

FARLOW HERBARIUM COCKROACH HOSTS NEW
RECORD OF LABOULBENIALES FOR NORTH AMERICA

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The order Laboulbeniales (Fungi, Ascomycota, Laboulbeniomycetes) consists of obligate ectoparasites that superficially penetrate the cuticle of insects (Vega and Blackwell 2005). Hosts include a wide range of arthropods, including beetles (Coleoptera), flies (Diptera), earwigs (Dermaptera), and cockroaches (Blattodea; see an overview of host orders in Haelewaters et al. 2012 and Weir and Hammond 1997). To date, 27 species of Laboulbeniales belonging to three genera have been reported on cockroaches (Appendix). The genus *Herpomyces* Thaxt., with 25 species, is by far best represented, followed by *Rickia* Cavara (1 species) and *Laboulbenia* Mont. & C.P. Robin (1 species). The vast majority of these species were described by Harvard professor Roland Thaxter.

Herpomyces chaetophilus and *H. periplanetae* were among the 1260 species of Laboulbeniales Thaxt. described (Thaxter 1902). The distribution of *H. chaetophilus* includes “the Amazon,” Mauritius, Peninsular Malaysia, and Zanzibar (Sugiyama and Mochizuka 1979; Thaxter 1902, 1931). *Herpomyces periplanetae* is much more widely spread, with records in all continents but Antarctica and Australia (Santamaría et al. 1991).

In the midst of excitement over heavy rainfall and building-flooding at the end of July 2014, we collected a few specimens of the American cockroach (*Periplaneta americana*) that appeared in the basement of the Farlow Herbarium, Harvard University. After careful screening for Laboulbeniales under 50× magnification, thalli were removed and mounted onto microscope slides (Haelewaters et al. 2015). To our surprise, the thalli represented a new record for North America: *Herpomyces chaetophilus* Thaxt.

We decided to collect more cockroaches on Harvard campus, with sticky traps or by hand. A total of 31 *Periplaneta americana* specimens were collected in student dormitories and in the basement of the Harvard University Herbaria. Of these, 30 specimens (96.8%) were infected with *Herpomyces chaetophilus*. In addition, 21 roaches (67.7%) also bore thalli of *H. periplanetae*. This is the first such documentation of a double infection (or co-infection) by *H. chaetophilus* and *H. periplanetae*.

Of the 25 described species in *Herpomyces*, only five were previously recorded from North America: *H. arietinus* Thaxt. on *Temnopteryx* and *Ischnoptera* spp. in Georgia, Kentucky, and Massachusetts (MA); *H. ectobiae* Thaxt. on *Blatella germanica* [as *Ectobia*] in Cambridge, MA; *H. nyctoborae* Thaxt. on “*Nyctobora lactipennis*” in Texas; *H. periplanetae* on *Periplaneta americana* in Cambridge, MA; and *H. stylopygae* Speg. on *Blatta orientalis* [as *Stylopyga*] in Boston, MA (Thaxter 1908, 1931). Thaxter (1905, 1908) described *H. nyctoborae* from one specimen of “*Nyctobora lactipennis*” in the collection of Samuel H. Scudder, apparently collected in Texas. Thaxter’s host species name is not valid; presumably he meant *Nyctibora latipennis* (= *N. tomentosa*) that is reported from Suriname, Brazil, and Bolivia (Beccaloni 2014). The genus *Nyctibora*, which has not been revised since establishment by Burmeister (1838), is reported from South and Central America to the southern border of the US (H. Hopkins, Species File Group, University of Illinois, Urbana-Champaign, IL, pers. comm.). Since there is no current distribution map for *Nyctibora* it is probable that one or more species could be found in Texas.

Herpomyces chaetophilus is easily distinguished from these five species by its solitary perithecium, the tip of which bends anteriorly (Figure 1), and by the absence of a cellular upgrowth (“shell-like shield”; Thaxter 1908) at the base of the perithecium.

