A remarkable, endohymenial species of *Arthothelium* (*Arthoniales*) from Campbell Island, New Zealand

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**Abstract:** A new *Arthothelium* species, *A. hymeniicola* in the apothecia of an unidentifiable *Bacidia* sp., is described from Campbell Island, New Zealand. The new species is remarkable, not only by being the first lichenicolous *Arthothelium* species, but also by being an endohymenial fungus not forming ascomatal structures. Previously, no Arthoniaceae species were reported as parasitic from *Bacidia* spp. However, both generic and family placements are tentative and the possibility of a placement in the Cookellaceae is also discussed. Differences between Arthoniaceae and Cookellaceae, and the generic delimitations within them, are generally based on the structures of the fruiting bodies, rendering the taxonomic placement of the new species challenging without molecular data; neither fruiting bodies nor molecular data are available for the new species and the Cookellaceae.

**Key words:** *Bacidia*, Cookellaceae, lichenicolous fungi, Myriangiales, subantarctic islands, taxonomy

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**Introduction**

Lichenicolous fungi are inconspicuous species that grow exclusively on lichens and develop diverse degrees of specificity and parasitic behaviour towards their hosts. They are generally host-specific parasites, but broad-spectrum pathogens, saprotrophs or commensals are not rare. Over 1800 species have been described throughout the Ascomycota and Basidiomycota, and it is estimated that c. 3000 species still need to be described (Lawrey & Diederich 2003, 2016). Among the lichens collected from the southern subpolar region by Henry Imshaug and co-workers and housed in the herbarium of Michigan State University (MSC; Fryday & Prather 2001), there is a single collection of an endohymenial species with more or less spherical asci and hyaline, muriform ascospores that we provisionally assign here to the genus *Arthothelium* A. Massal. The genus *Arthothelium* is a heterogeneous group of c. 121 more or less lichen-forming species (Kirk et al. 2008), but no lichenicolous species are known (Lawrey & Diederich 2016). As we are unaware of any other endohymenial species of Arthoniaceae producing muriform ascospores, we describe it here as a species new to science.

**Material and Methods**

Specimens were studied using an Olympus SZX12 stereomicroscope and an Olympus BX51 compound microscope. Hand-cut sections were investigated by light microscopy on material mounted in water, 5% KOH (K) and Lugol’s reagent (1%) without (I) or with (K/I) pre-treatment with K. Measurements of asci and ascospores refer to material examined in water.

*Arthothelium hymeniicola* Ertz & Fryday sp. nov.

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Endohymenial species of *Arthothelium* reduced to spherocylindrical, 8-spored ascus, 35–40×24–30μm, containing hyaline, muriform, 4–6×1-septate ascospores, 14–20×6–8μm.

Type: New Zealand, Campbell Island, north of Beeman Station, on branch of *Dracophyllum* scrub, on a *Bacidia* sp., 22 December 1969, R. C. Harris 4386 (MSC0102168—holotype!).

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lichenized, in hymenium of a
widening.

aspergilliform, apices not distinctly
68 sigmoid, without gelatinous sheath, 8
Ascospores 8-spored, wall thicker in upper part, I+
verse septa and one longitudinal septum, I+ orange, KI+ orange, 14
verse septa and one longitudinal septum, I+ orange, KI+ orange, 14–20 × 6–8 µm (in
water), without a distinct gelatinous sheath. 
Paraphysoids not seen.

Conidiomata not seen.

Notes. The absence of ascomatal structure
renders the generic placement of the new
species difficult. The short subspherical asci
with a thick upper wall and the parasitic
lifestyle on other ascomycetes are reminis-
cent of species of Arthoniaceae (Arthoniomyc-
etes) and of Myriangiales (encompassing
Cookellaceae; Dothideomycetes). We decided
to tentatively place the new species in the
family Arthoniaceae and to describe it in the
genus Arthothelium s. lat. for the reasons dis-
cussed hereafter.

