A new species of *Circinaria* (Megasporaceae) from New South Wales, Australia

Patrick M. McCarthy
64 Broadsmith St, Scullin, A.C.T. 2614, Australia
e-mail: pmcc2614@hotmail.com

John A. Elix
Research School of Chemistry, Building 137,
Australian National University, Canberra, A.C.T. 2601, Australia
e-mail: John.Elix@anu.edu.au

Abstract
Circinaria deminuta P.M.McCarthy & Elix sp. nov. (lichenized Ascomycota, Megasporaceae) is described from sandstone in central-western New South Wales, Australia. The new species has a dark greyish brown, areolate thallus containing aspicilin, small, aspicilioid apothecia with a dark brown to blackish disc, cylindrical, *Aspicilia*-type asci with (4–)8, minute, globose ascospores in uniseriate arrangement, and bacilliform conidia 3.5–5(–6) × 0.5 µm.

Introduction

Until recently, species of *Circinaria* Link (Megasporaceae) formed part of the much larger, predominantly saxicolous and pantemperate to arid zone genus *Aspicilia* A.Massal. (Magnusson 1939; Clauzade & Roux 1984, 1985; Owe-Larsson *et al.* 2008; Fletcher *et al.* 2009). However, following phylogenetic analyses, Nordin *et al.* (2010) reintroduced *Circinaria* for species with broadly ellipsoid to globose ascospores that are often fewer than 8 per ascus, as well as comparatively small conidia and, uniquely, the exclusive, although not obligate occurrence of the very uncommon, aliphatic compound aspicilin. The subsequent description of new taxa and the transfer of additional species from *Aspicilia* (Owe-Larsson *et al.* 2011; Sohrabi *et al.* 2013; Roux *et al.* 2016; Chesnokov *et al.* 2018; Ren & Zhang 2018; Ismayil *et al.* 2019) brought the known diversity of *Circinaria* to more than 40 crustose, foliose and subfruticose species.

Four taxa known from Australia include the mainly temperate, silicolous *Circinaria caesiocinerea* (Nyl. ex Malbr.) A.Nordin, S.Savić & Tibell, as well as the limestone-inhabiting *C. calcarea* (L.) A.Nordin, S.Savić & Tibell, *C. contorta* (Hoffm.) A.Nordin, S.Savić & Tibell and *C. hoffmanniana* (S.Ekman & Froberg ex R.Sant.) A.Nordin (the last including the synonymous "*Aspicilia*" *calcarea* var. *caesioalba* (Le Prévost) Hazsl.) (McCarthy 2018). A fifth species, *C. deminuta*, is described here from siliceous rock near Grenfell in central-western New South Wales.

Circinaria deminuta P.M.McCarthy & Elix, sp. nov. Figs 1, 2
MycoBank No. **MB 833005**
Thallus crustose, on sandstone, dark greyish brown, areolate, containing aspicilin; areoles adnate, 0.15–0.6(–1) mm wide, 100–180(–250) µm thick; cortex bilayered, paraplectenchymatous; algae chlorococcoid, 8–17(–20) µm wide. Apothecia aspicilioid, dominating the thallus, (0.12–)0.27(–0.45) mm diam., usually not subtended by algae; disc shallow-concave, dull dark brown to brown-black; proper excipulum thin, cupulate; hypothecium and subhymenium hyaline, together (20–)30–40(–50) µm thick; epihymenium medium to dark brown; paraphyses long-celled below, shorter-celled to moniliform towards the swollen, dark-pigmented apices; asci *Aspicilia*-type, cylindrical, with (4–)8, uniseriate ascospores that are globose and (6–)8(–11) µm diam. Pycnidia immersed in the thallus, *c.* 80–120 µm wide; conidia bacilliform, 3.5–5(–6) × 0.5 µm.

Type: Australia. New South Wales, Central West, Warraderry Range, beside the Gooloogong–Grenfell road, *c.* 38 km N of Grenfell, 33°38'42"S, 148°22'15"E, 330 m alt., on shaded, roadside sandstone boulders, *P.M. McCarthy 4892*, 2.x.2019 (holotype – CANB).

