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## Ectoparasitism and phoresy in Thysanoptera: the case of *Aulacothrips dictyotus* (Heterothripidae) in the Neotropical savanna

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Thrips are cosmopolitan and abundant insects with great diversity in the Neotropics, but taxonomic and crop pest aspects comprise almost all of our knowledge of these insects. Here we describe a unique case of an ectoparasite species, *Aulacothrips dictyotus* Hood (Heterothripidae), which infests and also uses as dispersal vector (phoresy behaviour) the hemipteran *Enchenopa brasiliensis* (Membracidae). Thrips fix themselves on the ventral region of their hosts, at the junction of thorax and abdomen. Phoresy takes place when the attached thrips are transported to other plants and/or host aggregations. Phoresy is a useful long range dispersal mechanism for this weakly flying thrip species. Out of the 6000 species of thrips described, most are phytophagous and fungivorous, and only *A. dictyotus* performs ectoparasitism and phoretic behaviour.

**Keywords:** cerrado; *Enchenopa brasiliensis*; parasite; Solanaceae; thrips

### Introduction

Thrips are small, opportunistic, vagile, and ubiquitous insects generally yellow, brown, or black in colour (Morse and Hoddle 2006). They occur throughout tropical, subtropical and temperate regions (Mound and Marullo 1996; Kirk and Terry 2003). Usually the diversity of thrips is related to the local flora (see Pinent et al. 2005), and these insects inhabit several kinds of flowers or inflorescences of various species, and also shoots, tender leaves and fungus-infested dead or decaying wood (Milne and Walter 2000; Mound and Reynaud 2005; Varanda and Pais 2006).

Thrips exhibit a diverse array of lifestyles including sociality (Crespi 1988), structural polymorphisms (Mound 2005), gall-induction on leaves (Perry et al. 2004), pollination interactions (Sakai 2001; Moog et al. 2002) and virus transmission on crop plants (Kritzman et al. 2002). Considering the cosmopolitan distribution of thrips it would not be surprising to find some unique types of interaction within the Thysanoptera, which encompasses 6000 species worldwide in eight families, with 700 species in Brazil belonging to six families (Mound 2002; Mound and Morris, 2007).

Despite the considerable number of described species, the thysanopterofauna of Brazil is largely unknown. The vast majority of studies have been limited to insecticide trials (Picanço et al. 2003), species that are associated with or are pests of crops (Hickel

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and Ducroquet 1998), and descriptive taxonomy (Monteiro et al. 2001). Moreover, the species dealt with in these studies belong usually to the family Thripidae, the only one considered to cause damage and economic losses in the cultivation of a wide range of vegetable and ornamental plants in fields and greenhouses, either by feeding damage or by the transmission of viruses (Nagata and Avila 1999; Sakurai 2004; Leite et al. 2006; Pinent et al. 2008). Thus studies on thrips in Brazil have been aimed at one family of thrips, and biased in considering only pests. This underestimates Brazilian native thysanoptero fauna, and excludes the aspects of ecology, biology and natural history of many other species which might contribute directly to our understanding of thrip-plant associations as well as their interactions with other arthropods.

Del-Claro et al. (1997) noted large numbers of the newly discovered *Heterothrips peixotoa* Del-Claro, Marullo and Mound, 1997 in the flowers of *Peixotoa tomentosa* (Malpighiaceae), a common shrub in the Brazilian savanna. This thrip lives under the flower chambers formed by the curling of the sepals towards the centre of the flower (Anderson 1979). This avoided predation by ants, and provided food and reproduction facilities. This noteworthy behaviour is comparable to leaf-litter arthropods in escaping from ants (Otis et al. 1986), and shows the diversity of thrips' habits, and how associations with other arthropods dictate thrips' behaviour.

