SEMINA
Ciências Agrárias

DOI: 10.5433/1679-0359.2021v42n5p2669

Parasitism and behavioral responses of *Acromyrmex coronatus* (Fabricius, 1804) and *Acromyrmex crassispinus* (Forel, 1909) (Hymenoptera: Formicidae) to *Myrmosicarius catharinensis* Borgmeier, 1928 (Diptera: Phoridae) in Londrina, PR

Parasitismo e respostas comportamentais de *Acromyrmex coronatus* (Fabricius, 1804) e *Acromyrmex crassispinus* (Forel, 1909) (Hymenoptera: Formicidae) a *Myrmosicarius catharinensis* Borgmeier, 1928 (Diptera: Phoridae) em Londrina, PR

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Highlights

First report of *Acromyrmex* spp. parasitized by *M. catharinensis* in Paraná.
Ants exhibit different behaviors in response to the attack of the parasitoid.
Foraging by *M. catharinensis* alters the collective behavior of leaf-cutting ants.

Abstract

Leaf-cutting ants of the genus *Acromyrmex* cause serious damage to cultivated forest areas. Some flies of the family Phoridae are known to parasitize them, and the result of this interaction can provide a promising basis for the management of these ants. This study was developed to record the parasitism and behavioral responses of *Acromyrmex* spp. leaf-cutting ants to parasitoid phorids in the municipality of Londrina-PR, Brazil. Visual examinations and collections of leaf-cutting ants and associated phorids were carried out between October/2019 and April/2020 in selected anthills and their trails, located on the campus of the State

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Received: Sept. 17, 2020 - Approved: May 30, 2021

University of Londrina (UEL) and at the Botanical Garden of Londrina. The collected insects were preserved in 70% alcohol, for later identification of the species. The behavioral response of the ants to the parasitoids was recorded individually and collectively, following protocols cited in the literature. The frequencies of the different response behaviors exhibited by the attacked ants were compared using analysis of variance. The leaf-cutting ant species *Acromyrmex coronatus* and Acromyrmex crassispinus were found at the two evaluated sites. *Myrmosicarius catharinensis* was the only species of parasitoid phorid found, which attacked both ant species. Although the occurrence of *M. catharinensis* has been reported in other Brazilian states and its association with *A. crassispinus* recorded in Buenos Aires, Argentina, this is the first report of the occurrence of the phorid in the state of Paraná with a new association for the species *A. coronatus.* Under foraging action by the parasitoid, 63.5% of the ants exhibited only one behavioral response, while 36.5% showed two. Accelerated walking, attempting to "bite" the parasitoid, and adopting a 'C' posture were the most frequent behavioral responses to avoid parasitism. Ants crowding together around a worker and the presence of "hitchhiker" workers on the transported leaf fragments were the observed changes in collective behavior, the latter being the most frequent. These changes occurred in all observed ant nests and, in two of them, the constancy of alteration in collective behavior was 53%. These results demonstrate the interference caused in nests of *Acromyrmex* spp. by the occurrence of *M. catharinensis,* a potential control agent for this pest.
Key words: Behavioral change. Leaf-cutting ant. Natural enemy. Parasitoid.

