

# Two new lichenicolous species of *Arthonia* (Ascomycota: Arthoniomycetes) from Tasmania

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**Abstract:** Eight lichenicolous species of *Arthonia* from Tasmania are treated. Two are described as new: *A. aurantia* Kantvilas & Motiej., which infects the thallus of a *Leprocaulon*-like lichen and is characterised by vivid orange, K+ magenta ascomata, 0.07–0.1(–0.15) mm wide, and 1-septate, macrocephalic ascospores, 10–12.5(–13.5) × 4–5.5 μm; and *A. endocarpa* Kantvilas & Motiej., which infects the apothecia of *Amandinea neoconglomerata* Elix, and has non-amyloid asci interspersed with those of the host, and is characterised by 1-septate, macrocephalic ascospores, 8.5–13 × 4.5–6 μm. Two other species, *A. epiphyscia* Nyl. and *A. stictaria* Nyl., are here recorded for Tasmania for the first time. Salient features of all species are compared.

**Keywords:** Arthoniaceae, lichens, parasymbionts, taxonomy, Australia

## INTRODUCTION

The genus *Arthonia* has long been recognised as being heterogeneous, and much recent work, based mainly on molecular data, has seen the segregation of numerous, natural groupings as distinct genera (e.g. Sundin & Tehler, 1998; Grube, 2001a, b; Ertz et al., 2009; Frisch & Thor, 2010; Ertz & Tehler, 2011; Frisch et al., 2014, 2015; Van den Broeck et al., 2018; Cannon et al., 2020). Even so, with in excess of possibly 500 species classified in *Arthonia* as currently treated, it remains one of the largest genera of Ascomycetes that forms or is associated with lichens. Species of *Arthonia* can be found in almost every habitat and vegetation type, and are able to colonise almost any substratum, including bark, wood, rocks, living leaves or other lichens. Lichenicolous species can occur either on the surface of their host, ± within the thallus and burst out on development, or, in the case of a small number of species, within the apothecia of their host. It is the lichenicolous species, and specifically those that occur in Tasmania, that are the focus of the present paper.

Study of *Arthonia* in general and of the lichenicolous species in particular has been very limited in Australasia. McCarthy (2017) lists seven species for Australia, a figure that includes five based on Australasian types described by Wedin (1993), Kondratyuk (1996) and Kantvilas & Wedin (2015), with additional species treated by Kantvilas & Vězda (1992) and Wedin & Hafellner (1998). For New Zealand, Galloway (2007) deals with 11 lichenicolous *Arthonia* species of which

three were considered to be endemic to that country. In this paper, we describe two new lichenicolous species of *Arthonia* from Tasmania and record three others from the island for the first time. This brings the total number of taxa for Tasmania to eight; the salient features of these are compared.

## MATERIALS AND METHODS

The study is based on Tasmanian collections housed in the Tasmanian Herbarium (HO). Anatomical observations and measurements are based on thin, hand-cut sections of the ascomata, mounted in water, 10% KOH (K), Lugol's Iodine (I), ammoniacal erythrosin, Trypan Blue and/or Lactophenol Cotton Blue. Application of I after pretreatment with K and subsequent rinsing with water is indicated in the text as KI. Ascospore measurements are presented in the format 5<sup>th</sup> percentile–average–95<sup>th</sup> percentile, with outlying values in brackets and *n* signifying the number of observations.