Recently, a remarkable ecological interaction was found in Brazil in the family Heterothripidae, which comprises about 70 described species in four genera (Mound and Marullo 1996) exclusively in the New World. With one exception, all the species of this family are flower-living (Del-Claro et al. 1997). The exception, *Aulacothrips dictyotus* Hood, is of considerable biological interest, because it was suggested as being an ectoparasite of *Aetalion reticulatum* Linne (Hemiptera: Aetalionidae), a way of life that is unique in Thysanoptera (Izzo et al. 2002). The ectoparasitism was considered to occur whenever thrips were associated with and attached to hemipterans. The occurrence of thrips together with phloem-sucking hemipterans may be very risky, both because the latter are very sensitive in perceiving other arthropods in their groups and elicit dispersive and fight responses (Drosopoulos and Claridge 2006), and because hemipterans are tended by carnivorous ants which protect the colony in order to obtain the sugar-rich honeydew (Del-Claro and Oliveira 1996; Santana et al. 2005; Styrsky and Eubanks 2007; see also Byk and Del-Claro 2010).

Other than *A. reticulatum*, field observations in the Brazilian savanna showed that *A. dictyotus* may also be associated with *Enchenopa brasiliensis* Strümpel (Membracidae), another small phloem-sucking hemipteran. These insects form aggregations of nymphs and a few adults on *Solanum lycocarpum* (Solanaceae), where they feed on leaves and apical meristems tended by ants (Moreira and Del-Claro 2005). Thus, the aims of this study were to verify the occurrence and abundance of *A. dictyotus* in association with *E. brasiliensis*, to observe the behaviour of tending ants in the presence of thrips at membracid aggregations, and to examine the evidence for ectoparasitism (as suggested by Izzo et al. 2002) and also phoresy in this particular association.

## Methods

The behavioural observations (all occurrence sampling, see Altmann 1974) were carried out in a tropical savanna area (cerrado, *sensu stricto*, see Goodland 1971) of Clube de Caça e Pesca Itororó de Uberlândia (CCPIU), Minas Gerais State, Brazil (15°57'S, 48°12'W; 863 m), in August, 2008. We tagged shrubs ( $n = 20$ ) of *S. lycocarpum*

of similar phenological state and size (one to two metres in height) infested with *E. brasiliensis*, and as soon as an aggregation of membracids was found by active search, we registered: the number of individuals and their stage of development; the presence of thrips (larvae or adults, and their numbers) and if they were attached to a membracid's body; the body part used by the thrips; and the presence of ants tending the membracids.

Fieldwork observations were made in the mornings from 08:00 to 11:00 ( $n = 10$  days). Each day, two *S. lycocarpum* individuals were chosen by sort, and we spent 90 minutes of observations on the membracid aggregation present on each plant, either on the leaves or on the branches, totalling 30 hours of field observation. Each plant observed was used only once.

Seven individuals of *E. brasiliensis* (three adults and four nymphs) infested with thrips were collected from *S. lycocarpum* plants other than the ones used in the observations, and placed individually in small plastic tubes (5 cm in diameter and 6 cm in height) and taken to the laboratory in order to observe the thrips' behaviour under the stereomicroscope. The membracids were kept in the tubes for three days and observations were made for 15 minutes every two hours, from 08:00 to 18:00. In each period of observation, we registered the presence or absence of *A. dictyotus* on the membracids' bodies. Another eight membracids (four adults and four nymphs) that were not associated with thrips were also taken to the laboratory, in order to offer them for thrips which eventually had left their hosts by means of the death of the latter.

In March 2010, we conducted complementary observations on the same plants used in 2008. We investigated the interactions of thrips, tending ants and membracids, as earlier observations showed that not only the membracids, but also ants could dislocate or inhibit the presence of thrips in the colonies of membracids. We registered whenever there were *E. brasiliensis* parasitized and what species of ants were present at the aggregation. Moreover, more thrips were collected in the field and taken to the laboratory in order to observe their feeding behaviour on the membracids. The observations involved one adult and eight larvae of the thrips, which were put into a Petri dish on a leaf of *S. lycocarpum* infested with *E. brasiliensis* (12 nymphs and two adults). The Petri dish was put under a stereomicroscope and filmed with a Motic Moticam 2000® (Sony Electronic Inc., California, USA) digital camera for five hours.