Resumo

Formigas-cortadeiras do gênero *Acromyrmex* causam sérios prejuízos em áreas florestais cultivadas. Algumas moscas pertencentes à família Phoridae são conhecidas por parasitá-las e o resultado dessa interação pode fornecer bases promissoras para o manejo destas formigas. Este estudo objetivou registrar o parasitismo e as respostas comportamentais de formigas-cortadeiras *Acromyrmex* spp. aos forídeos parasitoides no município de Londrina, PR. Entre outubro/2019 e abril/2020 foram realizadas inspeções visuais e coletas de formigas-cortadeiras e forídeos associados em formigueiros selecionados e suas trilhas, situados no Campus da Universidade Estadual de Londrina (UEL) e no Jardim Botânico de Londrina. Os insetos coletados foram preservados em álcool 70%, para posterior identificação das espécies. O registro comportamental das formigas aos parasitoides foi realizado a nível individual e coletivo, seguindo protocolos citados em literatura. As frequências entre os diferentes comportamentos de resposta exibidos pelas formigas atacadas foram comparadas por meio de análise de variância. As espécies de formigas-cortadeiras *Acromyrmex coronatus* e *Acromyrmex crassispinus* foram encontradas nos dois locais avaliados. *Myrmosicarius catharinensis* foi a única espécie de forídeo parasitoide encontrada e atacou as duas espécies de formigas. Embora a ocorrência de *M. catharinensis* seja relatada para outros estados brasileiros e sua associação com *A. crassispinus* registrada em Buenos Aires - Argentina, este é o primeiro relato da ocorrência do forídeo no Paraná com nova associação para a espécie *A. coronatus.* Sob a ação de forrageamento do parasitoide, 63,5% das formigas apresentaram apenas uma resposta comportamental, enquanto 36,5% apresentaram duas respostas comportamentais. Acelerar o caminhamento, tentar "morder" o parasitoide e adotar posturas em 'C' foram as respostas comportamentais mais frequentes para evitar o parasitismo. A aglomeração de formigas em torno de uma operária e a presença de operárias "caroneiras", sobre os fragmentos de folha transportados, foram as alterações de comportamento coletivo observadas, sendo a última a mais frequente. Estas alterações ocorreram em todos os ninhos de formigas observados e em dois deles a constância de alteração no comportamento coletivo foi de 53%. Estes resultados evidenciam a interferência provocada em ninhos *Acromyrmex* spp., pela ocorrência de *M. catharinensis,* um potencial agente de controle desta praga.

Palavras-chave: Alteração de comportamento. Formiga-cortadeira. Inimigo natural. Parasitoide.

Introduction

Ants of the genus *Acromyrmex* Mayr, 1865 (Hymenoptera: Formicidae) are known as leafcutters. They belong to the tribe Attini, which is characterized by cultivating a symbiotic fungus (*Leucoagaricus gongylophorus* (Singer, 1986)) for their feeding (Wartchow, 2018). Thanks to their complex social organization (castes and nest architecture) as well as sophisticated communication (trophallaxis and pheromones), these ants are adapted to agricultural, forest, and urban environments (Hölldobler & Wilson, 2009).

The genus *Acromyrmex* is spread from California (35ºN) to Argentina (44ºS), with the exception of the west coast of Chile and Peru (Fowler, 1983; Brener & Ruggiero, 1994). Of the 24 species recorded in Brazil, the following have been reported in Paraná: *Acromyrmex aspersus* (F. Smith, 1858), *Acromyrmex balzani* (Emery, 1890), *Acromyrmex coronatus* (Fabricius, 1804), *Acromyrmex crassispinus* (Forel, 1909), *Acromyrmex diasi* Gonçalves, 1982, *Acromyrmex disciger* (Mayr, 1887), *Acromyrmex heyeri* (Forel, 1899), *Acromyrmex hispidus fallax* Santschi, 1925, *Acromyrmex muticinodus* (Forel, 1901), *Acromyrmex niger* (F. Smith, 1858), *Acromyrmex rugosus rugosus* (F. Smith, 1858), and *Acromyrmex subterraneus subterraneus* (Forel, 1893) (Rando & Forti, 2005; Baccaro et al., 2015).

Leaf-cutting ants can play important ecological functions, either in seed dispersal (Leal, Wirth, & Tabarelli, 2011) or incorporation of organic matter into the soil (Swanson et al., 2019) through the waste chambers of their nests. However, greater importance is attached to the foraging of fresh plant material in large quantities, which can cause significant damage to production systems, especially in silviculture (Nickele et al., 2021).

The state of Paraná has the largest *Pinus* sp. planted area (896,242 ha) in Brazil (Indústria Brasileira de Árvores [IBÁ], 2020). Studies indicate that *Acromyrmex lobicornis* (Emery, 1888) and *A. heyeri* are capable of causing severe attacks on *Pinus taeda* seedlings at 65 days after replanting, compromising up to 20.8% of seedlings (Cantarelli, Costa, Pezzutti, Zanetti, & Fleck, 2019).

