

Lichenicolous species of the Ascomycete genus *Arthonia* Ach. from Kangaroo Island

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Abstract

Three lichenicolous species of *Arthonia* Ach. are reported from Kangaroo Island, South Australia. Two are described as new: *Arthonia caliciae* Kantvilas & Wedin grows on the thallus of the lignicolous species *Calicium tricolor* F.Wilson, whereas *Arthonia insularis* Kantvilas & Wedin grows on the saxicolous *Caloplaca eos* S.Y.Kondr. & Kärnefelt. A third species, the widespread *A. intexta* Alm., infects the apothecia of the saxicolous crustose lichen, *Lecidella sublapicida* (Knight) Hertel. A key to the eight lichenicolous species of *Arthonia* recorded for Australia is provided.

Key Words: biodiversity, lichens, lichen parasites, new taxa, Arthoniaceae, South Australia.

Introduction

Arthonia is a cosmopolitan genus of ascomycete fungi that occurs in most habitats, ranging from dry steppes and savannahs to closed wet forest, and from littoral to alpine elevations. It has been estimated to contain approximately 400 species (Kirk et al. 2001), but this is an old and certainly outdated estimate. It is obvious both from the large variation in morphological traits (Grube & Matzer 1997, Sundin & Tehler 1998, Wedin & Hafellner 1998, Ihlen & Wedin 2008) and molecular phylogenies (Frisch et al. 2014) that *Arthonia* in its current circumscription is not monophyletic, and it is likely that a substantial change in its generic concept and delimitation will eventually occur. The majority of species are lichenised with the filamentous green alga *Trentepohlia*, and can be found on bark, wood, rocks or living leaves. These species are well represented in the Australian biota with 40 taxa recorded by McCarthy (2015). This figure is undoubtedly a very large underestimate, because the genus remains poorly collected and largely unstudied in the region. Most Australian herbaria hold significant numbers of specimens identified to genus only or tentatively identified to species using some of the more accessible Northern Hemisphere publications, such as Coppins & Aptroot (2009), Grube (2007) and Willey (1890), or the account of the genus for New Zealand (Galloway 2007).

Some species of *Arthonia* may be non-lichenised or weakly or only putatively lichenised, and occur as saprophytes on bark, although it is sometimes difficult

to confirm this lifestyle without detailed anatomical study. Another highly diverse group within *Arthonia* comprises lichenicolous species, growing on the thalli of a wide range of fruticose, foliose or crustose genera. Collections of such species are also well-represented in Australian herbaria but are largely unstudied and filed under the name of the host species. However, a few of these have been studied and described on the basis of Australian collections, for example, Kondratyuk (1996), Wedin (1993), Wedin & Hafellner (1998) and Kantvilas & Vězda (1992). Based on the literature, McCarthy (2012) records five lichenicolous species for Australia. It is three species from this group that are the focus of the present study.

Methods

The study is based on collections of the first author, housed in the Tasmanian Herbarium (HO), but with some duplicates distributed to other herbaria, as cited in the text, and on comparisons with reference herbarium material (also as cited). The descriptions are based on hand-cut sections of the ascomata, mounted in water, 15% KOH, lactophenol cotton blue and Lugol's Iodine, with (K/I) or without (I) pretreatment in KOH, and examined at high-power with a light microscope. Measurements of ascospores are based on more than 50 observations for each taxon and are presented in the form 5th percentile–average–95th percentile; outlying values are given in brackets.

Taxonomy

1. *Arthonia caliciae* Kantvilas & Wedin, sp. nov.

Hospite singulari (Calicio tricolori F.Wilson), *ascosporis hyalinis, ellipsoideis, uni-septatis, 10–14 µm longis, 3–5 µm latis et ascis omnino non-amyloideis recognita.*

Mycobank no.: MB 812915.

Typus: SOUTH AUSTRALIA, Kangaroo Island: Billy Goat Falls, 35°42'S 136°55'E, 200 m alt., on thallus of *Calicium tricolor* on dead wood in dry sclerophyll forest, 20 Sep. 2012, G. Kantvilas 773/12 (holo: HO; iso: AD, S).