The family Arthoniaceae is well known for
including taxa with reduced or absent asco-
matal structures. It also includes many
lichenicolous fungi. Among them, Arthonia
intexta Almq. is a notable example of an
endothymenial parasite that forms only asci
and a few interascal filaments intermixed
with those of the host. However, contrary to
our new species, A. intexta differs by having
only transversely 2–3(–4)-septate ascospores,
narrower asci (10–20 µm wide) generally
having a KI+ blue ring-structure and
different host species belonging to the genus
Lecidella (e.g. Hertel 1969; Triebel 1989;
Grube 2007; Sussey 2012). Many other
lichenicolous Arthonia species are strictly
or facultatively parasitic on the hymenia
of their host lichen but all produce distinct
ascomatal structures (e.g. Arthonia
apotheciorum (A. Massal.) Almq., A. clemens
(Tul.) Th. Fr., A. glacialis Alstrup &
E. S. Hansen, A. haematommatum Kalb &
Hafellner, A. lecanoriola Alstrup & Olech,
A. lecanorina (Almq.) R. Sant., A. obscurior
Triebel, A. protoparmeliopseos Etayo &
Diederich, A. sherparum Grube & Matz
er, A. subfuscicola (Linds.) Triebel and A. vari
(Davies) Nyl.) and non-muriform ascospores
(Triebel 1989; Kalb et al. 1995; Grube &
Matzer 1997; Alstrup & Hansen 2001;
Grube 2007; Coppins & Aptroot 2009; Etayo
& Diederich 2009), whereas a tendency for
reduced ascomatal structures is observable in
Arthonia varians (= A. glaucomaria) (Hertel
1969; Triebel 1989). The genus Arthonia was
formerly separated from Arthothelium by
ascospore septation: transversely septate in
Arthonia and muriform in Arthothelium (e.g.
Santesson 1952; Makhija & Patwardhan
1995; Grube & Giralt 1996; Sundin & Tehle
1998; Sundin 1999; Grube 2007). However,
in recent molecular studies Arthonia and
Arthothelium were recovered as polyphyletic

Host (Bacidia sp.). Thallus greyish to pale
brown or cream, thin, rimose.

Apothecia round, constricted at the base,
0.3–0.8 mm diam., at first flat with a thin pale
brownsih to cream margin, often becoming
slightly convex and immarginate; hymenial
disc cream to pale brown, sometimes paler
than the margin. True exciple colourless.
Hymenium 70–85 µm high, colourless;
epihymenium yellowish, K−, often covered by
a thin layer of pruina with colourless crystals
dissolving in K. Hypothecium colourless or
yellowish; paraphyses 1–5 µm wide, irregularly
branched, apices not distinctly widening. Asci
narrowly clavate, 8–spored, 68–76 × 10–13 µm, I+ blue becoming
brownish, KI+ blue. Ascospores hyaline,
tapered at one end, slightly to strongly
sigmoid, without gelatinous sheath, 8–13-
septate, 55–57 × 3–5 µm.

Distribution and ecology. Known only from
the type collection from Campbell Island, on
a branch of a Dracophyllum shrub, and strictly
confined to the hymenia of its host (an
apparently undescribed Bacidia sp.).

Notes. The absence of ascomatal structure
renders the generic placement of the new
species difficult. The short subspherical asci
with a thick upper wall and the parasitic