The application of synthetic chemical insecticides directly on anthills or through ant baits is the most used method for the control of leaf-cutting ants (Della Lucia, Gandra, & Guedes, 2014). However, the use of these products may not be effective due to the difficulty of monitoring and effectiveness on the reproductive caste (queen). In addition, synthetic chemical insecticides can cause human intoxication, elimination of non-target organisms (Belchior, Souza Saraiva, López, & Scheidt, 2017), and contamination of ecosystems (Toffoli, Mata, Bisinoti, & Moreira, 2015; Nascimento et al., 2018).

Coupled with the pressure to adopt more friendly and sustainable forms of production, research has been directed towards new, less environmental-impacting management strategies (Della Lucia & Amaral, 2020). Strategies that favor the occurrence of entomopathogens, predators, and parasitoids may enhance biological control and reduce the populations of leaf-cutting ants with less environmental impact (Britto et al., 2016).

Phorids, which belong to the family Phoridae, have a rich diversity of species with different behaviors, including parasitism on social insects (Ament & Brown, 2016). Parasitoid species vary in size (0.5 to 4.0 mm in length) and foraging location (trails and cutting areas); are host-specific (Elizalde, Patrock, Disney, & Folgarait, 2018); and act through different attack strategies to oviposit (Elizalde, Folgarait, & Muscedere, 2012).

Research with parasitism on leaf-cutting ants is advancing, yet slowly (Della Lucia & Amaral, 2020). Phorids related to these leaf-cutting ants are known to belong to the genera *Apocephalus* Coquillett, 1901, *Neodohrniphora* Malloch, 1914, and *Myrmosicarius* Borgmeier, 1928 (Guillade, Goffre, & Folgarait, 2017). In Brazil, research groups studying this ant-parasitoid interaction are few in number, occurring in the states of Rio de Janeiro (Elizalde & Queiroz, 2013) and Tocantins (Arruda, Teresa, Martins, Pesquero, & Bragança, 2019). The state of Paraná, however, lacks bioecological studies on the occurrence and behavioral aspects of phorids that parasitize leaf-cutting ants.

Thus, in view of the great expansion of areas with nests of leaf cutters and their “status” as pests (Cantarelli et al., 2019), coupled with the possibility that the phorids occur in Paraná, this study was undertaken to record the parasitism and the behavioral responses of leaf-cutting ants of the genus *Acromyrmex* to parasitic phorids, in the municipality of Londrina-PR, Brazil.

Material and Methods

Study site

The study was conducted between October/2019 and April/2020 at the campus of the State University of Londrina (UEL) (23º19’ S; 51º12’ W) and in the native forest of the Botanical Garden of Londrina (BGL) (23º21’S; 51º10’ W), in Londrina-PR, Brazil. The locations are 7 km apart, and according to the Köppen climate classification, the region has a humid subtropical climate (Cfa).

The average altitude of the study region is 570 m and the annual average temperature is 21 ºC (e-Flora UEL, 2017). In addition to areas of gardens and lawns with *Hibiscus* sp. and *Rhododendron* sp., the region harbors many plant species such as gymnosperms (*Araucaria angustifolia,* Pinus sp.), angiosperms (*Mangifera indica, Persea americana, Melia azedarach,* etc.) and ferns (*Azolla filiculoides, Dennstaedita* sp., *Meniscium serratum,* etc.). The Botanical Garden of Londrina, in turn, constitutes one of the most important research and conservation units for native and exotic species in Paraná, with a forest area of 57 ha (Grizio-Orita, Hirata, Tissiano, & Marques, 2020). Its flora is composed of stratified layers with predominance of the following species: *Pilocarpus microphyllus* (herbaceous/shrub stratum), *Plinia cauliflora* (understory stratum), *Caesalpinia pluviosa* and *Aspidosperma polyneuron* (canopy-forming tree stratum).