The 96.8% parasite prevalence only hints at the potential fungal reserves in urban areas. The new record of *Herpomyces chaetophilus* comes as a surprise, considering that Thaxter did most of his research on Laboulbeniales in Cambridge, MA. It is possible that *H. chaetophilus* was not yet present in the Cambridge area in Thaxter’s time. How this tropical taxon could find its way to this temperate site is not clear, but we think a single introduction with an infected *Periplaneta americana* specimen may have been enough to spread the parasite within an existing host population. The high parasite prevalence at the collecting sites is probably due to the fact that Laboulbeniales thrive best in densely packed host populations (Tavares 1985) in moist and damp places (De Kesel et al. 2011). The constant

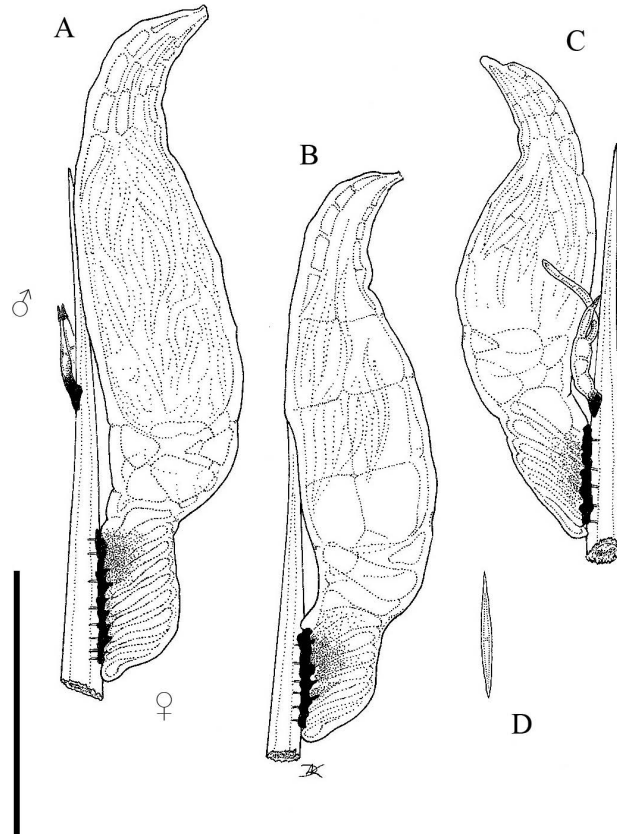


Figure 1. *Herpomyces chaetophilus*. A-C. Three mature female thalli on hairs of left antenna from *Periplaneta americana*, collected in the basement of the Farlow Herbarium (slide T. W. Wang 351b). D. Symmetrical, spindle-shaped ascospore. Scale bar = 100 μ m. *Herpomyces* is a dioecious genus, with sexual organs separated on female and miniature male thalli (in A and C).

grooming and contacts between host individuals (antennae) combined with a typical habitat choice of *P. americana* (Bell and Adiyodi 1982; Tavares 1985) promotes the development and transmission of their laboulbenian parasites.

Despite its name, *Periplaneta americana* is not a native to the American continent; it was introduced to North America early in the 17th century (Bell and Adiyodi 1982). Current urban populations all

over the world can be considered invasive and it is likely that these populations were established through human-mediated dispersal (von Beeren et al. 2015). We hypothesize that *Herpomyces chaetophilus*, also, is not native to the US but was somehow introduced with *P. americana*, most likely after Thaxter's time. Two scenarios are possible (Haelewaters 2015). The first is an unintended "co-colonization" of the habitat by the host and parasite species (at the same time). The second is "host pursuit," where areas invaded by the host are later also invaded by the parasite from the original populations (Nicholls et al. 2010), thus involving a lag time between host and parasite invasion.

Since Thaxter did not report *Herpomyces chaetophilus* from North America in any of his contributions, despite extensive collections in the Atlantic coastal states of the US, we believe that introduction of *H. chaetophilus* occurred after Thaxter's time. The key to test the above hypothesis is generating sequences of highly variable marker loci. In this way we will be able to trace the fungal parasites to their origin, and to investigate genetic differences among infected populations and between isolates taken from different hosts.