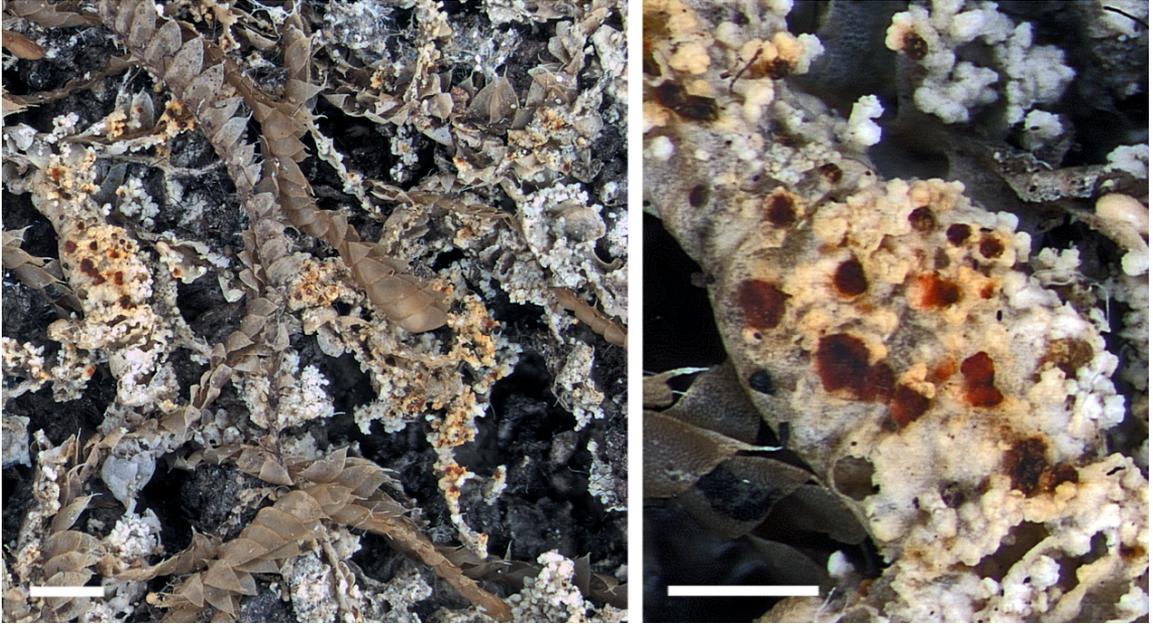
## RESULTS AND DISCUSSION

### TAXONOMY

ARTHONIA AURANTIA Kantvilas & Motiej. (Figs 1, 2A)

Mycobank No. MB849501

Infecting the thallus of an undescribed *Leprocaulon*-like lichen and characterised by vivid orange, K+ magenta ascomata, 0.07–0.1(–0.15) mm wide, clavate asci, 21–34 × 11.5–16 μm, and 1-septate, macrocephalic ascospores,



**Fig. 1.** Habit of *Arthonia aurantia* (holotype collection), overgrowing an undescribed squamulose lichen and the liverwort *Cuspidatula monodon* (Taylor ex Lehm.) Stephani. Scales = 1 mm (LHS) and 500 µm (RHS).

10–12.5(–13.5) × 4–5.5 µm; similar to *A. pseudocyphellariae* Wedin, which differs by having larger ascomata (0.1–0.6 mm wide), larger asci (30–40 × 15–21 µm) and larger ascospores (10–16 × 4–6 µm).

Type: Australia, Tasmania, c. 0.5 km E of Olga River, 42°51'S 145°50'E, lichenicolous on an undescribed "*Leprocaulon*", on *Phyllocladus aspleniifolius* in a large, forested *Eucalyptus-Phyllocladus* copse in buttongrass moorland, 7 March 1991, G. Kantvilas 35/91 (HO 611130).

Lichenicolous on the thallus of an unidentified squamulose lichen, thallus lacking. Ascomata erumpent from the host thallus, irregularly roundish, ± plane to slightly convex, 0.07–0.1(–0.15) mm wide, c. 0.1–0.14 mm thick, vivid orange to orange-red, becoming brownish red with age, dispersed or closely adjacent and fused together, immarginate. Internal tissues poorly differentiated, deeply infused with a golden-orange, K+ magenta pigment insoluble in K. Hymenium I+ red, KI+ deep blue; paraphysoids richly branched and anastomosed, slender, c. 1 µm thick, with apices not enlarged; asci 8-spored, clavate, 21–34 × 11.5–16 µm ( $n = 12$ ),

approximating the *Arthonia*-type: outer wall thinly KI+ blue; tholus well-developed, non-amyloid, lacking a ring structure and ocular chamber, with an apically truncate to concave ascoplasm. Ascospores ellipsoid, 1-septate, macrocephalic, with the proximal cell enlarged, ± persistently hyaline with only the oldest spores becoming discoloured greyish or pale brown and minutely granular-papillate, 10–11.4–12.5(–13.5) × 4–4.7–5.5 µm ( $n = 60$ ). Conidiomata not seen.

**Etymology.** The specific epithet refers to the reddish orange colour of the ascomata.

**Remarks.** This new species is known only from the type collection, growing on the thallus of an undescribed, obligately sterile, squamulose lichen that contains 2'-*O*-methylperlatolic acid. The host resembles a species of *Leprocaulon* and is relatively widespread in Tasmania's cool temperate rainforests where it occurs on trunks and branches in the forest understorey. The same lichen is also the host for the recently described *Arthothelium insolitum* Kantvilas (Kantvilas, 2021).