Thallus crustose, epilithic, determinate, uniformly dark greyish brown, to 100–180(–250) µm thick, areolate, forming scattered or contiguous colonies to 30(–50) mm wide; thallus margin effuse or faintly radiate-effigurate. *Areoles* rounded to ellipsoid or oblong to angular and irregular, 0.15–0.6(–1) mm in maximum extent, plane to slightly or moderately convex, smooth to minutely and irregularly uneven, epruinose, uniformly adnate to the substratum or (in older parts of the thallus) with slightly raised margins, commonly somewhat radially elongate towards the thallus margin, but not forming distinct lobes; cracks separating dark areoles showing the pale substratum, 60–100(–150) µm wide. *Cortex* rather thick, bilayered, paraplectenchymatous, subtending or not a hyaline, amorphous necral layer to 5–10 µm thick; upper cortical layer dark brown, (5–)10–15 µm thick, the cells rounded, thick-walled, 2.5–4(–5) µm wide; lower cortical layer hyaline, 15–20 µm thick, the cells rounded to angular, thick-walled, 3–4(–5) µm wide. *Algal layer* 50–80(–150) µm thick; cells green, globose, chlorococcoid, 8–17(–20) µm wide towards the thallus surface, mostly smaller (to 10 µm diam.) below; interstitial hyphae short-celled, thin-walled, 2–2.5(–3) µm wide. *Medulla* to 100–120 µm thick, dominated by whitish crystals and minute rock fragments, not containing calcium oxalate (H_2SO_4–), I–; hyphae short-celled, 2–3 µm wide. *Prothallus and hypothallus* not apparent. *Apothecia* very numerous, aspicilioid, innate, rounded, narrowly to broadly ellipsoid or more irregular in outline, (0–)1–2(–4) on each areole in older parts of the thallus, (0.12–)0.27(–0.45) mm diam. [*n* = 80], usually not subtended by algae at maturity; disc mostly shallow-concave, less commonly deeply concave or plane, dull dark brown to brown-black, smooth, epruinose; thalline margin prominent or not, entire, 60–80(–100) µm thick. *Proper excipulum* thin, cupulate, 20–35 µm thick laterally towards the surface, dark olivaceous and apparently continuous with the epihymenium; hyaline to paler brown below, 10–15(–20) µm thick at the base and pale to medium brown, K–, N–; cells periclinal 4–8 × 3–4 µm. *Hypothecium* hyaline to very pale yellowish, indistinguishable from the subhymenium, together (20–)30–40(–50) µm thick, inspersed with minute granules, KI–, K–, N–. *Hymenium* hyaline, 80–120 µm thick, not inspersed with granules or oil droplets, K–, N–; hymenial gel I–, KI–. *Epihymenium* medium to dark brown, 10–15 µm thick, K– (paler brown), N+ paler orange-brown, not inspersed with granules. *Paraphyses* rather conglutinate in water, loosening in K (but remaining contiguous near their apices), simple or with sparse furcate branches and anastomoses below, more richly branched in and below the epihymenium; longer-celled and not or only slightly constricted at the septa below, (1–)1.5–2(–2.5) µm wide, shorter-celled to moniliform distally and more markedly constricted at the septa (the distalmost 3–5 cells); apical cells swollen, rounded, ellipsoid or somewhat irregular, the uppermost walls usually dark olivaceous to almost black, 3–5(–6) µm wide. *Asci Aspicilia*-type, narrowly or more broadly cylindrical, (4–)8-spored (only *c.* 1–2% of asci with fewer than 8 ascospores), 66–88 × 10–13 µm [*n* = 20]; apex rounded, lacking a tholus and apical apparatus; ocular chamber usually lacking, when apparent rather broad and possibly only an artefact; wall I+ dark blue-grey, KI+ medium blue; ascoplasm KI+ orange-brown or olive-brown. *Ascospores* colourless, simple, globose, uniseriate in the ascus, thin-walled, lacking a perispore, (6–)8(–11) µm diam. [*n* = 100], mostly 9–11 µm diam. in 4-spored asci, usually containing a large, ± central vacuole and granules. *Pycnidia* very sparse, completely immersed in the thallus and extremely inconspicuous (sectioned only fortuitously), ± globose, blackish above, hyaline at middle and lower levels, *c.* 80–120 µm wide; pycnidial wall 8–10 µm thick laterally and at the base; conidiogenous layer simple; conidiophores unbranched, 10–15 × 0.5 µm. *Conidia* bacilliform, straight, 3.5–5(–6) × 0.5 µm.
Chemistry: Aspicilin (major) by TLC (Elix 2014).

