

A Mid-Cretaceous Ectoparasitic Fungus, *Spheciophila adercia* gen et sp. nov., Attached to a Wasp in Myanmar Amber

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Abstract

A mid-Cretaceous ectoparasitic fungus in Myanmar amber is described as *Spheciophila adercia* gen. et sp. nov. in the new Family Spheciophilaceae fam. nov. While the specimen shares an ectoparasitic habit with representatives of the Laboulbeniales, morphological and behavioral features are not consistent with members of that group. The fossil is attached to the abdominal tergite of a primitive wasp. Its presence establishes a unique lineage of ectoparasitic insect fungi in the mid-Cretaceous. The present paper describes this interesting fossil, which adds to the diversity of ectoparasitic fungi and their insect hosts some 100 mya.

Keywords: Ectoparasitic fungus; Myanmar amber; *Spheciophila adercia* gen et sp. nov

Introduction

The fossil record of entomogenous fungi is not extensive, with most cases representing ectoparasitic forms found on the body surface of insects in Tertiary amber [1-3]. Today, while several groups of fungi parasitize the integument of arthropods [4,5], the most common and only group that forms thalli on the surface of arthropods is the Laboulbeniales [6,7]. This Order consists of small, microscopic obligate ectoparasites that normally occur on the integument of their hosts. The Laboulbeniales produce thalli directly from ascospores that stick to the integument of the host. In contrast to most fungi, mycelium is not produced. The thalli, which contain a three-celled receptacle with a single point of attachment to the host, can occur on many different sites on the body of the host. Spermatia produced in antheridial appendages fertilize perithecia, with the latter forming the major portion of the thallus. Nourishment is obtained through the foot (haustorium) of the fungus that is embedded in the host's cuticle. In some cases, as in members of the genus *Hesperomyces*, the haustoria extend through the body wall and obtain nutrients from the haemocoel [8].

This cosmopolitan group of fungi parasitizes invertebrates in soil, water and decomposing plant and animal matter, although the majority of hosts are beetles (Coleoptera) [6-13]. While the present fossil has some characteristics of members of the Laboulbeniales, other morphological and behavioral features are not consistent with those of this group, which is why it is described as a new genus and species in an extinct family. This interesting and unusual fossil adds to the biodiversity of ectoparasitic fungi and their hosts that existed some 100 mya.

Materials and Methods

The specimen originated from the Noije Bum 2001 Summit Site mine excavated in the Hukawng Valley in 2001 and located southwest of Maingkhwan in Kachin State (26°20' N, 96°36' E) in Myanmar. Based on paleontological evidence this site was dated to the late Albian of the Early Cretaceous [14], placing the age at 97 to 110 mya. A more recent study using U-Pb zircon dating determined the age to be 98.79 ± 0.62 Ma or at the Albian/Cenomanian boundary [15]. Nuclear magnetic resonance (NMR) spectra and the presence of araucaroid wood fibers in amber samples from the Noije Bum, 2001 Summit Site indicates an araucarian tree source for the amber [16].

Observations and photographs were made with a Nikon SMZ-10 R

stereoscopic microscope and Nikon Optiphot compound microscope with magnifications up to 800 X. Terminology follows that used by Benjamin [6] and Tavares [7] for Laboulbeniales.

Results

Detailed observations on the cellular structure of the perithecia and antheridia were hindered by the thickness of the amber and a viscous deposit surrounding the thallus (Figure 1). Also, since the host's integument is black, it was not possible to view the specimen in transmitted light.

Description

Kingdom: Fungi

Division: Ascomycota

Class: "Incertae Sedis"

Order: "Incertae Sedis"

Spheciophilaceae fam. nov. (MycoBank # = 819144)

Type genus: *Spheciophila* Poinar gen. Nov.

Diagnosis: As for type species (monotypic)

Genus *Spheciophila* Poinar, gen. nov. (MycoBank # = 819145)

Type species: *Spheciophila adercia* Poinar gen. et sp. nov.

Spheciophila adercia Poinar gen. et sp. nov. (MycoBank # = 819146) (Figures 1-4)

Thallus growing prostrate on host, opaque with thick cell walls, 1.05 mm in total length; consisting of a single stalk of five erect cells with

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Figure 1: Thallus of *Spheciophila adercia* gen. et sp. nov. (large arrow) attached to the abdominal segment of its hymenopteran host in Myanmar amber. Small arrow shows viscous droplet partly surrounding thallus. Bar=72 μ m

