrolechia apiculata* Verseghy, *Opegrapha aff. spodopolia* Nyl., several species each of Caliciaceae, Parmeliaceae and Physciaceae, *Porina heterocarpa* P.M.McCarthy, *P. rhaphidiophora* (Nyl.) Müll.Arg. and *Pseudocyphellaria* sp.

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McCarthy, PM; Elix, JA (2017): Five new lichen species (Ascomycota) and a new record from southern New South Wales, Australia. *Telopea* **20**, 335–353.

Figure 1. *Arthonia cryptica* (holotype). Scale: 2 mm.

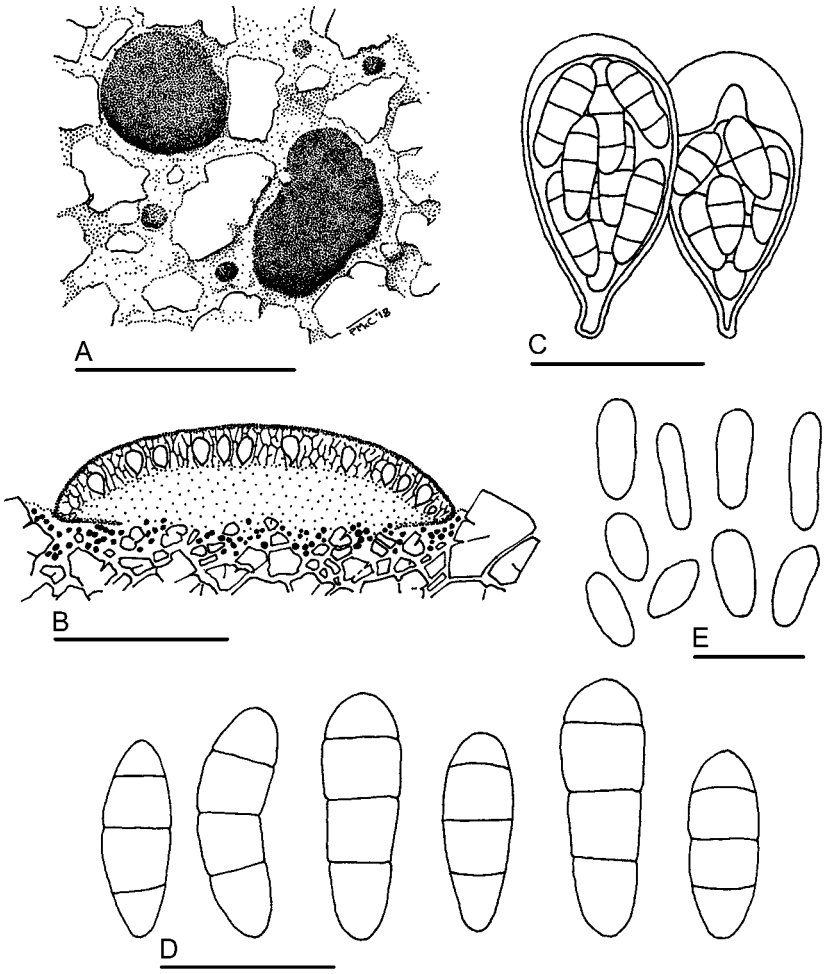

Figure 2. *Arthonia cryptica* (holotype). A, Habit of thallus, two ascomata and four pycnidia; B, Vertical section of an ascoma (semi-schematic); C, Mature (left) and submature asci; D, Ascospores; E, Conidia. Scales: A = 0.5 mm; B = 0.2 mm; C = 20 µm; D = 10 µm; E = 5 µm.

Placidiopsis parva (lichenized Ascomycota, Verrucariaceae), a new species from siliceous rocks in the Australian Capital Territory

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Abstract
Placidiopsis parva P.M.McCarthy (Verrucariaceae) is described from siliceous rocks in the Australian Capital Territory. It is characterized by a blackish, corticate, microsquamulose thallus, a concolorous, hyphal hypothallus, very small but prominent, simple perithecia (0.07–)0.12(–0.15) mm diam., and 1-septate ascospores measuring (13–)17(–21) × (5.5–)7(–8.5) µm.

Introduction
Placidiopsis Beltr., a predominantly Northern Hemisphere genus of 14 species, is known from soil and rock at temperate to boreal latitudes and in arid and semi-arid regions (Breuss 1996; Prieto *et al.* 2010a). Closely related to *Catapyrenium* Flotow, it is characterized by the combination of a small- to minutely squamulose thallus attached by loose rhizohyphae or a more prominent hypothallus, verrucarioid perithecia (with or without an involucrellum, and lacking paraphyses but with periphyses) and 1-septate ascospores (Breuss 1996; Prieto *et al.* 2010a, b).

In this paper, a new species of *Placidiopsis* is documented from siliceous rocks in the A.C.T., the genus itself being reported for the first time from Australia.

Methods
Observations and measurements of thallus and ascomatal anatomy, asci and ascospores were made on hand-cut sections mounted in water and dilute KOH (K). Asci were also observed in Lugol's Iodine (I), with and without pretreatment in K.

Placidiopsis parva P.M.McCarthy, sp. nov. Fig. 1

MycoBank No.: **MB 830821**

Similar to *P. hypothallina* Aptroot in having a dark, microsquamulose thallus on a hypothallus of blackish hyphae, and diminutive perithecia, but differs in having superficial rather than fully immersed perithecia and discontinuously larger asci and ascospores.

Type: Australia: Australian Capital Territory, Woodstock Nature Reserve, Shepherds Lookout Walk, 20 km WNW of Canberra, 35°14'34"S, 148°58'38"E, 555 m alt., on porphyry pebbles in open *Eucalyptus-Callitris* woodland, *J.A. Elix 46625*, 17.vii.2018 (holotype – CANB).

Thallus epilithic on siliceous rocks, crustose-areolate to minutely squamulose, forming colonies to 1.5(–2) cm wide, greyish black to dull green-black, slightly paler and ± pulpy when wetted; areoles/squamules scattered to contiguous, plane to slightly convex, entire or with a minutely lobate margin, smooth, rounded (when scattered) to ± angular (when contiguous), to 0.08–0.2(–0.33) mm wide, 50–80 µm thick, epruinose, corticate above and below. *Upper cortex* parenchymatous, 8–10 µm thick, usually a single layer (rarely 2 layers) of thick-walled, dark greenish brown-pigmented cells (4–)5–7(–8) µm wide; lower cortex to 20 µm thick, of scattered or clustered, rounded, dark-walled cells (as in the upper cortex), these giving rise to blackish hypothalline hyphae that form a loose to dense reticulum linking adjacent or more dispersed areoles/squamules, and also 'foraging' ahead of the thallus margin as a prothallus; hyphae of dark brown to blackish, thick-walled cells 6–10(–14) µm long and 4–6(–7) µm wide, usually slightly to markedly constricted at the septa. *Photobiont* chlorococcoid; cells green, globose, (7–)8–13(–16) µm diam., evenly dispersed between the upper and lower cortices; interstitial hyphae short-celled, 2.5–3.5(–4) µm wide. *Medulla* not apparent. *Ascomata* perithecia, usually very numerous, solitary, scattered, (0.07–)0.12(–0.15) mm diam. [*n* = 50], 1–3 per squamule, subglobose, dull black, smooth, 1/3 immersed to almost superficial, not overgrown by the thallus; perithecial apex rounded, the apices of post-mature ascomata rounded to excavate; ostiole punctiform, in a shallow, central depression. *Involucrellum* absent. *Excipulum* uniformly 15–25(–32) µm thick at the base, sides and towards the apex, greenish black and parenchymatous in thin section, K–; cells rounded to periclinally elongate, thick-walled, 5–7.5 × 3–4(–5) µm. *Subhymenium* pale brown, *c.* 10 µm thick. *Paraphyses* absent. *Periphyses* sparingly branched, 10–18 × 1–1.5(–2) µm. *Hymenium* I–, KI–. *Asci* 8-spored, broadly obclavate to clavate-cylindrical, with a short, usually abrupt stalk, 42–56 × 16–24 µm [*n* = 20]; ascus wall initially thickened at the apex and with a tall, narrow ocular chamber that all but disappears as the apical wall becomes very thin at maturity, I–, KI–; ascoplasma I+ red-brown, KI+ red-brown. *Ascospores* irregularly arranged or biseriate in the ascus, colourless, 1-septate, narrowly ellipsoid to oblong-fusiform, straight or slightly curved, with a median or supramedial septum (the distal cell shorter and more rounded than the proximal) and with rounded or subacute ends, slightly to markedly constricted at the septum, (13–)17(–21) × (5.5–)7(–8.5) µm [*n* = 50]; wall thin, smooth, lacking a perispore; contents clear to minutely granulose or small- to large-vacuolate. *Pycnidia* absent.

Etymology: The epithet *parva* refers to the diminutive perithecia of the new species.

Remarks
The new species is characterized by the dark, minutely areolate to microsquamulose, silicolous thallus on a loose hypothallus of blackish hyphae, along with very small, almost superficial perithecia and comparatively large ascospores. Thus, comparing it with other saxicolous species of *Placidiopsis*, the Brazilian *P. hypothallina* Aptroot (Aptroot 2002) and *P. porinoides* Aptroot from China (Aptroot & Seaward 1999) have immersed perithecia up to 0.1 mm in diameter and ascospores 8–13 µm long, while *P. minor* R.C.Harris, from eastern U.S.A. and Greenland, has a pruinose thallus and ascospores of 8–10 × 4–5 µm (Harris 1979; Alstrup 1991; Breuss 1996). Furthermore, *P. sbarbaronis* Servít from Italy and *P. cavicola* Etayo & Breuss from Spain have perithecia of broadly similar size to the Australian lichen, the former having perithecia with an apical involucrellum (Servít 1953; Clauzade & Roux 1985), while *P. cavicola* has a hyaline excipulum and ascospores of 13–17 × 6–7 µm (Etayo & Breuss 1994).

Incidentally, when describing the pseudosquamulose *Thelidium robustum* P.M.McCarthy & Kantvilas from limestone in South Australia, the authors speculated that the lichen might actually be referable to *Placidiopsis*, given the combination of thallus morphology, simple perithecia and 1-septate ascospores (McCarthy & Kantvilas 2016). However, the outwardly squamulose morphology of *T. robustum* at maturity is derived from crustose thallus initials, and the medulla and algal layer are impregnated with minute rock fragments and crystals, a feature typical of hemiendolithic Verrucariaceae (such as *Thelidium*) and not of taxa in which squamules develop on the substratum (e.g. *Placidiopsis*).

The new species is known from comparatively soft to much harder siliceous rocks in dry *Eucalyptus* woodland in the Australian Capital Territory. It appears to be a primary colonizer of freshly exposed surfaces, later forming part of a diverse lichen community that can include various *Caloplaca* and *Xanthoparmelia* species, *Acarospora citrina* (Taylor) Zahlbr. ex Rech., *Aspicilia* spp., *Buellia amandineiformis* Elix & Kantvilas, *B. suttonensis* Elix & A.Knight, *Candelariella vitellina* (Hoffm.) Müll.Arg., *Diploschistes eugeneus* (A.Massal.) J.Steiner, *D. sticticus* (Körb.) Müll.Arg., *Lecanora pseudistera* Nyl., *Lecidea terrena* Nyl., *Lepra erubescens* (Hook.f. & Taylor) A.W.Archer & Elix, *Monerolechia badia* (Fr.) Kalb, *Myriospora smaragdula* (Wahlenb.) Nägeli ex Uloth, *Pertusaria lophocarpa* Körb., *Rhizocarpon geographicum* (L.) DC., *R. reductum* Th.Fr., *Trapelia coarctata* (Sm.) M.Choisy and *Verrucaria aff. nigrescens* Pers.

ADDITIONAL SPECIMENS EXAMINED
Australian Capital Territory: ● Woodstock Nature Reserve, Shepherds Lookout Walk, 20 km WNW of Canberra, 35°14'34"S, 148°58'38"E, 555 m alt., on porphyry rocks in open

Eucalyptus-Callitris woodland, *P.M. McCarthy 4778, 4797*, 5.xii.2018 (CANB); ● *loc. id.*, *P.M. McCarthy 4809, 4810*, 17.vii.2018 (CANB); ● Mount Ainslie, Canberra, W-facing slope below summit, 35°16'10"S, 149°09'32"E, 846 m alt., on siliceous rock outcrop in dry *Eucalyptus* woodland, *P.M. McCarthy 4812, 4815, 4818, 4819*, 2.i.2019 (CANB); ● Mount Ainslie, Canberra, E-facing slope below summit, 35°15'59"S, 149°09'43"E, 780 m alt., on siliceous rock outcrop in dry *Eucalyptus* woodland, *P.M. McCarthy 4821, 4823*, 2.i.2019 (CANB); ● Kowen Road, Kowen Forest, 11.7 km E of Canberra, 35°19'02"S, 149°15'07"E, 700 m alt., on sandstone outcrops on old road bank bordering dry *Eucalyptus* woodland, *P.M. McCarthy 4829, 4838, 4839, 4842*, 9.i.2019 (CANB).

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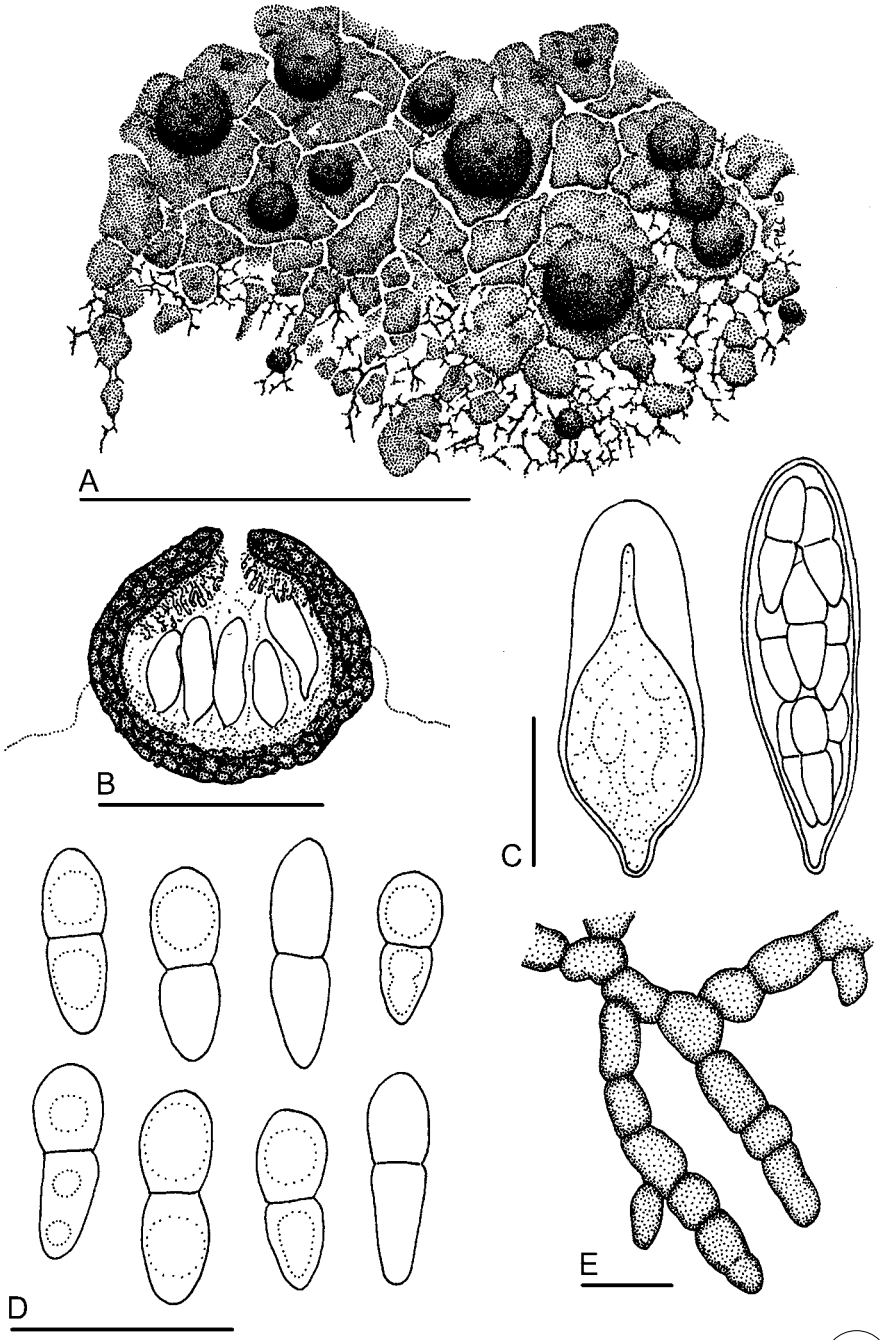
Figure 1. *Placidiopsis parva* (holotype). A, Habit of fertile thallus, the squamules linked by dark hypothalline hyphae; B, Vertical section of an ascoma (semi-schematic); C, Immature (left) and mature asci; D, Ascospores; E, Hypothalline hyphae. Scales: A = 0.5 mm; B = 0.1 mm; C, D = 20 µm, E = 10 µm.



A further new species of *Rinodina* (Physciaceae, Ascomycota) from eastern Australia

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Abstract
Rinodina arthomelina U.Grube, H.Mayrhofer & Elix, characterized by the presence of thiomelin, arthothelin and zeorin, is described as new to science. A key is provided to the Australasian species of *Rinodina* containing xanthones and zeorin.

The saxicolous species of *Rinodina* (Ach.) S.F.Gray in Australia are relatively well known following the initial treatment by Mayrhofer (1984), further additions by Mayrhofer *et al.* (1990), Matzer & Mayrhofer (1994), Matzer *et al.* (1998) and Trinkaus *et al.* (1999), and the more recent revisions by Kaschik (2006) and Elix (2011), as well as four additional species (Elix & Giralt 2015; Mayrhofer & Elix 2018; Elix *et al.* 2019). Of particular focus in the present work are those species containing zeorin and xanthones, which include *Rinodina fijiensis* Elix & Giralt, *R. michaelae* H.Mayrhofer & Elix, *R. teniswoodiorum* Elix & Kantvilas, *R. thiomela* (Nyl.) Müll.Arg. and *R. xanthomelana* Müll.Arg. In this paper we describe a new saxicolous species of *Rinodina* from eastern Australia which contains thiomelin, arthothelin and zeorin. Methods are as described in the papers cited above.

New species

Rinodina arthomelina U.Grube, H.Mayrhofer & Elix, sp. nov. Figs 1, 2
MycoBank No.: **MB 830141**

Similar to *Rinodina thiomela*, but differs in containing arthothelin as the major xanthone present.

Type: Australia, New South Wales, Blue Mountains National Park, near Glenbrook, *c.* 60 km W of Sydney, on rock, *M. Mayrhofer 3279*, ix.1981 (GZU – holotype).

Thallus to 35 mm wide, crustose, areolate or granular; individual areoles 0.05–0.3 mm wide, to 0.15 mm thick, papillate and isidia-like to flattened and becoming imbricate to form a secondary crust up to 0.5 mm thick; upper surface matt, smooth, esorediate, pale yellow-green to pale yellow-brown; prothallus black, marginal and ± between adjacent areoles; medulla white, lacking calcium oxalate (H_2SO_4–), I–; photobiont cells 7–12 µm diam. *Apothecia* 0.1–0.7 mm wide, scattered, lecanorine to cryptolecanorine, broadly adnate to usually sessile and basally constricted; disc brown to black, epruinose, plane to weakly concave; thalline exciple thick and raised above the disc at first, becoming thinner and excluded in older apothecia; proper excipulum greenish black, persistent, thick, in section 65–75 µm thick; outer zone brown to dark brown, K–, N–; inner zone paler brown. *Epihymenium* 10–20 µm thick, brown, K–, N–. *Hypothecium* 100–120 µm thick, colourless, K+ yellow solution, N–. *Hymenium* 90–130 µm thick, colourless, not inspersed; paraphyses 1.5–2.5 µm wide, simple to branched, capitate, with apices 3–3.5 µm wide and brown caps, with scattered oil paraphyses 4–6 µm wide. *Asci* of the *Lecanora*-type, 8-spored or with fewer spores. *Ascospores Teichophila*-type (with internal wall thickenings transitioning from *Pachysporaria*- to *Buellia*-, *Milvina*- or *Mischoblastia*-types at different stages of development), 1-septate, brown, broadly ellipsoid, 17–[*21.5*]–32 × 11–[*13.9*]–20 µm, not constricted at the septum; ontogeny of type-A; outer spore-wall finely ornamented. *Pycnidia* pyriform, immersed, brown to brown-black; conidia bacilliform, 3.5–5 × 1–1.5 µm.
Chemistry: Thallus K+ pale yellow, C+ orange, P–, UV+ orange; containing zeorin (major), arthothelin (major), 4,5-dichloronorlichexanthone (minor), thiomelin (minor or trace).

Etymology: The species is named after its unusual chemistry, the presence of arthothelin and thiomelin, two biosynthetically unrelated xanthones.

Remarks

In many respects the new species closely resembles the well-known *R. thiomela.* Both have adnate to sessile, lecanorine to cryptolecanorine apothecia and similar-sized ascospores, and contain zeorin and xanthones. However, *R. thiomela* contains thiomelin and satellites rather than arthothelin, the major xanthone present in *R. arthomelina*. Further, both species have *Teichophila*-type ascospores where the spores transition from mainly *Pachysporaria*-type to *Mischoblastia*-, *Milvina*- or *Buellia*-types at different stages of development. However, they differ in the colour of their upper surface, *R. thiomela* varying from intense mustard-yellow to shiny yellow-green with a metallic lustre, whereas *R. arthomelina* varies from pale yellow-green to dull yellow-brown. *Rinodina teniswoodiorum* is also very similar to *R. arthomelina*, but differs in having somewhat narrower ascospores, 10–14 µm wide, which become constricted with age, and in containing additional 2,5-dichlorolichexanthone, 4,5-dichlorolichexanthone and ± lichexanthone. In *R. arthomelina*, the ascospores do not become constricted with age and are 11–20 µm wide, and the species lacks dichlorolichexanthones and lichexanthone. Chemically, *R. arthomelina* is identical to *R. fijiensis*, although the latter species was initially reported to contain additional atranorin. That was an error — the atranorin observed was a contaminant that obscured the trace amounts of thiomelin present (Elix & Giralt 2015). *Rinodina fijiensis* differs from *R. arthomelina* in having immersed apothecia and smaller ascospores, 15–21 × 8–12 µm.

At present, the new species is known from hinterland regions of Victoria, New South Wales and Queensland. Associated lichens include *Heterodermia speciosa* (Wulfen) Trevis., *Lepra subventosa* (Malme) I.Schmitt & Lumbsch var. *subventosa*, *Pertusaria xanthoplaca* Müll.Arg. and numerous *Xanthoparmelia* species.