Etymology: The epithet *deminuta* (Latin: diminished, reduced, small) refers to the comparatively small apothecia and exceptionally minute, globose ascospores of this species.

Remarks

As noted by Nordin *et al.* (2010), the occurrence of aspicilin is unique to *Circinaria* and, critically, while it is not found in every *Circinaria* species, the compound is not known *at all* from *Aspicilia* or its other segregates, such as *Lobothallia* (Clauzade & Cl.Roux) Hafellner.

The latter genus, sharing with *C. deminuta* a sometimes obscurely lobate thallus margin and comparatively small ascospores (although ellipsoid rather than globose) and conidia, is represented in the Australian lichen flora by the almost cosmopolitan, calcicolous *L. radiosa* (Hoffm.) Hafellner. While the recognition of the new species as a *Circinaria* is supported by aspicilin and globose ascospores, it is the exceptionally small ascospores themselves that distinguish it from all known representatives of the genus. Thus, the ascospores of *C. deminuta*, being only (6–)8(–11) µm diam. in 8-spored asci and mostly 9–11 µm diam. in the very uncommon 4-spored asci, are in stark contrast to those of other species which are all or mostly in the range 18–36 × 12–26 µm (Magnusson 1939; Clauzade & Roux 1984, 1985; Owe-Larsson *et al.* 2008, 2011; Fletcher *et al.* 2009; Nordin *et al.* 2010; Sohrabi *et al.* 2013; Roux *et al.* 2016; Chesnokov *et al.* 2018; Ren & Zhang 2018; Ismayil *et al.* 2019).

The new species is known only from the type locality beside the Gooloogong–Grenfell road north of Grenfell in the Central-West of New South Wales. There it is abundant on sandstone rubble and larger boulders in a well-established community dominated by *Caloplaca* spp., *Lecidea* spp. and Parmeliaceae. Other associated crustose lichens include *Acarospora citrina* (Taylor) Zahlbr. ex Rech., *Buellia homophylia* (C.Knight) Zahlbr., *B. suttonensis* Elix & A. Knight, *Lecanora pseudistera* Nyl., *Myriospora smaragdula* (Wahlenb.) Nägeli ex Uloth and *Trapelia pruinosa* Elix & P.M.McCarthy.

References

Chesnokov, S; Konoreva, L; Paukov, A (2018): New species and records of saxicolous lichens from the Kodar Range (Trans-Baikal Territory, Russia). *Plant and Fungal Systematics* **63**, 11–21.

Clauzade, G; Roux, C (1984): Les genres *Aspicilia* Massal. et *Bellemerea* Hafellner et Roux. *Bulletin de la Société Botanique de Centre-Ouest*, Nouvelle Série **15**, 127–141.

Clauzade, G; Roux, C (1985): Likenoj de Okcidenta Eŭropo. Ilustrita Determinlibro. *Bulletin de la Société Botanique du Centre-Ouest*, Nouvelle Série, Numéro Spécial **7**, 1–893.

Elix, JA (2014): *A Catalogue of Standardized Thin-Layer Chromatographic Data and Biosynthetic Relationships for Lichen Substances*, 3rd edn. Published by the author, Canberra.

Fletcher, A; Purvis, OW; Coppins, BJ (2009): *Aspicilia* A.Massal. (1852) *in* Smith, CW; Aptroot, A; Coppins, BJ; Fletcher, A; Gilbert, OL; James, PW; Wolseley, PA (eds), *The Lichen Flora of Great Britain and Ireland* 2nd edn, pp. 181–188. The British Lichen Society, London.

Ismayil, G; Abbas, A; Guo, S-Y (2019): A new saxicolous *Circinaria* species (Megasporaceae) from northeast China. *Bryologist* **122**, 23–31.

Magnusson, AH (1939): Studies in species of *Lecanora*, mainly the *Aspicilia gibbosa* group. *Kunglinga Svenska Vetenskaps-Akademiens Handlingar*, ser. III, **17**(5), 1–182.