*Arthonia aurantia* is extremely inconspicuous, although under magnification, its tiny vivid reddish orange ascomata contrast sharply with

the whitish thallus of the host (Fig.1). Red-fruited *Arthonia* species are not uncommon (Grube et al., 1995; Frisch et al., 2018) and include a few lichenicolous species. Whereas some of the autonomous species have been transferred to the genus *Coniocarpon* (Frisch et al., 2020), the particular pigment that characterises these species is different from that seen in *A. aurantia*. In *Coniocarpon*, the pigment is reddish, reacts K<sup>+</sup> purple and gradually dissolves, whereas in *A. aurantia*, it is orange, reacts K<sup>+</sup> magenta, remains insoluble and is identical to “*endoaurantiacum-gold*” as seen in several species of *Arthothelium* (Kantvilas, 2021). *Coniocarpon* differs further in having more elongate asci with a small ocular chamber when young, and ascospores that are transversely septate multiple times. Clearly very similar to the new species is *Arthonia pseudocypbellariae* Wedin, which occurs in austral cool temperate rainforests (Wedin, 1993) and, in Tasmania, is confined exclusively to *Pseudocypbellaria glabra* (Hook. f. & Taylor) C. W. Dodge. It has identical ascomatal pigmentation and asci, but the ascomata, asci and ascospores are all larger than in *A. aurantia* (Table 1). Furthermore, discoloured, granular-papillate spores are commonly seen in *A. pseudocypbellariae* but appear to be rare in *A. aurantia*.

Additional red- to orange-pruinose lichenicolous *Arthonia* species include *A. cinnabarinula* Müll. Arg. and *A. lopingensis* Zahlbr. The former is confined to foliicolous species of Trichotheliaceae and is known from tropical America and Asia (Lücking et al., 2000); it is now classified in the genus *Helicobolomyces* (Wijayawardene et al., 2020). This species differs from *A. aurantia* by its smaller ascospores (5–11 × 2–4 µm) and asci (17–27 × 9–14 µm), and its wider (up to 0.4 mm diam.) but thinner (40–70 µm thick) ascomata. Moreover, unlike in *A. aurantia*, the pigment in *A. cinnabarinula* dissolves in K (Grube et al., 1995). The Asian species *A. lopingensis* is a juvenile parasite on species of *Graphis* but later becomes an autonomous lichen. It differs from *A. aurantia* by having a thallus, and by its lirellate, weakly yellow-orange pruinose to epruinose ascomata where the pigment dissolves in K, and by its 2–3-septate ascospores, (11.0–)11.4–13.6(–15.0) × (3.5–)4.0–5.2(–5.5) µm (Frisch et al., 2018).

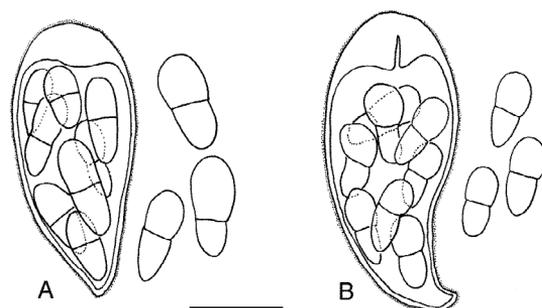
ARTHONIA ENDOCARPA Kantvilas & Motiej. (Fig 2B)

Mycobank No. MB849502

Infecting the apothecia of *Amandinea neoconglomerata* Elix, with its non-amyloid asci interspersed with amyloid asci of the host, and characterised by 1-septate, macrocephalic ascospores, 8.5–13 × 4.5–6 µm.

Type: Australia, Tasmania, Cape Huay, 43°08'S 148°00'E, 110 m, lichenicolous within the apothecia of *Amandinea neoconglomerata*, 20 November 2021, G. Kantvilas 467/21 (HO 605500).

