




An Unprecedented Record of Parasitoidism of Formicidae by a Sarcophagid Fly

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Abstract: The first case of parasitoidism of a Myrmecinae ant by a sarcophagid fly has been observed in the Brazilian Cerrado. The larva of a *Helicobia* Coquillet (Sarcophagidae) specimen fed on head tissues of an *Atta laevigata* Smith, 1858 soldier and an adult male fly emerged from a puparium formed outside the host.

Keywords: Brazilian savanna; *Helicobia*; natural enemies; parasitoid-host interaction.

Um registro sem precedentes de parasitoidismo de Formicidae por uma mosca sarcófaga

Resumo: O registro do parasitoidismo de uma formiga Myrmecinae por uma mosca Sarcophaginae foi relatado no Cerrado brasileiro. A larva de um exemplar de *Helicobia* Coquillet (Sarcophagidae) se alimentou dos tecidos da cabeça de um soldado de *Atta laevigata* Smith, 1858 e um adulto macho emergiu de um pupário que se formou fora do hospedeiro.

Palavras-chave: Savana Brasileira; *Helicobia*; inimigos naturais; interação parasitoide-hospedeiro.

Introduction

Parasitoidism of ants by flies (Diptera) have been reported for single species of the families Tachinidae and Syrphidae and many species of the family Phoridae. The tachinid *Strongygaster globula* Meigen, 1824 (formerly called *Tamiclea globula*) has as its host young queens of the genus *Lasius* Fabricius, 1804 (Hymenoptera: Formicidae: Formicinae) (Schmid-Hempel 1998, Herting 2017), while the syrphid *Hypselosyrphus trigonus* Hull, 1937 is known as a parasitoid of workers of the tree ant *Neoponera villosa* (Fabricius, 1804) (Hymenoptera: Formicidae: Ponerinae) (Pérez-Lachaud et al. 2014). On the other hand, phorid flies are important parasitoids of a wide range of social insects, with ants as the main hosts (Disney 1994). Accordingly, interactions between phorid parasitoids and many members of the family Formicidae have been described, including species of the genus *Atta* Fabricius, 1805 and *Acromyrmex* Mayr, 1865 (Myrmecinae) of the tribe Attini (Disney 1994, Schmid-Hempel 1998, Bragança 2011, Uribe et al. 2014). Generally, phorids that attack ants are small flies that pursue workers along their trails or in foraging areas, ovipositing eggs on the heads or abdomens of the host (Erthal & Tonhasca 2000, Tonhasca et al. 2001, Bragança et al. 2002).

The large leaf-cutting ant *Atta laevigata* Smith, 1858, an eusocial insect widely distributed in Brazil, causes significant damage to agricultural and forest crops (Montoya-Lerma et al. 2012) and therefore, it is a target of biological control. We observed the interactions between phorid flies and leaf-cutting ants along their foraging trails to assess the levels of parasitoidism of *A. laevigata* in the Cerrado of the Central-West region of Brazil.

During fieldwork, we observed a single sarcophagid fly interacting with an *A. laevigata* soldier. The observation was noteworthy because sarcophagid species commonly establish predatory, kleptoparasitic, or parasitic interactions with butterflies, grasshoppers, moths, termites, wasps, and bees, but not with ants (Pape 1987, Schmid-Hempel 1998).

Material and Methods

Fieldwork was carried out in a Cerrado area (10°10'56.3"S, 48°18'23.8"W) close to the city of Palmas, Tocantins, Brazil. During the search for phorids attacking *A. laevigata* workers, an unidentified sarcophagid or tachinid was observed flying over, and sometimes walking on, the head and back of an individual soldier, who was moving unusually slowly manner.

The soldier was collected carefully using forceps, transferred to a small glass jar, and taken to the laboratory. However, the ant-attacking fly escaped during the capture attempt. Later that same day, the soldier was examined under a magnifying lens, and a larva was detected moving within the cephalic capsule. The ant was placed in a Petri dish, fed with 10% honey solution soaked into a cotton wool pad, and maintained at 26°C in a rearing chamber. The larva developing inside the cephalic capsule was observed every 24 hours. The puparium was subsequently detached from the pad, transferred to a glass vial (100 mm high x 13 mm diameter), and maintained in the rearing chamber. An adult male fly emerged from the puparium (Figure 1A), and the specimen was identified by Dr. Cátia Mello Patiu (National Museum, Rio de Janeiro, RJ, Brazil), using a Sarcophagidae identification key for the genus (Pape & Dahlem 2010). Although the male holotype was fully described, the specimen, along with its description and undigitized drawings, was unfortunately lost in a fire that destroyed the Rio de Janeiro's National Museum on 2 September 2018 (personal communication, C. Mello-Patiu).