Growing on the scurfy crustose thallus of *Calicium tricolor* F.Wilson, thallus lacking, trebouxoid photobiont cells of the host lichen often penetrating the base of the ascomata. *Ascomata* irregularly roundish, 0.12–0.3 mm wide, blackish brown to black, convex, minutely scabrid-verruculose, immarginate, slightly basally constricted to sessile, in section 60–120 µm thick, lacking any differentiated exciple. *Hypothecium* hyaline to pale olive-brown, poorly differentiated from the hymenium. *Hymenium* 30–55 µm thick, diffusely pale olive-brown, intensifying olive-greenish in K, I+ red, K/I+ blue, overlain by a more intensely pigmented epihymenial layer c. 5 µm thick; paraphysoids highly branched and anastomosing, rather indistinct, remaining rather coherent in K, c. 1 µm thick, with apices neither expanded nor capitate but strongly conglutinated with pigment; asci 8-spored, 23–38 × 12–20 µm, of the *Arthonia*-type: broadly clavate to subglobose, mostly with a short 'foot' at the base and a well-developed tholus I–, K/I–, lacking an amyloid ring-structure; apex of ascoplasm variable with age, concave, rounded or extending in a beak-like ocular chamber. *Ascospores* hyaline, 1-septate, 10–11.3–13 (–14) × (3–) 4–4.7–5 µm, narrowly ellipsoid, typically with the upper cell a little larger and the septum slightly constricted. *Pycnidia* immersed at the base of the ascomata; conidia rod-shaped, 4–5 × 0.5 µm. **Fig. 1, 2A–E.**

Etymology. The specific epithet refers to the unusual host of this new species.

Remarks. *Arthonia caliciae* is characterised by its completely hyaline, ellipsoid, 1-septate ascospores, its totally non-amyloid asci, and by its host. Most licheniculous fungi that grow on species of *Calicium* are themselves other calicioid fungi; for example, species of *Chaenothecopsis* or *Microcalicium*. Thus *Arthonia caliciae* is the first species of *Arthonia* to be reported growing on a *Calicium*. Among other *Arthonia* species known to occur on lichens related to the host (i.e. the non-mazaediate Caliciaceae; Wedin et al. 2002) are *A. epimela* (Almq.) I.M.Lamb, which grows on the thallus of *Amandinea punctata* (Hoffm.) Coppins & Scheid. This species differs from *A. caliciae* by the considerably larger ascomata (c. 0.4–0.6 mm diam.) and the hyaline hymenium. *Arthonia punctella* Nyl. grows on various crustose lichens, including *Diplotomma*



Fig. 1. *Arthonia caliciae*, seen as abundant black, speck-like apothecia on the pale yellowish thallus of *Calicium tricolor*. The stalked, mazaediate, trumpet-shaped ascomata of the *Calicium* are also present. — Scale bar: 1 mm.

alboatrum (Hoffm.) Flot., but is clearly parasitic and has ascospores that turn brown and verrucose. None of these species are currently known from Australia. Indeed few calicioid species are associated with *Arthonia* sens. lat.; *Chaenothecopsis vainioana* (Nádv.) Tibell (Tibell 1981, 1999), which is associated with both free-living *Trentepohlia* and *Trentepohlia*-containing lichens, is an exception.

The new species is known only from the type collection, growing on decorticated, bleached, rotting eucalypt lignin in dry open eucalypt forest. Other species growing on the same substratum included *Calicium abietinum* Pers., *C. salicinum* Pers., *Ochrolechia gyrophorica* (A.W.Archer) A.W.Archer & Lumbsch, *Ramboldia stuartii* (Hampe) Kantvilas & Elix, *Lecidella xylogena* (Müll.Arg.) Kantvilas & Elix and *Caloplaca wilsonii* S.Y.Kondr. & Kärnefelt.

2. *Arthonia insularis* Kantvilas & Wedin, sp. nov.