SPECIMENS EXAMINED
Queensland: ● Carnarvon National Park, Salvator Rosa section, Nooga River campground, 24°48’S, 147°12’E, 450 m alt., on sandstone escarpment, *B. Barnsley 1670*, 16.viii.1992 (CANB); ● between Breakneck and Quandong Creeks, 24 km WSW of Proserpine, 20°29’S, 148°22’E, 150 m alt., on weathered basalt rocks in *Eucalyptus-Planchonia*-dominated woodland, *J.A. Elix 21161 & H. Streimann*, 2.vii.1986 (CANB); ● Carnarvon National Park, track to Baloon Cave, 91 km NNW of Injune, 25°04’S, 148°15’E, 460 m alt., on sandstone rocks in *Eucalyptus* woodland, *J.A. Elix 34122*, 19.viii.1993 (CANB); ● Dawson Highway, Staircase Range, 18 km SE of Springsure, 24°13’S, 148°13’E, 380 m alt., on weathered granite rocks in *Eucalyptus* woodland, *J.A. Elix 34278*, 23.viii.1993 (CANB); ● Expedition National Park, Robinson Gorge, 73 km NW of Taroom, 25°17’S, 149°09’E, 400 m alt., on sandstone rocks in steep gorge with palms and *Melaleuca* shrubs, *J.A. Elix 35250, 35255*, 1.ix.1993 (CANB, GZU); ● Carnarvon National Park, Mickey Creek, 91 km NNW of Injune, 25°04’S, 148°14’E, 450 m alt., on rock outcrops in open *Eucalyptus* woodland, *H. Streimann 52213*, 21.viii.1993 (CANB).
New South Wales: ● Morton National Park, Pidgeon House Mountain, 35°21’S, 150°15’E, 720–750 m alt., on sandstone rocks near summit, *U. Trinkaus s.n.*, 21.x.1999 (GZU, seven collections); ● North Coast, Toonumbor State Forest, 29 km W of Kyogle, 150 m from Coxes Road, 28°29’S, 152°45’E, 200 m alt., on volcanic rocks in disturbed rainforest, *D. Verdon 3944.*, 18.x.1978 (CANB).
Victoria: ● Brisbane Ranges, Little River Gorge, *c.* 25 km S of Bacchus Marsh, 37°51’S, 144°22’E, on rock, *R. Filson & H. Mayrhofer 2928, 3007*, 18.x.1981 (GZU).

Key to Australasian species of *Rinodina* containing xanthones and zeorin

1 Hypothecium brown to deep yellow-brown; 6-*O*-methylarthothelin present; Australia (N.S.W., southern Qld)..... **R. michaelae**
1: Hypothecium colourless to pale yellow-brown; arthothelin and/or thiomelin present.... 2

2 Thiomelin (major) present; arthothelin absent..... 3
2: Arthothelin (major) present; thiomelin present in minor or trace amounts 4

3 Apothecia immersed; ascospores 14–21 × 7–11 µm; subtropical to mainly tropical, Australia (W.A., Qld, N.S.W.), Papua New Guinea, SE Asia, Jamaica .... **R. xanthomelana**
3: Apothecia adnate to sessile at maturity; ascospores 20–34 × 11–17 µm; temperate (to subtropical) Australia, New Zealand..... **R. thiomela**

4 Apothecia immersed; ascospores 15–21 × 8–12 µm; Fiji..... **R. fijiensis**
4: Apothecia adnate to sessile at maturity; ascospores 17–32 × 10–20 µm; Australia 5

5 2,5-Dichlorolichexanthone, 4,5-dichlorolichexanthone ± lichexanthone present; ascospores 10–14 µm wide; Tas..... **R. teniswoodiorum**
5: Dichlorolichexanthones and lichexanthone absent; ascospores 11–20 µm wide; eastern Australia..... **R. arthomelina**

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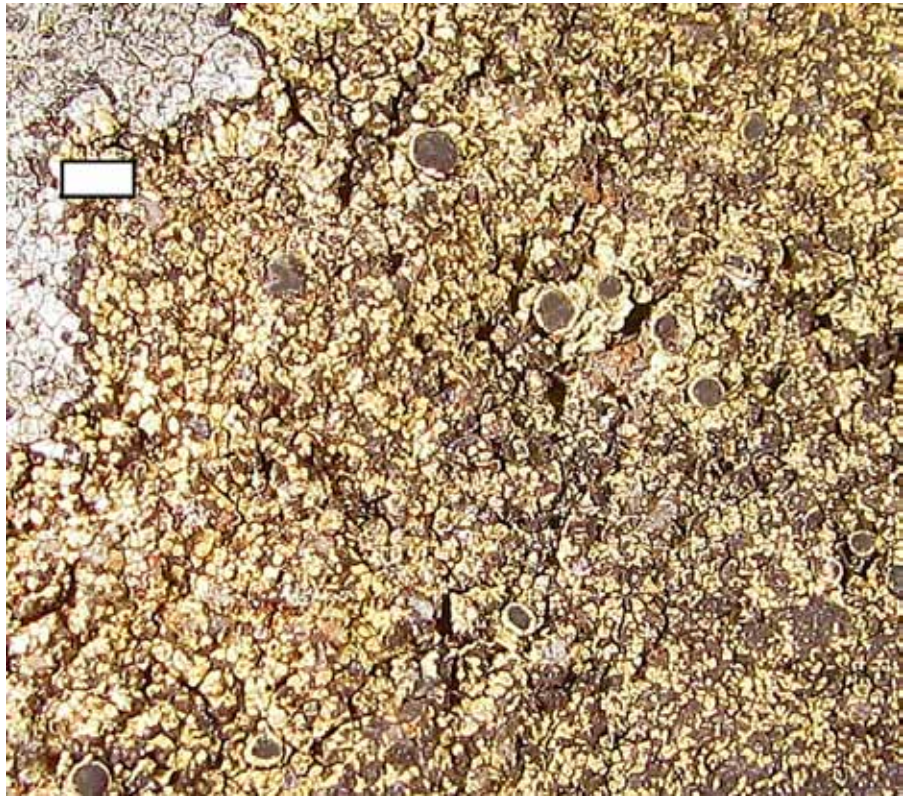

Figure 1. *Rinodina arthomelina* (holotype in GZU). Scale = 1 mm.

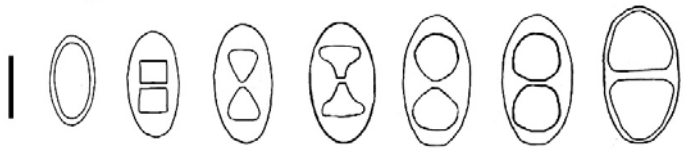

Figure 2. Ascospore ontogeny of *R. arthomelina*. Scale = 10 µm.

Five new species of *Pertusaria* (Pertusariales, lichenized Ascomycota) from Australia

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Abstract
Three new corticolous species of *Pertusaria* are described from Lord Howe Island, *viz. P. insularicola* with thiophaninic and 2-*O*-methylperlatolic acids, *P. roccellica* with lichexanthone and roccellic acid and *P. submaritima* with 2'-*O*-methylperlatolic, confluentic and stictic acids. A new lignicolous species, *P. albidopunctata* (with 4,5-dichlorolichexanthone), is described from Tasmania, and a new saxicolous species, *P. wallingatensis* (with 4,5-dichlorolichexanthone and 2-*O*-methylperlatolic acid), is described from New South Wales.

Introduction
This paper continues our investigation of the lichen genus *Pertusaria* in Australia (Archer & Elix 2010, 2014, 2017a, 2017b). Here we describe three new corticolous species from Lord Howe Island, a new lignicolous species from Tasmania and a new saxicolous species from New South Wales. Specimens were examined microscopically and their chemistry studied by thin-layer chromatography (Elix 2014) and comparison with authentic samples.

1. *Pertusaria albidopunctata* A.W.Archer & Elix, sp. nov. Fig. 1
IF 556455
Type: Australia. Tasmania, Timbs Track, 27 km WSW of Maydena, 42°49'S, 146°19'E, 350 m alt., on dead log on forest floor, *J.A. Elix 27164*, 27.iv.1992 (holotype – CANB).

Similar to *Pertusaria albopunctata* A.W.Archer & Elix, but differs in containing 4,5-dichlorolichexanthone rather than stictic acid.

Thallus corticolous, pale grey, somewhat rimose, sorediate, lacking isidia; soralia numerous, white, scattered, disciform, 0.3–0.6 mm diam.; apothecia not seen.
Chemistry: 4,5-dichlorolichexanthone (major).

Etymology: From the Latin *albidus* (whitish) and *punctum* (a small spot), in reference to the white soralia present on the thallus surface.

The new species is characterized by the sterile, sorediate thallus and the presence of 4.5-dichlorolichexanthone as the sole lichen compound. Other similar sterile, corticolous, sorediate species with 4.5-dichlorolichexanthone contain additional lichen substances *viz*. *P. expolita* R.C.Harris (Harris 1990) (syn. *P. balekensis* A.W.Archer & Elix) from North America, Australia and Papua New Guinea, with stictic acid; *P. puttyensis* A.W.Archer & Elix (Archer & Elix 2017b) from Australia with planaic acid and *P. submaritma* A.W.Archer & Elix from Australia with 2'-*O*-methylperlatolic, confluentic and stictic acids (*vide infra*).
At present this new species is only known from the type locality.

2. *Pertusaria insularicola* A.W.Archer & Elix, sp. nov. Figs 2, 3
IF 556456
Type: Australia. New South Wales, Lord Howe Island, track from Smoking Tree Ridge to Rocky Run, 31°33'35"S, 159°05'09"E, 170 m alt., on tree in lowland forest on moderate slope, *J.A. Elix 42438*, 10.ii.1995 (holotype – CANB).

Similar to *Pertusaria leucophaea* Elix & A.W.Archer, but differs in containing thiophaninic acid and 2'-*O*-methylperlatolic acid rather than 4,5-dichlorolichexanthone.

Thallus corticolous, pale greyish white, plicate and somewhat cracked, lacking isidia and soralia. *Apothecia* verruciform, conspicuous, scattered, rarely confluent, flattened-hemispherical to subspherical, constricted at the base, 1–1.7 mm diam.; ostioles conspicuous, pale brown, 1 per apothecium. *Ascospores* (3–)4 per ascus, hyaline, narrowly ellipsoid, with rough inner walls, 4 per ascus and 82–100 µm long and 30–36 µm wide [3 per ascus and 102–120 µm long and 30–34 µm wide].
Chemistry: Thiophaninic acid (major) and 2'-*O*-methylperlatolic acid (minor).

Etymology: The epithet is derived from the Latin *insularis* (of an island) and *-cola* (dweller), in reference to the type locality, Lord Howe Island.

Pertusaria insularicola is characterized by conspicuous apothecia, the plicate thallus surface, asci with 3 or 4 rough-walled ascospores and the presence of thiophaninic and 2'-*O*-methylperlatolic acids. Morphologically, it resembles *P. leucophaea* Elix & A.W.Archer (Archer & Elix 2010), a species with 4 rough-walled ascospores per ascus but containing 4,5-dichlorolichexanthone. It also resembles *P. gadgarrenis* A.W.Archer & Elix, from Queensland (Archer & Elix 2017), but that species has smaller ascospores, 70–80 µm long, and contains stictic and 2'-*O*-methylperlatolic acids. The combination of thiophaninic and 2'-*O*-methylperlatolic acids is uncommon in *Pertusaria*, but is found in three other *Pertusaria* species from the Southern Hemisphere (each of which has smooth-walled ascospores), *viz. P. cinerella* Müll.Arg from Uruguay with 2 spores per ascus, 110 × 35 µm (Müller 1888a), *P. formosensis* Messuti & A.W.Archer from Argentina with 8 spores per ascus, 40–80 × 24–36 µm (Messuti & Archer 1998), and *P. rechingeri* Zahlbr. from Papua New Guinea with 2–6 biseriate spores per ascus, 65–95 × 40–45 µm (Zahlbruckner 1913).
At present the new species is known only from the type locality on Lord Howe Island.

3. *Pertusaria roccellica* A.W.Archer & Elix, sp. nov. Fig. 4
IF 556457
Type: Australia. New South Wales, Lord Howe Island, track from Smoking Tree Ridge to Rocky Run, 31°33'35"S, 159°05'09"E, 170 m alt., on tree in lowland forest on moderate slope, *J.A. Elix 42441*, 10.ii.1995 (holotype – CANB).

Thallus sterile, sorediate, similar to *Pertusaria oahuensis* H.Magn., but differs in containing lichexanthone and roccellic acid rather than lichexanthone and stictic acid.

Thallus corticolous, thin, greyish white, smooth, lacking isidia, sorediate; soralia numerous, scattered, circular, flattened, 0.25–0.4(–0.6) mm diam.; apothecia not seen.
Chemistry: Lichexanthone (minor) and roccellic acid (major).

Etymology: The epithet *rocellica* is derived from roccellic acid which is present in the species.

Pertusaria roccellica is characterized by the sterile, sorediate thallus, and the presence of lichexanthone and roccellic acid. Roccellic acid, an aliphatic dicarboxylic acid, was first isolated from *Roccella montagnei* Bél., but is now known to be widely distributed in the species of many lichen genera (see Culberson 1969 and references therein).
Several species morphologically similar to *P. roccellica* contain lichexanthone but differ in the accompanying compounds: *P. confluentica* Jariangpr. & Elix (Elix *et al.* 2008) with confluentic acid; *P. verdonii* A.W.Archer [*Lepra verdonii* (A.W.Archer) I.Schmitt, B.P.Hodk. & Lumbsch] with picrolichenic acid (Elix *et al.* 1992); *P. scaberula* A.W.Archer [*Lepra scaberula* (A.W.Archer) I.Schmitt, B.P.Hodk. & Lumbsch] with thamnolic acid (Archer 1991) and *P. oahuensis* H.Magn. with stictic acid (Magnusson & Zahlbruckner 1944).
At present the new species is known only from the type locality on Lord Howe Island.

4. *Pertusaria submaritima* A.W.Archer & Elix, sp. nov. Fig. 5
IF 556458
Type: Australia, New South Wales, Lord Howe Island, near junction of tracks to Mutton Bird Point and Intermediate Hill, 31°32'43"S, 159°04'48"E, 60 m alt., on dead palm in dry lowland forest with basalt outcrops, *J.A. Elix 32744B*, 21.vi.1992 (holotype – CANB).

Similar to *Pertusaria maritima* A.W.Archer & Elix, but differs in containing 2'-*O*-methylperlatolic acid and confluentic acid. but lacking thiophaninic acid.

Thallus corticolous, pale fawn, smooth and slightly cracked, sorediate, lacking isidia; soralia numerous, scattered, 0.25–0.5 mm diam., slightly sunken, with thalline margins; soredia pale yellow. Apothecia not seen.
Chemistry: 4,5-dichlorolichexanthone (trace), 2'-*O*-methylperlatolic acid (major), confluentic acid (minor), stictic acid (minor) and constictic acid (trace).

Etymology: The epithet is derived from the Latin prefix *sub* (almost, somewhat), and the specific epithet *maritima*, from the morphologically similar species *Pertusaria maritima*.

Pertusaria submaritima is characterized by the sterile sorediate thallus and the presence of 2'-*O*-methylperlatolic, confluentic and stictic acids. The morphologically similar species *P. maritima* (Archer & Elix 1994), contains thiophaninic and stictic acids. *Pertusaria submaritima* is one of a number of sterile, sorediate *Pertusaria* [or *Lepra* or *Varicellaria*] species found in Australia which are differentiated by their chemistry. They include: *P. albopunctata* A.W.Archer & Elix with stictic acid (Archer & Elix 2009); *P. confluentica* Jariangpr. & Elix, with lichexanthone and confluentic acid (Elix, Jariangprasert & Archer 2008); *P. heinarii* A.W.Archer & Elix, lacking lichen compounds (Archer & Elix 2016) and *P. roccellica*, with lichexanthone and roccellic acid (*vide supra*).

At present the new species is known only from the type locality on Lord Howe Island.

5. *Pertusaria wallingatensis* A.W.Archer & Elix, sp. nov. Figs 6, 7
IF 556459
Type: Australia. New South Wales, Whoota Whoota Hill, Wallingat State Forest, 13 km SSW of Forster, 32°18'S, 152°28'E, 200 m alt., on sandstone rocks at edge of dry sclerophyll forest and *Cryptocarya*-dominated regrowth on ridge, *J.A. Elix 24651*, 24.iv.1990 (holotype – CANB).

Similar to *Pertusaria lophocarpa* Körb., but differs in containing 2-*O*-methylperlatolic acid rather than 2'-*O*-methylperlatolic acid.

Thallus saxicolous, pale fawn, smooth or somewhat cracked, lacking isidia and soredia. *Apothecia* verruciform, concolorous with the thallus, scattered or crowded, rarely confluent, flattened-hemispherical or irregular in outline, 0.5–1.0 mm diam. *Ostioles* inconspicuous, punctiform, pale brown 1(–2) per verruca. *Ascospores* 8 per ascus, imbricate, 1-seriate, hyaline, narrowly ellipsoid, 50–70 µm long and 24–30 µm wide.
Chemistry: 4,5-dichlorolichexanthone (minor) and 2-*O*-methylperlatolic acid (major).

Etymology: The epithet is derived from the type locality, Wallingat State Forest.

Pertusaria wallingatensis is characterized by verruciform apothecia, asci with 8 ascospores and the presence of 4,5-dichlorolichexanthone and 2-*O*-methylperlatolic acid. The 2-*O*-methylperlatolic acid is less common in *Pertusaria* than its isomeric depside 2'-*O*-methylperlatolic acid, but it occurs in four saxicolous *Pertusaria* species with 8-spored asci: *P. petrophyes* C.Knight (Knight 1882) [syn: *P. leucoxantha* Müll.Arg. (Müller 1895)] from Australia contains additional thiophaninic acid; *P. consanguinea* Müll.Arg. (Müller 1884a) and *P. rudis* Müll.Arg. (Müller 1884b), both from near Apiai in Brazil and *P. mariae* de Lesd. (de Lesdain 1914) from Mexico all contain additional lichexanthone and are possibly conspecific.

The new species is distinguished from the three species containing lichexanthone by the presence of 4,5-dichlorolichexanthone and smaller ascospores (50–70 µm long, compared to 75–110 µm in *P. mariae*, 75–85 µm in *P. rudis* and 75–105 µm in *P. consanguinea.*

At present, the new species is known only from the type locality.

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Fig. 1. *Pertusaria albidopunctata*, habit. *J.A. Elix 27164* (holotype CANB). Bar = 1 mm.

Fig. 2. *Pertusaria insularicola,* habit. *J.A. Elix 42438* (holotype CANB). Bar = 1 mm.

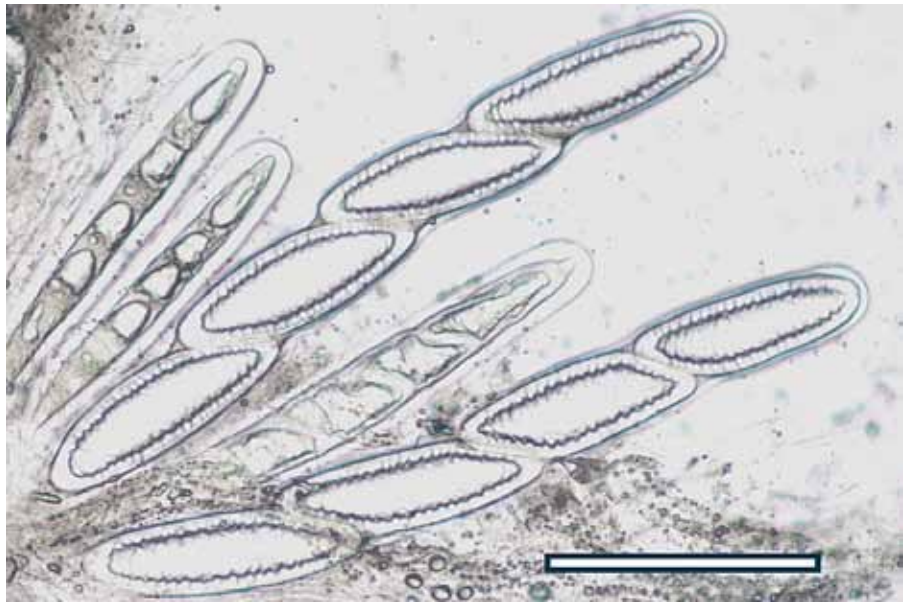

Fig. 3. *Pertusaria insularicola* ascospores. *J.A. Elix 42438* (holotype CANB). Bar = 1 mm.

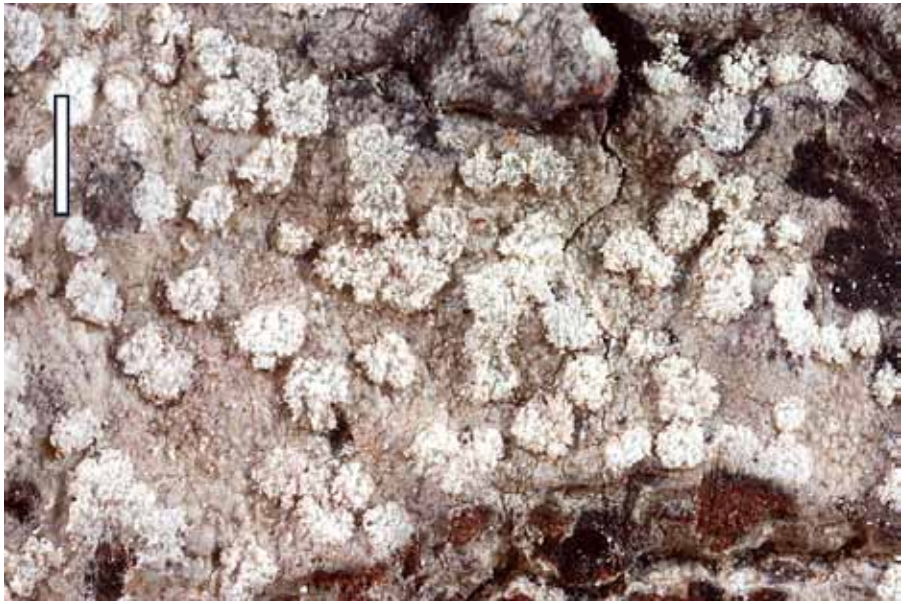

Fig. 4. *Pertusaria rocellica,* habit. *J.A. Elix 42441* (holotype CANB). Bar = 1 mm.

Fig. 5. *Pertusaria submaritima*, habit. *J.A. Elix 32744B* (holotype CANB). Bar = 1 mm.

Fig. 6. *Pertusaria wallingatensis*, habit. *J.A. Elix 24651* (holotype CANB). Bar = 1 mm.

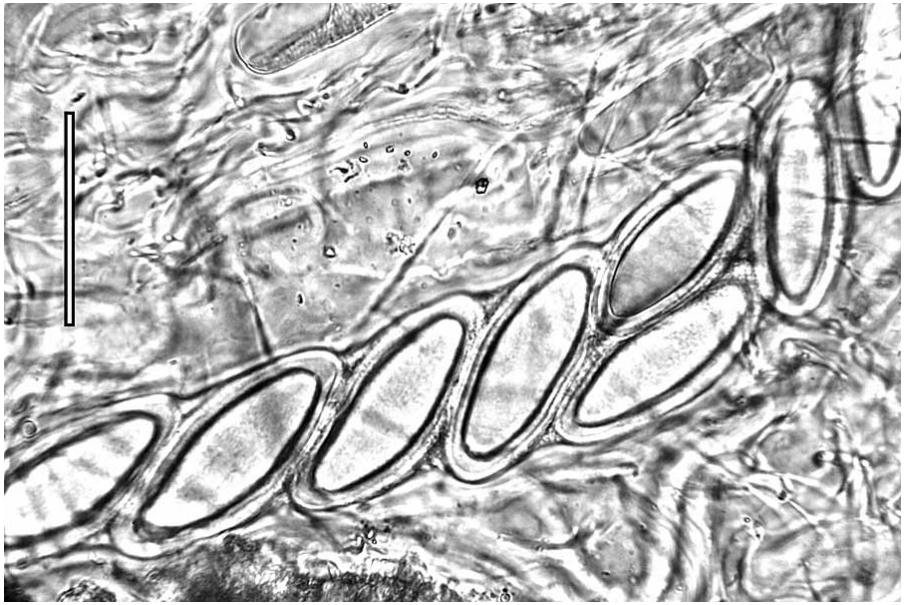

Fig. 7. *Pertusaria wallingatensis* ascospores. *J.A. Elix 24651* (holotype, CANB). Bar = 50 µm.

The structure of hafellic acid, a new diphenyl ether from the lichen *Cratiria subtropica*

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Abstract
Hafellic acid has been isolated from the lichen *Cratiria subtropica*, and its structure established by mass spectrometry and NMR spectroscopy.