Samples of ants and parasitoids

Five nests of *Acromyrmex* sp. were collected from each environment. Because the fungus *L. gongylophorus,* grown in the inner chambers, is highly dependent on the soil temperature (20-30 ºC) for adequate growth (Bollazzi, Kronenbitter, & Roces, 2008), some species of the genus *Acromyrmex* nest on the subsurface, which makes their location difficult. Thus, foraging trails (Figure 1A) with the flow of workers were used to characterize the nest (Gonçalves, 1961). To determine the species, 10 workers from each nest, which were traveling along the trail, close to the nest entrance, were collected.

Parasitoid phorids were collected over 13 surveys, every 15 days. These took place between October 2019 and April 2020, in the morning period (between 9h00 and 12h00), which was the time when the ants performed their foraging activity and the parasitoids could be seen (Elizalde & Queiroz, 2013). The phorids were captured using a portable vacuum cleaner specifically for insect collections, at an interval of 30 min/nest, when they attacked ants near the main entrance of the nest (Barrera, Becker, Elizalde, & Queiroz, 2017). This procedure is known as 'adult parasitoid collection' (Elizalde & Folgarait, 2011).

The collected insects were temporarily stored in cylindrical plastic bottles (2.5 cm wide × 11 cm long) with a lid and properly labeled according to the place and date of collection. Subsequently, they were sent to the Multiagro - Insect Ecology Laboratory (UEL), where the insects were killed in a freezer (0 ºC) for 30 min and stored in 70% alcohol, for identification.

The species belonging to the genus *Acromyrmex* were identified by Dr. Adriano T. Hoshino, from the Entomology Laboratory at UEL, according to the descriptions proposed by Gonçalves (1961). The parasitoid flies were identified by Dr. Thalles P. L. Pereira, from the Diptera Systematics and Biogeography Laboratory at the University of São Paulo-USP, using a Leica MZ16 stereomicroscope.

The ants were deposited in the museum of the Laboratory of Systematic Entomology of the State University of Londrina (MZUEL), and the Phoridae flies were deposited in the collection of the Zoology Museum of the University of São Paulo (MZUSP).

Figure 1. Foraging trail of a nest of *Acromyrmex crassispinus* (A); Leafcutter parasitoid phorid (*Myrmosicarius catharinensis*) (B); Behavioral reaction of *Acromyrmex crassispinus* workers attacked by *Myrmosicarius* sp. (C). Horizontal lines indicate the scale in millimeters.

Analyzed variables

Along with the 13 surveys for the capture of the phorids, a 30-min visual examination of the foraging trails of each nest was carried out to record the number of ants that were attacked by the parasitoid phorid and the number and type of behavioral reactions an ant exhibited during the parasitoid-leafcutter interaction. These interactions were categorized based on the observations of Elizalde et al. (2012), Folgarait (2013), and Bailez (2016), who emphasized that phorids recognize their hosts by chemical and/or visual cues that trigger their attack. At that moment, the female oviposits on the head, the thorax or the gaster of the ant, when the ant is on the trails and entrances of the nests. Table 1 shows the expected responses of the workers, which are classified as an absence of reaction (1), escape (2), or defense (3 and 4), and further details.

Table 1
Responses of *Acromyrmex* sp. to parasitoid attacks

Ant reaction	
1. Not reacting	Proceeds with the activity
2. Escaping	Increases walking speed
3. Scaring the phorid away	Thrashes legs and antennae to dislodge the parasitoid
4. Adoption of body postures	
4.1 Ball	Ant curled on itself, forming a small ball, with the head down and the gaster between its legs
4.2 Biting	Head facing upwards with mandible open and antennae and legs stretched out
4.3 C posture	Gaster between the legs, forming a "C" with the body
4.4 Gaster down	Gaster facing the ground, with the tip (pygidium) not accessible
4.5 Head against thorax	The ant put its head against the thorax, blocking the access to the neck area
4.6 Lying	Ant lies against the ground

Source: Elizalde et al. (2012).

