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# Ectoparasitic fungi (Ascomycota: Laboulbeniomycetes: Laboulbeniales) associated to scorpions and short-tailed whipscorpions (Arachnida: Scorpiones, Schizomida)

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**Abstract:** The until now "enigmatic organism" attached to some tropical American scorpions, schizomids and woodlice, has been recently confirmed as the thallus of ectoparasitic fungi belonging to the order Laboulbeniales (Ascomycota). Besides the already published but unidentified records, 30 additional scorpion species belonging to three families (Buthidae, Diplocentridae and Vaejovidae), are herein recorded as new known hosts for these fungi. Among arachnids, these ectoparasitic fungi have been detected on Opiliones, Schizomida (first record), Scorpiones (second record) and Acari.
**Key words:** Scorpiones, Schizomida, Isopoda, Ascomycota, tropical America.

**Hongos ectoparásitos (Ascomycota: Laboulbeniomycetes: Laboulbeniales) asociados a escorpiones y esquizómidos (Arachnida: Scorpiones, Schizomida)**
**Resumen:** El hasta ahora "organismo enigmático" adherido a algunos escorpiones, esquizómidos y cochinillas de América tropical se ha identificado recientemente como el talo de hongos ectoparásitos del orden Laboulbeniales (Ascomycota). Aparte de los registros no identificados ya publicados, 30 especies adicionales de escorpiones pertenecientes a tres familias (Buthidae, Diplocentridae y Vaejovidae) se registran aquí como nuevos hospedantes conocidos de dichos hongos. Entre los arácnidos, estos hongos ectoparásitos se han observado en Opiliones, Schizomida (primer registro), Scorpiones (segundo registro) y Acari.
**Palabras clave:** Scorpiones, Schizomida, Isopoda, Ascomycota, América tropical.

The identity of two "enigmatic organisms" associate to some Neotropical scorpions, recorded almost 20 years ago by Armas (2003), has definitely been solved. The supposedly "perilampid larvae" (Armas & Cruz, 1984; Armas, 2003) found on some West Indian scorpions were posteriorly identified by Armas (2008) as planidium larvae of the family Eucharitidae (Insecta: Hymenoptera), perhaps belonging to the genus *Kapala*.

The second unidentified organism deserves more detailed attention. Because of its ambiguous and inconspicuous habitus (i.e., a flattened fusiform structure lacking any visible appendages or tegumentary sculpture, firmly attached by a narrow "pedicel" to the host exoskeleton causing a small, darkened circular scar), it has been informally referred to in very different ways. First, Armas (2003) coined the term "enigmatic organism" after finding it in two species of scorpions, i.e., a buthid from Cuba and a vaejovid from Mexico (Table I).

Later, it was recorded from two species of hubbardiid schizomids from Colombia and Cuba: first, Delgado-Santa & Armas (2013: 40–41; figs. 3b–c) called it "strange organism" and stated that its identity was unknown yet, but it could be an insect egg or the reproductive structure of a fungus; second, Teruel (2015: 75, 77–78; fig. 2a–b) referred to it as "enigmatic organism" and hypothesized it could be either parasitic or phoretic in nature, most likely the former.

Then, Armas & Rodríguez-Cabrera (2016: 4–5; fig. 5g) described it from one species of Delatorreidae isopod from Cuba, mentioning it twice as "globular structures" and "enigmatic globular structures", but did not explicitly recognized it as the same recorded earlier from arachnids. And last, Armas (2020: 4) found it in a third scorpion species from the Lesser Antilles, defined it indistinctly as "egg-like organism" and "enigmatic organism", and stated that it resembles an insect or mite egg, but its real origin was yet unknown.

In the recent description of a new species of the genus *Troglotayosicus* Lourenço, 1981 (Troglotayosicidae) from Ecuador, Botero-Trujillo *et al*. (2021: 8–9: figs. 5d, 6b, d), illustrated the same type of organism attached to the sternum, pectines and leg coxa IV of this scorpion and identified it as the thalli of Laboulbeniales fungi (Ascomycota), thus confirming one of the previous tentative identifications suggested by Delgado-Santa & Armas (2013: 40). Nevertheless, Botero-Trujillo *et al*. (2021) neither commented on those parasitic fungi found by them, nor mentioned the clearly identifiable, earlier illustrative records of the same enigmatic organisms by Armas (2003, 2020), Delgado-Santa & Armas (2013), Teruel (2015) and Armas & Rodríguez-Cabrera (2016). A careful comparison of the figures of *T. ballvei* demonstrates beyond any doubt that it is the same type of organism already recorded for some West Indian and Mexican scorpions, the Colombian and Cuban schizomids and the Cuban woodlouse.