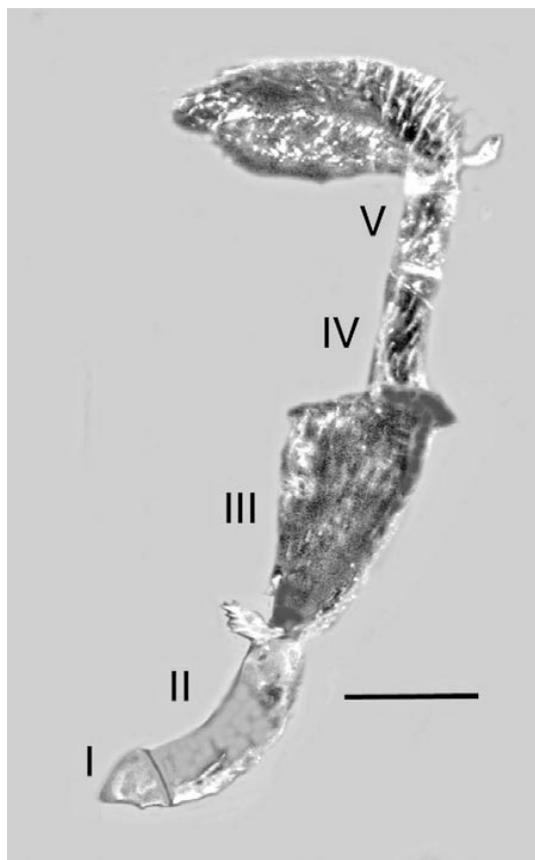


Figure 2: Thallus of *Spheciophila adercia* gen. et sp. nov. in Myanmar amber with surrounding material (including extended appendages) removed. I=Basal cell; II=Suprabasal cell; III=Terminal cell; IV and V=Additional stalk cells Bar=90 μ m

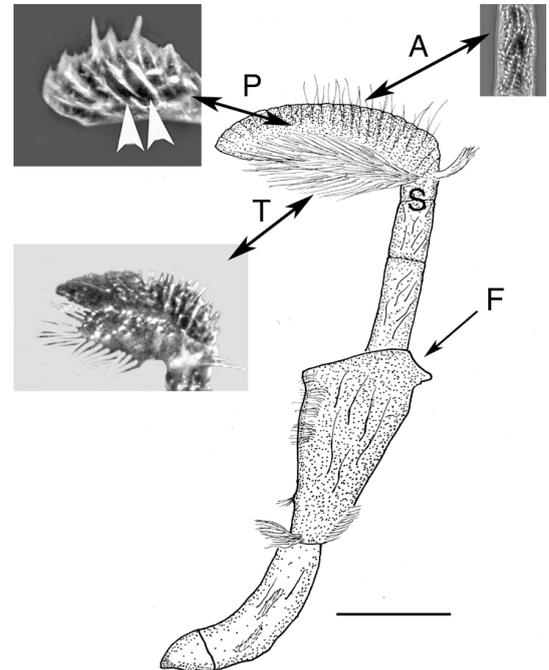


Figure 3: Drawing of the thallus of *Spheciophila adercia* gen. et sp. nov. in Myanmar amber with additional features and inserts of photos from different regions of the fossil.

A=Vertical conidial branch; F=Flattened area on terminal receptacle cell where a secondary stalk may have broken off; P=Region of perithecia on bent portion of primary stalk. Arrowheads show two perithecia. S=Primary stalk that bends approximately 90° degrees inwards and contains some 22 short compact cells bearing perithecia, antheridia and sterile appendages. T=Bent portion of stalk and antheridial-bearing tufted branch that is attached at its base to the primary stalk. Bar=130 μ m

a terminal portion bent at an angle of 90 degrees bearing antheridia and perithecia. Basal cell (I) short, suprabasal cell (II) slightly longer and curved, cell III long, robust and triangular-shaped, cells IV and V straight and subequal in length (Figure 2). Filamentous setaceous conidial and sterile appendages occur sporadically on the surfaces of the stalk cells. The terminal bent portion anterior to cell V contains some 22 short compact cells bearing perithecia, antheridia and sterile appendages. The perithecia are flask-shaped with terminal or subterminal appendages that resemble trichogynes. Just prior to and below the bent terminal portion of the primary stalk is a tufted branch that is attached at its base to the primary stalk. The tufted branch bears numerous antheridial receptacle cells with developing endogenous spermatia. Measurements: Cell I: length, 70 μ m; greatest width, 53 μ m; Cell II: length, 140 μ m; greatest width, 55 μ m; Cell III: length, 245 μ m; greatest width, 160 μ m; length primary stalk, 580 μ m; width primary stalk 55 μ m; length tufted branch, 230 μ m; width tufted branch, 70 μ m; length developing perithecia, 62 μ m-64 μ m; length extended tip of perithecia, 12 μ m-14 μ m long; maturing antheridial receptacle cells from 26 μ m-45 μ m in length.