Response at the collective level was also recorded. This was identified as an attacked worker being surrounded by its mates, which would approach and feel it with their antennae and mouthpieces, causing crowding; as well as hitchhikers, which would remain on the plant fragments carried by other workers during transport to the nest.

All observations and records were made by visual examinations at the same times of the day and with the same duration, as previously described in the capture procedures.

Analysis

The number of recorded observations was divided into two categories: ants that exhibited only one response behavior; and ants that exhibited two response behaviors. For each of these categories, the number of observations was divided into four blocks over time, with approximately 16 and 9 observations per block for ants that exhibited one and two response behaviors, respectively. The 1st, 2nd, 3rd and 4th blocks referred to surveys carried out in October, November/December, January/February and March/April, respectively. For each category, the average relative frequency of individual response behavior (listed in Table 1) was compared with each other by analysis of variance, followed by Tukey's test at 5% significance.

The constancy of alterations in collective behaviors (crowding or hitchhiking), surveyed on the foraging trails of the different nests over 13 examinations, was evaluated by descriptive analysis.

Results and Discussion

The leaf-cutting ant species *A. coronatus* and *A. crassispinus* were identified at the UEL campus and at BGL. The occurrence of these species in Paraná is known (Rando & Forti, 2005), with *A. crassispinus* being of greater economic relevance due to their prevalence in forest areas in southern Brazil (Nickele, Reis, Penteado, & Queiroz, 2018).

Myrmosicarius catharinensis Borgmeier, 1928 (Diptera: Phoridae: Metopininae) (Figure 1B) was the only parasitoid fly species sampled in this study, consisting of 23 specimens from the UEL campus and 18 from BGL, which showed a greater frequency on *A. crassispinus* worker ants. This parasitoid phorid species had already been reported in Argentina (provinces of Buenos Aires, Córdoba, Corrientes, Entre Ríos, and Santa Fé), but being related to the ant species *Acromyrmex ambiguus* (Emery, 1888), *Acromyrmex lundii* (Guerin-Meneville, 1838), and *A. heyeri* (Elizalde et al., 2012; Goffre & Folgarait, 2019). In Brazil, *M. catharinensis* was found in the states of Santa Catarina, Rio de Janeiro, and Tocantins, being related to an unidentified species of *Acromyrmex*, *A. niger,* and *Atta sexdens* (Linnaeus, 1758), respectively (Disney, Elizalde, & Folgarait, 2006); and also in the state of Rio Grande do Sul, through capturing with malaise traps (Duarte, Vaz, & Krüger, 2018). However, this is the first time this parasitoid has been recorded in Paraná.

The expansion of the geographical distribution of *M. catharinensis* to other locations was reported by Guillade et al. (2017). In addition to the ants already mentioned, it has been associated with the species *A. crassispinus, A. lobicornis,* and *A. hispidus.* These authors suggest that the dispersion of the parasitoid to other locations is related to the availability of hosts in the new environment.

Although only one parasitoid phorid species was observed in the present study, the occurrence of more than one phorid species or genus sharing the same ant nest is common and has been reported for different species in forests in Rio de Janeiro (Barrera et al., 2017).

In this study, both at the UEL campus, and BGL, the parasitoid *M. catharinensis* was foraging over the trail and close to the nest entrance, chasing or hovering over some workers and subsequently attacking to oviposit. In most of the parasitoid-leafcutter interactions, the action of only a single parasitoid was observed, in a certain segment of the trail or near the entrance of the nest, and seldom were two parasitoids found acting together. Moreover, the presence of phorids was observed even on trails with low foraging activity. These findings corroborate the descriptions of Elizalde and Queiroz (2013), who recorded the prevalence of foraging by this parasitoid on trails and at entrances of *A. niger* nests, even in nests with little foraging activity by worker ants.