McCarthy, PM (2018): *Checklist of the Lichens of Australia and its Island Territories*. http://www.anbg.gov.au/abrs/lichenlist/introduction.html (Version 17 May 2018). Australian Biological Resources Study, Canberra.

Nordin, A; Savić, S; Tibell, L (2010): Phylogeny and taxonomy of *Aspicilia* and Megasporaceae. *Mycologia* **102**, 1339–1349.

Owe-Larsson, B; Nordin, A; Tibell, L ('2007') [2008]: *Aspicilia in* Nash III, TH; Gries, C; Bungartz, F (eds) *Lichen Flora of the Greater Sonoran Desert Region* **3**, 61–108. Lichens Unlimited, Arizona State University, Tempe.

Owe-Larsson, B; Nordin, A; Tibell, L; Sohrabi, M (2011): *Circinaria arida* sp. nova and the '*Aspicilia desertorum*' complex. *Bibliotheca Lichenologica* **106**, 235–246.

Ren, Q; Zhang, L-H (2018): Taxonomic studies on the genus *Circinaria* in northern China. *Mycosystema* **37**, 865–880.

Roux, C; Bertrand, M; Nordin, A (2016): *Aspicilia serenensis* Cl.Roux et M.Bertrand sp. nov., espèce nouvelle de lichen (groupe d'*A. calcarea*, Megasporaceae). *Bulletin de la Société Linneenne de Provence* **67**, 165–182.

Sohrabi, M; Stenroos, S; Myllys, L; Søchting, U; Ahti, T; Hyvönen, J (2013): Phylogeny and taxonomy of the 'manna lichens'. *Mycological Progress* **12**, 231–269.