Arthoniae anjutii A. sytnikii *que similis et item ascis non-amyloideis et ascosporis brunnescentibus, 10–18 µm longis, 5–9 µm latis sed thallum Caloplacae eos S.Y.Kondr. & Kärnefelt incolens et apotheciis non-immersis, gallas non-formantibus vel thallum hospitis non decolorantibus.*

Mycobank no.: MB 812916.

Typus: SOUTH AUSTRALIA, Kangaroo Island, summit of bluff W of Windmill Bay, 35°51'S 138°07'E, 40 m alt., on thallus of *Caloplaca eos* on granite boulders in coastal heathland, 17 Sep. 2012, G. Kantvilas 506/12 (holo: HO; iso: AD, KW, S).

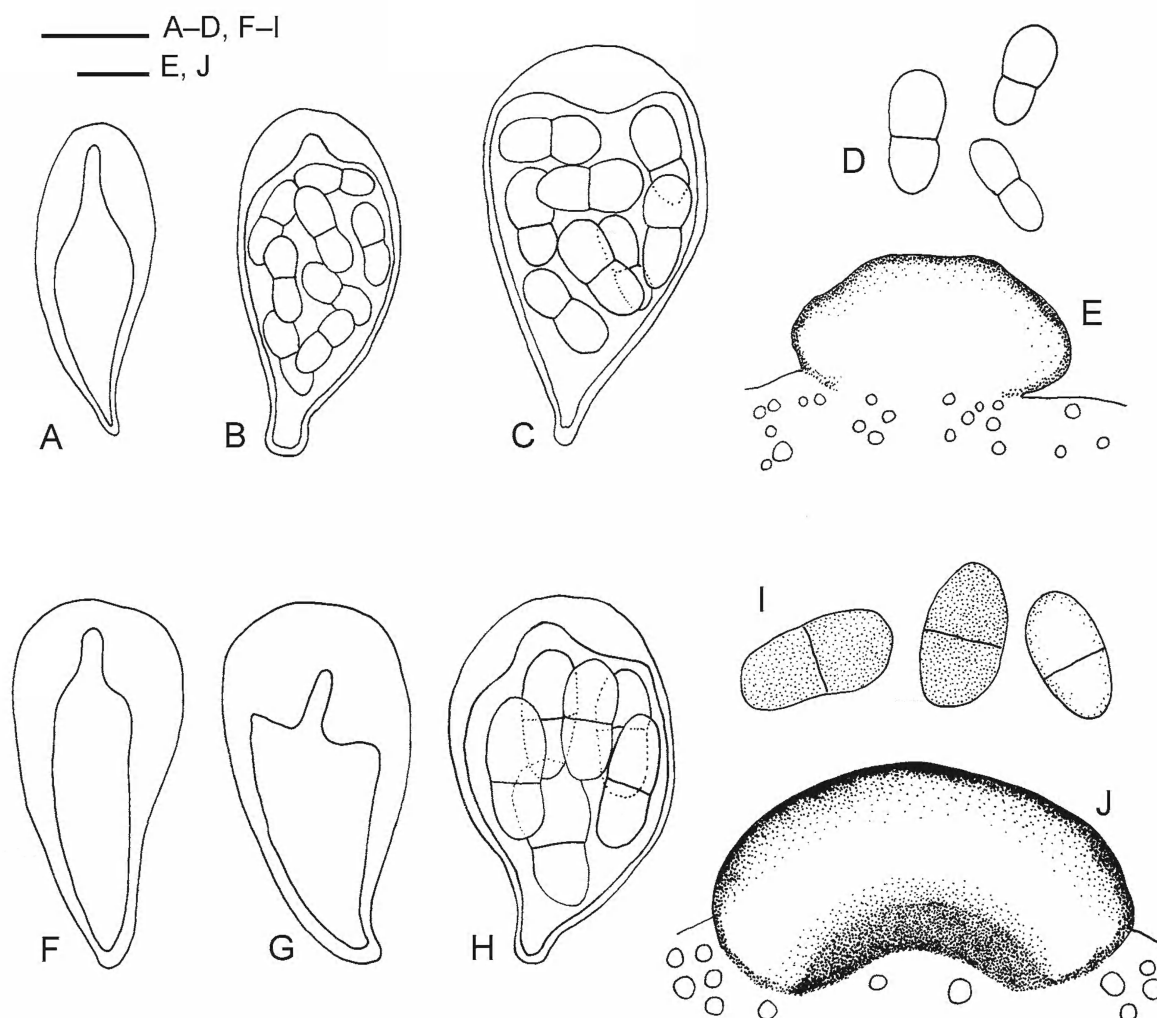


Fig. 2. Anatomy of the new species. **A–E** *Arthonia caliciae*: **A–C** non-amyloid asci mounted in K/I; **D** ascospores; **E** transverse section of ascoma (semi-schematic). **F–J** *A. insularis*: **F–H** non-amyloid asci mounted in K/I; **I** ascospores; **J** transverse section of ascoma (semi-schematic). — Scale bars: A–D, F–I = 10 µm; E, J = 40 µm. — **A–E** G.Kantvilas 773/12. **F–J** G.Kantvilas 506/12.

Growing on the thallus or, very rarely, the apothecia of *Caloplaca eos* S.Y.Kondr. & Kärnefelt, *thallus* lacking. *Ascomata* roundish, 0.05–0.4 mm wide, black, slightly to strongly convex, rarely \pm plane, immarginate, at first immersed in the cortex of the host, soon emergent and adnate, in section 80–150 µm thick. *Hypothecium* dilute reddish brown, K+ deep olive-grey, poorly differentiated from the hymenium, subtended by a cupulate, excipulum-like tissue 10–20 µm thick, composed of densely packed, rather cellular hyphae, deep reddish brown, K+ dark olive-grey. *Hymenium* 50–60 µm thick, hyaline to diffusely pale reddish brown, K+ olive-grey, I+ red, K/I+ blue, overlain by a dark reddish brown, K+ dark olive-grey epihymenial layer c. 10 µm thick; paraphysoids highly branched and anastomosing, coherent in K, 2–3 µm thick, with apices neither expanded nor capitate but strongly