Introduction
Hafellic acid was first detected in the lichen *Cratiria subtropica* (Elix) Elix (Elix & McCarthy 2008), and subsequently found in *Lecanora hafelliana* Lu *et al.* (Lu *et al.* 2011). Although hafellic acid could readily be characterized by thin-layer chromatography (Elix & McCarthy 2008; Elix 2014), its structure remained unknown. This paper describes the structural elucidation of hafellic acid. Methods are as described in *Elix et al.* (2019).

Extraction of *Hafellia subtropica* (Elix) Elix
The lichen *Cratiria subtropica* was collected in the Queens Head area, Limeburners Creek Nature Reserve, 15 km south of Crescent Head, 31°19'09"S, 152°58'05"E, 5 m alt., New South Wales, *J.A. Elix 43588*, 7.viii.2008 (CANB). The dried lichen thallus (0.3 g) was extracted in a Soxhlet extractor with anhydrous diethyl ether (320 mL) and anhydrous acetone (320 mL) for 48 h, respectively. The corresponding extracts were concentrated to dryness to yield 23.6 mg and 12.5 mg of a white solid, respectively. The white solids were combined and then purified by flash column chromatography over silica gel using 50% ethyl acetate/ light petroleum as eluent. Four major bands developed, and the third band eluting had strong blue fluorescence under UV light (254 nm). This blue fluorescent band was collected from the chromatographic column and concentrated to afford hafellic acid (1) (1.6 mg) as a colourless solid, $[\alpha]_D$ –12.5 (c = 0.08, $(CH_3)_2CO$).

Structural elucidation of hafellic acid (1)
The hafellic acid (1) exhibited *m/z* $[M+Na]^+$ 523.1942 on high-resolution ESIMS with a sodiated adduct ion corresponding to $C_{27}H_{32}O_9Na^+$, thus establishing the molecular formula of hafellic acid as $C_{27}H_{32}O_9$. UV (MeOH) λ_{max} 225 (ε10,450), 263 (8030), 302 (2920) nm.

NMR spectroscopic evidence showed that hafellic acid (1) possessed a novel structure, which is similar to the lichen metabolite epiphorellic acid 1 (2) (Fiedler *et al.* 1986; Elix & Jenie 1989) and the artefact 8"-*O*-ethyl-β-alectoronic acid (3) (Gollapudi *et al.* 1994) [Figure 1].

Assignments in the ^{1}H-NMR spectrum of compound (1) are summarized in Table 1. The ^{13}C-NMR spectrum of hafellic acid (1) (Table 2) exhibited twenty six carbon signals with one overlapping carbonyl resonance [d 170.5], the integral of which was almost twice that of the carbonyl resonance [d 167.4]. In the HSQC spectrum of (1), two carbon signals (d 14.06 and 14.13) were strongly associated with two triplet CH_3 proton signals (d 0.89 and 0.97) respectively, indicating that two methyl groups are bonded to methylene groups in (1). A carbon signal (δ 21.0) was associated with a singlet proton signal (δ 1.93, 3H) indicating this methyl is bonded to a carbonyl group. A carbon signal (δ 52.2) was associated with a singlet proton signal (δ 3.69, 3H), as expected for a methoxy group in (1). Two tertiary carbon signals (δ 74.6, 79.9) were associated with two methine proton signals (δ 5.07–5.10 and 4.63–4.66) respectively, indicating that these carbon atoms were bonded to oxygen. Four carbon signals (d 103.5, 107.9, 108.2 and 115.9) were associated with four proton signals (δ 6.26, 6.48, 6.36 and 6.75) respectively, with proton signals (δ 6.26, 6.36 having J = 2.4 Hz) and proton signals (δ 6.48, 6.75 with J = 2.3 Hz), consistent with two *meta*-substituted aromatic rings. No carbon signals were found to be associated with proton signals (d 9.16, 11.30), indicating the presence of two hydroxy groups, the latter forming an intramolecular hydrogen bond.

Correlations in the gHMBC spectrum of hafellic acid (1) are illustrated in Figure 2.

In the NOESY spectrum (Figure 3), H1"-a (δ 2.91-2.94), H1"-b (δ 3.02) and H1 (δ 6.36) are correlated with one another. However, only H1"-a and H4" (δ 1.48-1.60) are correlated with one another, while there is no correlation between H1"-b and H4".

Both compound 1 and 2 have a methoxycarbonyl group (COOMe) bonded directly to an aromatic ring, so the close similarity of ^{1}H and ^{13}C NMR data for these respective groups is as expected (Table 1, 2). Further, both compounds 1 and 3 possess carbon side chains substituted by oxygen atoms at C2"' position and a saturated lactone ring. The similarity of ^{1}H and ^{13}C NMR data for the respective C1"' methylene groups can be observed in Table 1 and 2. More particularly, the chemical shift of the lactone carbonyl in 3 (d 169.1), is very close to that observed in hafellic acid (1) (d 170.5), with the latter being weakly associated with adjacent protons in gHMBC spectrum and overlapping in ^{13}C-NMR spectrum. All these data are consistent with structure (1) for hafellic acid.

Acknowledgement
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Table 1. ^{1}H-NMR data of compounds **1–3**

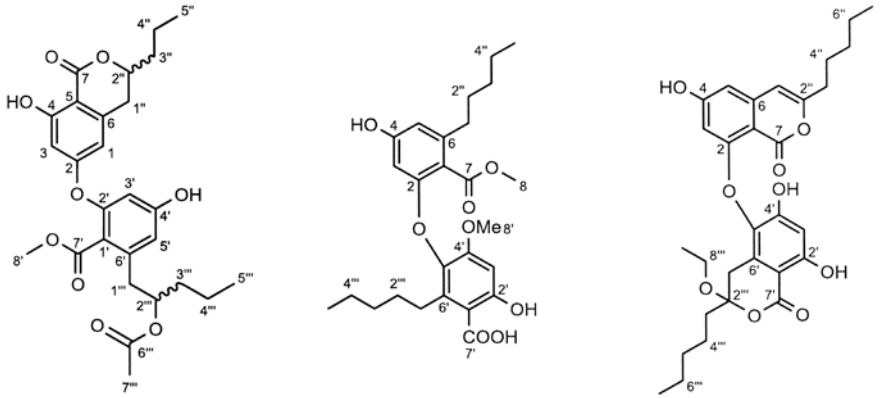
Position	δ_H mult (*J* in Hz) **1** ($(CD_3)_2CO$)	**2** ($(CD_3)_2CO$)*	**3** ($CDCl_3$)#
1-H	6.36, m	-	-
3-H	6.26, d (2.4)	5.83, d (2.5)	6.32, br s
5-H	-	6.40, d (2.5)	6.46, d (1.5)
8-H	-	3.90, s	-
3'-H	6.48, d (2.3)	6.50, s	6.40, s
5'-H	6.75, d (2.3)	-	-
8'-H	3.69, s	3.70, s	-
1"-H	a 2.91-2.94, m b 3.02, dd (16.6, 3.2)	2.57, t (7.0)	6.13, s
2"-H	4.63-4.66, m	1.37, m	-
3"-H	a 1.70-1.74, m b 1.80-1.84, m	1.37, m	2.44, t, (7.5)
4"-H	1.48-1.60, m	1.37, m	1.24-1.64, m
5"-H	0.97, t (7.4)	0.90, m	1.24-1.64, m
6"-H	-	-	1.24-1.64, m
7"-H	-	-	0.84, t (5.9)*
1'''-H	2.93, d (6.6)	2.90, t (7.0)	2.90, br d (15.8) 3.10, br d (15.8)
2'''-H	5.07-5.10, m	1.37, m	-
3'''-H	1.54-1.57, m	1.37, m	1.90, m
4'''-H	1.31-1.40, m	1.37, m	1.24-1.64, m
5'''-H	0.89, t (7.4)	0.90, m	1.24-1.64, m
6'''-H	-	-	1.24-1.64, m
7'''-H	1.93, s	-	0.89, t (6.9)*
8'''-H	-	-	3.57, m 3.63, m
9'''-H	-	-	1.07, t (6.9)
4-OH	11.30, s	-	8.98, br s
2'-OH	-	-	11.0, br s
4'-OH	9.16, s	-	8.98, br s

* Fiedler *et al.* (1986), Elix & Jenie (1989)
# Gollapudi *et al.* (1994)

Table 2. ^{13}C-NMR data of compounds **1–3**

Position	δ_C **1** ($(CD_3)_2CO$)	**2** ($(CD_3)_2CO$)*	**3** ($CDCl_3$)#
1-C	108.2	115.1	102.5
2-C	165.2	163.8	161.8
3-C	103.5	99.3	103.4
4-C	164.8	158.5	162.8
5-C	104.3	109.6	105.6
6-C	143.4	143.7	142.2
7-C	170.5	168.7	160.8
8-C	-	51.7	-
1'-C	119.9	104.5	99.9
2'-C	154.4	159.4	163.8
3'-C	107.9	98.5	103.4
4'-C	160.5	157.8	156.9
5'-C	115.9	140.6	133.3
6'-C	141.4	134.4	131.7
7'-C	167.4	173.6	169.1
8'-C	52.2	56.0	-
1"-C	33.4	30.3	103.2
2"-C	79.9	29.6	159.1
3"-C	37.5	32.0	33.1
4"-C	18.8	22.7	26.4
5"-C	14.1	14.0	31.1
6"-C	-	-	22.3
7"-C	-	-	13.9
1'''-C	38.8	31.3	35.5
2'''-C	74.6	28.8	107.7
3'''-C	37.2	32.5	31.6
4'''-C	19.2	22.7	23.1
5'''-C	14.1	14.0	31.2
6'''-C	170.5	-	22.4
7'''-C	21.0	-	13.9
8'''-C	-	-	58.1
9'''-C	-	-	15.2

* Fiedler *et al.* (1986), Elix & Jenie (1989)
# Gollapudi *et al.* (1994)



1 2 3

Figure 1. Structures of compounds (1), (2), and (3)

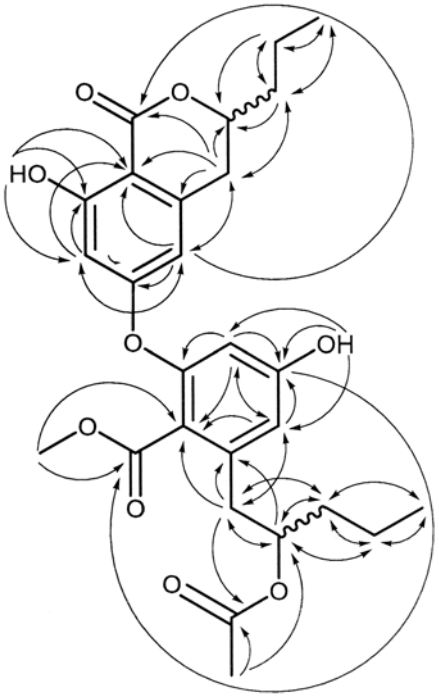


Figure 2. gHMBC correlations of hafellic acid (1)

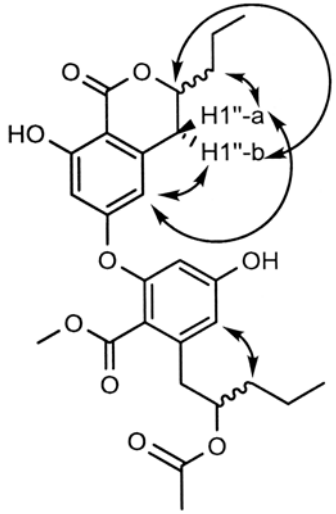


Figure 3. NOESY associations of hafellic acid (1)

The structure of testacein, a new hybrid polyketide-sesquiterpene metabolite from the lichen *Notoparmelia testacea*

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Abstract
Testacein has been isolated from the lichen *Notoparmelia testacea* and its structure established by mass spectrometry and NMR spectroscopy.

Introduction
Testacein was first detected in the lichens *Notoparmelia testacea* (Stirt.) A.Crespo, Ferencova & Divakar and *N. subtestacea* (Hale) A.Crespo, Ferencova & Divakar (Hale 1987, as unknown #27) and subsequently found in other lichen genera including *Pyxine* (Kalb 2004; Elix 2009), *Heterodermia* (Elix 2010) and *Buellia* (Elix & Kantvilas 2013). Although testacein could readily be characterized by thin-layer and high-performance liquid chromatography (Hale 1987; Elix 2014), its structure remained unknown. This paper describes the structural elucidation of testacein. Methods are as described in Elix *et al.* (2019)

Extraction of *Notoparmelia testacea*
The lichen *Notoparmelia testacea* was collected in the Otepatotu Scenic Reserve, Outer Banks Peninsula, South Island, New Zealand, 43°45'S, 173°10'E, 720 m alt., on dead wood at margin of cool temperate rainforest, *J.A. Elix 7716*, 30.iii.1980 (CANB).

The dried lichen thallus (7.3 g) was extracted in a Soxhlet extractor with anhydrous diethyl ether (300 mL) for 48 h. The extract was filtered and the solid [salazinic acid] discarded. The filtrate was concentrated to 30 mL and filtered again and the solid discarded. The final filtrate was concentrated to dryness to yield 111.6 mg of a pale brown oil. A portion (38.3 mg) of this oil was purified by column chromatography over silica gel using 60% ethyl acetate/light petroleum [bp 60–80 °C] as eluent. The major band was collected from the chromatographic column and concentrated to afford testacein (1) (19.6 mg) as a pale yellow oil, $[\alpha]_D^{25} = -8.6$ (c 0.12, $(CH_3)_2CO$).

Structural elucidation of testacein
Testacein (1) exhibited *m/z* $[M+Na]^+$ 497.2157 on high resolution ESIMS with a sodiated adduct ion corresponding to $C_{26}H_{34}O_8Na^+$, thus establishing the molecular formula of testacein as $C_{26}H_{34}O_8$. Testacein was found to be unstable in $CDCl_3$ solution, forming an insoluble precipitate, but was stable in $(CD_3)_2CO$ solution. Assignments in the ^{1}H-NMR spectrum of (1) are summarized in Table 1 and assignments in the ^{13}C-NMR spectrum in Table 2.

Spectroscopic evidence showed that testacein possesses the structure (1), similar to the known fungal metabolites pestalotiopene A (2) (Hemberger *et al.* 2013) and pestalotiopene C (3) (Hammerschmidt *et al.* 2014).

In the HSQC spectrum of (1), four C signals (δ 21.8, 33.8, 17.4, 21.2) were strongly associated with four singlet CH_3 proton signals (δ 0.84, 0.91, 1.19, 1.63), indicating the presence of four quaternary methyl groups in this compound. A carbon signal (δ 64.0) was associated with a singlet proton signal (δ 4.17, 3H), as expected for a methoxy group in (1). The presence of two CHO groups in (1) was supported by the association between the C signals (δ 206.2, 194.4) and singlet proton signals (δ 9.93, 10.30), respectively.

A comparison of the ^{1}H and ^{13}C NMR resonances of the aromatic moiety and associated phthalide ring in testacein with those of cyclopaldic acid (4) (Achenbach *et al.*, 1982), pestalotiopene A (2) (Hemberger *et al.* 2013) and pestalotiopene C (3) (Hammerschmidt *et al.* 2014), revealed the close analogy of the respective chemical shifts and indicated the presence of the substructure (5) in (1). Observed correlations in the gHMBC spectrum of testacein (1) (Figure 2) confirmed the presence of this substructure.

The observed NOESY correlations for (1) (Figure 3) indicated that the aliphatic CHO (δ 9.94) and three CH_3 groups (δ 0.91, 1.19 and 1.63) were on the same face of the molecule while one CH_3 group (δ 0.86) and a methine proton resonance (δ 0.97-1.00) were on the opposite face. These data confirmed the relative configuration of the asymmetric centres in the decaline moiety of (1).

The structure of aliphatic portion in testacein (1), followed from a comparison of ^{13}C-NMR data of (1) with those of the known diterpene aldehydes (6) and (7) (Figure 4). As the reported ^{13}C-NMR signals for (6) and (7) were simply listed rather than assigned, the data for these three compounds are listed in increasing order of chemical shifts for comparison (Table 3) [Kinoshita *et al.* 2003; Hua *et al.* 2004; Margaros *et al.* 2006; George *et al.* 2010]. Most of the signals are well matched except at and in the vicinity of C8 (at C7, C8, C9, C11 and C12), which is not surprising since the 8-OH group in (6) is replaced by an 8-*O*-substituted benzyl group in (1). Thus the most significant variations were observed at C8 [δ 78.5 in (1) and δ 72.9 in (6) and at C12 [δ 21.0 in (1) and 25.4 in (6)]. However, in pestalotiopene C (3) the chemical shift of C8 was recorded at δ 78.5, consistent with that observed in testacein (1) (Hammerschmidt *et al.* 2014). Further, the observed correlations in gHMBC spectrum of (1) (Figure 2) were consistent with the proposed structure of the aliphatic portion of this molecule.

The specific rotation of testacein (1) was measured as $[\alpha]_D^{24} = -8.6$ (c 0.12, $(CD_3)_2CO$), while specific rotation of the terpene (7) has been variously measured as $[\alpha]_D^{21} = +37.0$ (c 1.0, $CDCl_3$), $[\alpha]_D^{22} = +39.2$ (c 0.65, $CDCl_3$) and $[\alpha]_D^{22} = +31.9$ (c 0.0075, $CDCl_3$), while the specific rotation of the diastereomeric aldehyde (6) was recorded as $[\alpha]_D^{27} = -38.2$ (c= 0.84, $CDCl_3$) [Kinoshita *et al.* 2003; Hua *et al.* 2004; George *et al.* 2010]. As the absolute configuration of (6) is known with confidence, the absolute configuration of the aliphatic portion of testacein (1) was tentatively assigned as (5*R*,8*S*,9*S*,10*R*) as shown in Figure 4 (while recognized that alternative configurations such as (5*S*,8*R*,9*R*,10*S*) as observed in the fungal pestalotiopenes would also be possible).

Acknowledgement
We thank Mr Chris Blake (Research School of Chemistry, ANU) for his unfailing assistance with the NMR erxperiments.

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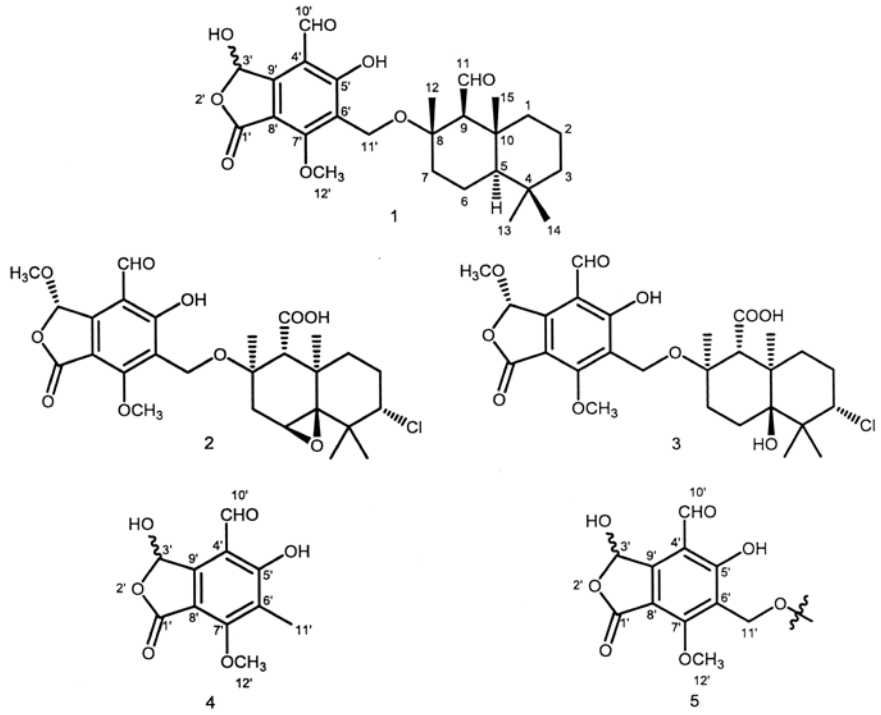

Figure 1. Structure of testacein (1), pestalotiopene A (2), pestalotiopene C (3), cyclopaldic acid (4) and substructure (5).

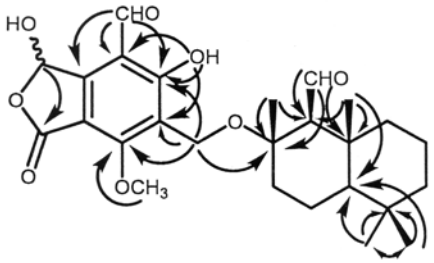

Figure 2. Correlations in gHMBC spectrum of testacein (1)

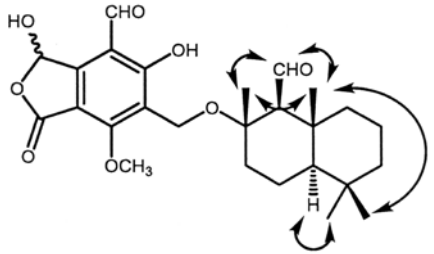

Figure 3. Correlations in NOESY spectrum of testacein (1)

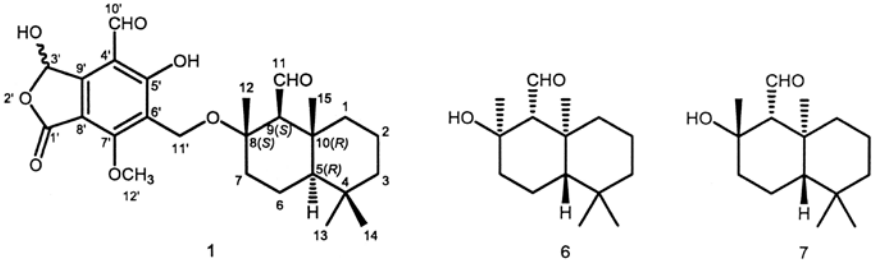

Figure 4. Structures of testacein (1) and terpenes (6) and (7)

Table 1. ^{1}H-NMR data for compounds (1), (2), (3) and (4) (δ ppm)

	1 $(CD_3)_2CO$	1 $(CDCl_3)$	2 $(CDCl_3)^{\$}$	2 $(CD_3)_2SO$*	3 $(CD_3)_2SO$*	4 $(CDCl_3)^{\#}$
1	1.14, 1.67	1.13, 1.67	1.44, 2.41	1.60	1.22	--
2	1.39, 1.62-1.66	1.44, 1.63	2.04-2.07, 2.17	1.90, 2.15	1.92, 2.07	--
3	1.21-1.24, 1.38-1.41	1.18, 1.40	3.94	4.01	4.51	--
5	0.97-1.00	0.93	--	--	--	--
6	1.46-1.49, 1.79-1.83	1.39, 1.79	3.24	3.36	1.97, 2.05	--
7	1.77, 2.12	1.70, 2.11	2.09, 2.84	2.05, 2.79	1.83, 2.28	--
9	2.20	2.20	3.25	3.25	3.31	--
11	9.93-9.94	9.94	--	--	--	--
12	1.63	1.63	1.40	1.36	1.39	--
13	0.86	0.84	0.95 (1.22)	0.95 (1.25)	1.09 (1.15)	--
14	0.91	0.90	1.22 (0.95)	1.25 (0.95)	1.15 (1.09)	--
15	1.19	1.20	1.47	1.50	1.61	--
3′	7.02	6.67	6.44	6.76	6.75	6.80
3′-OH	7.39	5.64	--	--	--	--
5′-OH	12.36	12.02	12.42	--	--	12.29
10′	10.30	10.16	10.08	10.22	10.20	10.21
11′	4.55	4.54	4.59, 4.71	4.57, 4.75	4.58, 4.61	2.16
12′	4.17	4.18	4.34	4.19	4.16	4.20

$ Hemberger *et al.*, * Hammerschmidt *et al.*, # Achenbach *et al.*)

Table 2. ^{13}C-NMR data for compounds (1), (2), (3) and (4) (δ ppm)

	1 $(CD_3)_2CO$	1 $(CDCl_3)$	2 $(CDCl_3)^{\$}$	2 $(CD_3)_2SO$*	3 $(CD_3)_2SO$*	4 $(CD_3)_2CO^{\#}$
1	40.6	40.2	35.5	34.9	--	--
2	18.8	18.2	28.9	28.9	--	--
3	42.5	41.8	68.4	68.4	71.0	--
4	33.8	33.4	41.2	41.2	46.2	--
5	56.0	55.5	66.8	66.0	78.5	--
6	20.7	20.1	53.5	53.7	39.0	--
7	39.5	39.0	32.9	33.6	34.6	--
8	78.5	78.7	75.7	74.6	78.5	--
9	70.2	69.6	55.2	52.9	56.4	--
10	39.3	38.8	36.6	36.0	--	--
11	206.2	207.0	171.0	173.1	--	--
12	21.2	21.0	26.9	27.5	28.7	--
13	21.8	21.7	22.6 (21.6)	21.1 (22.6)	18.5 (25.1)	--
14	33.8	33.5	21.6 (22.6)	22.6 (21.1)	25.1 (18.5)	--
15	17.4	17.4	18.3	17.8	17.6	--
1′	165.5	165.2	164.5	164.7	--	167.5
3′	96.0	94.8	99.9	100.8	--	96.0
4′	112.7	112.2	111.6	113.1	--	112.3
5′	167.9	167.8	167.0	167.0	--	166.0
6′	122.6	121.0	119.6	122.1	--	121.5
7′	164.8	164.0	163.9	162.8	--	163.4
8′	111.2	109.7	109.5	111.5	--	111.0
9′	155.6	153.8	152.4	151.3	--	153.7
10′	194.4	192.1	191.8	195.2	--	194.7
11′	51.1	51.6	52.2	51.7	--	8.1
12′	64.0	64.0	64.1	63.3	62.7	63.1

Table 3. Comparison of ^{13}C-NMR data for compounds (1), (6) and (7)

	1 $(CD_3)_2CO$	1 $(CDCl_3)$	6 $(CDCl_3)^{\alpha}$	6 $(CDCl_3)^{\beta}$	6 $(CDCl_3)^{\gamma}$	6 $(CDCl_3)^{\delta}$	7 $(CDCl_3)^{\beta}$
1	17.4	17.4	17.4	17.6	17.7	17.7	16.9
2	18.8	18.2	18.1	18.2	18.3	18.3	17.9
3	20.7	20.1	19.8	19.9	20.0	20.0	18.2
4	21.2	21.0	21.3	21.4	21.5	21.5	21.5
5	21.8	21.7	25.2	25.3	25.4	25.4	31.0
6	33.8	33.4	33.1	33.2	33.3	30.5	33.3
7	33.8	33.5	33.2	33.3	33.4	33.5	33.5
8	39.3	38.8	37.3	37.4	37.4	37.5	39.8
9	39.5	39.0	39.7	39.8	39.8	39.9	40.2
10	40.6	40.2	41.5	41.6	41.7	41.8	41.4
11	42.5	41.8	42.7	42.7	42.7	42.9	41.6
12	56.0	55.5	55.0	55.1	55.2	55.3	55.1
13	70.2	69.6	71.2	71.3	71.3	71.4	69.3
14	78.5	78.7	72.7	72.8	72.7	72.9	71.3
15	206.2	207.0	208.0	208.2	207.7	208.3	209.7

α Margaros *et al.*, β George *et al.*, γ Kinoshita *et al.*, δ Hua *et al.*

A new species of *Buellia* (Caliciaceae, Ascomycota) from Île Matthew, New Caledonia

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Abstract
Buellia mackeei Elix & H.Mayrhofer, a saxicolous species with *Physconia*- then *Buellia*-type ascospores, bacilliform conidia, and 4,5-dichlorolichexanthone and stictic acid, is described as new to science.