Diagnosis

The multi-celled receptacle with a single point of attachment to the host, spermatia produced in antheridial appendages and the presence of perithecia are features of *Spheciophila adercia* gen et sp. nov. that also occur in members of the Laboulbeniales [6,7]. However, the large size of the thallus (in most species of Laboulbeniales, the thallus is under 1

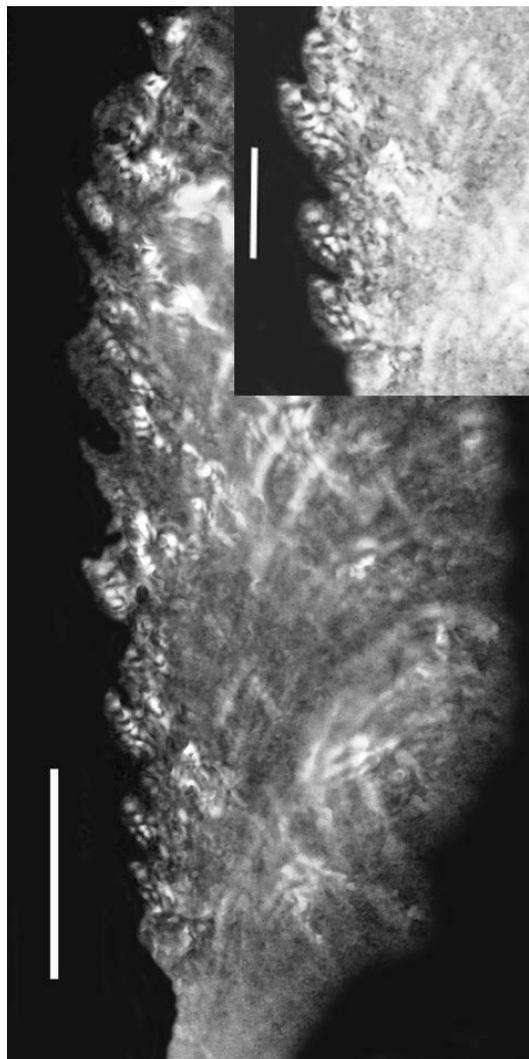


Figure 4: Portion of the tufted branch of *Spheciophila adercia* gen. et sp. nov. in Myanmar amber with maturing antheridial receptacle cells developing endogenous spermatia. Bar=23 μ m. Insert shows detail of four maturing antheridial receptacle cells. Bar=7 μ m

mm in length), the long multicellular stalk bearing numerous perithecia and antheridia (Figure 3), the presence of a separate large tufted branch containing antheridial receptacle cells with developing endogenous spermatia, and possessing five stalk cells in a simple linear series distinguishes the fossil from present day lineages of Laboulbeniales. Also, the extended tufted branch containing antheridial receptacle cells (Figure 4) is not found among the Laboulbeniales and while perithecia in the Laboulbeniales are normally produced by cell II of the receptacle [6-13], in *Spheciophila adercia* gen. et sp. nov., perithecia occur on the bent portion of the extended stalk that arises from the top of stalk cell (Figure 3).

Holotype

Holotype female No. B-Hy-19 deposited in the Poinar amber collection maintained at Oregon State University.

Etymology

The family and generic names are derived from the Greek

“sphecion”=small wasp and the Greek “philios”=loving. The specific epithet is from the Greek “adercia”=unexpected.

Type locality

Myanmar (Burma), state of Kachin, Noije bum 2001 Summit Site amber mine in the Hukawng Valley, SW of Maingkhwan (26°20'N, 96°36'E).

Type host

Wingless adult female ceraphronoid wasp (Hymenoptera: Ceraphronoidea) [17] (Figure 1).

Discussion

Nourishment of *Spheciophila adercia* gen et sp. nov. was probably obtained through the basal foot of the thallus that penetrated the cuticle to reach the hemolymph. The thallus appears to be very well secured and its prostrate position probably protected it from abrasion, although the flattened area on the terminal receptacle cell (Figure 3F) may be where a secondary stalk was broken off. The recumbent orientation of *Spheciophila adercia* gen et sp. nov. on its host is another character that separates it from the Laboulbeniales, which are normally vertically or sub-vertically positioned on their host [6,7].

Also separating it from the Laboulbeniales is the wasp host since the only known hymenopteran hosts of Laboulbeniales are ants (Hymenoptera: Formicidae) [7] and in general, Hymenoptera are very infrequently parasitized by fungi [4,5]. It is obvious that *Spheciophila adercia* gen et sp. nov. is a very unique fungus that may represent a stem group of the Laboulbeniales since there are no other extant thallus-bearing ectoparasitic fungi that develop on the integument of insects. The wasp host, which was described as *Aptenoperissus burmanicus*, is also quite bizarre and belongs to an extinct family in the superfamily Ceraphronoidea [17].

Conclusion

In the past the Laboulbeniales was considered to be an enigmatic lineage of insect symbionts and mycoparasites and the group was placed in a number of different Orders and even Phyla [1]. In the scheme of Hibbett et al. [18], the Laboulbeniales is placed in a separate Class Laboulbeniomycetes, along with the Order Pyxidiophorales. However Schoch et al. [19] later placed the Laboulbeniomycetes as a sister to the Sordariomycetes and included the former with Sordariomycetes and Leotiomycetes in a clade (Sordariomyceta) comprising poricidal, unitunicate taxa. It is not possible to determine whether *Spheciophila adercia* gen. et sp. nov. belongs to one of the above orders, but chances are good that it represents an early lineage of the Laboulbeniomycetes since there are no other extant thallus-bearing ectoparasitic fungi that develop on the integument of insects. Its discovery provides a rare glimpse of an extinct lineage of ectoparasitic fungi attacking wasps some 100 mya.

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