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APPENDIX

LABOULBENIALES SPECIES DESCRIBED FROM COCKROACHES

All 27 species of Laboulbeniales described thus far on cockroaches (order Blattodea) are listed here, with geographical distribution: NA = North America, CA = Central America and Caribbean, SA = South America, EU = Europe, AF = Africa, AS = Asia, and OC = Oceania (Arndt and Santamaría 2004; Richards and Smith 1954; Santamaría et al. 1991; Spegazzini 1917; Sugiyama 1978; Tavares 1985; Thaxter 1902, 1905, 1918, 1931).

The new record of *Herpomyces chaetophilus* for North America is indicated with an asterisk (*). ^aThe type collection of *H. diplopterae* was found on Ascension Island, which is located in the South Atlantic Ocean, midway between South America and Africa.

Genus	Species	NA	CA	SA	EU	AF	AS	OC
<i>Herpomyces</i>	<i>amazonicus</i> Thaxt. 1931	–	–	X	–	–	–	–
<i>Herpomyces</i>	<i>anaplectae</i> Thaxt. 1905	–	X	X	–	–	X	–
<i>Herpomyces</i>	<i>appendiculatus</i> Thaxt. 1931	–	–	–	–	–	–	X
<i>Herpomyces</i>	<i>arietinus</i> Thaxt. 1902	X	–	–	–	–	–	–
<i>Herpomyces</i>	<i>chaetophilus</i> Thaxt. 1902	*	–	X	–	X	X	–
<i>Herpomyces</i>	<i>chilensis</i> Thaxt. 1918	–	–	X	–	–	–	–
<i>Herpomyces</i>	<i>diplopterae</i> Thaxt. 1902 ^a	–	–	–	–	–	–	X
<i>Herpomyces</i>	<i>ectobiae</i> Thaxt. 1902	X	X	X	X	X	X	–
<i>Herpomyces</i>	<i>forficularis</i> Thaxt. 1902	–	–	–	–	X	–	X
<i>Herpomyces</i>	<i>gracilis</i> Thaxt. 1931	–	–	–	–	–	X	–
<i>Herpomyces</i>	<i>grenadinus</i> Thaxt. 1931	–	X	–	–	–	–	–
<i>Herpomyces</i>	<i>leurolestis</i> Thaxt. 1931	–	X	X	–	–	–	–
<i>Herpomyces</i>	<i>lobopterae</i> Thaxt. 1931	–	–	X	–	–	–	–
<i>Herpomyces</i>	<i>macropus</i> Speg. 1917	–	X	X	–	–	–	–
<i>Herpomyces</i>	<i>nyctoborae</i> Thaxt. 1905	X	–	X	–	–	–	–
<i>Herpomyces</i>	<i>panchlorae</i> Thaxt. 1931	–	X	–	–	–	–	–
<i>Herpomyces</i>	<i>panesthiae</i> Thaxt. 1915	–	–	–	–	–	X	–
<i>Herpomyces</i>	<i>paranensis</i> Thaxt. 1902	X	X	X	–	–	–	–
<i>Herpomyces</i>	<i>periplanetae</i> Thaxt. 1902	X	X	X	X	X	X	–
<i>Herpomyces</i>	<i>phyllodromiae</i> Thaxt. 1905	–	–	–	–	X	–	–
<i>Herpomyces</i>	<i>platyosteriae</i> Thaxt. 1905	X	–	–	–	–	–	–
<i>Herpomyces</i>	<i>stylopygae</i> Speg. 1917	X	–	X	X	–	–	–
<i>Herpomyces</i>	<i>supellae</i> Thaxt. 1931	–	X	–	–	–	–	–
<i>Herpomyces</i>	<i>tricuspidatus</i> Thaxt. 1902	X	X	X	–	X	X	–
<i>Herpomyces</i>	<i>zanzibarinus</i> Thaxt. 1902	–	–	X	–	X	X	–
<i>Laboulbenia</i>	<i>feae</i> Speg. 1915	–	–	–	–	X	–	–
<i>Rickia</i>	<i>oceana</i> Sugiy. 1978	–	–	–	–	–	X	–