(Fig. 1)
FIG. 1. *Arthothelium hymeniicola* and its host lichen (*Bacidia* sp.) (holotype). A, apothecia of the host lichen: the lowermost apothecium, for which a large part was removed, was examined under the microscope and found to be infected by *A. hymeniicola*, although no visible sign of infection was evident to the naked eye; the two apothecia situated above look healthy but they are probably also infected. B, macroscopical overview of an apothecium of the host lichen which was infected with *A. hymeniicola*, with the right-hand part removed; no visible sign of infection was evident to the naked eye. C, cross-section of the hymenium of the *Bacidia* sp. in KI, showing two KI+ orange-red asci of *A. hymeniicola* (arrows) in the upper part of the hymenium and many KI+ blue asci of the host lichen. D–F, asci of *A. hymeniicola* (D, in water; E, in KOH; F, in KI). G & H, ascospores of *A. hymeniicola* (G, in KI; H, in water). I, ascus of the host lichen (in water). J, ascospore of the host lichen. Scales: A & B = 250 µm; C = 50 µm; D–J = 10 µm. In colour online.
with different lineages including species of both genera (Ertz & Tehler 2010; Frisch et al. 2014; Van den Broeck & Ertz 2016). Moreover, the lichenicolous lifestyle has evolved several times in the Arthoniaceae (Diederich et al. 2012; Frisch et al. 2014) but too few species of Arthoniaceae were included in molecular phylogenies for a reassessment of generic delimitations of the lichenicolous taxa. Therefore, we decided to describe our new species in the very heterogeneous genus Arthothelium pending a molecular taxonomic revision of the lichenicolous taxa of Arthoniaceae. The placement in Arthothelium must be considered provisional because the type species of Arthothelium (A. spectabile A. Massal.) is a lichenized species forming distinct ascomata. It must be noted that Cryptothecia Stir. is a genus of Arthoniaceae with muriform ascospores that does not form ascomatal structures, the asci being loosely scattered in the thallus (Grube 1998). However, no lichenicolous/parasitic species of Cryptothecia are known and the asci are of a different type (Grube 1998, fig. 3). Stirtonia A. L. Sm. is another genus of Arthoniaceae that does not form ascomatal structures, but species of this genus differ by having transeptate ascospores and a lichenized habit. Lichenicolous Arthoniales with globose to subglobose asci and muriform ascospores are also found in the genera Paradoxomyces Matzer and Trichophyma Rehm (Matzer 1996, who questioned the placement of the latter genus in either Arthoniales or Myriangiales). Both genera differ from Arthothelium notably by ascomata having a true exciple. Another Arthoniales known to occur on Bacidia is Opegrapha diffracticola (Harris & Ladd 2007) but this species has very different ascomata, ascii and ascospores.

We also considered a possible placement of our new species in the Myriangiales because similar ascii and ascospores are found in some taxa. This order is characterized by pulvinate, irregular ascostromata in which ascii are irregularly arranged in one or more layers in locules, each locule containing single or multiple ascii (Hyde et al. 2013). However, most species are parasitic or saprobic on plants (Hyde et al. 2013) and no lichenicolous species are known from the order (Lawrey & Diederich 2016) making a placement of our new species in this order unlikely. However, parasites on fungi are known in the family Cookellaceae which was placed in Myriangiales by von Arx (1963) but now considered as Dothideomycetes of uncertain order by some authors (e.g. Eriksson 2005; Lumbsch & Huhndorf 2010; Hyde et al. 2013). Unfortunately, no molecular data are available for this poorly known family which includes only 13 species in three genera (Cookella Sacc., Uleomyces Henn. and Pycnoderma Syd. & P. Syd.) (Kirk et al. 2008). Cookella differs from our new species by having dark brown ascospores, whereas, according to Hyde et al. (2013) the differences between Pycnoderma and Uleomyces, the species of which are mainly hyperparasites of leaf fungal parasites (Hennings 1895; von Arx 1963), refer to their ascomatal structure: superficial, cushion or disc-shaped ascostromata in Uleomyces and superficial, disc-shaped thyriothecia in Pycnoderma. However, the ascii and ascospores of several members of these two genera are similar to our new species (e.g. Pycnoderma bambusinum Syd. & P. Syd., P. congestum (Syd.) Arx, Uleomyces breneesii (Petr.) Arx, U. comedens Syd., U. struthanthi G. Arnaud and U. wellmanii J. Jenkins & Limber) so that a placement here might be considered, especially as these species do not form (pseudo)paraphyses. However, these fungi differ from our new species by the formation of ascostromata on fungal leaf parasites (von Arx 1963) and lichenicolous species are not known from the Cookellaceae. It must be noted that, interestingly, Grube (1998, p. 377) mentioned that members of the Cookellaceae have some similarities with Arthothelium, Stirtonia and Cryptothecia species, which highlights the difficulties we encountered placing a species not developing ascomatal structures in either Arthoniaceae or Cookellaceae.

As a conclusion, our new species could be placed in the Arthoniaceae or the Cookellaceae, but because the former family is the only one known to include lichenicolous species, and as some of these species are known to have a
tendency for reduced ascomatal structures, a placement in the Arthoniaceae was preferred. The placement in Arthonothelium should, however, be considered provisional.

References