Unlike some other phorid genera, *Myrmosicarius* is a very active and agile parasitoid. By flying, it searches for potential hosts along the foraging trails in different directions and is then able to oviposit in the head region (mandible, clypeus, occiput) or the abdomen (Folgarait, 2013). Phorid attacks generate responses from worker ants, and the expected behavior is related to the way the parasitoid acts. For species that oviposit in the head region, ants leave their mandibles open and facing upwards, while for species that oviposit in the abdomen, ants tend to lower this organ as a protection mechanism (Elizalde et al., 2012).

Elizalde et al. (2012) mentioned that, in the process of coevolution, leaf-cutting ants acquired generalized responses against parasitoids, and once unable to predict how they will be attacked, a single worker can defend itself with more than one behavioral strategy.

The attack of *M. catharinensis* to oviposit on its host occurred in a short time and was directed at the heads of the ants, which exhibited defensive behaviors in response to the attack. Upon receiving the attack of the parasitoid, a single worker ant was found to possibly show more than one response behavior. However, the observations indicate that 63.5% of the attacked ants exhibited only one response behavior, whereas the others (36.5%) showed two (Figure 2).

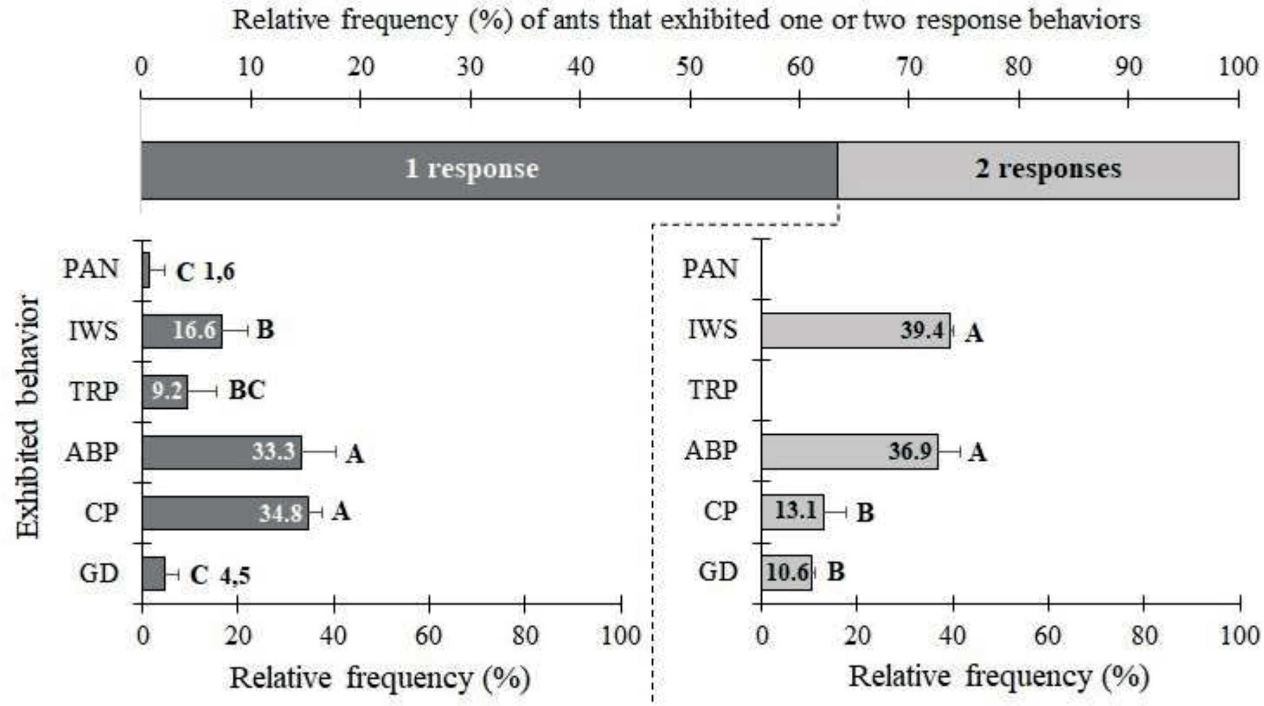

Figure 2. Relative frequency (%) of ants that exhibited one or two response behaviors, as well as relative frequency (%) of the types of behaviors displayed by each group of ants. Types of behavior: Proceeds with the activity normally (PAN); increases walking speed (IWS); thrashes to repel the parasitoid (TRP); attempts to bite the parasitoid (ABP); "C" posture (CP); gaster down (GD). Londrina-PR, 2020. Means followed by common letters do not differ by Tukey's test at 5% significance.