Lichenicolous within the apothecia of *Amandinea neoconglomerata*, thallus lacking. Ascumata not developed. Hymenium entirely within the apothecia of the host, consisting of asci and clumps of paraphysoids dispersed amongst the asci and paraphyses of the host; paraphysoids rather indistinct, highly branched and anastomosing, short celled, 1–2 µm thick, with apices not expanded; asci 8-spored, elongate-clavate, 25–38 × 11–16 µm ( $n = 15$ ), of the *Arthonia*-type: I–, KI–, lacking a ring structure, with a well-developed tholus, a narrow ocular chamber, an apically truncate to concave ascoplasm, and a short, basal ‘foot’. Ascospores ellipsoid, 1-septate, macrocephalic with the proximal cell a little enlarged, ± persistently hyaline with only the oldest spores becoming discoloured greyish or pale brown with age, remaining smooth-walled throughout development, (8.5–)9–10.2–12(–13) × 4.5–5.1–6 µm ( $n = 60$ ). Conidiomata not seen.



**Fig. 2.** Asci (with KI<sup>+</sup> portions stippled) and ascospores of new *Arthonia* species. A: *A. aurantia*. B: *A. endocarpa*. Scale = 10 µm.

**Table 1.** Salient features of lichenicolous species of *Arthonia* recorded from Tasmania. All data are derived from Tasmanian collections only.

	host in Tasmania	ascomata	ascomatal pigment	hymenium	asci	ascospores
<i>A. aurantia</i>	thallus of "Leptocaulon" sp.	0.07–0.1(–0.15) mm wide, erumpent to superficial	reddish orange, K+ magenta	I+ red, KI+ blue	21–34 × 11.5–16 µm; tholus non-amyloid, lacking a ring structure; wall KI+ blue	ellipsoid, macrocephalic, 1-septate, 10–11.4–12.5(–13.5) × 4–4.7–5.5 µm, rarely becoming granular-papillate and discoloured with age
<i>A. endocarpa</i>	apothecia of <i>Amandinea</i>	not developed	nil	not developed	25–38 × 11–16 µm; tholus and wall non-amyloid; ring structure lacking	ellipsoid, macrocephalic, 1-septate, (8.5–)9–10.2–12(–13) × 4.5–5.1–6 µm, mostly persistently hyaline and smooth-walled
<i>A. epiphyscia</i>	thallus of <i>Physcia neonubila</i>	0.1–0.2 mm wide, superficial	brown, K+ dingy olive-grey	I+ blue → reddish; KI+ blue	25–35 × 13–20 µm; tholus non-amyloid, lacking a ring structure; wall KI+ blue	ellipsoid to ± clavate, asymmetrically 1-septate, (10–)11–13.0–15 × 4–5.0–6(–7) µm, very soon becoming grey-brown and sometimes warty-papillate*
<i>A. intexta</i>	apothecia of <i>Lectidella sublapicida</i>	not developed	nil	I, KI+ blue	22–35(–40) × 12–20 µm; tholus non-amyloid, lacking a ring structure; wall KI+ blue.	fusiform-ellipsoid, 2-septate, 11–13.2–15 × (3.5–)4–4.5–(–5.5) µm, remaining smooth and hyaline
<i>A. pseudo-cypbellariae</i>	thallus of <i>Pseudocypbellaria glabra</i>	0.1–0.6 mm wide, soon superficial	reddish orange, K+ magenta	I+ red, KI+ blue	30–40 × 15–21 µm; tholus non-amyloid, lacking a ring structure; wall KI+ blue	ellipsoid, macrocephalic, 1-septate, (10–)11–13.1–15(–16) × 4–4.9–5.5(–6) µm, commonly becoming granular-papillate and discoloured with age.
<i>A. sagenidii</i>	thallus of <i>Lecanactis mollis</i>	0.1–0.15 mm wide, superficial	brown, K+ olive	I+ red, KI+ blue	20–30 × 8–13 µm; tholus non-amyloid, lacking a ring structure; wall KI+ blue	narrowly ellipsoid, 1-septate, 6–7.2–8(–9) × 2–2.2–2.5(–3) µm, persistently hyaline and smooth-walled
<i>A. strictaria</i>	thallus of <i>Pseudocypbellaria</i> ( <i>Crocodia aurata</i> )	0.2–1 mm wide, superficial, forming necrotic patches	greenish, intensifying greenish in K, N± brownish	I+ red, KI+ blue	28–35 × 13–15 µm; tholus non-amyloid, with a highly reduced amyloid ring structure; wall KI+ blue	oblong-ellipsoid, 1-septate, slightly macrocephalic, 8–10.2–12 × (3–)3.5–4.0–5 µm, persistently hyaline and smooth-walled**
<i>A. syntikii</i>	thallus of <i>Dufourea</i> ( <i>Xanthoria ligulata</i> )	0.15–0.45 mm wide, forming galls	brownish, K± olive	I+ red, KI+ blue	27–33 × 13–17 µm; tholus K– or very weakly + blue, with a highly reduced amyloid ring structure; wall KI+ blue	ellipsoid, asymmetrically 1-septate, sometimes weakly macrocephalic, (8–)9–12.8–14(–15) × 3–4.1–5 µm, remaining smooth and hyaline