We performed descriptive statistical analysis (mean and standard deviation (SD)) regarding the number of thrips and membracids sampled as well as their stage of development. To compare the difference in the numbers of adults and immatures of *E. brasiliensis* we made a Mann-Whitney  $U$  test, given that data did not present normal distribution. For thrips we made a non-parametric goodness of fit chi-square test, grouping the data for all 20 plants, both because of the small number of individuals found and also because in many plants the presence of thrips was zero as recommended in Wimp and Whitham 2001. The chi-square test was also used to compare the preference of thrip larvae for infesting adults or nymphs of *E. brasiliensis*. All the statistical procedures were made according to Zar (1984).

## Results

From all *S. lycocarpum* analysed ( $n = 20$  shrubs), we sampled 126 *E. brasiliensis* individuals ( $3.15 \pm 1.12$  per plant) comprising 56 adults and 70 nymphs ( $U = 118$ ;  $df = 1$ ;  $p = 0.021$ ) (Figure 1A). The chi-square test ( $\chi^2 = 79.364$ ;  $df = 1$ ;  $p < 0.0001$ )

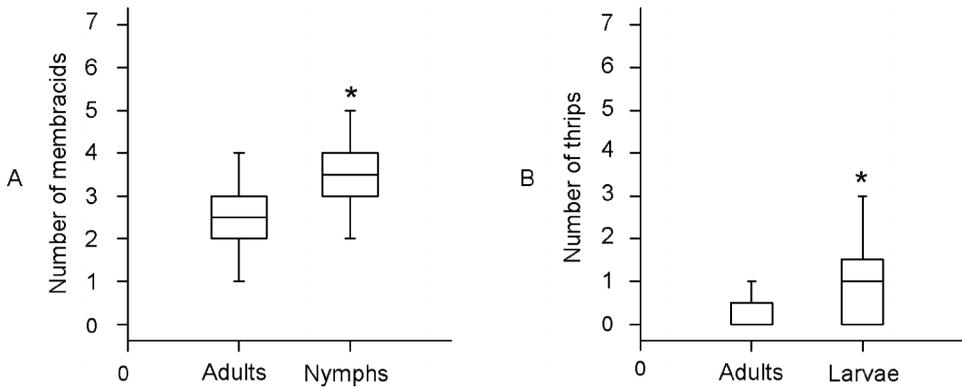


Figure 1. The number ( $\bar{X} \pm 1SD$ ) of adult and immature (A) *Enchenopa brasiliensis* and (B) *Aulacothrips dictyotus* found on *Solanum lycocarpum*. (\* upon the bars indicates statistically significant differences).

revealed that membracid occurrence was more common on leaves ( $4.71 \pm 1.37$ ;  $n = 113$  in 24 leaves analysed) than on the branches ( $0.65 \pm 0.93$ ;  $n = 13$  in 10 branches). *E. brasiliensis* aggregations occurred only on leaves, since on the branches individuals stayed alone or in pairs. *E. brasiliensis* aggregations were formed by three to seven individuals, and nymphs were always found together with adults.

*A. dictyotus* was represented by 28 individuals, consisting of 7 adults and 21 larvae ( $\chi^2 = 7.000$ ;  $df = 1$ ;  $p = 0.0082$ ) (Figure 1B). Ectoparasitism was recorded on 24 membracids, 10 adults and 14 nymphs ( $\chi^2 = 0.667$ ;  $df = 1$ ;  $p = 0.4142$ ). Of the 10 adults, five were infested by adult thrips and five by larvae. Generally, one *E. brasiliensis* supported one *A. dictyotus*, but we observed two *E. brasiliensis* nymphs each with two larval thrips attached. The chi-squared test revealed that thrip larvae showed a preference for membracid nymphs ( $n = 14$ ) rather than adults ( $n = 5$ ) ( $\chi^2 = 5.000$ ;  $df = 1$ ;  $p = 0.0389$ ) (Figure 2).