This paper describes a continuation of investigations into *Buellia*-like lichens in Australia, New Zealand (Elix 2018; Elix & McCarthy 2018 and references therein) and the islands of the South Pacific Ocean (Elix 2016; Elix & de Lange 2017). Here we describe a new saxicolous species of *Buellia sens. lat.* from Île Matthew, New Caledonia. Methods are as described in the papers cited above.

Buellia mackeei Elix & H.Mayrhofer sp. nov. Fig. 1
MycoBank No.: **MB 830140**

Similar to *Buellia maunakeansis* Zahlbr., but differs in having a continuous, rimose-areolate thallus and in containing stictic acid as its major secondary metabolite.

Type: New Caledonia, Île Matthew, Pic Est, [22°20'40"S, 171°21'20"E], 100 m alt., on volcanic rock, *H.S. McKee 38687*, 17.i.1981 (GZU – holotype).

Thallus crustose, rimose-areolate, white to pale grey, continuous, to 25 mm wide; areoles 0.2–1 mm wide, chinky, more or less flat; upper surface smooth or subgranular, matt; prothallus not apparent; medulla white, containing calcium oxalate (H_2SO_4+), I–; photobiont cells 7–11 µm diam. *Apothecia* 0.2–0.5 mm wide, lecideine, scattered, broadly adnate to sessile; disc black, epruinose, ± plane; proper exciple thin, concolorous with the disc, entire, persistent, cupuliform, in section 30–50 µm thick; outer zone opaque brown-black, K–, N–; inner zone pale brown. *Hypothecium* 130–225 µm thick, red-brown to dark brown, K–. Epihymenium 10–15 µm thick, dark brown, K–, N–. *Hymenium* 80–95 µm thick, colourless, not inspersed; subhymenium 25–35 µm thick, pale brown, not inspersed; paraphyses 1.7–2.0 µm wide, simple to branched, capitate; apices dark brown, 4–5 µm wide. *Asci* approximating the *Bacidia*-type, with 8 or fewer spores. *Ascospores* at first of the *Physconia*-type, then of the *Buellia*-type, 1-septate, olive-brown to brown, ellipsoid, 12–[*13.9*]–17 × 6–[*7.7*]–10 µm, not constricted at the septum; outer spore-wall smooth. *Pycnidia* immersed; conidia bacilliform, straight, 3.5–4.5 × 0.7–1 µm.
Chemistry: Thallus K+ yellow, C–, P+ orange, UV+ pale orange; containing 4,5-dichlorolichexanthone (minor), stictic acid (major), cryptostictic acid (minor), constictic acid (trace), norstictic acid (trace).

Etymology: The species is named after the collector of the type specimen, the late Australian botanist Dr H.S. McKee.

Remarks
This new species is characterized by the rimose-areolate, white to pale grey crustose thallus, with a non-amyloid medulla that contains calcium oxalate, the adnate to sessile, lecideine apothecia with epruinose discs, *Physconia*- then *Buellia*-type ascospores, 12–17 × 6–10 µm, the bacilliform conidia, 3.5–4.5 µm long, and the presence of 4,5-dichlorolichexanthone and stictic acid. Its anatomy resembles that of *B. maunakeansis*, a widely distributed Pacific species (Elix 2016). However, the thallus of *B. maunakeansis* differs in comprising markedly bullate, contiguous to dispersed, convex areoles and rust-brown pruinose discs, and in containing 4,5-dichlorolichexanthone, norstictic and connorstictic acids. Chemically, *B. mackeei* is identical to the stictic acid race of *Buellia mamillana* (Tuck.) W.A.Weber, but the latter has cryptolecanorine apothecia, an amyloid medulla lacking calcium oxalate, and longer, subfiliform conidia, 6–12 × 1–1.5 µm (Elix 2011).

At present, the new species is known only from the type locality. Île Matthew is an uninhabited volcanic islet located 446 km east of the New Caledonian mainland. It is 0.7 km^2 in area, and composed of two andesitic-to-dactic volcanic cones, piton Est (142 m high) and Soufrière Ouest (177 m high), separated by a rocky isthmus 200 m wide (Maillet *et al.* 1986). The only associated species are *Physcia dactylifera* Elix and *P. integrata* Nyl.

Acknowledgements
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Figure 1. *Buellia mackeei* (holotype in GZU). Scale = 1 mm.

A new lichenicolous species of *Sclerococcum* (Dactylosporaceae, Ascomycota) from south-eastern Australia

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Abstract
The new lichenicolous species *Sclerococcum ewersii*, collected on *Trapeliopsis* in south-eastern Australia, is described and illustrated.

Recently Diederich *et al.* (2018) have shown that *Sclerococcum sphaerale* (Ach.) Fr., a common, anamorphic lichenicolous fungus on *Lepra corallina*, and numerous *Dactylospora* species form a monophyletic group. Because the generic name *Sclerococcum* Fr. has priority over *Dactylospora* Körb., the authors transferred many species from the latter to the former. In addition, many newly detected teleomorphs were also included in *Sclerococcum*. In this paper we describe a new lichenicolous species of *Sclerococcum* from south-eastern Australia.

Sclerococcum ewersii Elix, P.M.McCarthy & Hafellner, sp. nov. Fig. 1
MycoBank No.: **MB 831354**

Similar to *Sclerococcum saxatile* (Schaer.) Ertz & Diederich, but differs in being lichenicolous on *Trapeliopsis* species. Apothecia immersed then broadly adnate, 0.1–0.25 mm wide; discs black, epruinose; ascospores brown, 1-septate, 9–13 × 4–5.5 µm.

Type: Australia, New South Wales, South Coast, Bodalla State Forest, Mummaga Lake Walk, 7 km SSE of Bodalla, 36°09'03"S, 150°05'46"E, *c.* 4 m alt., on sterile *Trapeliopsis* over sandstone in wet *Eucalyptus* woodland along inlet, *J.A. Elix 45698*, 17.ix.2008 (holotype – CANB; isotype – GZU).

Apothecia 0.1–0.25 mm wide, scattered or in groups, lecideine, round, emerging from the host thallus without appearing to produce any harm to the host tissues, immersed then broadly adnate; disc black, epruinose, weakly concave to plane or weakly convex. *Proper excipulum* persistent, black, initially raised above level of disc, in section 20–35 µm thick; outer part dark brown, K–, N+ orange-brown; inner part paler brown. *Epihymenium* 7–10 µm thick, dark brown, K–, N–. *Hypothecium* 65–80 µm thick, colourless in upper part, yellow-brown below, K–. *Hymenium* 45–55 µm thick, colourless, not inspersed; paraphyses rarely branched and anastomosing, 1.5–1.7(–2) µm wide, with apices 3–5 µm wide and brown caps. *Asci* 8-spored, of the *Dactylospora*-type, with a marked, external, amyloid cap (Hafellner 1979), 30–45 × 11–15 µm. *Ascospores* 1-septate, brown, ellipsoid, 9–[*11.1*]–13 × 4–[*4.7*]–5.5 µm; outer spore-wall smooth. *Pycnidia* not seen.
Chemistry: K–, P–, C–, UV–; no substances detected by TLC.

Etymology: The species is named after the Australian biologist, the late Dr W.H. (Bill) Ewers, who first collected it.

Remarks
Sclerococcum ewersii is a distinctive species, characterized by its lichenicolous habit, the dark brown epihymenium, the colourless to yellow-brown hypothecium and the small, 1-septate ascospores. Superficially, it resembles *Sclerococcum saxatile*, which occurs on *Pertusaria* spp. in the Northern and Southern Hemispheres (Hafellner 2004). However, *S. saxatile* has broader ascospores, 4.5–7.5 µm wide, and a pale brown hypothecium. *Sclerococcum australe* (Triebel & Hertel) Ertz & Diederich is also rather similar to *S. ewersii*, but it occurs on *Lecidea*, *Paraporpidia*, *Poeltiaria* and *Porpidia* species; it also has a thicker excipulum, 20–[*30*]–50 µm, and a deeper hymenium, 45–80 µm high (Triebel 1989).

ADDITIONAL SPECIMEN EXAMINED
Victoria: ● Victorian Volcanic Plain region, Mount Eccles, on rim near dry crater, 38°04'S, 141°56'E, on *Trapeliopsis granulosa* over basalt, *W.H. Ewers 75*, 11.x.1986 (CANB).

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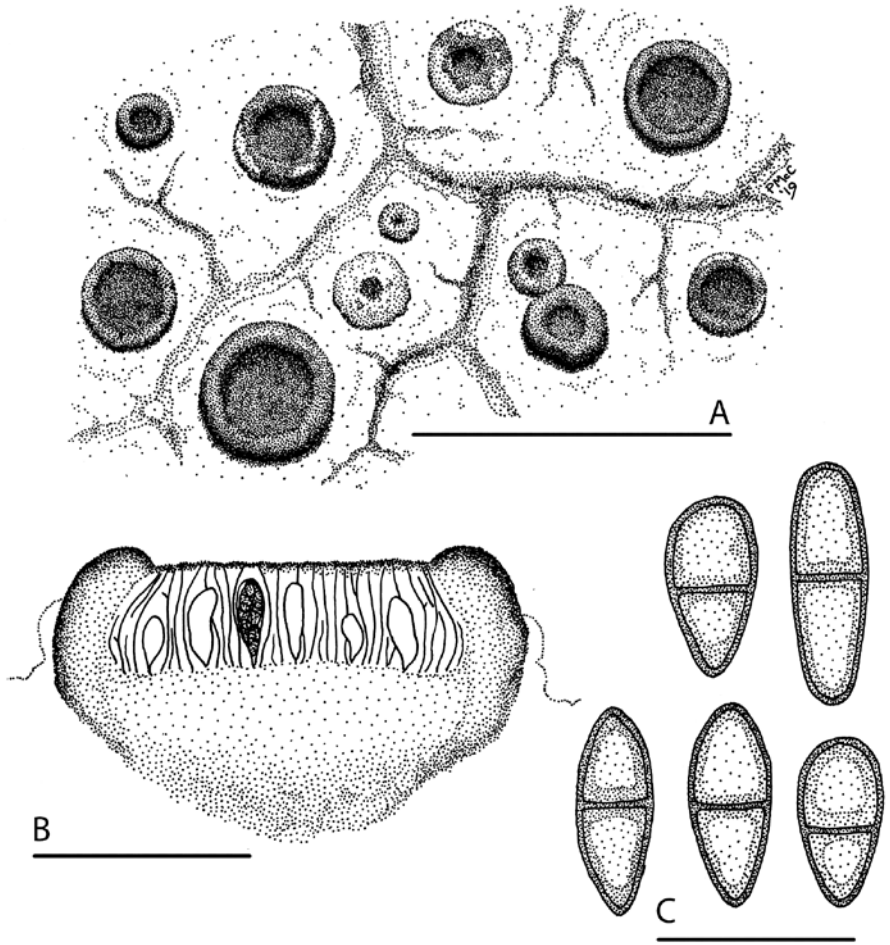

Figure 1. *Sclerococcum ewersii* (holotype in CANB). Scales A = 0.5 mm, B = 0.1 mm, C = 10 µm.

Trapelia concentrica (lichenized Ascomycota, Trapeliaceae), a new species from south-eastern Australia, with a key to the genus in Australia

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Abstract
Trapelia concentrica Elix & P.M.McCarthy (Trapeliaceae) is described as new from siliceous rocks and soil in south-eastern Australia. It is characterized by the inconspicuous, greyish white to dark grey, areolate thallus containing gyrophoric acid and calcium oxalate, and small, immersed to adnate, pseudolecanorine apothecia with white-pruinose discs often surrounded by a series of more-or-less concentric, circular fissures with a white-pruinose upper surface such that the apothecium can appear almost gyrose. A preliminary key to *Trapelia* in Australia is provided.

Introduction
The genus *Trapelia* M.Choisy (1929), based on *Lecidea coarctata* Sm., includes lichens with a *Chlorella*-type photobiont, hemiangiocarpic apothecia that burst through the upper surface of the thallus, a reduced, cupulate excipulum composed of prosoplectenchymatous hyphae, eight-spored, hemiamyloid asci (Baral 1987) in which the tholus typically lacks internal amyloid structures, simple ascospores, richly branched paraphyses and bacilliform to filiform conidia (Lumbsch & Kainz 2004; Kantvilas & Elix 2007; Purvis *et al*. 2009; Kantvilas *et al.* 2015; Orange 2018). All species contain gyrophoric acid or related substances.

Seven species of *Trapelia* have been reported from Australia (McCarthy 2018), including the widespread and probably cosmopolitan *T. coarctata* (Sm.) M.Choisy and *T. involuta* (Taylor) Hertel, the latter listed incorrectly by McCarthy (2018) as a synonym of the non-Australian *T. glebulosa* (Sm.) J.R.Laundon, as well as the Australasian *T. macrospora* Fryday, and four Australian endemics, *T. calvariana* Kantvilas & Lumbsch, *T. crystallifera* Kantvilas & Elix, *T. lilacea* Kantvilas & Elix and *T. thieleana* Kantvilas, Lumbsch & Elix. In this paper, a new species, *T. concentrica*, is described and illustrated from siliceous rocks and clay soil in the Australian Capital Territory and southern New South Wales. A preliminary key to the Australian species of *Trapelia* is also provided.

Trapelia concentrica Elix & P.M.McCarthy, sp. nov. Figs 1, 2
MycoBank No.: **MB 830251**
Similar to *Trapelia crystallifera*, but differs in having an areolate rather than a squamulose thallus, markedly pruinose discs, apothecia commonly surrounded by concentric fissures and thus appearing gyrose, and somewhat larger ascospores, 11–17 × 6–10 µm.

Type: Australia, Australian Capital Territory, Mount Majura Nature Reserve, Mawson Trail to Mt Majura, 35°13'34"S, 149°10'48"E, 720 m alt., on volcanic rocks in dry *Eucalyptus* woodland, *J.A. Elix 46713*, 13.ii.2019 (CANB – holotype).

Thallus whitish grey to glaucous grey or dark grey, sometimes with a pale fawn tinge, smooth at first, soon becoming rather scabrid, at length irregularly cracked, mealy and coarsely crystalline, not sorediate, areolate; areoles dispersed or contiguous, 0.15–0.3 mm wide, roundish then irregularly crenulate, plane to convex; medulla white, containing calcium oxalate (H_2SO_4+), I–. *Photobiont* green, of the *Chlorella*-type, with individual cells irregularly roundish or rhomboid, 6–9 × 5–8 µm, solitary or in pairs, triads or tetrads. *Apothecia* scattered, 0.1–0.7 mm wide, irregularly roundish, at first appearing as a pale pruinose disc, then often splitting at the apex, soon becoming superficial and often with white, slightly roughened or pruinose margins; proper margin very thin, brownish, usually with a well-developed, rather ragged, white thalline rim; apothecia occasionally surrounded by 1–3 more-or-less concentric fissures with a white-pruinose surface so that the apothecium appears almost gyrose; disc concave or plane to rather convex, brown, often densely white-pruinose. *Excipulum* in section cupular, brown at the sides, pale brown to colourless within, unchanged in K, 25–30 µm thick at the sides, 8–10 µm thick at the base. *Hypothecium* 40–60 µm thick, colourless to very pale brown, poorly differentiated from the hymenium. *Hymenium* 75–90 µm thick, colourless, I+ blue, not inspersed with granules or oil droplets. *Paraphyses* richly branched, particularly at the base and near the apices, slender, 1–2.5(–3) µm thick, flexuose, tangled, separating readily in K; apices not markedly expanded. *Asci* 8-spored, of the *Trapelia*-type, with an amyloid wall and a prominent, non-amyloid tholus, elongate-clavate, often with a long tapering stalk, 50–80 × 10–18 µm. *Ascospores* simple, non-halonate, thin-walled, often vacuolate, ovate to subglobose, 11–[*13.3*]–17 × 6–[*7.7*]–10 µm. *Pycnidia* punctiform, brown-black, immersed in areoles; conidia filiform, straight or weakly curved, 11–17 × 0.7 µm.
Chemistry: Thallus K–, C+ red, KC+ red, P–, UV–; containing gyrophoric acid (major), 5-*O*-methylhiascic acid (trace or absent).

Etymology: The specific epithet refers to the apothecia that are commonly surrounded by concentric fissures.

Remarks
The new species is characterized by small but conspicuous, pseudogyrose apothecia with pruinose discs, the nondescript, areolate thallus with a cracked, mealy surface, the simple, ovate to subglobose ascospores and the presence of gyrophoric acid. *Trapelia concentrica* appears to be most closely related to the widespread Australian endemic *T. crystallifera*, with both species having a crystalline, cracked, mealy surface and an esorediate, areolate to squamulose thallus that contains gyrophoric acid. There are, however, clear and consistent differences between the two taxa. In *T. crystallifera*, the squamules are very well-developed, generally separate and relatively large and crenulate-lobate throughout. By contrast, *T. concentrica* is areolate, with the areoles rounded, often dispersed and only rarely becoming crowded, overlapping, convex and bullate. In addition, *T. crystallifera* has epruinose discs, somewhat smaller spores, 9–[*12.3*]–15 × 4–[*6.4*]–8 µm, often pointed at one end, and a hymenium that is orange-brown in the upper part (intensifying orange in K) and colourless below.

At present, this species is known from siliceous rocks and clay soil in dry *Eucalyptus* woodland in the Australian Capital Territory and southern New South Wales. Commonly associated lichens on rock include various *Caloplaca* and *Xanthoparmelia* species, *Acarospora citrina* (Taylor) Zahlbr. ex Rech., *Buellia amandineiformis* Elix & Kantvilas, *B. suttonensis* Elix & A.Knight, *Candelariella vitellina* (Hoffm.) Müll.Arg., *Diploschistes eugeneus* (A.Massal.) J.Steiner, *D. sticticus* (Körb.) Müll.Arg., *Lecanora pseudistera* Nyl., *Lecidea terrena* Nyl., *Lepra erubescens* (Hook.f. & Taylor) A.W.Archer & Elix, *Pertusaria lophocarpa* Körb., *Rhizocarpon geographicum* (L.) DC. and *R. reductum* Th.Fr.

ADDITIONAL SPECIMENS EXAMINED
New South Wales: ● South Western Plains, 15 km SE of Berrigan, on "Brynton" farm, 35°47'23"S, 145°51'15"E, on consolidated clay soil in open *Eucalyptus* woodland, *D.J. Eldridge SAND 91 & D. Freudenberger*, 4.x.2000 (CANB); ● Coornartha Nature Reserve, Numeralla road, 15 km E of Cooma, 36°11'12"S, 149°16'50"E, 950 m alt., on sandstone in pasture, *P.M. McCarthy 4693*, 3.xi.2017 (CANB).
Australian Capital Territory: ● Woodstock Nature Reserve, Shepherds Lookout Walk, 20 km WNW of Canberra, 35°14'34"S, 148°58'38"E, 555 m alt., on porphyry rocks in open *Eucalyptus-Callitris* woodland, *J.A. Elix 46640*, 5.xii.2018 (CANB); ● Mugga Mugga Nature Reserve, W face of Mt Mugga Mugga, 8 km S of Canberra, 35°20'48"S, 149°07'09"E, 700 m

alt., on porphyry rocks in open *Eucalyptus-Allocasuarina* woodland, *J.A. Elix 46702*, 27.xii. 2018 (CANB); ● along the Molonglo River, 0.5 km W of Coppins Crossing, 8.5 km W of Canberra, 35°17'17"S, 149°01'58"E, 530 m alt., on porphyry rock outcrops in pasture, *J.A. Elix 46710*, 30.i.2019 (CANB); *P.M. McCarthy 4844*, *4849*, 30.i.2019 (CANB).