\* Ascospore sizes in the literature (e.g. Ihlen & Wedin 2008) are generally narrower. Here only hyaline ascospores are measured; old, pigmented spores can be up to 17–18 µm long and 7.5 µm wide.

\*\* Wedin & Hafellner (1998) give the range of the holotype as c. 11–13 × 4–5.5 µm.

Etymology. The specific epithet refers to the occurrence of this species entirely within the fruiting bodies of its host.

Remarks. The Caliciaceae are known to serve as hosts for lichenicolous species of *Arthonia*, including the Australian endemic, *A. calicii* Kantvilas & Wedin, which occurs on the thallus of *Calicium tricolor* F. Wilson. Whereas most lichenicolous species of *Arthonia* (and all species known from *Buellia* and *Amandinea*) infect the thallus of their host, there is a small number which, like the new species, occur on or within apothecia. *Arthonia endocarpa* offers no outward sign of its presence; the host apothecia are, for all intents and purposes, neither deformed nor discoloured in any way, and so the discovery of the *Arthonia* was entirely by chance. The single specimen studied is richly fertile with *Amandinea* apothecia, and almost every apothecium sectioned revealed scattered *Arthonia* asci between the typical *Buellia*-type asci of the host, containing brown, 1-septate spores. Likewise the anastomosed paraphyses of the *Arthonia* occur in clumps amongst the sparsely branched, brown-capitate paraphyses of the *Amandinea*. Thus the *Arthonia* does not form a contiguous hymenium and any iodine reaction is “swamped” by the intensely I+ blue reaction of the *Amandinea* hymenium. It is only when the individual *Arthonia* asci are squashed out that their characteristic staining in KI can be observed. In one section, short strands of *Trentepohlia* with cells 8–15 × 5–11 µm were seen beneath the apothecia amongst the cells of the trebouxoid *Amandinea* photobiont. Whether or not these are associated with the *Arthonia* could not be established but, significantly, none of the other lichens present on the same rock have a trentepohlioid photobiont.

Five other lichenicolous *Arthonia* species are known from *Amandinea* hosts: *A. amandineicola* van den Boom & Ertz on *Amandinea efflorescens* (Müll. Arg.) Marbach, *A. rakusae* Alstrup & Olech on *Amandinea petermannii* (Hue) Matzer et al., *A. subantarctica* Øvstedal on *Amandinea babingtonii* (Hook. f. & Taylor) Søchting & Øvstedal, and *A. epimela* (Almq.) I. M. Lamb and *A. vorsoeensis* Alstrup, both of which occur on *Amandinea punctata* Coppins & Scheid. None of these species inhabits the apothecia of their hosts, but forms autonomous ascomata. Some (*A. subantarctica*, *A. vorsoeensis*, *A. rakusae*)

also exhibit pathogenicity towards their host (Alstrup, 1993, 2002; Alstrup et al., 2018). All these species differ further from *A. endocarpa* in ascospore measurements. In addition, *A. amandineicola* differs by its 4-spored asci and 1–2-septate ascospores that become dark brown and granulose when old (van den Boom et al., 2017).

In Tasmania, only *A. intexta* is known to infect the apothecia of its host (*Lecidella*), and, in the same way, this species also gives no outward sign of its presence. Aside from the totally unrelated host, *A. intexta* differs by having longer, predominantly 2–3-septate, fusiform-ellipsoid ascospores that show no sign of becoming papillose or discoloured with age, and an ascus tholus with a KI+ blue ring-structure (Table 1). *Arthonia endocarpa* and *A. intexta* are the only known representatives of the genus that do not form ascomatal structures throughout the whole course of their development, although this feature can be observed in *A. varians* (Davies) Nyl. in the early stages of infection (Triebel, 1989). A further host hymenium-inhabiting species of the Arthoniaceae that entirely lacks apothecial structures is *Arthothelium hymeniicola* Ertz & Fryday, hitherto recorded from New Zealand. This species inhabits the apothecia of *Bacidia* (Ertz & Fryday, 2017) and differs from all lichenicolous *Arthonia* species by its muriform ascospores.