conglutinated with pigment; asci initially 8-spored but usually with several spores aborted at maturity, 20–45 \times 15–25 µm, of the *Arthonia*-type: broadly clavate to subglobose, mostly with a short ‘foot’ at the base and a well-developed tholus I–, KI–, lacking an amyloid ring-structure; apex of ascoplasm variable with age, concave, rounded or extending in a beak-like ocular chamber. *Ascospores* 1-septate, hyaline at first but soon becoming pale reddish brown, K+ olive-grey, (10–) 12–14.3–17 (–18) \times 5–7.2–8.5 (–9) µm, oblong-ovoid to ellipsoid, mostly with the upper cell a little larger, not markedly constricted at the septum; wall becoming minutely papillate in older spores. *Pycnidia* immersed at the base of the ascomata; conidia narrowly fusiform to rod-shaped, 4–6 \times 1–1.5 µm. **Fig. 2F–J, 3.**

Etymology. The specific epithet refers to the island provenance of the type collection.

Remarks. Species of Teloschistaceae are known to serve as hosts for several species of *Arthonia*. The common and widespread *A. molendoi* (Heufl. ex Frauenf.) R.Sant., which occurs on various Teloschistaceae, differs from *A. insularis* by having smaller ascomata (rarely more than 0.2 mm diam.), somewhat smaller ascospores (c. $12\text{--}15 \times 5\text{--}6 \mu\text{m}$) that do not become brownish and papillate, and asci with an apical K/I+ blue ring-structure. There are two further *Arthonia* species known to occur on Teloschistaceae (Kondratyuk 1996) that share with *A. insularis* similar-sized ascospores and entirely non-amyloid asci, but which differ from the new species by being clearly parasitic: *A. sytnikii* S.Y.Kondr., described from Australia (Adelaide), forms distinct, raised galls on its host *Xanthoria ligulata* (Körb.) P.James, whereas *A. anjutii* S.Y.Kondr. & Alstrup, which grows on species of *Teloschistes* in the highlands of Victoria, differs by causing \pm discoloured and sometimes almost deformed areas on its host. The latter in particular has ascomata that are initially immersed, but break through the host thallus, frequently retaining some host cortical tissue as a thin, discontinuous veil that is also discernible in thin transverse sections.