Preliminary Key to *Trapelia* in Australia

1 Thallus squamulose or subsquamulose 2
1: Thallus crustose; surface continuous, rimose or areolate 3

2 Thallus squamulose; upper surface scabrid, mealy, coasely crystalline; ascospores 9–16 × 4–8 µm ..... **T. crystallifera**
2: Thallus subsquamulose; upper surface smooth or minutely rugose; ascospores 15–25 × 7–13 µm ..... **T. involuta**

3 Ascospores 25–30 × 12–20 µm; apothecia immersed ..... **T. macrospora**
3: Ascospores 9–25 × 4–13 µm; apothecia immersed at first, then adnate to sessile 4

4 Thallus surface scabrid, mealy, coarsely crystalline; apothecia becoming pseudogyrose; disc pruinose at least in part ..... **T. concentrica**
4: Thallus surface smooth to rugulose, not crystalline; apothecia not pseudogyrose; disc epruinose 5

5 Thallus thicker at margins; containing 5-*O*-methylhiascic acid (major) 6
5: Thallus thinner at margins; containing gyrophoric acid (major) 7

6 Ascospores 16–23 × 9–15 µm; conidia 10–17 µm long; containing additional 5-methoxylecanoric acid ..... **T. lilacea**
6: Ascospores 11–18 × 5–10 µm; conidia 16–30 µm long; lacking 5-methoxylecanoric acid ..... **T. calvariana**

7 Upper surface often yellow-pigmented; containing gyrophoric acid (major) and 5-*O*-acetylhiascic acid (minor) ..... **T. thieleana**
7: Upper surface greenish grey; containing gyrophoric acid (major); 5-*O*-acetylhiascic acid absent ..... **T. coarctata**

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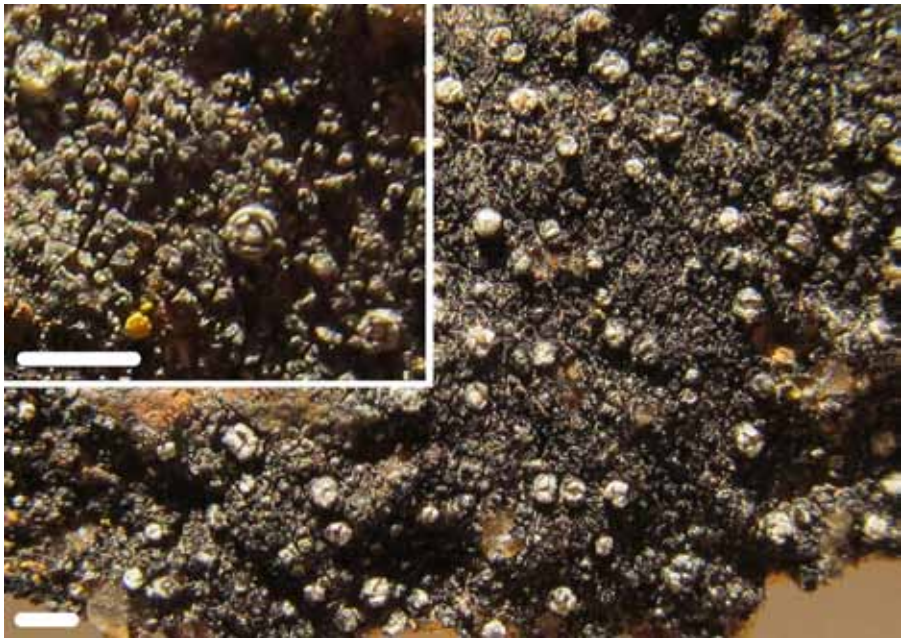

Figure 1. *Trapelia concentrica* (holotype in CANB), Scale = 1 mm.

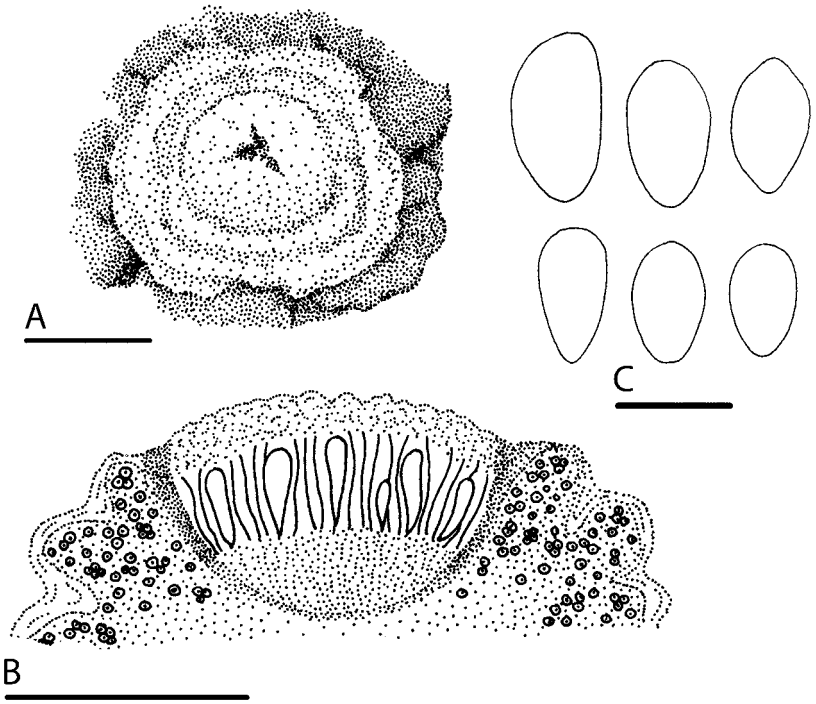

Figure 2. *Trapelia concentrica* (holotype in CANB), Scales A, B = 0.2 mm; C = 10 µm.

Rhizocarpon bicolor (lichenized Ascomycota, Rhizocarpaceae), a new species from south-eastern Australia

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Abstract
Rhizocarpon bicolor Elix & P.M.McCarthy (Rhizocarpaceae) is described as new from siliceous rocks in south-eastern Australia. It is characterized by the conspicuous black prothallus, a combination of small, dispersed, greenish grey to greyish brown and bright yellow areoles containing bourgeanic acid and rhizocarpic acid, respectively, a non-amyloid medulla, and small, lecideine apothecia developing on the prothallus adjacent to the areoles, with dark greenish blue to dark brown, 1-septate ascospores, 20–35 × 11–18 µm. An updated key is provided to the 18 species in Australia.

Introduction
Rhizocarpon Ramond ex DC. (Rhizocarpaceae) is a genus of *c.* 200 crustose species with areolate thalli, a usually distinct prothallus, diverse thalline chemistry, innate to superficial lecideine apothecia, mostly anastomosing and conglutinate paraphyses, distinctive 1–8-spored asci and hyaline to greenish black, halonate, ellipsoid ascospores that can be transversely septate or submuriform to densely muriform. Although predominantly free-living, a substantial minority of species are parasitic on other lichens, at least early in their development. The genus is most diverse and abundant on siliceous rocks in montane habitats and at temperate to higher latitudes; it is much rarer or completely absent in the wet and dry tropics and subtropics and in hot-arid regions (Clauzade & Roux 1985; Feuerer & Timdal 2004; Ihlen 2004; Fletcher *et al*. 2009).

In our recent revision of *Rhizocarpon* in mainland Australia (McCarthy & Elix 2014), we recognized 16 species including the pantemperate and rather common *R. geographicum* (L.) DC. and *R. reductum* Th.Fr., as well as *R. adarense* (Darb.) I.M.Lamb, *R. disporum* (Nägeli ex Hepp) Müll.Arg., *R. distinctum* Th.Fr., *R. flavomedullosum* Elix & P.M.McCarthy, *R. geminatum* Körb., *R. intersitum* Arnold, *R. lavatum* (Fr.) Haszl., *R. lecanorinum* Anders, *R. polycarpum* (Hepp) Th.Fr., *R. superficiale* (Schaer.) Malme, *R. vigilans* P.M.McCarthy & Elix and *R. viridiatrum* (Wulfen) Körb. In addition, *R. austroamphibium* Fryday & Kantvilas appears to be endemic to Tasmania, while *R. petraeum* (Wulfen) A.Massal. has a known Australian distribution restricted to Tasmania (Fryday & Kantvilas 2012; McCarthy 2018). More recently, *R. ridescens* (Nyl.) Zahlbr., previously known from the Northern Hemisphere, has been reported from New South Wales (Elix *et al.* 2018). In this paper, a new species, *R. bicolor*, is described and illustrated based on specimens from siliceous rocks in the Australian Capital Territory, New South Wales and Victoria, some of which were misidentified previously as *R. badioatrum* (Flörke ex Spreng.) Th.Fr. or *R. eupetraeoides* (Nyl.) Blomb. & Forsell (McCarthy & Elix 2014).

Rhizocarpon bicolor Elix & P.M.McCarthy, sp. nov. Figs 1, 2
MycoBank No.: **MB 830945**

Characterized by the conspicuous black prothallus and the minutely areolate thallus with a combination of dispersed, greenish grey to greyish brown areoles containing bourgeanic acid and bright yellow to yellow-green areoles containing rhizocarpic acid, a non-amyloid medulla, and lecideine apothecia, 0.25–0.6 mm wide, developing on the prothallus adjacent to the areoles, with dark greenish blue to dark brown, 1-septate ascospores, 20–35 × 11–18 µm.

Type: Australia. Australian Capital Territory, Namadgi National Park, former Honeysuckle Creek Tracking Station, 32 km SSW of Canberra, 35°35'03"S, 148°58'35"E, 1020 m alt., on granite rocks in open *Eucalyptus* woodland, *J.A. Elix 46725*, 27.ii.2019 (CANB – holotype; HO – isotype).

Thallus crustose, epilithic, areolate; areoles mainly dispersed, some greenish grey to greyish brown, 0.4–1 mm wide, *c.* 0.25 mm thick, others yellow to yellow-green and 0.2–0.7 mm wide; upper surface of grey-brown areoles smooth, shiny; upper surface of yellow areoles dull, granular; yellow areoles ± plane to weakly concave, often with slightly raised margins, sometimes becoming lobulate, the lobules rounded, 0.05–0.2 mm wide; grey-brown areoles ± plane to weakly convex, with down-turned margins. *Cortex* poorly defined, *c.* 10 µm thick, often subtending a hyaline necral layer up to 10–15 µm thick; cells rounded, 3.5–7 µm diam., thick-walled, with a dark olive-brown distal wall; inward-facing wall hyaline. *Photobiont* layer continuous, 40–80(–100) µm thick; cells green, globose, chlorococcoid, 7–16 µm diam. *Medulla* 0.10–0.15 mm thick, I–, white or brownish adjacent to the substratum; hyphae 3–6 µm wide, larger, thin-walled and more compacted above, more irregular in shape and loosely arranged below. *Prothallus* black, prominent, marginal and between areoles. *Apothecia* numerous, dull black, usually solitary, lecideine, roundish, immersed at first but soon broadly adnate, (0.25–)0.42(–0.6) mm wide [*n* = 30], not subtended by algae; disc black, epruinose, plane, weakly concave or weakly convex; proper excipulum thin, black, persistent, in section 40–65 µm thick; outer part brown-black, K–, N+ intense purple-brown; inner part brown. *Epihymenium* 12–20 µm thick, dark brown to brown-black, K+ weak purple-brown, N+ purple-brown. *Hypothecium* 200–250 µm thick, medium to dark brown, K–, N+ intense red-brown. *Hymenium* 90–120 µm thick, colourless, not inspersed, I+ blue; *paraphyses* richly branched and anastomosing, 1.5–2.2 µm wide, shortly septate, apices expanded, 4–5 µm, with dark brown caps. *Asci* cylindrical to clavate, 50–75 × 25–35 µm, 8-spored, *Rhizocarpon*-type, the spores irregularly biseriate or massed. *Ascospores* initially colourless, but soon dark greenish blue to dark brown, 1-septate, straight or rarely curved, ellipsoid, constricted at the septum with age, 20–[*29.5*]–35 × 11–[*15.1*]–18 µm [*n* = 50]; apices rounded to subacute. *Pycnidia* not seen.
Chemistry: Medulla K–, C–, PD–, UV–; yellow areoles containing rhizocarpic acid (major), ± bourgeanic acid (major); greenish grey to greyish brown areoles containing bourgeanic acid (major).

Etymology: The species is named for the contrasting yellow to yellow-green and greenish grey to greyish brown areoles.

Remarks

The new species is characterized by the conspicuous black prothallus, a combination of tiny, dispersed, greenish grey to greyish brown and bright yellow areoles with a non-amyloid medulla, containing bourgeanic acid and rhizocarpic acid, respectively, and small, lecideine apothecia developing on the prothallus adjacent to the areoles, and dark greenish blue to dark brown, 1-septate ascospores, 20–35 × 11–18 µm. Previously, several specimens with predominantly yellow areoles were misidentified as *R. eupetraeoides* (Nyl.) Blomb. & Forss. (McCarthy & Elix 2014), a species from northern Eurasia, North America, Greenland and Japan. Both *R. bicolor* and *R. eupetraeoides*, as well as *R. inarense* (Vain.) Vain. (known from Europe and North America), have similar-sized, dark, 1-septate ascospores and yellow-green areolate thalli containing rhizocarpic acid. However, *R. eupetraeoides* and *R. inarense* have larger areoles and apothecia, and all areoles are yellow-pigmented (Figs 3, 4). In addition, *R. eupetraeoides* typically has an amyloid medulla (Runemark 1956; Timdal & Holtan-Hartwig 1988; Matwiejuk 2008; Fletcher *et al.* 2009). On the other hand, mainland Australian specimens with predominantly greenish grey to greyish brown areoles were misidentified as *R. badioatrum* by McCarthy & Elix (2014). Although the ascospores of that species are very similar to those of *R. bicolor*, *R. badioatrum* has a much thicker, more robust thallus, larger apothecia, and it either contains stictic acid, diffractaic acid or lacks lichen substances (Timdal & Holtan-Hartwig 1988; Feuerer & Timdal 2004; Fletcher *et al.* 2009).

Rhizocarpon bicolor is known from siliceous rocks in *Eucalyptus* woodland in north-eastern and south-eastern New South Wales, the Australian Capital Territory and Victoria. Commonly associated lichens include *Acarospora citrina* (Taylor) Zahlbr. ex Rech., *Buellia homophylia* (C.Knight) Zahlbr., *B. procellarum* A.Massal., *Candelaria concolor* (Dicks.) B.Stein, *Candelariella vitellina* (Hoffm.) Müll.Arg., *Lecanora farinacea* Nyl., *Notoparmelia signifera* (Nyl.) A.Crespo, Ferencova & Divakar, *Paraporpidia leptocarpa* (C.Bab. & Mitt.) Rambold & Hertel, *Ramboldia petraeoides* (Nyl. ex C.Bab. & Mitt.) Kantvilas & Elix, *Tephromela atra* (Huds.) Hafellner, *Rhizocarpon geographicum* (L.) DC. and *R. reductum* Th.Fr.

ADDITIONAL SPECIMENS EXAMINED

New South Wales: ● Northern Tablelands, Dilgry Circle Road, Barrington Tops State Forest, 41 km NW of Gloucester, 31°52'S, 151°31'E, 1240 m alt., on rock face in dry sclerophyll forest with granite boulders, *J.A. Elix 24925* (*part*)*, H. Streimann 44551, 44562*, 26.iv.1990 (CANB); ● Southern Tablelands, 46 km S of Cooma along the Snowy Mountains Highway, alt. 1150 m, on granite in pasture, *J.A. Elix 5451*, 23.xi.1978 (CANB); ● Southern Tablelands, Big Badja Hill, 47 km NE of Cooma, 36°00'S, 149°34'E, alt. 1360 m, on metamorphic rock in heath with *Ghania subaequiglumis*, *D. Verdon 3468*, 2.iii.1978 (CANB); ● Southern Tablelands, at head of Merricumbene Creek, 11 km S of Monga, 35°16'S, 149°06'E, 820 m alt., on metamorphic rocks on open rocky ridge, *J.A. Elix 6417*, 21.xi.1979 (CANB); ● Southern Tablelands, Scottsdale Bush Heritage Reserve, 4 km N of Bredbo, 35°55'06"S, 149°08'07"E, 680 m alt., on exposed sandstone rocks in grassland, *J.A. Elix 46082*, *46083*, 7.v.2014 (CANB).
Australian Capital Territory: ● along Kangaroo Creek near Corin Dam, 35°32'S, 148°53'E, 1000 m alt., on granite in *Eucalyptus* forest, *J.A. Elix 1343*, 25.xi.1975 (CANB); ● Booroomba Rocks, 11 km SW of Tharwa, 35°31'S, 149°04'E, 1360 m alt., on exposed granite in subalpine heath, *J.A. Elix 6154* (*part*), 11.vii.1979 (CANB); ● below summit, Mt Bimberi, Namadgi Natl Park, 35°39'27"S, 148°47'20"E, alt. 1882–1900 m, on exposed granite, *P.M. McCarthy 4132, 4133* (*part*), 12.xii.2013 (CANB); ● type locality, on granite rock outcrops in open *Eucalyptus* woodland, *J.A. Elix 46726*, 27.ii.2019 (CANB); *loc. id.*, *P.M. McCarthy 4850, 4853*, 27.ii.2019 (CANB).
Victoria: ● Midlands, Horan Track, Tallarook State Forest, 17 km S of Seymour, 37°11'S, 145°10'E, 600 m alt., on exposed rock outcrop in dry sclerophyll forest, *H. Streimann 36060*, 25.xii.1985 (CANB); ● East Gippsland, Mt Ellery, Errinundra Natl Park, 29 km SSW of Bendoc, 37°24'S, 148°47'E, alt. 1280 m, on large, semi-exposed boulder in wet sclerophyll forest, *H. Streimann 47913*, 17.iv.1991 (CANB).

ADDITIONAL SPECIES EXAMINED

Rhizocarpon badioatrum (Florke ex Spreng.) Th.Fr.
Austria. ● Corinthia, Corinthian Alps, 10 km SW Koelschach-Mauthen, 4 km NW of Ploeckenpass, 500 m W of Obere Valentinalm, 46°37'15"N, 12°53'55"E, 1650 m alt., on horizontal face of schist outcrops near ground in alpine pasture, *W. Obermayer 12181,* 18.vii.2007 (CANB, [W. Obermayer, *Dupla Graecensis Lichenum* No. 778]).
Slovakia. ● High Tatras, Ticha Dolina, upper part of the valley, 1550 m alt., on a granite block at the edge of a stream, *J. Lambinon, 66/T/1105*, 9.viii.1966 (CANB).
Rhizocarpon eupetraeoides (Nyl.) Blomb. & Forss.
U.S.A. ● Alaska, Brooks Range, Atigun Pass, 68°07'N, 149°30'W, 1430 m alt., on Kanayut Formation, *F. Calkin & J. Ellis s.n.*, 11.viii.1979 (CANB, [*Lichenes Exsiccati* No. 608, distributed by the University of Colorado Museum, Boulder]).
Rhizocarpon inarense (Vain.) Vain.
Sweden. ● Torne Lappmark, Kiruna, summit of Mt Slåttatjåkka, Abisko (just outside the boundary of Abisko National Park), 68°21'35"N, 18°40'50"E, 1170 m alt., on silicate rock, *H. Hertel s.n.*, 16.viii.1980 (CANB, [H.Hertel, *Lecideaceae Exsiccatae* No. 37, distributed by the Botanischen Staatssammlung München]); ● Torne Lappmark, Kiruna, in the highest part of the Kärkevagge Valley, S of the main Låktatjåkka railway station, 68°23'20"N,

18°20’25”E, 850 m alt., on boulder at head of moraine at Lake Kärkevagge-padajaure, *H. Hertel s.n.*, 14.viii.1980 (CANB, [H.Hertel, *Lecideaceae Exsiccatae* No. 38, distributed by the Botanischen Staatssammlung München]).

Key to *Rhizocarpon* species in Australia

1 Upper surface of thallus yellow-green; cortex containing rhizocarpic acid.....2
1: Upper surface of thallus whitish, brown, green or grey; cortex lacking rhizocarpic acid..8

2 Thallus with punctiform to capitate soralia; soredia yellow-green, granular.....***R. ridescens***
2: Thallus lacking soralia.....3

3 Ascospores 1-septate.....4
3: Ascospores submuriform to muriform.....6

4 Ascospores 20–35 × 11–18 µm.....***R. bicolor***
4: Ascospores 12–23 × 6–10 µm.....5

5 Medulla yellow; containing only rhizocarpic acid.....***R. adarense***
5: Medulla white; containing rhizocarpic and stictic or perlatolic acids.....***R. superficiale***

6 Thallus forming a pseudolecanorine margin around apothecia.....***R. lecanorinum***
6: Thallus not forming a pseudolecanorine margin around apothecia.....7

7 Thallus initially parasitic on the lichen *Aspicilia sens. lat.*; upper surface usually pale green; containing rhizocarpic and ± norstictic acids.....***R. viridiatrum***
7: Thallus not parasitic on other lichens; upper surface predominantly yellow; containing rhizocarpic and psoromic, barbatic or 2’-*O*-methylperlatolic acids.....***R. geographicum***

8 Ascospores 1-septate.....9
8: Ascospores 3-septate to submuriform or muriform.....12

9 Mature ascospores hyaline, 17–22 × 8–11 µm; medulla I+ blue.....***R. polycarpum***
9: Mature ascospores dark grey-green to dark brown; medulla I+ blue or I–.....10

10 Medulla white, I+ blue.....***R. vigilans***
10: Medulla yellow or white, I–.....11

11 Medulla yellow above [rhizocarpic acid]; ascospores 12–22 × 6–10 µm.....
.....***R. flavomedullosum***
11: Medulla uniformly white; ascospores 20–35 × 11–18 µm.....***R. bicolor***

12 Mature ascospores predominantly 3-septate, rarely 1-septate, occasionally with 1 or 2 longitudinal or diagonal septa, colourless (collapsed post-mature ascospores can be dark brown); medulla I+ blue.....***R. distinctum***
12: Mature ascospores submuriform to muriform, with 8–50 cells in optical section, colourless to dark brown; medulla I–.....13

13 Mature ascospores colourless.....14
13: Mature ascospores dark grey-green to dark brown.....16

14 Ascospores 22–35 µm long.....***R. reductum***
14: Ascospores 33–50 µm long.....15

15 Upper surface pale brown; proper margin thick, swollen; thallus lacking lichen substances; on siliceous rocks.....***R. lavatum***
15: Upper surface white to grey; proper margin not swollen; thallus with stictic acid; usually on calcareous rocks.....***R. petraeum***

16 Asci 1-spored; ascospores 50–75 × 20–30 µm.....***R. disporum***
16: Asci 2–8-spored; ascospores smaller.....17

17 Ascospores 24–34 × 10–16 µm, (4–)8 per ascus.....***R. intersitum***
17: Ascospores 30–55 × 17–25 µm, 2–6 per ascus.....18

18 Paraphyses anastomosing; ascospores (1–)2(–4) per ascus; apothecia ± elevated, uniformly black; on comparatively dry montane rocks, not associated with water bodies.....
.....***R. geminatum***
18: Paraphyses ± simple; ascospores 2–4(–6) per ascus; apothecia immersed, with a white rim; on rocks in and around Tasmanian alpine lakes.....***R. austroamphibium***

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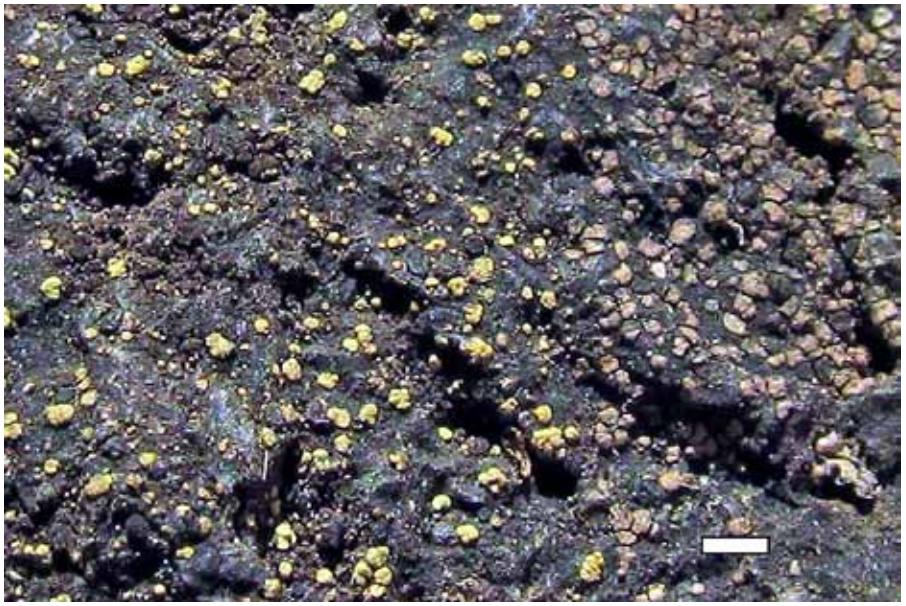

Figure 1. *Rhizocarpon bicolor* (holotype in CANB). Scale = 2 mm.