For the ants that exhibited only a single response behavior, six types of behavior were observed, namely: proceeding with the activity normally (PAN), without changing their foraging behavior; increasing their walking speed (IWS); thrashing the forelegs to repel the parasitoid (TRP); maintaining the gaster down (GD); attempting to bite the parasitoid (ABP); contracting the body by adopting a "C" (CP) posture. These last two postures were the most frequent (F = 32.75; DF = 5; p-value <0.01), representing 34.8% and 33.3% of the adopted postures, respectively (Figure 2).

In the case of the ants that exhibited two behavioral responses to phorid attack, four different types of postures were recorded, namely, GD, CP, IWS, and ABP. The last two were the most frequent (F = 84.71; DF = 3; p-value <0.01), representing 39.4% and 36.9% of the adopted postures, respectively (Figure 2).

During the ABP posture, the ants often remained with their head turned upwards, their mandible open and their antennae and anterior legs stretched (Figure 1C). In this way, the phorids could be captured and killed a situation we observed in the laboratory observations—and further exposure of the body could be avoided. During the attack of the phorids, we did not quantify how much the *Acromyrmex* sp. workers increased their walking speed, but there was greater mobility of the attacked ants in comparison to the other workers.

Elizalde et al. (2012) also observed the ants' ability to detect the phorid during their flight, where they displayed an escape or confrontational response. When attacked by the parasitoid, the ants adopted a ball or "C" posture and did not show a reaction on some occasions. In this case, the absence of behavioral defense would be related to the host's immune system through different mechanisms, e.g., inactivation by encapsulating the parasitoid egg (Elizalde, Treanor, Pamminger, & Hughes, 2019). However, lack of response in the presence of the parasitoid was the least frequent reaction in this study.

Overall, ABP was the most frequent behavior. Folgarait (2013) stressed that this behavior is related to the preference of the parasitoid to oviposit on the host's head. Guillade (2013) suggested that the choice for this part of the host is due to the adequate development of the larva in that region, where pupation and the later emergence of the adult take place, with the head of the host protecting against predation and weather adversities.

A collective defense behavior against the presence of the parasitoid was observed in all nests. In all examined nests, small workers ("hitchhikers") were carried on leaves to the nest. This was the most frequent collective behavior, occurring in 53.8% of the observations made in two evaluated nests. Crowding around a newly parasitized worker occurred jointly with the presence of hitchhikers in 7 out of the 10 evaluated nests, but with low constancy (7.7%) throughout the evaluations (Figure 3).