*A. dictyotus* larvae attached to the membracid body ventrally, at the junction of the thorax with the abdomen. Adult thrips stayed on the ventral face of the abdomen, longitudinally, with the head directed to the anus of the membracid. Thrips were taken wherever membracids were found, but the range of phoresy depended on the stage of host development. Membracid nymphs are wingless and confined to an individual *S. lycocarpum*. On the other hand, winged *E. brasiliensis* adults flew when disturbed, including by wind and shaking of leaves, and thrips attached to them (adults or larvae) were carried to further distances.

Host nymphs stayed immobile most of the time, sucking the phloem. Adults were very mobile but stayed immobile when tended by ants (*Camponotus* sp. 1, ( $n = 2$ ); *Camponotus* sp. 2, ( $n = 3$ ); *Crematogaster* sp. ( $n = 7$ )). Membracids were present on all plants, but thrips were present only among aggregations without tending ants, or those aggregations tended by *Camponotus* sp. 1 (Figures 3A, B). Ants did not react to thrips' presence. Thrip larvae were found only on the bodies of membracids, but adult thrips wandered on leaves with or without membracids. However, host-free thrips were present only at the aggregations tended by *Camponotus* sp. 1. The observations made in 2010 revealed that the parasitized membracid aggregations ( $n = 5$ ) were tended by *Camponotus* sp. 1. The other *E. brasiliensis* groups ( $n = 11$ ) were tended

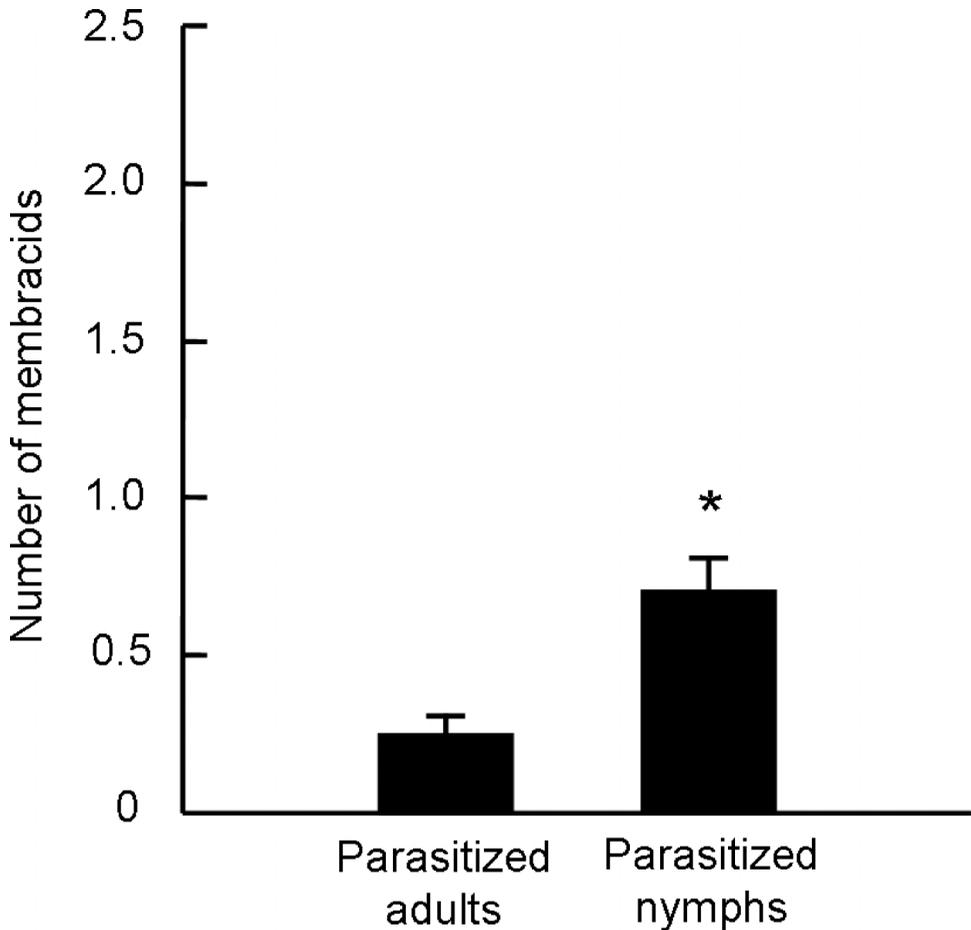


Figure 2. The number of *Enchenopa brasiliensis* adults and nymphs supporting *Aulacothrips dictyotus*. Infestation by thrips was higher in membracid nymphs, as indicated by \* upon the bar.

by *Crematogaster* sp., and though very abundant, these membracids were not infested with thrips.