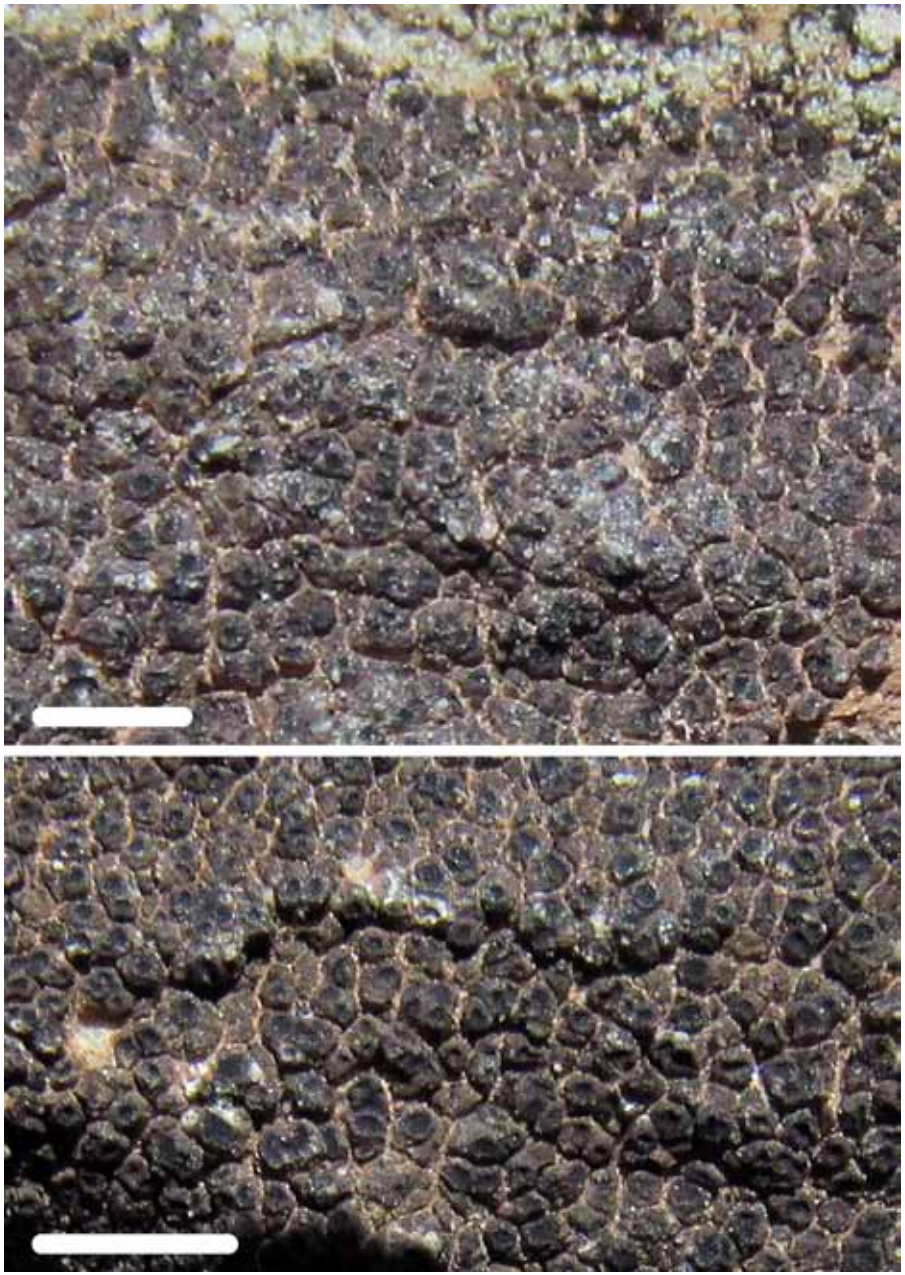

Figure 1. *Circinaria deminuta* (holotype). Scales: 2 mm.

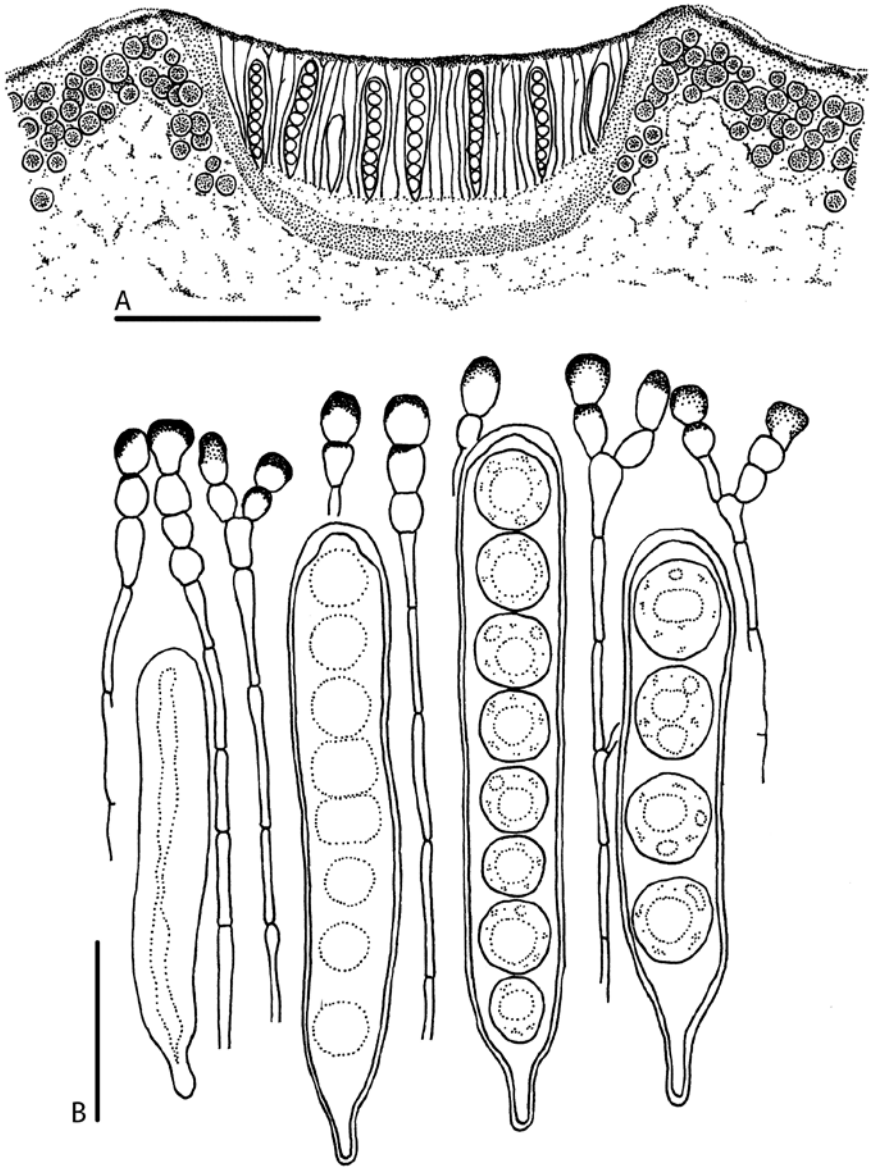

Figure 2. *Circinaria deminuta* (holotype). A, Section of apothecium and adjacent thallus (semi-schematic); B, Immature and mature asci, with ascospores and paraphyses. Scales: A = 0.1 mm; B = 20 µm.