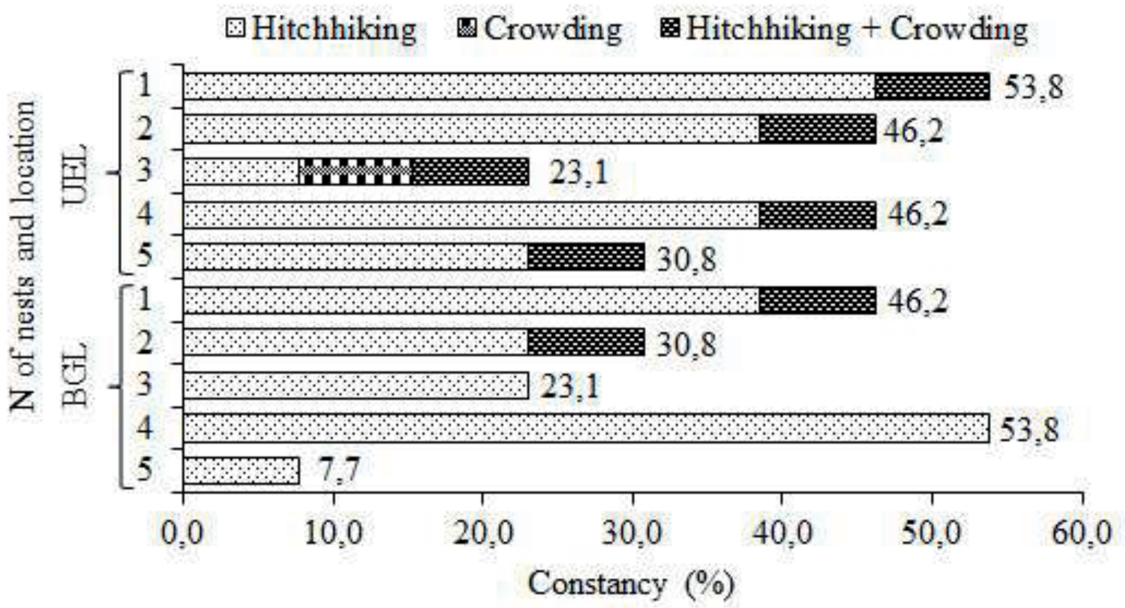

Figure 3. Constancy (%) of collective behaviors displayed on foraging trails of *Acromyrmex coronatus* and *Acromyrmex crassispinus* nests over thirteen evaluations, at the State University of Londrina (UEL) and at the Botanical Garden (BGL). Londrina-PR, 2020.

Crowding of ants after the phorid attack was also addressed in the study by Elizalde et al. (2012), in which the nestmates felt the area where the ant had been attacked with their legs and antennae. Additionally, the presence of hitchhiker workers presupposes the action of flies on the trails, as noted by Disney et al. (2006), and corroborates the hypotheses raised by Vieira, Mundim and Vasconcelos (2006), that the smaller workers protect their mates.

This intimate interaction, represented by different organisms, is the result of a long evolutionary process, in which new associations of parasitism tend to occur as the geographical distribution of a host increases (De Bekker, Will, Das, & Adams, 2018). Because they perform activities with task divisions, involving specialization of functions, ants are prone to a diversity of parasitoids in the environment, with some acting on foraging trails, nest entrances, and even sites of material-waste deposit (Guillade & Folgarait, 2011; Elizalde et al., 2012). In addition, the coexistence between these insects shapes different behaviors that oppose themselves and define the adaptive success of both (Bailez, 2016).

Although the rates of natural parasitism on leaf-cutting ants are low (Bragança, Tonhasca, & Della Lucia, 2009; Feener & Brown, 1993) and their use as biological controllers in applied biological control programs is not a current practice (Britto et al., 2016), studies aimed at biological control are essential. Parasitoids can interfere with the dynamics of ants' nesting activities, altering their foraging behavior. Moreover, parasitoids have the following advantages: specificity to guilds of leaf-cutting ants, not posing a threat to other species; varied behavioral plasticity (strategies and sites of attack), which increases their impact on ants; species that can be mass-cultured in the laboratory; and absence of hyperparasitism (Elizalde & Folgarait, 2011; Folgarait, 2013). It is, therefore, essential to encourage biological, ecological, and ethological knowledge of these organisms.

Conclusions

The species *M. catharinensis* was recorded as a parasitoid phorid of *A. coronatus* and *A. crassispinus,* interfering with their foraging activity in nests in the municipality of Londrina. In an effort to defend themselves against the parasitoid, ants increase their walking speed, attempt to bite the parasitoid or adopt a "C" posture.

Acknowledgments

Thanks are extended to the Graduate Program in Agronomy at the State University of Londrina and the Botanical Garden for the research opportunity; and to CAPES - Coordination for the Improvement of Higher Education Personnel for the fellowship grant.

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