*A. dictyotus* larvae were easily observed on their host, since their red-coloured body contrasted with the pale green membracids (Figures 3B, C). Adult thrips used their antennae (Figure 3D) to touch the end of the abdomen of adult membracids in the same way tending ants do to receive droplets of honeydew.

Laboratory observations showed that all *A. dictyotus* larvae collected in the field stayed firmly attached to the *E. brasiliensis* body, but when the host died the thrip larvae left the membracid. Thrips wandered on the host's body and touched it with their enlarged antennae (Figure 3D), and they groomed these frequently. After leaving one host, the thrips walked on the substrate and fixed themselves on another membracid after no more than 24 hours. The *A. dictyotus* larvae climbed onto an *E. brasiliensis* actively, by leaning their body towards the membracid when both were close enough to permit contact (Figure 3C) then stretching their forelegs and climbing onto the membracid. The thrips attached under *E. brasiliensis* have the dorsal part of their

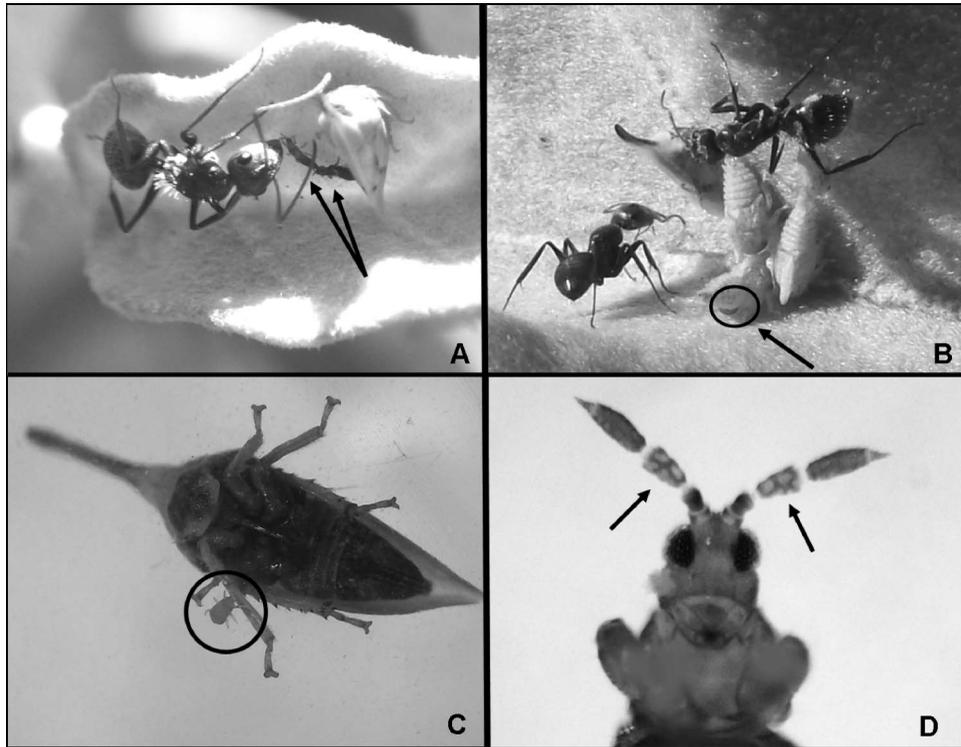


Figure 3. (A) Arrows indicate two adult thrips (*Aulacothrips dictyotus*) next to an adult membracid (*Enchenopa brasiliensis*) tended by a *Camponotus* sp.1 ant on a leaf of *Solanum lycocarpum* in the Neotropical savanna; (B) the arrow indicates the red larva of *A. dictyotus* fixed on the ventral part of a membracid nymph body; (C) a host-free thrip larva approaching from the side of an adult membracid; (D) the arrows indicate the convoluted and continuous sensoria on adult thrip antennae.

body (pro-, meso- and metanotum, and the tergites) constantly in friction with the substrate, particularly large and fat larvae which infest young and small membracid nymphs. Moreover, in this situation thrips fit the full width of a membracid at the junction of thorax and abdomen.