Results and Discussion

Approximately 72 hours after being placed in the rearing chamber, the soldier was confirmed dead, with the mandibles open. Further inspection revealed that the cephalic capsule was empty and the head devoid of tissues. Except for the mandibles, all other mouthparts were released from the cephalic capsule (Figure 2). The larva exited the capsule through the gap between the mandibles and formed a puparium between the cotton fibers inside the Petri dish. The fly emerged 12 days later and the fly was identified as a member of the genus *Helicobia* Coquillet, 1985 (Diptera: Sarcophagidae: Sarcophaginae) (Figure 1B).



Figure 2. Ventral face of the cephalic capsule of an *Atta laevigata* Smith, 1858 (Hymenoptera: Formicidae: Myrmicinae) soldier. Capsule width: 6.4 mm.

The association between Formicidae (*A. laevigata*) and Sarcophagidae (*Helicobia* sp.) is reported here for the first time. The biological characteristics of this interaction are comparable with those described for *A. laevigata* and the phorid *Apocephalus attophilus* Borgmeier, 1928, which is one of the several parasitoids of the family that oviposit on at least four other species of leaf-cutting ants (Erthal & Tonhasca 2000, Bragança & Medeiros 2006, Bragança 2011). In both interactions, the parasitoid larva develops inside the head of an *A. laevigata* worker, consumes the capsule contents, exits through the gap between the mandibles, and forms a puparium outside the host. When *A. laevigata* is parasitized by *A. attophilus*, the number of larvae per host ranges between 1 and 14, depending on the size of the cephalic capsule of the workers and soldiers, with the number of puparia also varying (Erthal & Tonhasca 2000, Bragança et al. 2016).

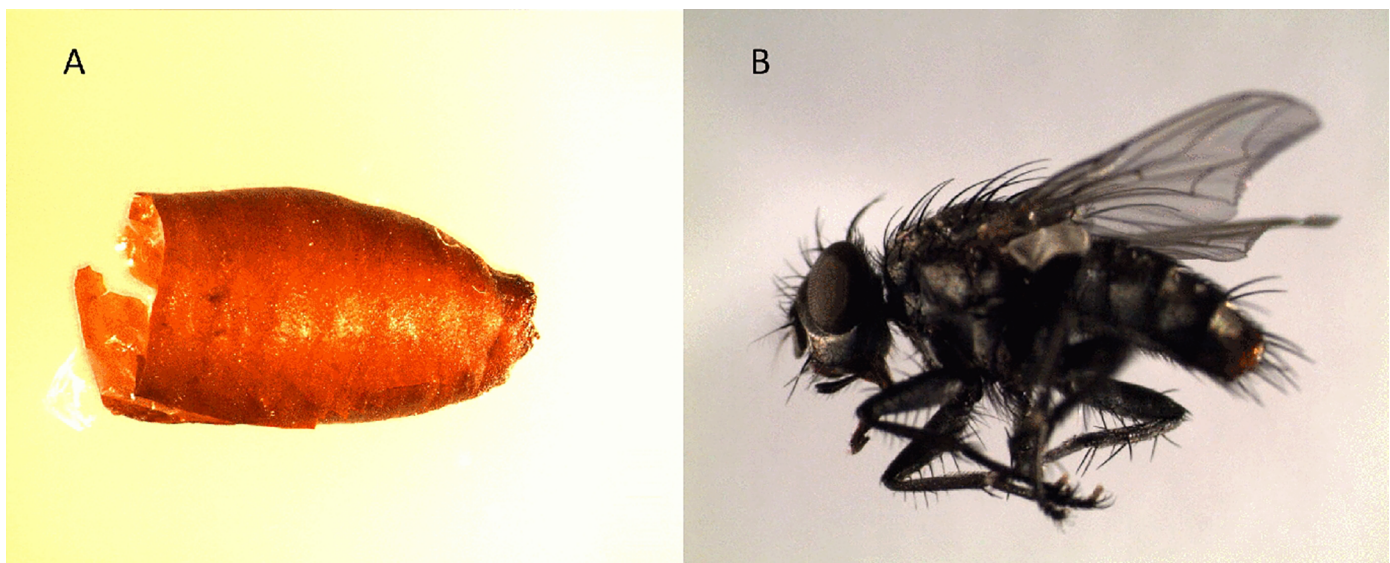


Figure 1. (A) Puparium of the *Helicobia* sp. Coquillet (Diptera: Sarcophagidae: Sarcophaginae) after emergence of the adult fly, showing the operculum detached from the rest of the puparium. Puparium length: 3.5 mm. (B) Adult male of the sarcophagid parasitoid.