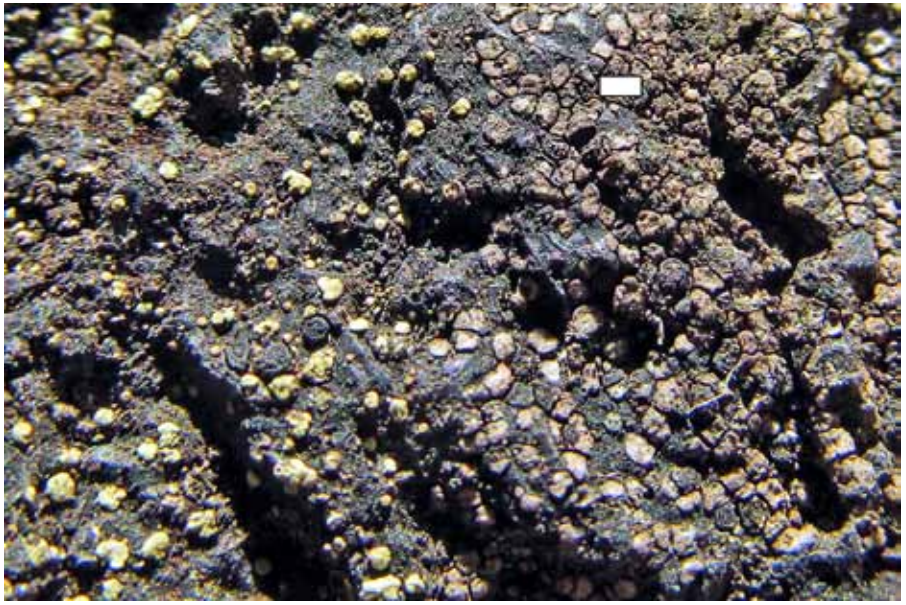

Figure 2. *Rhizocarpon bicolor* (holotype in CANB). Scale = 1 mm.

Figure 3. *Rhizocarpon eupetraeoides* (*Calkin & Ellis s.n.* in CANB). Scale = 2 mm.

Figure 4. *Rhizocarpon inarense* (*Hertel 37* in CANB). Scale = 2 mm.

Two new corticolous species of *Eugeniella* (lichenized Ascomycota, Pilocarpaceae) from Norfolk Island, south-western Pacific Ocean

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Abstract
Eugeniella pacifica P.M.McCarthy & Elix (Pilocarpaceae) is described as new from bark in Norfolk Island, south-western Pacific Ocean. It is characterized by the preferred substratum, the distinctive, greyish white, verruculose thallus containing stictic acid, and comparatively large, sessile, pseudolecanorine apothecia with a thick, cupulate, proper exciple containing K-soluble granules, but not calcium oxalate, and 3-septate ascospores that are narrowly ellipsoid, short-fusiform or broadly oblong and (10–)13(–15) × (3.5–)4.5(–5) µm. The corticolous *E. zeorina* P.M.McCarthy & Elix, sp. nov., also from Norfolk Island, is superficially very similar, and most anatomical attributes are almost identical. However, the dark brown hypothecium is thicker, and it merges with and penetrates the excipulum base, the 3(–5)-septate ascospores are elongate-fusiform to narrowly oblong or oblong-fusiform and (14–)20(–28) × (3–)4(–4.5) µm, and the thallus contains substantial quantities of zeorin, in addition to stictic acid. A key is provided to the 13 species of *Eugeniella*.

Introduction

Eugeniella Lücking, Sérus. & Kalb was described for several species previously included in *Bacidia sens. lat.* and *Byssoloma* Trevis. (Lücking 2008). It is defined primarily by its excipular anatomy of moniliform hyphae heavily encrusted with crystals or granules, along with *Byssoloma*-type asci, mostly unbranched paraphyses, and transversely septate to muriform ascospores. The genus includes 11 foliicolous and corticolous species, most of which are exclusively Neotropical (Lücking 2008; Cáceres *et al.* 2013; Breuss & Lücking 2015), as well as the broadly Palaeotropical *E. microммata* (Kremp.) Lücking, Sérus. & Kalb, which has been reported from north-eastern New South Wales (Lücking *et al.* 2001), and two temperate Australian species, *viz.* the corticolous *E. farinosa* P.M.McCarthy & Elix from Tasmania and the foliicolous *E. usnica* P.M.McCarthy & Elix from leaves in southern New South Wales and eastern Victoria (McCarthy & Elix 2016). In this paper, *E. pacifica* and *E. zeorina* are described and illustrated from bark in Norfolk Island, an external territory of Australia in the south-western Pacific Ocean.

New species

1. Eugeniella pacifica P.M.McCarthy & Elix, sp. nov. Figs 1, 2
MycoBank No.: **MB 830075**

Characterized by the thin, greyish white, verruculose, corticolous thallus containing stictic acid and associated substances, but not calcium oxalate; sessile, biatorine apothecia 0.37–1.15 mm wide, with an epruinose, initially pinkish medium to dark grey or greyish brown, and finally blackish grey disc and a greyish white, flexuous to undulate proper margin of moniliform hyphae encrusted with K-soluble granules; the proper excipulum cupulate beneath the dark brown hypothecium; an inconspicuous epihymenium; simple to sparingly branched paraphyses; and *Byssoloma*-type asci, 38–56 × 9–14 µm, containing narrowly ellipsoid to oblong or fusiform, 3-septate ascospores of 10–15 × 3.5–5 µm.

Type: Australia: Norfolk Island, Mount Pitt Reserve, Red Road Track to Mt Bates, 29°00'30"S, 167°56′30"E, alt. 220 m, on bark of sapling in mixed, subtropical rainforest, *J.A. Elix 18618 & H. Streimann*, 6.xii.1984 (holotype – CANB).
Thallus crustose, epiphloeodal, silvery greyish white, 50–100 µm thick, continuous to richly rimose or abundantly but obscurely areolate, the areoles to *c.* 0.5 mm wide, separated by thin, very faint cracks, not containing calcium oxalate (H_2SO_4–); surface dull to slightly glossy, abundantly verruculose, the verrucules rounded to irregular in outline, low-convex, most clearly defined towards the thallus margin, 50–80(–100) µm wide, ecorticate, but with a distal, hyaline amorphous layer 15–40 µm thick. *Algal cells* green, globose, chlorococcoid, 4–8(–10) µm diam., thick-walled. *Medulla* not clearly delimited; hyphae long-celled, 2–3 µm wide. *Prothallus* marginal, blackish or not apparent. *Apothecia* numerous, sessile, solitary and rounded or shallowly to deeply lobate, often proliferating from the margin into clusters of 3 or 4 daughter apothecia, their shape distorted by mutual pressure, or new apothecia emerging from the disc; individual apothecia (0.37–)0.78(–1.15) mm wide [*n* = 40]; disc at first pinkish medium to dark grey or greyish brown, finally blackish grey, becoming darker still when wetted, smooth, epruinose, plane to slightly convex; proper margin concolorous with the thallus, biatorine, prominent, persistent, 60–100(–120) µm thick in surface view, initially entire, but soon flexuose to coarsely undulate or deeply lobate. *Proper excipulum* cupulate, 50–90 µm thick laterally, 60–100 µm thick at the base, sharply delimited from the hypothecium, opaque-hyaline to pale yellowish brown in thin section, N–, I–, not containing calcium oxalate (H_2SO_4–), heavily impregnated with minute granules that dissolve in K, revealing radiating, thin-walled, moniliform hyphae that are branched and sparingly anastomosed; cells narrowly ellipsoid, 5–10(–12) µm long and 3.5–6(–7) µm wide. *Hypothecium* dark brown, 60–95 µm thick, not inspersed with granules or oil droplets, non-amyloid, K+ intensifying reddish, N+ deep red-brown; central cells ± rounded, 4–6 µm wide; cells adjacent to the hymenium and excipulum anticlinally elongate. *Hymenium* 50–70 µm thick, not inspersed, I+ dark blue, K+ patchily dark greenish brown. *Epihymenium* 8–15 µm thick, poorly delimited, pale yellowish brown and minutely granular, the pigment dissolving in K, but the crystals persisting, N–. *Paraphyses* simple to sparingly branched (mainly distally), long-celled, moderately conglutinate in water, loosening a little in K, 1–1.5 µm thick; apical cells neither swollen nor pigmented. *Asci* narrowly to broadly clavate or clavate-cylindrical, 8-spored, 38–56 × 9–14 µm [*n* = 20], *Byssoloma*-type (Hafellner 1984); tholus well-developed, uniformly amyloid, but with an inconspicuous *masse axiale* bordered by a more intensely amyloid zone; ocular chamber conical or not apparent. *Ascospores* colourless, 3-septate at maturity, narrowly ellipsoid to oblong or fusiform, irregularly biseriate in the ascus, straight or slightly bent, with rounded or subacute apices, not or only slightly constricted at the septa, (10–)13(–15) × (3.5–)4.5(–5) µm [*n* = 80], thin-walled; perispore *c.* 0.5 µm thick or not apparent. *Pycnidia* not seen. *Chemistry*: Containing stictic acid (major), cryptostictic acid (minor), atranorin (minor) and menegazziaic acid (trace) by TLC (Elix 2014).

Etymology: The epithet *pacifica* refers to the oceanic location of Norfolk Island.

Remarks

Prior to the recognition of the new species, *E. farinosa*, from Tasmania, and the Central American *E. palleola* Breuss & Lücking were the only obligately corticolous species of *Eugeniella* with 3-septate spores. However, unlike *E. pacifica*, the former has a farinose thallus and a thin apothecial margin, both containing usnic acid and calcium oxalate, while the apothecia are 0.25–0.60 mm wide and have a convex, medium greenish brown disc (McCarthy & Elix 2016). *Eugeniella palleola* has a minutely uneven but non-farinose thallus containing, as does *E. pacifica*, stictic acid and atranorin, the apothecia are 0.6–1.5 mm wide, while the apothecial margin contains norstictic acid, and the brown-black hypothecium is subtended by a concolorous "apothecial base" (Breuss & Lücking 2015). The second, newly described Norfolk Island species, *E. zeorina*, is very similar in outward appearance and anatomy, but it also exhibits significant differences in thallus chemistry, hypothecial extent and in the size and shape of the ascospores (see below).

The predominantly foliicolous *E. micrommata* occurs throughout much of the Palaeotropics, and usually has a sparingly verruculose thallus, sessile apothecia 0.2–0.5(–0.7) mm wide, an excipulum *c.* 40 µm thick, a dark brown hypothecium only 20–30 µm thick and ascospores 12–20 µm long (Santesson 1952; as *Bacidia micrommata*). A somewhat anomalous specimen was reported from north-eastern New South Wales [Cedar Park, Tamban Forest Drive, 30 km NW of Kempsey, 30°55'S, 152°49'E, on leaves of tree in rainforest, *J.A. Elix 33157A*, 14.vii.1992 (CANB)] by Lücking *et al.* (2001). While this specimen has thin, smooth, non-verruculose thallus, it "agrees in all other features with typical populations" Lücking *et al.* (2001). Furthermore, the apothecial margins contain calcium oxalate (H_2SO_4+), but not K-soluble granules, and TLC demonstrated the presence of usnic acid.

The remaining Australian species, *E. usnica*, is characterized by a very thin, often smooth, pale to medium green or pale greyish green thallus on herb and tree leaves and on fern pinnae. It has highly conspicuous, sessile apothecia 0.24–0.62 mm diam., with a plane, epruinose, dark olive-brown to blackish disc, a persistent, white to pale yellowish proper margin encrusted with crystals of calcium oxalate and containing usnic acid. The excipulum is cupulate or only partially subtending the medium to dark reddish brown hypothecium, and the 3-septate ascospores are 11–16 × 3.5–5 µm (McCarthy & Elix 2016).

Eugeniella pacifica is known only from the bark of a sapling in subtropical rainforest at the type locality in Norfolk Island, in the south-western Pacific Ocean. Associated lichens include *Caloplaca* sp., *Graphis crassilabra* Müll.Arg., *Lecanora* sp., *Letrouitia* sp., *Megalaria insularis* P.M.McCarthy & Elix and *Pyrenula quassiaecola* Fée.

2. Eugeniella zeorina P.M.McCarthy & Elix, sp. nov. Figs 3, 4
MycoBank No.: **MB 830242**

Similar to *E. pacifica* P.M.McCarthy & Elix, but differs in having a thicker hypothecium (100–160 µm thick vs 60–95 µm) merging with and penetrating the excipulum base, 3(–5)-septate ascospores that are elongate-fusiform to narrowly oblong or oblong-fusiform and (14–)20(–28) × (3–)4(–4.5) µm [vs (10–)13(–15) × (3.5–)4.5(–5) µm], and the thallus containing substantial quantities of zeorin in addition to stictic acid.

Type: Australia: Norfolk Island, Mount Pitt National Park, Duncombe (Bay) Road, 29°00'35"S, 167°52′05"E, on bark of treelet in subtropical rainforest on moderate slope with numerous rock outcrops, *J.A. Elix 29238*, 18.vi.1992 (holotype – CANB).

Thallus crustose, epiphloeodal, greenish white to cream-white, 50–100 µm thick, continuous to richly rimose but scarcely or only very obscurely areolate, not containing calcium oxalate (H_2SO_4–); surface dull to slightly glossy, abundantly verruculose, the verrucules rounded to irregular in outline, low-convex, to *c.* 50–80 µm wide, ecorticate, but with a distal, hyaline amorphous layer 8–15(–20) µm thick. *Algal cells* green, globose, chlorococcoid, 5–10 µm diam., thick-walled. *Medulla* not clearly delimited; hyphae long-celled, 2–3 µm wide. *Prothallus* not apparent. *Apothecia* moderately numerous, sessile, solitary and rounded or shallowly to deeply lobate, often proliferating from the margin into clusters of 3–6(–8) daughter apothecia, their shape distorted by mutual pressure, or new apothecia emerging from the disc; individual apothecia (0.43–)0.68(–1.05) mm wide [*n* = 45]; disc medium to dark greyish brown, finally blackish grey, becoming darker still when wetted, smooth, epruinose, slightly concave to plane; proper margin concolorous with the thallus, biatorine, prominent, persistent, 50–80(–100) µm thick in surface view, initially entire, but soon flexuose to coarsely undulate or deeply lobate. *Proper excipulum* initially cupulate, 60–110 µm thick laterally, 50–80 µm thick at the base, or finally appearing pseudoannulate as the base is penetrated from above by the hypothecium, otherwise not sharply delimited from the hypothecium, opaque-hyaline to pale yellowish brown in thin section, N–, I–, not containing calcium oxalate (H_2SO_4–), heavily impregnated with minute granules, most of which (but not all) dissolve in K, revealing radiating, thin-walled, moniliform hyphae that are branched and sparingly anastomosed; cells narrowly ellipsoid, 5–10 µm long, 3–5(–6) µm wide. *Hypothecium* dark brown, 100–160 µm thick, not inspersed with granules or oil droplets, non-amyloid, K– or K+ intensifying reddish, N+ deep red-brown; central cells ± rounded, 4–6 µm wide; cells adjacent to the hymenium and excipulum anticlinally elongate. *Hymenium* 60–80 µm thick, not inspersed, or with granules diffusing down from the epihymenium, I+ dark blue, KI+ medium lilac-blue. *Epihymenium* 8–12 µm thick, poorly delimited, pale yellowish brown and minutely granular, the pigment dissolving in K, but the crystals persisting, N–. *Paraphyses* simple to very sparingly branched (mainly distally), long-celled, moderately conglutinate in water, loosening a little in K, 1–1.5(–2) µm thick; apical cells hyaline, not or only slightly swollen. *Asci* narrowly to broadly clavate or clavate-cylindrical, 8-spored, 54–69 × 9–13 µm [*n* = 14], *Byssoloma*-type (Hafellner 1984). *Ascospores* colourless, mostly 3-septate at maturity (fewer than 1% 4- or 5-septate), elongate-fusiform to narrowly oblong or oblong-fusiform, irregularly biseriate in the ascus, straight or slightly bent to moderately curved, with rounded or subacute apices, not constricted at the septa, (14–)20(–28) × (3–)4(–4.5) µm [*n* = 90], thin-walled; perispore *c.* 0.5 µm thick or not apparent. *Pycnidia* not seen.
Chemistry: Containing atranorin (major), stictic acid (major), zeorin (major) and cryptostictic acid (minor) by TLC (Elix 2014).

Etymology: The epithet *zeorina* alludes to the abundance of the terpenoid zeorin in the thallus of the new species.

Remarks

The striking morphological and anatomical similarities between *E. zeorina* and *E. pacifica*, set against unambiguously significant differences (see the diagnosis above and the key to species below), bring to mind the series of closely related, Neotropical and pantropical taxa, highlighted by Lücking (2008), and comprising *E. leucocheila* (Tuck.) Lücking, Sérus. & Kalb, *E. newtoniana* (Henriques) Lücking, Sérus. & Kalb and *E. ortizii* (Lücking) Lücking, Sérus. & Kalb. All have similar thallus and apothecial morphology, but they differ in ascospore size and septation (Lücking 2008). However, the apparently sympatric and possibly comparatively recent speciation exhibited by the two taxa in remote Norfolk Island is especially noteworthy.

Eugeniella zeorina is known only from the bark of a treelet in subtropical rainforest at the type locality in Norfolk Island, in the south-western Pacific Ocean.

Key to the species of *Eugeniella*

[Based on Lücking (2008); Cáceres *et al.* (2013); Breuss & Lücking (2015); McCarthy & Elix (2016) and the two newly described species]

1 Ascospores submuriform, 7–10 µm wide [foliicolous; Costa Rica, West Africa & Thailand] ..... **E. newtoniana**
1: Ascospores with 3–7 transverse septa only, 2.5–5.5 µm wide 2

2 Most or all ascospores 3-septate 3
2: Most or all ascospores 5–7-septate 12

3 Apothecial disc pale brown to grey or medium greenish brown 4
3: Apothecial disc dark brownish grey, dark olive-brown, dark grey or blackish 5

4 Thallus farinose; apothecial margin containing usnic acid; hypothecium medium to dark reddish brown; ascospores 10–15 µm long [corticolous; SE Australia] ..... **E. farinosa**
4: Thallus minutely uneven but not farinose; apothecial margin containing norstictic acid; hypothecium brown-black; ascospores 13–17(–20) µm long [corticolous; Nicaragua] ..... **E. palleola**

5 Thallus minutely and abundantly or more coarsely and sparingly warted 6
5: Thallus smooth or minutely uneven, but not warted 9

6 Thallus corticolous 7
6: Thallus foliicolous 8

7 Ascospores 10–15 × 3.5–5 µm; hypothecium 60–95 µm thick, not penetrating the excipulum base; thallus not containing zeorin [Norfolk Island] ..... **E. pacifica**
7: Ascospores 14–28 × 3–4.5 µm; hypothecium 100–160 µm thick, penetrating the excipulum base; thallus containing zeorin [Norfolk Island] ..... **E. zeorina**

8 Thallus greenish; verrucae white, 0.07–0.15 mm wide; paraphyses unbranched [Neotropics] ..... **E. psychotriae**
8: Thallus bluish grey or white; verrucae concolorous, 0.1–0.2 mm wide; paraphyses branched and anastomosing [pantropical] ..... **E. micrommata**

9 Apothecial margin evanescent; tubular or coralloid pycnidia usually present [foliicolous; Neotropics] ..... **E. corallifera**
9: Apothecial margin well-defined and persistent; pycnidia absent 10

10 Apothecial margin pale grey to brownish grey; ascospores 2.5–3.5 µm wide [foliicolous; Brazil] ..... **E. atrichoides**
10: Apothecial margin white, pale yellowish white or pale brown; ascospores 3–5 µm wide. 11

11 Hypothecium and subhypothecial tissues dark brown to brownish black; apothecial margin white to pale brown; thallus containing perlatolic acid (major), also stenosporic and glomelliferic acids [corticolous & foliicolous; Neotropics, SE U.S.A. & tropical Africa] ... . **E. leucocheila**
11: Hypothecium medium to dark reddish brown; subhypothecial tissue hyaline to pale brown; apothecial margin white to yellowish; thallus containing usnic acid (major), also atranorin and chloroatranorin [foliicolous; SE Australia] ..... **E. usnica**

12 Most ascospores 5-septate, 17–26 µm long [foliicolous; Neotropics] ..... **E. ortizii**
12: Ascospores 7-septate, 25–42 µm long [corticolous; Brazil] ..... **E. nigrodisca**

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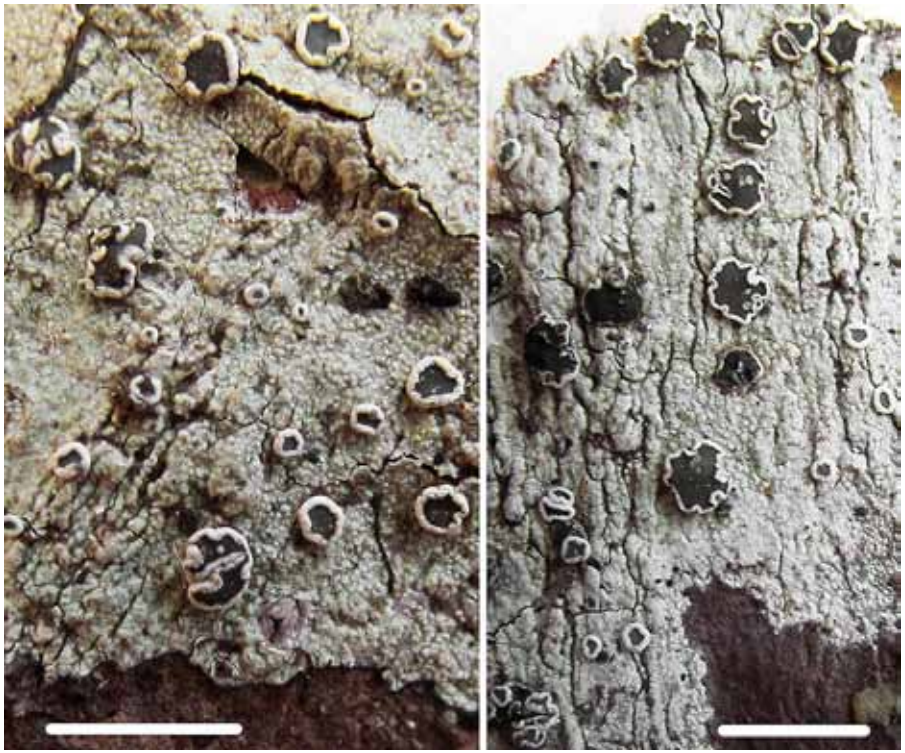

Figure 1. *Eugeniella pacifica* (holotype). Scales: 2 mm.

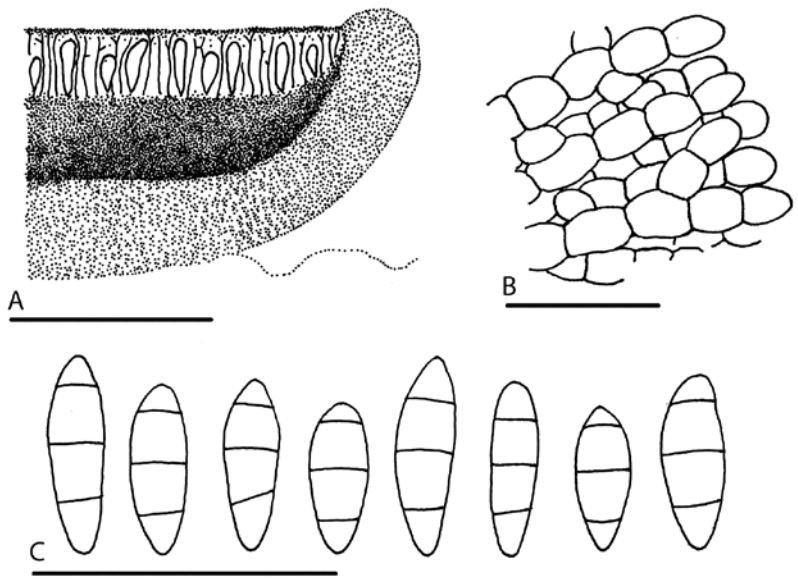

Figure 2. *Eugeniella pacifica* (holotype). A, Part of the vertical section of an apothecium (semi-schematic); B, Outer hyphae of the lateral excipulum following the dissolution of cellular granules in K; C, Ascospores. Scales: A = 0.2 mm; B, C = 20 µm.