The new species is known only from the type locality, where it grew on granite boulders in windswept, exposed, low coastal heathland. It infected the thallus of *Caloplaca eos*, associated with other species of the genus, including *C. gallowayi* S.Y.Kondr., Kärnefelt & Filson and *C. tomareeana* S.Y.Kondr. & Kärnefelt. Significantly, the thalli of these related lichens were not infected by the *Arthonia*.

Comparative material of A. anjutii studied:

NEW SOUTH WALES: Kosciuszko Nat. Park, Charlotte's Pass, on *Teloschistes fasciculatus*, 6.iv.1981, L. Tibell 12114 (UPS).

VICTORIA: "The Sentinel" peak, SE of Lake Tali Karng, Mt Wellington area, 1450 m alt., on *Teloschistes velifer*, 12.iii.1966, J.H. Willis s.n. (MEL); Bogong High Plains, Mt Cope, on *Teloschistes velifer*, 19.i.1966, R. Filson 8104 (MEL); Bogong High Plains, Spion Kopje ridge, 1820 m alt., on *Teloschistes velifer*, 23.i.1967, R. Filson 9533 (MEL).

3. *Arthonia intexta* Almq.

Kongl. Svenska Vetensk.-Akad. Handl. 17(6): 60 (1880).

Growing within the apothecia of *Lecidella sublapicida* (Knight) Hertel, thallus lacking. Ascomata poorly differentiated from those of the host. Hymenium entirely within and at length completely supplanting the hymenium of the host, I+ red, K/I+ red; paraphysoids highly branched and anastomosing, rather indistinct, coherent in K, $1.5\text{--}2 \mu\text{m}$ thick, with apices internally olive-brown, K+ olive-grey, $2\text{--}5 \mu\text{m}$ wide; asci 8-spored, $27\text{--}33 \times 10\text{--}15 \mu\text{m}$, of the *Arthonia*-type: broadly clavate, mostly with a short 'foot' at the base and a well-developed tholus I-, K/I-, lacking an amyloid ring-structure. Ascospores hyaline, (1-) 2-septate, $10\text{--}11\text{--}13\text{--}(14) \times 3\text{--}4\text{--}5 \mu\text{m}$, narrowly ellipsoid. Pycnidia immersed in the apothecia of the host; conidia fusiform, $4\text{--}5 \times 1\text{--}1.2 \mu\text{m}$.

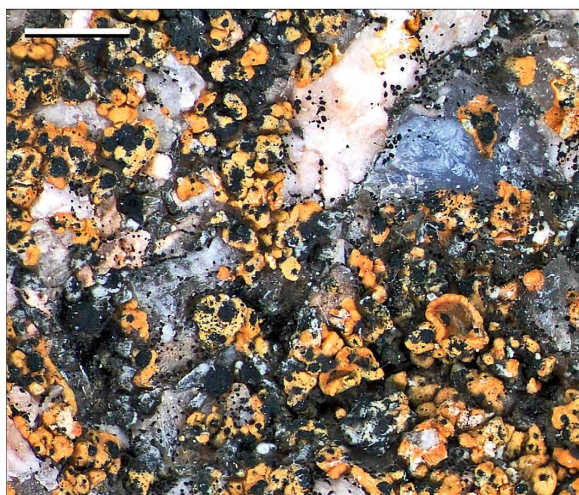


Fig. 3. *Arthonia insularis*, seen as abundant black, speck-like apothecia on the orange thallus and apothecium of *Caloplaca eos*. — Scale bar: 1 mm.