The videos showed that thrips feed on the membracids, however adults and larvae feed on different parts of the membracid body. While larvae stayed fixed and fed by sucking at the ventral surface of the host, at the junction of thorax and abdomen, the adult thrips grabbed at the pro-, meso- and metanotum of a membracid, and inserted their stylets into the tergites of membracid nymphs (see online content).

### Discussion

The thrip species *A. dictyotus* not only parasitizes nymphs of the honeydew-producing treehopper *E. brasiliensis*, a membracid of the Brazilian tropical savanna, but also uses these bugs in phoretic behaviour. Our data support the prediction of Izzo et al. (2002), in suggesting that this thrip species is an ectoparasite. The term “ectoparasite” is used

here in its strict sense, as being an arthropod that is closely associated with its host for all or extended parts of its life cycle (Nelson et al. 1975). We showed that *A. dictyotus* can use a hemipteran species other than *Aetalion reticulatum* as host (Izzo et al. 2002), as well as attach to and feed on different body parts.

The presence of thrips inside *E. brasiliensis* aggregations did not affect membracid behaviour in any perceived way. In fact, the tending ants of *Camponotus* sp. 1 also did not react to thrips' presence, often walking upon them. In order to explain this behaviour, a brief description of membracid ecology and their association with ants is necessary.

Membracids use vibratory signals and chemical volatiles to warn the group about predators (Cocroft 2005). In their exposed locations on the growing leaves of host plants, aggregations are vulnerable to invertebrate predators including flies, predatory Hemiptera and spiders (Cushman and Whitman 1989; Morales 2000), and because aggregations are stationary, predators can either remain near the aggregation or make repeated visits (Drosopoulos and Claridge 2006). When a predator is perceived, membracids elicit signals from siblings which change the behaviour of the group, and individuals fly away or fight against the predators (Wood 1993). However, in *E. brasiliensis* groups, deterrence of predators is a role played by ants, mainly *Camponotus* species. These ants provide protection for membracids so they can feed calmly and release sugar-rich honeydew which serves as food for the ants. Protection includes the predation upon or the dislocation of membracids' natural enemies so they cannot get close to the aggregations (Moreira and Del-Claro 2005).

The fact that *A. dictyotus* may remain unnoticed in *E. brasiliensis* colonies suggests that thrips may use camouflage chemicals or vibratory signals that inhibit a response by ants and membracids, in the same way lepidopterans use chemicals to camouflage themselves from natural enemies (see Cocroft 2001). Portugal and Trigo (2005) have demonstrated that the similarity of cuticular lipids between the larva of the butterfly *Mechanitis polymnia* (Nymphalidae) and its host plant *Solanum tabacifolium* (Solanaceae) confers protection to caterpillars via chemical camouflage, reducing predation levels by foliage-dwelling ants. Many thrips produce a great variety of substances including alkanes, alkenes, alkanoic and alkenoic acids, aliphatic and cyclic esters, monoterpenes, and aromatic compounds, used as contact irritants, alarm pheromones, or in some cases, fumigants (Milne et al. 2002; Tschuch et al. 2002; MacDonald et al. 2003). Given this wide range of volatile secretions produced by several species of thrips, we suggest that *A. dictyotus* possibly produces camouflage chemicals so they can remain ignored in membracid colonies and not be attacked by ants. Moreover, the tending behaviour presented by thrips on membracids, similar to tending behaviour of ants, may avoid membracids exhibiting anti-predatory responses which once initiated could affect the whole colony, with individuals rapidly dispersing (see Del-Claro and Oliveira 1999, 2000).