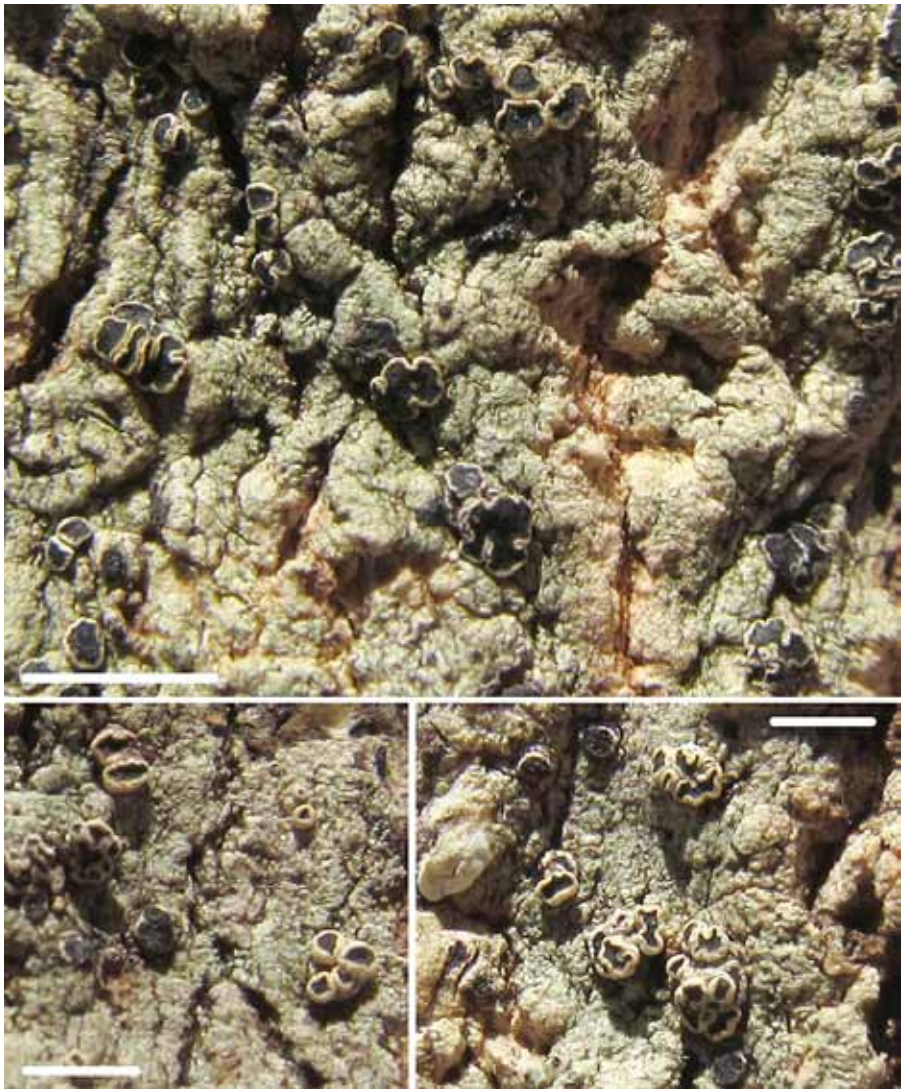

Figure 3. *Eugeniella zeorina* (holotype). Scales: 2 mm.

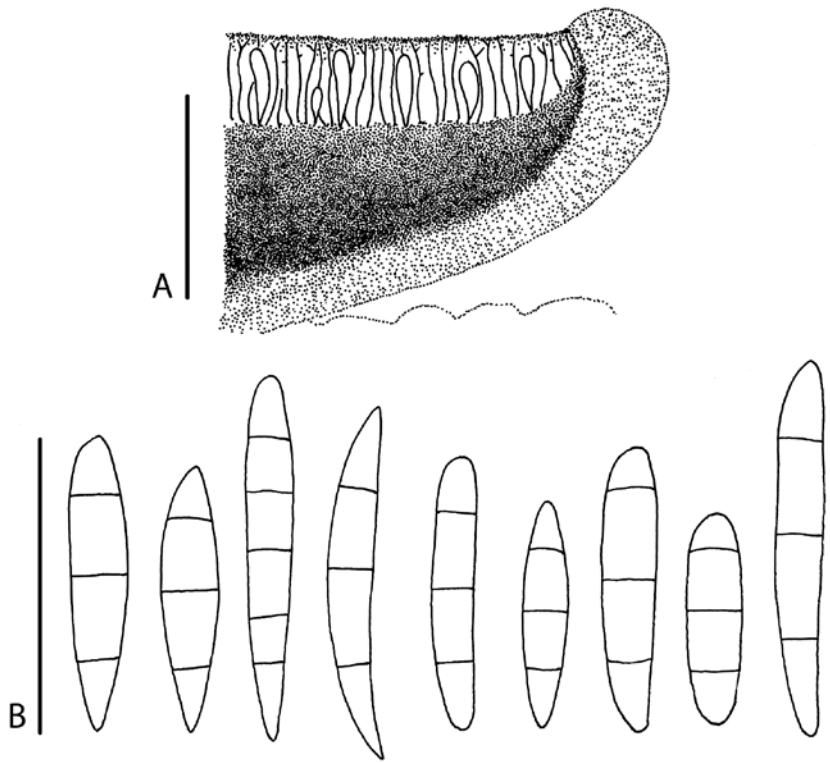

Figure 4. *Eugeniella zeorina* (holotype). A, Part of the vertical section of an apothecium (semi-schematic); B, Ascospores. Scales: A = 0.2 mm; B = 20 µm.

Graphis norfolkensis, a new species in the Australian Graphidaceae (lichenized Ascomycota, Ostropales) from Norfolk Island

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Abstract
Graphis norfolkensis, characterized by a completely carbonized proper exciple, small hyaline, muriform ascospores, and the presence of salazinic and protocetraric acids, is described as new to science.

Introduction
Some selected lichen genera on Norfolk Island have been studied previously (Elix & Streimann 1989; Elix *et al.* 1992), and four *Graphis* species have been reported from the island: *G. caesiella* Vain., *G. crebra* Vain., *G. crassilabra* Müll.Arg. and *G. subvelata* Stirt. (Archer 2009; McCarthy 2018). In this paper we describe a further new corticolous species of *Graphis* from Norfolk Island. Chemical constituents were identified by thin-layer chromatography (Elix 2014) and comparison with authentic samples.

Graphis norfolkensis A.W.Archer & Elix, sp. nov. Figs 1, 2
Mycobank No.: **MB 829602**

Type: Australia. Norfolk Island, West Palm Glen Track, Mount Pitt National Park, 29°01'06°S, 167°56'33°E, 140 m alt., on base of *Cyathea* in subtropical rainforest on moderate slope. *J.A. Elix 29068*, 16.vi.1992 (holotype: CANB).

Similar to *Graphis subelmeri* (A.W.Archer) A.W.Archer, but differs in having lirellae with conspicuous thalline margins and in containing salazinic acid.

Thallus thin, pale grey, corticolous, sorediate, lacking isidia. *Soralia* white, numerous, conspicuous, scattered, globose, sessile, 0.3–0.6 mm diam. *Apothecia* lirelliform, inconspicuous, scattered among soralia, straight or branched, 1–1.5 mm long, 0.3–0.4 mm wide, lips closed, with a conspicuous thalline margin; proper exciple completely carbonized; hymenium 140–150 µm tall, not inspersed, I–. *Ascospores* hyaline, obovate, muriform, 20–22 µm long and 5–6 µm wide, 4–5 × 1–2 locular, I+ pale blue.
Chemistry: Thallus K+ yellow then red, C–, PD+ orange-red; containing salazinic acid (major) and protocetraric acid (minor).

ADDITIONAL SPECIMEN EXAMINED
Norfolk Island: ● Pop Rock, near Mount Pitt Road, 29°01'23" S, 167°56'10" E, on dead *Cupressus* in disturbed remnant subtropical rainforest with large rock outcrops, *J.A. Elix 29295*, 18.vi.1992 (CANB).

Etymology: named after the type locality, Norfolk Island.

Discussion
Graphis norfolkensis is characterized by inconspicuous lirellae with thick thalline margins, a completely carbonized proper exciple, small muriform ascospores and the presence of sal-

azinic and protocetraric acids. It resembles *Graphis subelmeri* (A.W.Archer) A.W.Archer (Archer 2002, 2007) from the Solomon Islands, in that both species have completely carbonized exciples, small (*c*. 20 µm long) muriform ascospores and contain protocetraric acid, but *G. subelmeri* lacks both the conspicuous thalline margins of *G. norfolkensis* and salazinic acid as the major lichen acid (Fig. 2). At present this species is known from two localities on Norfolk Island. Commonly associated lichens include *Crocodia aurata* (Ach.) Link, *C. poculifera* (Müll.Arg.) D.J.Galloway & Elix, *Crytothecia bartlettii* G.Thor, *Porina exocha* (Nyl.) P.M.McCarthy, *Ramalina peruviana* Ach., *R. stevensiae* Elix and *Teloschistes flavicans* (Sw.) Norman.

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Figure 1. *Graphis norfolkensis* (holotype CANB). Scale bar = 1 mm

Figure 2. *Graphis subelmeri* (holotype BM). Scale bar = 1 mm

The distribution and diversity of buellioid lichens in Australasia

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Abstract
An overview is provided of the distribution and diversity of buellioid lichens (Caliciaceae and Physciaceae) in Australasia, including Australia, New Zealand, Papua New Guinea and the subantarctic Macquarie Island, Auckland Islands, Campbell Island, Snares Islands and Antipodes Islands. In total, 233 taxa of buellioid lichens have been reported from Australasia, of which 138 (*c.* 60%) are currently thought to be endemic to the region, suggesting that Australasia is a global centre of diversity of these lichens.

The new combinations *Amandinea analgifera* (Aptroot & Diederich) Elix, *A. polyxanthonica* (Elix) Elix, *A. polyxanthonica* var. *isidiata* (Elix & Kantvilas) Elix, *Cratiria lauricassiaeoides* (Aptroot) Elix and *C. submuriformis* (Aptroot & Diederich) Elix are made.

Introduction

The genus *Buellia* includes a large, heterogeneous assemblage of mostly crustose lichens with a chlorococcoid photobiont, lecideine to biatorine apothecia, and usually *Bacidia*-type asci with mainly 1-septate, dark-pigmented ascospores. Research on buellioid lichens over the last decade or so has led to the segregation of several well-defined groups of species as separate genera, particularly for the corticolous taxa (Marbach 2000). Thus, *Buellia* in the strict sense is now limited to species with *Callispora*-type ascospores, bacilliform or weakly clavate conidia and a hymenium that is usually inspersed with oil droplets (Bungartz *et al.* 2007) i.e. the so-called *Hafellia* group (Moberg *et al.* 1999). However, there is a large residue of often-unrelated taxa that cannot be assigned to any segregate genera at this stage and remain classified in *Buellia* in the broad sense. Resolving the taxonomy of the Physciaceae/Caliciaceae clearly remains a challenge, because sometimes the traditional characters offer insufficient resolution. For a sound phylogenetic re-assessment, it will be necessary to use molecular tools and examine a broad, representative range of the diverse species in this group.

This paper provides an overview of our investigations of *Buellia*-like lichens in Australia, New Zealand, Papua New Guinea and the Australasian subantarctic islands. In Australia it follows the first accounts of *Buellia* and related genera (Elix 2009a, 2011) and our additions and revisions to *Amandinea* (Elix & Kantvilas 2013a, 2016a; Blaha *et al.* 2016), *Buellia sens. lat.* (Bungartz *et al.* 2011; Elix & Kantvilas 2013b; Elix 2015b, 2016a; Elix *et al.* 2017b), *Buellia sens. str.* (Elix & Kantvilas 2014a), *Baculifera* (Elix & Kantvilas 2014b), *Cratiria* (Elix 2014), *Monerolechia* (Elix 2015a) and other crustose Physciaceae (Elix & Kantvilas 2015, 2016b; Elix 2016b; Elix *et al.* 2017a; Elix & McCarthy 2018). Similarly, accounts of New Zealand *Buellia* and related genera have appeared in numerous papers (Elix *et al.* 2015, 2017a, 2017b; Elix 2016c, 2017a, 2017b, 2018b; Elix & Kantvilas 2016a; Elix & Knight 2017; Elix & Mayrhofer 2016, 2017, 2018; Elix & McCarthy 2018), and additions to and revisions of *Amandinea* in Blaha *et al.* (2016) and Mayrhofer *et al.* (2016). Accounts of the buellioid lichens in Macquarie Island (Elix 2017a) and New Zealand's subantarctic islands have also been published (Elix 2017b, 2018a). Aptroot *et al.* (1997) described six new species of *Buellia* from Papua New Guinea, but more recent records can be found in Aptroot (2009), where 18 taxa were listed. Since that time some additional species have been reported for Papua New Guinea and several new species described (Elix 2015a, 2016d) to bring the total to 22 taxa.

Amandinea Choisy ex Scheid. & H.Mayrhofer

Fifty-five taxa of *Amandinea* are known from the Australasian region, 37 of them saxicolous, 19 corticolous and one lichenicolous (Table 1). Approximately 56% of the species are endemic to the region (31 taxa), including *c.* 45% of the corticolous taxa and *c.* 60% of the saxicolous taxa. Five saxicoles have a broad austral distribution, also being found in southernmost South America (*A. discreta*, *A. fuscoatratula*, *A. nitrophila*, *A. subcervina* and *A. subplicata*; Elix *et al.* 2018). A further four species occur in the Australasian region and in the Kerguelen Islands (*A. antipodensis*, *A. austroconiops*, *A. lignicola* var. *australis* and *A. variabilis*), but have not yet been recorded from South America (Elix 2019).

Seven of the nine taxa of tropical Australian *Amandinea* taxa exhibit a pantropical distribution (*A. brugierae*, *A. diorista* var. *hypopelidna*, *A. efflorescens*, *A. efflorescens* var. *pseudohypopelidna*, *A. montana*, *A. prospersa* and *A. subduplicata*). *Amandinea brugierae* and *A. efflorescens* also occur in Papua New Guinea, while *A. mediospora* is restricted to Papua New Guinea. *Amandinea polyxanthonica* has only been found in Australia, and *A. polyxanthonica* var. *isidiata* in Australia and Papua New Guinea. Interestingly, the holotype of *A. diorista* var. *hypopelidna* was collected in temperate New Zealand (near Wellington), as was the type of the closely related pantropical species *A. melaxanthella*. The former species has even been reported for the subantarctic Auckland Islands (Fineran 1971), but this is likely to have been a misdetermination.

Thirty-two species of *Amandinea* have been recorded from temperate Australia, including 10 endemic taxa, with a further 15 restricted to Australia and New Zealand (*c.* 78% endemic to Australasia). Three Tasmanian species, *A. austroconiops*, *A. fuscoatratula* and *A. variabilis*, also occur on the Kerguelen Islands and Campbell Island (Elix 2017a, 2019) and in southern New Zealand. Additional species include the cosmopolitan *A. punctata*, the pantemperate *A pelidna*, the pantropical/pantemperate *A. extenuata* and, in Tasmania, the bipolar *A. coniops*.

In temperate New Zealand, four of the 26 *Amandinea* species are considered endemic (*A. okainensis*, *A ornata*, *A. porulosa* and *A. rangitatensis*), together with a further 15 species restricted to Australia and New Zealand (in total 73% Australasian). Three pantropical/subtropical taxa are present, *A. diorista* var. *hypopelidna* and *A. melaxanthella* as mentioned above, as well as *A. extenuata*. In addition to *A. coniops* and *A. pelidna* (both bipolar) and *A. punctata* (cosmopolitan), four further species, *A. austroconiops*, *A. fuscoatratula*, *A. nitrophila* and *A. variabilis*, all present on coastal rocks in the South Island, have distributions spanning austral cool-temperate and subantarctic regions. Two of those species (*A. fuscoatratula* and *A. nitrophila*) also occur in southernmost South America (Elix *et al.* 2018).

The antarctic/subantarctic species *Amandinea isabellina* occurs on rocks in alpine areas of south-eastern Australia, Tasmania and New Zealand as well as in continental Antarctica. The subantarctic *A. austoconiops* occurs in alpine Tasmania and New Zealand, but has not been found in mainland Australia. The only endemic alpine species is *A. subbadioatra*, restricted to alpine rocks in the South Island of New Zealand. *Amandinea discreta*, present in the mountains of central Otago (South Island), also occurs in southern Argentina and the Falkland Islands.

Two endemic species (*A. hnatiukii* and *A. hypopallida*) have so far been identified from among the 15 taxa present on the Australasian subantarctic islands, together with one bipolar species, *A. adjuncta*, and seven subantarctic species, *viz. A. antipodensis*, *A. austroconiops*, *A. fuscoatratula*, *A. nitrophila*, *A. subcervina*, *A. subplicata* and *A. variabilis*, four of which also occur in southernmost South America (*A. fuscoatratula*, *A. nitrophila*, *A. subplicata*, *A. subcervina*; Elix 2017a). The distinctive corticolous *A. dudleyensis* exhibits an interesting disjunct distribution, occurring in Kangaroo Island, South Australia, and in the Auckland Islands and Campbell Island. In addition to the cosmopolitan *A. extenuata*, the Australasian species *A. lignicola* var. *australis*, *A. litoralis* and *A. porulosa* have been recorded from the islands (Elix 2017b).

Table 1. Distribution of Australasian species of *Amandinea*

	Aus	NZ	PNG	Sub	Ant	Afr	CAm	SAm	NAm	P	As	Eu
adjuncta (Th.Fr.) Hafellner				●					●			●
antipodensis Elix				●								
australasica Blaha, H.Mayrhofer & Elix	●	●										
austroconiops Elix & Kantvilas	●	●		●								
brugierae (Vain.) Marbach	●		●			●		●		●		

brunneola Elix & Kantvilas	•	•										
conglomerata Elix & Kantvilas	•											
coniops (Wahlenb.) M.Choisy ex Scheid. & H.Mayrhofer	•	•		•	•				•	•		•
conranensis Elix & P.M.McCarthy	•											
decedens (Nyl.) Blaha, H.Mayrhofer & Elix	•	•										
destituta Elix & Kantvilas	•											
devilliersiana Elix & Kantvilas	•											
diorista var. *hypopelidna* (Stirt.) Marbach & Kalb	•	•								•	•	
discreta (Darb.) Elix & H.Mayrhofer		•						•				
dudleyensis Elix & Kantvilas	•			•								
efflorescens (Müll.Arg) Marbach	•		•			•	•	•	•	•	•	
efflorescens var. *pseudohypopelidna* Marbach	•									•		
extenuata (Müll.Arg) Marbach	•	•		•		•	•	•		•	•	
feraxioides Elix & Kantvilas	•											
fuscoatratula (Zahlbr.) Elix	•	•						•				
hnatiukii Elix				•								
hypopallida Elix				•								
hypostictica (Elix) Elix	•	•										
isabellina (Hue) Søchting & Øvstedal	•	•			•							
julianeae H.Mayrhofer & Elix	•	•										
lignicola var. *australis* Elix & Kantvilas	•	•		•								
litoralis (Zahlbr.) Elix & H.Mayrhofer	•	•		•								
mediospora Marbach			•					•				
melaxanthella (Nyl.) Marbach		•						•			•	
montana (H.Magn.) Marbach	•					•					•	
nana Elix & P.M.McCarthy	•											
nebulosa Elix & Kantvilas	•											
neoconglomerata Elix	•											
nitrophila (Zahlbr.) Elix		•		•				•				
occidentalis Elix & Kantvilas	•											
okainensis Elix & H.Mayrhofer		•										
ornata Ropin, H.Mayrhofer & Elix		•										
otagensis (Zahlbr.) Blaha, H.Mayrhofer & Elix	•	•										
pelidna (Ach.) Fryday & L.Arcadia	•	•				•						•
pillagaensis Elix & Kantvilas	•	•										
polyxanthonica (Elix) Elix	•											
polyxanthonica var. *isidiata* (Elix & Kantvilas) Elix	•		•									
porulosa (Zahlbr.) Elix		•		•								
prospersa (Nyl.) Elix & H.Mayrhofer	•						•		•			
prothallinata Elix & H.Mayrhofer	•	•										
punctata (Hoffm.) Coppins & Scheid.	•	•			•	•		•	•		•	•
rangitatensis Elix & H.Mayrhofer		•										
ropinii H.Mayrhofer & Elix	•	•										
stajsicii Elix & Kantvilas	•											
subbadioatra (C.Knight) Elix & Kantvilas		•										

subcervina (Nyl.) Elix		•		•				•				
subduplicata (Vain.) Marbach	•							•	•		•	
subplicata (Nyl.) Øvstedal				•				•				
variabilis Elix, Blaha & H.Mayrhofer	•	•		•								
vitellina Blaha, H.Mayrhofer & Elix	•	•										

Abbreviations: Aus = Australia; NZ = New Zealand; PNG = Papua New Guinea; Sub = sub-antarctic islands; Ant = Antarctica; Afr = Africa; CAm = Central America; SAm = South America; NAm = North America; P = Pacific; As = Asia; Eu = Europe.

Buellia* De Not. *sens. str.

All 20 known Australasian species of *Buellia sens. str*. occur in Australia, although *B. claricollina* is restricted to Tasmania, but only two species have been collected in New Zealand (*B. disciformis* and *B. subcrassata*). Previous reports of *B. demutans* and *B. tetrapla* from New Zealand could not be verified and are probably erroneous. Both were recorded as occurring on rock in Banks Peninsula, South Island (Galloway 2007), but neither of those species grows on rock, even in areas where they are particularly common on wood or bark.

Five species are endemic to Australia, *B. claricollina* (Tasmania), *B. pigmentosa* (north Queensland), *B. ventricosa* (Victoria), together with *B. mesospora* and *B. xanthonica*, both common in temperate regions of southern Australia and Tasmania. Four species are widely distributed, the cosmopolitan *B. disciformis*, and the pantropical/subtropical species *B. bahiana*, *B. conspirans* and *B. parastata* (Table 2). The remaining 11 species are rather broadly distributed, particularly in the Southern Hemisphere (South Africa, South America and the Pacific) (Table 2).

Table 2. Distribution of Australasian species of *Buellia sensu stricto*

	C	pT	Aus	NZ	PNG	Afr	CAm	SAm	NAm	P	As	Eu
bahiana Malme		•	•			•	•	•	•	•		
claricollina Elix & Kantvilas			•									
conspirans (Nyl.) Vain.		•	•		•	•		•		•		
demutans (Stirt.) Zahlbr.			•			•		•		•		
disciformis (Fr.) Mudd	•		•	•					•	•	•	•
dissa (Stirt.) Zahlbr.			•		•	•						
fraudans (Starbäck) Elix			•					•		•		
levieri Jatta			•					•				
mesospora Elix & Kantvilas			•									
parastata (Nyl.) Zahlbr.		•	•				•	•	•	•	•	
pigmentosa Elix			•									
pleiotera Malme		•	•			•		•		•		
procellarum A.Massal.			•			•						
pseudotetrapla (Pusswald) Elix			•				•					
reagenella Elix			•					•				
rechingeri Zahlbr.			•							•		
subcrassata (Pusswald) Elix			•	•			•					
tetrapla (Nyl.) Müll.Arg.			•			•		•		•		
ventricosa Mull.Arg.			•									
xanthonica (Elix) Elix			•									

Abbreviations: C = cosmopolitan; pT = pantropical; Aus = Australia; NZ = New Zealand; PNG = Papua New Guinea; Afr = Africa; CAm = Central America; SAm = South America; NAm = North America; P = Pacific; As = Asia; Eu = Europe.