Two new corticolous species of *Rinodina* (Physciaceae, Ascomycota) from New Zealand

John A. Elix
Research School of Chemistry, Building 137,
Australian National University, Canberra, A.C.T. 2601, Australia
e-mail: John.Elix@enu.edu.au

Christiane Edler and **Helmut Mayrhofer**
Institute of Biology, Division of Plant Sciences, NAWI Graz,
University of Graz, Holteigasse 6, 8010 Graz, Austria
e-mail: helmut.mayrhofer@uni-graz.at

Abstract
The corticolous *Rinodina fineranii* Elix, Ch.Edler & H.Mayrhofer and *R. malcolmii* Elix, Ch.Edler & H.Mayrhofer, both characterized by the presence of *Mischoblastia*-type ascospores, are described as new to science. In addition, *Rinodina australiensis* Müll.Arg. is reported for the first time from New Zealand

Introduction

The corticolous and lignicolous species of *Rinodina* (Ach.) S.F.Gray in New Zealand are not well known. In the revised second edition of the *Flora of New Zealand Lichens*, *Lichen-forming and Lichenicolous Fungi*, eight species were recorded from bark or wood (Mayrhofer *et al.* 2007). These included the widespread *R. capensis* Hampe, *R. conradii* Körb., *R. ficta* (Stizenb.) Zahlbr. (as *R. boleana* Giralt & H.Mayrhofer), *R. inflata* Kalb, *R. oleae* Bagl., *R. pyrina* (Ach.) Arnold and *R. septentrionalis* Malme, as well as *R. exigua* (Ach.) S.F.Gray, but the latter record remains doubtful because the specimens cited were unavailable (Mayrhofer *et al.* 2007). Corticolous or lignicolous species of *Rinodina* with *Mischoblastia*-type ascospores are rare worldwide. The North American endemic, *R. wetmorei* Sheard, is one such species where the *Mischoblastia*-type spores become inflated at maturity and more *Pachysporaria*-type (Sheard 2010). *Rinodina australiensis* Müll.Arg. from the Southern Hemisphere exhibits a similar transition of the spore lumina with age (Mayrhofer *et al.* 1999, 2014), whereas the European *R. euskadiensis* A.Crespo & M.B.Aguirre has persistently *Mischoblastia*-type spores (Giralt 2001). *Rinodina colobina* (Ach.) Th.Fr., widespread in the Northern Hemisphere and characterized by its blue-grey K+ purplish red epihymenium, also has *Mischoblastia*-type spores at maturity after transitioning from a *Physcia*-type stage during development (Ropin & Mayrhofer 1995). In this paper, we describe two new corticolous species of *Rinodina* from New Zealand with *Mischoblastia*-type spores, and report the occurrence of *Rinodina australiensis* from the South Island.

Methods

Observations and measurements of photobiont cells, thallus and apothecium anatomy, asci and ascospores were made on hand-cut sections mounted in water and 10% KOH (K). Asci were also observed in Lugol's Iodine (I), with and without pretreatment in K. Medullary sections were treated with 10% sulfuric acid (H_2SO_4) and apothecial sections with 50% nitric acid (N). Chemical constituents were investigated by thin-layer chromatography (Elix 2014).

The new species

Rinodina fineranii Elix, Ch.Edler & H.Mayrhofer, sp. nov. Figs 1, 2
MycoBank number: **MB 832607**

Similar to *Rinodina australiensis*, but differs in having smaller *Physcia*- to *Mischoblastia*-type ascospores, 17–25 × 7–10 µm.

Type: New Zealand, Bird Island, Foveaux Strait, [41°45'52"S, 168°25'06"E], on twig of