However, in the novel interaction reported here, a single *Helicobia* sp. larva developed inside the head of an *A. laevigata* soldier, in which the cephalic capsule was 6.4 mm wide and the puparium was 3.5 mm in length, i.e., substantially larger than those of *A. attophilus* larvae (0.97 ± 0.11 mm [range from 0.86 to 1.23], $n = 26$; unpublished results). Interestingly, associations between *A. laevigata* and other phorid parasitoids, such as those of the genera *Eibesfeldtphora* Disney, 2009, and *Myrmosicarius* Borgmeier, 1928, almost invariably result in the development of a single larva per host. However, the puparium is generally formed between the mandibles of the ant, or inside its cephalic capsule or thorax (Bragança et al. 2002, Bragança et al. 2003, Bragança & Medeiros 2006).

The common biological characteristics of *A. attophilus* and *Helicobia* sp. differ from those of Tachinidae and Syrphidae flies that reportedly parasitize ants other than *A. laevigata*. For example, tachinid *S. globula* is an endoparasite that develops in the gaster of young queens (i.e., colony-founding queens) of the black garden ant *Lasius niger* Linnaeus, 1758 or *Lasius alienus* Foerster, 1850. During the final instar, the larva exits the abdomen of the host through the anus and forms a puparium among the offspring of other ants, where it is raised by workers as if it were part of the colony itself (Gösswald 1950, Hölldobler & Wilson 1990). On the other hand, the larva of the syrphid *H. trigonus* consumes almost all contents of the *N. villosa* prepupa and forms its puparium inside the cocoon of the host (Pérez-Lachaud et al. 2014).

Regarding the behavioral attraction mechanisms, phorids seem to use long-distance olfactory cues to guide them to ant nests and foraging trails (Feener & Brown 1997). In the interaction between *A. attophilus* and *A. laevigata*, the female fly approaches its prey in the foraging area and walks among the workers aiming to insert its ovipositor into their mouths while they are cutting the leaves (Erthal & Tonhasca 2000). Other phorid parasitoids of *A. laevigata*, such as *Eibesfeldtphora tonhascai* Brown, 2001, and *Eibesfeldtphora erthali* Brown, 2001, have been observed to fly over workers and insert their ovipositors into the back of the head or gaster, respectively (Bragança et al. 2002).

No information is currently available regarding the mechanisms of attraction of sarcophagids to their hosts. During the field research reported herein, we observed that the putative sarcophagid fly performed short flights and touched the head of the soldier. The fly also walked incessantly over the back of the ant, sometimes touching the last portion of the abdomen. Since sarcophagids typically lay ready-to-hatch or newly hatched larvae (Pape 1987), the touching and walking activities of the fly could be described as larviposition behavior. However, later examination of the soldier revealed that there was a larva already developing inside its cephalic capsule. Hence, it is possible that the touching and walking activities of the fly represented a host-searching behavior and that the soldier was rejected because it was already parasitized. It is worth noting that discriminatory activities towards parasitized and non-parasitized ant hosts have been observed previously among phorid flies, albeit with low frequency (Bragança et al. 2009).

Despite having no reports of *Helicobia* parasitoidism on Formicidae, there are parasitoidism records of this parasitic genus with other groups of the order Hymenoptera (e.g., bees) (Nowogrodzki & Morse 1990, Schmid-Hempel 1998).

Although the interaction between the leaf-cutting ant *A. laevigata* and the sarcophagid fly *Helicobia* sp. is atypical and rare, the form of parasitoidism resembles that observed between the same host and other flies, especially among phorids. Therefore, this sarcophagid species can be considered another natural enemy of leaf-cutting ants, which are destructive herbivores throughout South America.

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Author Contributions

Marcos Antonio Lima Bragança: funding acquisition, supervision, collection, writing.

Raquel Silva Acácio: collection and maintenance of the parasitoid fly.

Filipe Viegas de Arruda: writing and contribution to critical revision, adding intellectual content.

Marcos Antônio Pesquero: contribution to critical revision.

Conflicts of Interest

The authors declare no conflict of interest related to the publication of this manuscript.

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