Remarks. This remarkable species is characterized mainly by its unique habitat, and by the 2-septate, hyaline ascospores. It was first observed rather fortuitously in the course of routine sectioning of a specimen of *Lecidella sublapicida*. In earlier stages of its development, the asci of the *Arthonia* are interspersed amongst the asci of the *Lecidella*, and are easily distinguished by their different amyloid reactions, those of *Lecidella* being K/I+ blue. In later stages, the normally black, discoid apothecia of *Lecidella* become deformed, strongly contorted and convex, and their margin becomes rather indistinct. In such apothecia, the asci of the *Arthonia* dominate the whole apothecium, although the typical blue-green pigmented, *Lecidella*-type excipulum and the yellow-brown hypothecium remain evident. For a description of *L. sublapicida* see Kantvilas & Elix (2013). The observation of pycnidia was entirely by chance; they were seen in just one of a large number of apothecial sections made in the course of compiling the above description.

The description given here is based solely on the single Kangaroo Island specimen studied. It accords well with accounts of the species in the Northern Hemisphere, although European authors, for example Coppins & Aptroot (2009), Triebel (1989) and Ihlen & Wedin (2008), report ascospores that are somewhat larger, $11\text{--}20 \times 3\text{--}6 \mu\text{m}$.

The species was collected on Kangaroo Island as part of a large specimen of *Lecidella sublapicida*, growing on sunny rocks in pasture at the margins of mallee woodland. Other lichens present included *Lecidea sarcogynoides* Körb. and *Diploschistes gyrophoricus* Lumbsch & Elix.

Specimen examined:

SOUTH AUSTRALIA, Kangaroo Island: Cape Willoughby Rd, $35^{\circ}50'S$ $138^{\circ}06'E$, 110 m alt., 29 Sep. 2011, G. Kantvilas 325/11 (HO).

Provisional key to the lichenicolous species of *Arthonia* recorded for Australia

The study of lichenicolous *Arthonia* in Australia is in its infancy and it is very likely that many more species are yet to be discovered. Consequently, it is recommended that this key is used in conjunction with others, such as those of Clauzade et al. (1989) and Ihlen & Wedin (2008).

1. Ascomata orange-red, infused with a K⁺ purple pigment, forming necrotic patches on the thallus of *Pseudocyphellaria*; ascospores 1-septate, becoming brownish, 10–14.5 × 4–5.5 µm *A. pseudocyphellariae* Wedin
- 1: Ascomata brown to black, or poorly differentiated
 2. Ascomata poorly differentiated from host tissues, entirely immersed within the apothecia of *Lecidella* species; ascospores (1–) 2 (–3)-septate, hyaline, 10–20 × 3–6 µm 3. *A. intexta*
 - 2: Ascomata distinct; ascospores persistently 1-septate
 3. Ascomata discrete and emergent from the thallus of the host
 4. Ascomata minute, 0.1–0.15 mm wide, growing on the thallus of *Sagenidium molle* in cool temperate rainforest; ascospores hyaline, 6–9 × 2–2.2 µm *A. sagenidii* Vězda & Kantvilas
 - 4: Ascomata and ascospores generally larger, not on *Sagenidium*
 5. Ascomata flecklike, 0.3–1.5 (–2) mm wide, frequently confluent, growing on the thallus of *Lobaria*; hypothecium dark brown; ascospores hyaline, 11–15 × 3–4 µm *A. subconveniens* Nyl.
 - 5: Ascomata roundish and discrete, 0.05–0.4 mm wide, not on *Lobaria*; hypothecium hyaline to pale brownish
 6. Ascomata growing on the thallus of *Calicium*; ascospores hyaline, 10–14 × 3–5 µm 1. *A. caliciae*
 - 6: Ascomata growing on the thallus of *Caloplaca*; ascospores becoming brown, 10–18 × 5–9 µm .. 2. *A. insularis*
 - 3: Ascomata inducing galls or necrotic patches on the host
 7. Ascomata 0.15–0.45 mm wide, inducing galls on the thallus of *Xanthoria*; hypothecium hyaline; ascospores hyaline, 8–13 × 3–5 µm *A. sytnikii* S.Y.Kondr.
 - 7: Ascomata 0.25–0.35 mm wide, forming discoloured patches on the thallus of *Teloschistes*; hypothecium dark brown to black-brown; ascospores becoming brown, 11–16.5 × 4.5–7 µm *A. anjutii* S.Y.Kondr. & Alstrup

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