Ants are important predators of thrips as shown by Del-Claro et al. (1997), who demonstrated that *Brachymyrmex* species conferred protection on *Peixotoa tomentosa* (Malpighiaceae) by preying on thrips which otherwise would feed on pollen and affect the fitness of the plant. Some thrip species mimic ants in order to avoid predation and forage without restraint in the same habitats as their potential predators. Their mimicry is so specialized that not only thrips' shape, but also their behaviour is similar to the ants', many having been observed to run very actively and to palpate the substrate with their antennae (Mound and Reynaud 2005). Throughout the

year, membracids may be tended by a dozen different ant species, mainly *Camponotus* (see Moreira and Del-Claro 2005). *Aulacothrips dictyotus* was found only in the membracid aggregations tended by *Camponotus* sp. 1, although we noted that membracids were also tended by *Crematogaster* sp. Although smaller than *Camponotus* species, *Crematogaster* ants are faster and known for their aggressiveness (see Oliveira et al. 1987; Fiala et al. 1989). Hunting workers forage collectively due to short-range recruitment (Stapley 1999). They detect prey by contact, then rapidly attack, seizing small prey by the body and large prey by a leg (Richard et al. 2001). There is reason to believe that thrips do not get along with *Crematogaster* ants, given that in plants where thrips are common in the Brazilian savanna, like the flowers of *P. tomentosa* and the folioles of *Caryocar brasiliense* (Caryocaraceae) (author's unpublished data), whenever *Crematogaster* ants are present, thrips are not. Escaping from ants which could triple their number within 10 seconds (Stapley 1999) could be an easy task for thrips, since they can take flight rapidly at any disturbance (Mound and Marullo 1996). However *A. dictyotus* adult individuals are very reluctant to take flight at all. In this species of thrips, the wings are firmly attached under setae on the abdomen, demonstrating that this is a species quite reserved in taking flight (Laurence Mound 2009 pers. comm.) and indeed no flight behaviour of *A. dictyotus* was observed in the current study. So flight, which is a primary escape behaviour from predators and also the main way of dispersion, is not developed in this species (see Morse and Hoddle 2006).

Each plant supported no more than one *E. brasiliensis* colony, so the energy and time demanded for looking for new membracid aggregations might be a limiting factor for *A. dictyotus* maintenance, and presumably two features are very important in helping thrips to locate membracid aggregations: the greatly enlarged antennae, possessing highly convoluted and continuous sensoria (Mound and Marullo 1996), and the phoresy behaviour. The antennae bearing many sensoria are structures exclusive to *A. dictyotus*, providing the most specialized receptors responsible for olfactory and/or vibrational perception in the family Heterothripidae, allowing host-free thrips to locate membracid aggregations in the same way co-specific membracids do to find their aggregations (see Cocroft 2001). Furthermore, unlike other members of the Heterothripidae, the head and pronotum of *A. dictyotus* bear several pairs of long setae (Mound and Marullo 1996) which protect the insects from friction on the substrate when they are attached to membracid hosts.

The phoretic behaviour takes place when thrips attached to membracids' bodies are taken to other colonies, and the benefits of phoresy to thrips are similar to those evidenced in other arthropods, like increasing the chances to colonize new and more distant sites (Poinar et al. 1998; Tizo-Pedroso and Del-Claro, 2007; Del-Claro and Tizo-Pedroso, 2009). To *A. dictyotus* it also has the advantage of taking the thrips to new aggregations of *E. brasiliensis*. However, the phoresy of *A. dictyotus* may be a by-product of parasitism, because as thrips attach themselves to the membracids, the latter thus take thrips wherever they go. Nonetheless, if we consider the classic definition of phoresy proposed by Lesne (1896), the transport of certain insects on the bodies of other insects for purposes other than direct parasitism, we may include *A. dictyotus* in the list. Our observations showed that adult thrips attach to the host body and are carried whenever membracids fly away. Thrip larvae also fix themselves to membracids' bodies but the main objective is presumably food, so the phoresy is just a consequence of the ectoparasitic behaviour of thrips. In the definition of phoresy by Lesne (1896), the transport host serves its passengers only as a vehicle but may support

parasites which are carried together with the host. Contemporary studies consider phoresy to have occurred whenever one organism transports another organism of a different species, no matter whether or not it is a by-product of the ectoparasitism (Sivinski et al. 1999; Bologna and Pinto 2001; Bajerlein and Bloszyk 2004; Eng et al. 2005; Campos-Herrera et al. 2006).