The Laboulbeniales fungi comprise about 2,050 species of very small obligate ectoparasites of terrestrial and freshwater arthropods (Diplopoda, Insecta, Arachnida), mostly true insects (Enghoff & Santamaria, 2015; Haelewaters, 2018). Their vegetative body (thallus) remains outside the host, which is only penetrated by a discreet haustorium (Santamaria, 2001). Most of them are strictly specific, even to species level (De Kesel, 1996; Santamaria, 2001).

Amongst arachnids, the Laboulbeniales had been previously recorded from mites (Balazuc, 1990), Opiliones (Santamaria *et al*., 2017) and Scorpiones (Botero-Trujillo *et al*. 2021). Now, we add as new hosts the arachnid order Schizomida (two species of the family Hubbardiidae), three families of the order Scorpiones (Buthidae, Diplocentridae and Vaejovidae, with 34 species of which 30 were previously unrecorded; see table I), and the subphylum Crustacea (one species of the class Malacostraca, order Isopoda, suborder Oniscidea).

Unfortunately, the infra-ordinal categories of the Neotropical Laboulbeniales found on scorpions and schizomids are unknown, pending of further studies. But they apparently are very different from those found on mites and opilionids.

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**Fig. 1.** *Ananteris canalera*. Male from Sendero del Trogon, Achote, Colon Province, Panama (collected by R. Miranda & D. Murgas on September 16, 2016 and deposited in the arachnological collection of the Instituto Conmemorativo Gorgas de Estudios de Salud, Panama). Encircled is the thallus of the fungus on the basal plate of the pectines.

**Table I.** List of the scorpions species on which parasitic fungi of the order Laboulbeniales have been observed. For most species, excepting *Troglotayosicus ballvei*, these fungi were recorded as an unidentified organism. Cases that have actually been illustrated in photographs of published papers but went unnoticed are marked with an asterisk (*).

| Scorpion host | Country | References |
|---|---|---|
| **Buthidae** | | |
| *Alayotityus lapidicola* | Cuba | This paper |
| *Alayotityus nanus* | Cuba | This paper |
| *Alayotityus sierramaestrae* | Cuba | This paper |
| *Ananteris canalera* | Panama | This paper (Fig. 1) |
| *Ananteris tolimana** | Colombia | This paper (*see Teruel & García, 2007: 5; fig. 3a). On pectines |
| *Centruroides altagraciae** | Dominican Republic | This paper (*see Teruel *et al.*, 2015: 17; fig. 8). Pectines |
| *Centruroides anchorellus* | Cuba | This paper |
| *Centruroides baracoae* | Cuba | This paper |
| *Centruroides gracilis* | Cuba | This paper |
| *Centruroides guanensis* | Cuba | This paper |
| *Centruroides meisei* | Mexico | This paper |
| *Centruroides marcanoi* | Dominican Republic | This paper |
| *Heteroctenus junceus* | Cuba | This paper |
| *Isometrus maculatus* | Cuba | This paper |
| *Microtityus consuelo* | Dominican Republic | This paper |
| *Microtityus jaumei* | Cuba | This paper |
| *Microtityus kovariki* | Cuba | This paper |
| *Microtityus iviei* | Dominican Republic | This paper |
| *Microtityus trinitensis* | Cuba | This paper |
| *Rhopalurus caribensis** | Colombia | This paper (*see Teruel & Roncallo, 2008: 4; fig. 2c). On pectines |
| *Tityopsis inaequalis* | Cuba | This paper |
| *Tityopsis inexpectata* | Cuba | This paper |
| *Tityopsis sheylae** | Cuba | This paper (*see Teruel & Rodríguez-Cabrera, 2020: 31; figs. 29a, 30a). On pectines and leg coxa 3 |
| *Tityopsis* sp. (cited as *T. inexpectata*) | Cuba | Armas (2003) |
| *Tityus elii* | Dominican Republic | This paper |
| *Tityus estherae* | Puerto Rico | This paper |
| *Tityus ottenwalderi* | Dominican Republic | This paper |
| *Tityus obtusus* | Puerto Rico | This paper |
| *Tityus riverai** | Puerto Rico | This paper (*see Teruel & Sánchez, 2009: 331; fig. 4d). On pectines |
| **Diplocentridae** | | |
| *Cazierius neibae** | Dominican Republic | This paper (*see Kovařík & Teruel, 2014: 17, 19–20; figs. 62, 74–75). On coxosternal area and legs. |
| *Oiclus* sp. | Saint Kitts, Lesser Antilles | Armas (2020) |
| **Troglotayosicidae** | | |
| *Troglotayosicus ballvei* | Ecuador | Botero-Trujillo *et al.* (2021) |
| **Vaejovidae** | | |
| *Konetontli acapulco* (as *Vaejovis acapulco*) | Mexico | Armas (2003) |
| *Mesomexovis* sp. | Mexico | This paper |

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