The new species was collected from a coastal dolerite boulder seemingly affected by nutrient-enrichment, presumably by birds. The other species present are *Caloplaca holocarpa* (Hoffm.) A. E. Wade (syn. *Athallia holocarpa* (Hoffm.) Arup et al.) and *Lecanora dispersa* (Pers.) Sommerf. (syn. *Myriolecis dispersa* (Pers.) Śliwa et al.), neither of which displayed any sign of infection by the *Arthonia*.

#### Other lichenicolous *Arthonia* species in Tasmania

In addition to the two species described above, all other lichenicolous *Arthonia* species currently known in Tasmania are listed below, including two new records for the island:

ARTHONIA EPIPHYSCIA NYL. First record for Tasmania. On the thallus of *Physcia neonubila* Elix in *Melaleuca ericifolia*-dominated coastal swamp.

Australia, Tasmania: between mouths of Italian and Lagoon Rivers, Dago Plains, 41°29'S 144°49'E, 15 m, 2015, G. Kantvilas 98/15 (HO).

ARTHONIA INTEXTA ALMQ. Invading the apothecia of *Lecidella* species.

Australia, Tasmania: Bothwell to Steppes road, c. 8 km N of Hermitage turnoff, 42°12'S 146°54'E, 480 m, 1973, G.C. Bratt 73/571 & M.H. Bratt (HO); Barren Plains, 41°59'S 146°46'E, 1060 m, 2019, G. Kantvilas 41/19 (HO).

ARTHONIA PSEUDOCYPHELLARIAE WEDIN. On the thallus of *Pseudocyphellaria glabra* (Hook.f. & Taylor) C.W.Dodge in rainforest.

Australia, Tasmania: Quamby Bluff, 41°40'S 146°42'E, 840 m, 1990, M. Wedin 3128 (HO, UPS); summit ridge of Mt Scott, 41°18'S 147°31'E, 965 m, 2002, G. Kantvilas 237/02, K. Felton & B. de Villiers (HO).

ARTHONIA SAGENIDII VEZDA & KANTVILAS. On the thallus of *Lecanactis mollis* (Stirt.) Frisch & Ertz in rainforest.

Australia, Tasmania: Mt Mangana, 43°22'S 147°17'E, 420 m, 1971, G.C. Bratt 71/1096 (HO); Mt Victoria track, 41°20'S 147°50'E, 1973, G.C. Bratt 73/1225 (HO); Scotts Peak Road, N of Huon River, 42°50'S 146°22'E, 560 m, G. Kantvilas 525/88 pp (holotype, HO); Hartz Road, 43°12'S 146°46'E, 680 m, 1990, M. Wedin 3006 (HO, UPS); Scotts Peak Road, 42°49'S 146°23'E, 550 m, 1990, M. Wedin 3046 (HO, UPS).

ARTHONIA STICTARIA NYL. First record for Tasmania. On the thallus of *Pseudocyphellaria aurata* (Ach.) Vain.in *Melaleuca ericifolia*-dominated coastal swamp.

Australia, Tasmania: Woolnorth, "Paperbark Corner", 40°44'S 144°43'E, 15 m, 2023, G. Kantvilas 53/23 (HO).

ARTHONIA SYTNIKII S.Y.KONDR. On the thallus of *Xanthoria ligulata* (Körb.) P.James on coastal rocks.

Australia, Tasmania: between mouths of Italian and Lagoon Rivers, Dago Plains, 41°30'S 144°49'E, 3 m, 2015, G. Kantvilas 106/15 (HO).

## ACKNOWLEDGEMENTS

We thank Paul Diederich for many helpful comments on this manuscript in the capacity of referee. We also thank Jean Jarman for the photograph and for preparing all figures for publication. Some of the material studied was collected on the Tasmanian Museum and Art Gallery's collecting expeditions; GK acknowledges the support of the Australian Biological Resources Study's Bush Blitz Program and Woolnorth Wind Farm Holding Pty Ltd in this regard.

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