The lack of records of *E. brasiliensis* in Brazil does not permit us to state that their relationship with thrips is widespread in nature. According to Krasnov et al. (2002), ectoparasites are influenced not only by characters of the host, but also by characters of their off-host environment, because their contact with the host is usually intermittent. Unlike most free-living species, the geographic range of a parasite consists of a set of more-or-less uniform, inhabited "islands" or patches, represented by its host organisms, and the environment between these patches is absolutely unfavourable. Most individuals of the over-dispersed parasite occur on a few host individuals, while most host individuals have only a few parasites or none at all (Anderson and May 1978; Poulin 1993).

In general, our results were close to Izzo et al. (2002), who found a level of parasitism of 25% in *Aethalium reticulatum*, while in *E. brasiliensis* it was 21%. However, *A. reticulatum* were found living in groups of 30 to 80 individuals, while *E. brasiliensis* groups had no more than seven individuals. Parasite abundance is known to be influenced by resident host density (Anderson and May 1978; Krasnov et al. 2002). In the case of *Aethalium reticulatum* (Izzo et al. 2002) the dense host-aggregative behaviour facilitated the transfer of parasites between group members, but in *E. brasiliensis* the individuals become agitated making the transfer difficult. Izzo et al. (2002) observed thrip larvae beneath the hindwings of *A. reticulatum*. The thrips found in *E. brasiliensis* were found at the ventral region of the membracids, at the junction of the thorax and abdomen (thrip larvae) or only on tergites (adult thrips). No thrips were found under the wings or on any other part of the membracids' bodies. No more than two thrip larvae were seen on any *E. brasiliensis*, while in *A. reticulatum* more than 10 thrip larvae could be found simultaneously. This shows that *A. dictyotus* may change its behaviour in relation to different hosts, and so far *A. dictyotus* has only been found associated with hemipterans closely similar in structure and morphology. Membracidae are a very conservative group in morphological and ecological characteristics, they live in groups, are sap feeders and possess a hood-like pronotum that extends backwards over the body and hardened forewings (Alford 2007). Since *A. dictyotus* has been found on similar host species, one may expect to find this association in other membracids because, according to (Balashov 1984), a parasite tends to be specific to hosts characterized by bionomic and ecological similarities. Therefore biologists should look carefully because thrips may be inconspicuous due their minute size (Mound and Marullo 1996) and an appreciation of the potential occurrence of *A. dictyotus* in other membracids would be welcome to increase and enrich the knowledge of this neotropical species of thrips.

The Thysanoptera are a group with noteworthy habits including sociality, gall-making, mimicry, pollination and predation (Mound 2005). Thus, according to Pinent et al. (2002), there is no intrinsic reason to consider the ectoparasitic way of life as impossible for thrips, from either the nutritional or the behavioural aspect. Despite feeding primarily on leaf and flower tissues, a few species of thrip are able to feed on other arthropods, like mites and other thrips (Agrawal and Klein 2000; Mound and Reynaud 2005). Therefore, although thrips seem to be adapted particularly to

ingest materials of plant origin, some species are able to digest animal tissues (Pinent et al. 2002).

The Heterothripidae are a neotropical family which is poorly known; the unique record of its biology in tropical savanna pointed to this family as flower-living, with individuals feeding on the reproductive structures of Malpighiaceae (Del Claro et al. 1997). Unfortunately, our limited knowledge of host-parasite relationships between *A. dictyotus* and *E. brasiliensis* does not allow an accurate estimation of the influence of ectoparasitism on membracid population levels and structures. This parasitic association is surprising and future studies will aim to examine the feeding and reproductive behaviour of *A. dictyotus* as well as the costs to *E. brasiliensis* in supporting the parasitic behaviour of thrips.

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