Buellia sens. lat.

In total, 101 taxa of *Buellia sens. lat.* occur in Australasia (Table 3), with 87 taxa recorded from Australia, 43 from New Zealand, three from Papua New Guinea and four from the subantarctic islands. They are predominantly saxicolous and terricolous. Eighty-four taxa are endemic to Australasia (an amazing 83%), with 41 taxa restricted to Australia and 11 to New Zealand, and a further 24 taxa occur in both Australia and New Zealand. Two species are shared by New Zealand and the subantarctic islands (*B. hypopurpurea* and *B. seppeltii*), one is restricted to the Auckland and Campbell Islands (*B. prothallina*), and *B. manamiana* is found only in Papua New Guinea (Table 3). One Australasian taxon, *B. stellulata* var. *tasmanica*, has an austral distibution, while the remaining 17 species are rather broadly distributed, particularly in the Southern Hemisphere, and eight species can be considered to have a cosmopolitan distribution.

All seven terricolous species of *Buellia sens. lat.* are endemic to Australasia, six species occurring only in Australia (*B. dijiana*, *B. eldridgei*, *B. epigaella*, *B. lobata*, *B. subcoronata* and *B. ulliae*), and with *B. georgei* present in both Australia and New Zealand (on calcareous soils and rocks). Five endemic species occur on coastal rocks in New Zealand (*B. akatorensis*, *B. alutacea*, *B. haywardii*, *B. hypostictella* and *B. porphyrilica*), while a further five species are restricted to coastal rocks in Australia and New Zealand (*B. aeruginosa*, *B. ferax*, *B. kantvilasii*, *B. papanui* and *B. poolensis*). Alpine Australasia also supports endemic species, three in New Zealand (*B. alectorialica*, *B. billewersii* and *B. maungatuensis*), four in Australia (*B. bogongensis*, *B. canobolasensis*, *B. ewersii* and *B. pannarina*) and four in both Australia and New Zealand (*B. austroalpina*, *B. epiaeruginosa*, *B. macveanii* and *B. patearoana*). Eight saxicolous species are endemic to tropical Australia, namely *B. bohlensis*, *B. dimbulahensis*, *B. durackensis*, *B. herveyensis*, *B. hyporosea*, *B. kaproorea*, *B. polyxanthonica* and *B. rhizocarpella*), and one species (*B. desertorum*) is confined to the desert areas of central Australia.

Table 3. Distribution of Australasian species of *Buellia sensu lato*

	Aus	NZ	PNG	Sub	Ant	Afr	CAm	SAm	NAm	P	As	Eu
abstracta (Nyl.) H.Olivier	•	•					•		•		•	•
aeruginosa A.Nordin, Owe-Larsson & Elix	•	•										
aethalea (Ach.) Th.Fr.	•	•	•		•	•		•	•	•	•	•
akatorensis Elix & A.Knight		•										
alectorialica Elix		•										
albula (Nyl.) Müll.Arg.	•	•						•				
albulella Elix	•											
alutacea Zahlbr.		•										
amandineiformis Elix & Kantvilas	•	•										
arenaria Mull.Arg.	•											
austera Elix & Kantvilas	•											
austroabstracta Elix & Kantvilas	•	•										
austroalpina Elix & Kantvilas	•	•										
billewersii Elix		•										
bogongensis Elix	•											
bohlensis Elix	•											
canobolasensis Elix & P.M.McCarthy	•											
cinnabarina U.Grube	•											
cranfieldii Elix	•											
cranwelliae Zahlbr.	•	•										
desertorum Mull.Arg.	•											
dimbulahensis Elix	•											
dijiana Trinkaus	•											
dispersa A.Massal.	•					•			•			•
durackensis Elix & P.M.McCarthy	•											
ecclesensis Elix	•											
ectolechioides (Vain.) Erichsen	•										•	•
eldridgei Elix	•											
epiaeruginosa Elix	•	•										
epigaella Elix & Kantvilas	•											
ewersii Elix	•											
extenuatella Elix & Kantvilas	•											
fallax Elix & Kantvilas	•	•										
ferax Müll.Arg.	•	•										
fluviicygnorum Elix	•											
georgei Trinkaus, H.Mayrhofer & Elix	•	•										
griseovirens (Turner & Borrer ex Sm.) Almborn	•	•					•				•	•
halonia (Ach.) Tuck.	•	•					•			•	•	
halonioides Elix	•	•										
haywardii Elix & H.Mayrhofer		•										
herveyensis Elix	•											
homophylia (C.Knight) Zahlbr.	•	•										
hypopurpurea Elix & A.Knight		•		•								
hyporosea Elix	•											
hypostictella Elix & H.Mayrhofer		•										
insularicola Elix & P.de Lange	•										•	
intergescens Müll.Arg.	•											
jugorum (Arnold) Arnold	•											•
kantvilasii Elix, Blanchon & A.Knight	•	•										
kaproorea Elix	•											
kimberleyana Elix	•											
lobata Trinkaus & Elix	•											
macveanii Elix	•	•										
maficola Elix	•											
malcolmii Elix	•	•										
mamillana (Tuck.) W.A.Weber	•						•	•	•	•	•	•
manamiana Diederich			•									
maunakeansis Zahlbr.	•										•	
maungatuensis Elix & H.Mayrhofer		•										
mayrhoferae Elix & Kantvilas	•											
northallina Elix & Kantvilas	•	•										
ocellata (Flot.) Körb.	•	•					•		•	•		•
patearoana Elix & A.Knight	•	•										
pannarina Elix	•											
papanui Elix & H.Mayrhofer	•	•										
poimenae Elix & Kantvilas	•	•										
poolensis Elix	•	•										
porphyrilica Elix & H.Mayrhofer		•										
prothallina Elix				•								
psoromica Elix	•											
rhizocarpella Elix	•											
schaereri De Not.	•						•	•			•	•
seppeltii Elix		•		•								
servilosina Elix & Kantvilas	•											
spuria (Schaer.) Anzi	•	•		•			•	•	•		•	•
spuria var. *amblyogona* (Müll.Arg.) Elix	•	•	•									
stellulata (Taylor) Mudd	•	•		•			•		•		•	•
stellulata var. *tasmanica* Elix & Kantvilas	•	•							•			

subadjuncta Elix & Kantvilas	●	●										
subalbula (Nyl.) Müll.Arg.	●					●		●				
subarenaria Müll.Arg.	●	●										
subcoronata (Müll.Arg.) Malme	●											
suttonensis Elix & A.Knight	●	●										
ulliae Elix	●											
testaceina Elix & Kantvilas	●											
tinderryensis Elix & P.M.McCarthy	●											
tuapekensis Elix & A.Knight		●										
weberi Elix	●											
xantholeuca Bungartz & U.Grube	●											
yilliminningensis Elix & Kantvilas	●											

Abbreviations: Aus = Australia; NZ = New Zealand; PNG = Papua New Guinea; Sub = subantarctic islands; Ant = Antarctica; Afr = Africa; CAm = Central America; SAm = South America; NAm = North America; P = Pacific; As = Asia; Eu = Europe.

***Baculifera* Marbach & Kalb**

Baculifera is represented by 10 Australasian species (all ten of them occurring in Australia and four of them in New Zealand (Table 4). The three most common species, *B. entochlora*, *B. micromera* and *B. xylophila*, exhibit a pantropical/subtropical distribution that often extends into temperate latitudes. Those three species occur in eastern Australia and the North Island of New Zealand, with *B. micromera* and *B. xylophila* also present in Tasmania and *B. xylophila* in subantarctic Campbell Island. Three of the four endemic species (*B. metaphragmia*, *B. metaphragmoides* and *B. macromera*) occur in cooler temperate areas, with *B. macromera* restricted to Tasmania and the South Island of New Zealand. The fourth endemic, *B. epifuscescens*, occurs in subtropical areas of New South Wales and Queensland. Three additional pantropical/subtropical species occur in Queensland, *B. intermedioides, B. orosa* and *B. pseudomicromera.*

Table 4. Distribution of Australasian species of *Baculifera*

	Aus	NZ	Af	CAm	SAm	NAm	P	Sub
entochlora (J.Steiner) Marbach	●	●	●		●			
epifuscenscens Elix & Kantvilas	●							
intermedioides Marbach	●				●	●	●	
macromera Elix & Kantvilas	●	●						
metaphragmia (C. Knight) Elix & Kantvilas	●							
metaphragmoides Elix & Kantvilas	●							
micromera (Vain.) Marbach	●	●	●	●	●			
orosa Marbach & Kalb	●			●		●		
pseudomicromera Marbach	●		●		●			
xylophila (Malme) Marbach	●	●			●		●	●

Abbreviations: Aus = Australia; NZ = New Zealand; Af = Africa; CAm = Central America; SAm = South America; NAm = North America; P = Pacific; Sub = subantarctic islands.

***Cratiria* Marbach**

Tropical and subtropical Australasia appears to be the centre of speciation for the genus *Cratiria*, with 17 of the 23 known taxa occurring in the region (Table 5), 14 of them in Australia and seven in Papua New Guinea. Six species are endemic to the region, five in Australia (*C. burleighensis*, *C. mayrhoferi*, *C. streimannii*, *C. subtropica* and *C. verdonii*) and one in Papua New Guinea (*C. lauricassiaeoides*). The genus has not yet been collected in New Zealand. Three of the Papua New Guinean species have not been collected in Australia, namely *C. dissimilis*, *C. lauricassiaeoides* and *C. submuriformis.*

Table 5. Distribution of Australasian species of *Cratiria*

	Aus	PNG	Afr	CAm	SAm	NAm	P	As
aggrediens (Stirt.) Marbach	●		●	●	●		●	●
americana (Fée) Kalb & Marbach	●	●		●	●	●	●	
amphorea (Eckfeldt) Marbach	●			●		●		●
burleighensis Elix	●							
chloraceus Marbach	●	●					●	
dissimilis (Nyl.) Marbach		●					●	●
lauricassiae (Fée) Marbach	●	●		●	●		●	●
lauricassiaeoides (Aptroot) Elix		●						
mayrhoferi Elix	●							
melanochlora (Kremp.) Marbach	●	●			●		●	
obscurior (Stirt.) Marbach	●		●	●	●		●	●
rutilantoides Marbach	●						●	
streimannii Elix	●							
submuriformis (Aptroot & Diederich) Elix		●						●
subtropica Elix	●							
verdonii Elix	●							
vioxanthina (Elix) Kalb & Elix	●							●

Abbreviations: Aus = Australia; PNG = Papua New Guinea; Afr = Africa; CAm = Central America; SAm = South America; NAm = North America; P = Pacific; As = Asia.

***Gassicurtia* Fée**

Gassicurtia is a genus of *c.* 30 species, ten of which occur in Australasia, with nine species in Australia, and one in New Zealand, Papua New Guinea and the subantarctic islands (Table 6). Five species appear to be endemic to Australasia (*G. blencoensis*, *G. capricornica*, *G. gallowayi*, *G. jamesii* and *G. victoriana*). Although the majority of *Gassicurtia* species occur in tropical and subtropical regions (Marbach 2000), *G. gallowayi* is restricted to Tasmania and Stewart Island (southern New Zealand) and *G. jamesii* to the Auckland Islands. *Gassicurtia victoriana* shows an interesting disjunct distribution in Australia, occurring in temperate rainforest in East Gippsland (Victoria) and montane, tropical rainforest in north-eastern Queensland.

Table 6. Distribution of Australasian species of *Gassicurtia*

	Aus	NZ	PNG	Afr	CAm	SAm	NAm	P	Sub	As
blencoensis Elix	●									
capricornica Elix	●									
catasema (Tuck.) Marbach	●			●	●	●	●	●		
coccinea Fée	●			●	●	●				
gallowayi Elix & Kantvilas	●	●								
jamesii Elix									●	
pseudosubpulchella Marbach	●				●	●				
subpulchella (Vain). Marbach	●			●		●	●	●		●
vaccinii (Vain). Marbach	●		●	●	●	●				●
victoriana Elix & Kantvilas	●									

Abbreviations: Aus = Australia; NZ = New Zealand; PNG = Papua New Guinea; Afr = Africa; CAm = Central America; SAm = South America; NAm = North America; P = Pacific; Sub = subantarctic islands; As = Asia.

***Tetramelas* Norman**

Tetramelas is a genus with a predominantly Arctic-Antarctic or alpine-subalpine distribution (Kalb 2004). Five species are known from New Zealand, three from Macquarie Island, one from mainland Australia and one from Tasmania (Table 7). The only widespread species is *T. concinnus*, present in Australia, New Zealand and Macquarie Island as well as North America, Europe and Asia. New Zealand hosts two endemic taxa, *T. confusus* and T. *kopuwaianus*. Two common Antarctic species are found in Macquarie Island, *T. austropapillatus* and *T. anisomerus*.

Table 7. Distribution of Australasian species of *Tetramelas*

	Aus	NZ	Sub	Ant	SAm	NAm	As	Eu
allisoniae Elix & H.Mayrhofer	●	●						
anisomerus (Nyl.) Elix			●	●	●			
austropapillatus (Øvstedal) Elix			●	●				
concinnus (Th.Fr.) Giralt	●	●	●			●	●	●
confusus Nordin		●						
insignis (Nägeli) Kalb		●						●
kopuwaianus Elix & H.Mayrhofer		●						

Abbreviations: Aus = Australia; NZ = New Zealand; Sub = subantarctic islands; SAm = South America; NAm = North America; As = Asia; Eu = Europe.

Miscellaneous buellioid genera

The distribution of the Australasian taxa of *Australiaena* Matzer, H.Mayrhofer & Elix, *Diploicia* A.Massal., *Diplotomma* Flot., *Endohyalina* Marbach, *Monerolechia* Kalb, *Orcularia* Kalb & Giralt, *Rinodinella* H.Mayrhofer & Poelt, *Sculptolumina* Marbach and *Stigmatochroma* Marbach are summarized in Table 8. In global terms, those genera accommodate the following numbers of taxa: *Australiaena* (1), *Diploicia* (9), *Diplotomma* (*c.* 14), *Endohyalina* (11), *Monerolechia* (5), *Orcularia* (4), *Rinodinella* (4), *Sculptolumina* (4) and *Stigmatochroma* (9).

The monspecific *Australiaena* occurs only in northern Australia (northern Western Australia, Northern Territory and Queensland) and Papua New Guinea. Three of the four Australasian representatives of *Stigmatochroma* and two of the three species of *Sculptolumina* exhibit a pantropical distribution. Only *Stigmatochroma maccarthyi* and *Sculptolumina ramboldii* are endemic to north Queensland.

By contrast, three of the four Australasian representatives of *Monerolechia* are endemic to the region, *M. glomerulans* and *M. norstictica* to Australia, and *M. papuensis* to Papua New Guinea. Similarly, two of the three species of *Endohyalina* are Australasian endemics, *E. arachniformis* in Tasmania and New Zealand and *E. gillamsensis* in Tasmania. In Australasia, only *E. insularis* is broadly distributed (Table 8).

Table 8. Distribution of Australasian species of various buellioid genera

Species	Aus	NZ	PNG	Sub	Afr	CAm	SAm	NAm	P	As	Eu
Australiaena streimannii Matzer, H.Mayrhofer & Elix	●		●								
Dipoicia africana (Tuck.) Matzer, H.Mayrhofer & Rambold	●				●						
Diploicia canescens (Dicks.) A.Massal.	●	●			●		●	●	●	●	●
Diploicia canescens ssp. *australasica* Elix & Lumbsch	●	●								●	
Diplotomma chlorophaeum (Hepp ex Leight.) KrP.Singh & SR.Singh	●	●			●			●		●	●
Diplotomma nivale (Bagl. & Carestia) Hafellner		●									●
Diplotomma venustum Körb.	●	●			●			●		●	●
Endohyalina arachniformis Elix & Kantvilas	●	●									
Endohyalina gillamsensis Elix & Kantvilas	●										
Endohyalina insularis (Arnold) Giralt, P.P.G.Boom & Elix	●	●						●	●		●
Monerolechia badia (Fr.) Kalb	●	●		●	●			●	●	●	●
Monerolechia glomerulans (Mull.Arg.) Elix	●										
Monerolechia norstictica Elix	●										
Monerolechia papuensis Elix			●								
Orcularia elixii Kalb & Giralt	●	●								●	
Orcularia insperata (Nyl.) Kalb & Giralt	●	●			●	●	●				
Rinodinella fertilis (Körb.) Elix	●	●									
Rinodinella dubyanoides (Hepp) H.Mayrhofer & Poelt	●	●									●
Sculptolumina japonica (Tuck.) Marbach	●				●	●	●			●	
Sculptolumina serotina (Malme) Marbach	●					●	●				
Sculptolumina ramboldii Elix & H.Mayrhofer	●										
Stigmatochroma adaucta (Malme) Marbach	●		●				●			●	
Stigmatochroma epimarta (Nyl.) Marbach	●		●			●	●			●	
Stigmatochroma maccarthyi Elix	●										
Stigmatochroma metaleptodes Marbach			●			●	●			●	●

Abbreviations: Aus = Australia; NZ = New Zealand; PNG = Papua New Guinea; Sub = subantarctic islands; Afr = Africa; CAm = Central America; SAm = South America; NAm = North America; P = Pacific; As = Asia; Eu = Europe.

New combinations

Amandinea analgifera (Aptroot & Diederich) Elix, comb. nov.
MycoBank No.: **MB 829940**
Basionym: *Buellia analgifera* Aptroot & Diederich, *Bibliotheca Lichenologica* **64**, 28 (1997).
Type: Papua New Guinea, Simbu Province, Mt Wilhelm, Pindaunde Valley, near hut on S-Shore of Lake Piunde, 5°47'S, 145°03'E, *c.* 3600 m alt., subalpine forest remnants on W-slope of valley, on tree fern, *A. Aptroot 32684*, 5–8.viii.1992 (B – holotype !).
Synonym: *Amandinea mediospora* Marbach, *Bibliotheca Lichenologica* **74**, 81 (2000).
Type: Ecuador, Azuay, *c.* 35 km S of Cuenca, residual forest in a gras paramo, 3200 m alt., *K. Kalb 18365*, viii.1987 (KALB – holotype !).

Note
Detailed descriptions of the species are given in Aptroot *et al.* (1997) and in Marbach (2000, as *Amandinea mediospora*).

Amandinea polyxanthonica (Elix) Elix, comb. nov.
MycoBank No.: **MB 829738**
Basionym: *Buellia polyxanthonica* Elix, *Australas. Lichenol.* **64**, 31 (2009).
Type: Australia, Northern Territory, Umbrawarra Gorge, 22 km SW of Pine Creek, 13°57'56″S, 131°41'52″E, 210 m alt., on sheltered sandstone rock in steep-sided rocky gorge with *Melaleuca, Ilex* and *Ficus*, *J.A. Elix 38860*, 8.viii.2005 (CANB – holotype !).

Amandinea polyxanthonica var. **isidiata** (Elix & Kantvilas) Elix, comb. nov.
MycoBank No.: **MB 829739**
Basionym: *Buellia polyxanthonica* var. *isidiata* Elix & Kantvilas, *Australas. Lichenol.* **73**, 31 (2013).
Type: Australia, Western Australia, Erskine Range, Great Northern Highway, between Derby and Fitzroy Crossing, 17°51'S, 124°20'E, 120 m alt., on lateritic rocks with a SW aspect along the escarpment in *Triodia*-dominated grassland, *J.A. Elix 22329 & H. Streimann*, 18.v.1988 (CANB – holotype !)

Notes
The new generic placement of *A. polyxanthonica* and *A. polyxanthonica* var. *isidiata* follows the discovery of pycnidia and conidia in specimens of both. The pycnidia are minute, black and immersed, and the conidia are filiform, curved and 18–30 × 0.7–1 µm, consistent with the genus *Amandinea*. Detailed descriptions and illustrations are provided in Elix (2009b) and Elix & Kantvilas (2013b), respectively.

Cratiria lauricassiaeoides (Aptroot) Elix, comb. nov.
MycoBank No.: **MB 829728**
Basionym: *Buellia lauricassiaeoides* Aptroot, *Bibliotheca Lichenologica* **64**, 32 (1997).
Type: Papua New Guinea, Madang Province, Huon Peninsula, Finisterre Range, Yupna Valley, Teptep village, deep valley in N direction, 5°57'S, 146°33'E, 2300–2750 m alt., on tree fern in mountain forest, *A. Aptroot 32112*, 31.vii.1992 (B – holotype !).

Cratiria submuriformis (Aptroot & Diederich) Elix, comb. nov.
MycoBank No.: **MB 829729**
Basionym: *Buellia submuriformis* Aptroot & Diederich, *Bibliotheca Lichenologica* **64**, 35 (1997).
Type: Papua New Guinea, Simbu, Mt Wilhelm, in mossy mountain forest along track from Keglsugl to Pindaunde Valley, 5°48'S, 145°05'E, *c.* 3200 m alt., subalpine forest remnants on W-slope of valley, on tree, *A. Aptroot 18239*, iii.1987 (B – holotype !).

Notes
The genus *Cratiria* includes species that are characterized by relatively large, submuriform or 1-septate ascospores, 15–28 × 7–13 µm, with apical wall-thickenings, short, bacilliform conidia 4–6 µm long, a hymenium that can be inspersed with oil droplets or not and an excipulum containing lichen substances (Marbach 2000). Both *C. lauricassiaeoides* and *C. submuriformis* are consistent with those criteria. Detailed descriptions and illustrations are provided in Aptroot *et al.* (1997).

Summary
In this paper the distribution and diversity of buellioid lichens in Australasia are reviewed. Currently, 233 taxa are known from Australasia, including 138 endemic taxa (*c.* 60%), suggesting that Australasia is a centre of diversity of these lichens. This compares with North America, where *c*. 100 species have been recorded, 35% of which are endemic to the continent. In Europe (including Macaronesia), *c.* 80 species of buellioid lichens have been recorded (42% endemic). The distribution and diversity of the various buellioid taxa within Australasia are summarized in Table 9. This highlights that *Australiaena*, *Cratiria*, *Gassicurtia*, *Sculptolumina* and *Stigmatochroma* are tropical genera, whereas *Diploicia*, *Diplotomma*, *Endohyalina* and *Tetramelas* are essentially cool-temperate genera.

Table 9. Distribution and diversity of Australasian buellioid texa

	PNG	NA	NLh	SA	Tas	NZ	Sub
Amandinea	4	11	3	27	20	30	15
Buellia s.str.	2	17	1	16	11	2	0
Buellia s.lat.	3	20	4	49	27	35	5
Australiaena	1	1	0	0	0	0	0
Baculifera	0	7	0	6	3	4	1
Cratiria	7	13	0	1	0	0	0
Diploicia	0	0	0	3	2	2	0
Diplotomma	0	0	0	3	2	4	0
Endohyalina	0	0	0	1	2	2	0
Gassicurtia	1	8	2	1	1	1	1
Monerolechia	2	3	1	1	1	1	1
Orcularia	0	1	1	2	1	2	1
Rinodinella	0	0	0	2	1	2	0
Sculptolumina	0	3	0	0	0	0	0
Stigmatochroma	3	3	0	0	0	0	0
Tetramelas	0	0	0	1	1	5	3
Total buellioid species	22	85	11	114	72	90	26

Abbreviations: NA = northern Australia; SA = southern Australia [excluding Tasmania]; Tas = Tasmania; PNG = Papua New Guinea; NLh = Norfolk Is. and Lord Howe Is.; NZ = New Zealand; Sub = subantarctic islands.

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