Phoretic behaviour of *Attacobius attarum* (Roewer, 1935) (Araneae: Corinnidae: Corininae) dispersion not associated with predation?

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*Attacobius attarum* spiders exhibit a phoretic behaviour on the winged sexual of *Atta* leaf-cutting ants during their mating flight. However, it is unclear if this behaviour is for dispersion or to facilitate the predation of ants in the new colonies. A nest of *Atta sexdens* was monitored on the day of the mating flight, and the winged ants, as well as the spiders, were collected. The results obtained corroborate the hypothesis that phoretic behaviour is commonly used for dispersion of the spider *A. attarum*, predominantly females. Of these spiders, 64 individuals of *A. attarium* were collected, of which 62 were females (96.9%) and two were males (3.1%). Regarding the winged leaf-cutting ants sampled, 378 females and 361 males were collected, totaling 739 individuals. Of these, 64 individuals (8.7%) had a spider attached to its back for phoretic dispersal and none was observed on the queens after the nuptial flight. In our study, *A. attarum* females perform phoretic dispersal into the environment on winged leaf-cutting ants but do not settle in the new nests.

**Keywords:** leaf-cutting ants; spider; phoresy; *Atta sexdens*

**Introduction**

The genus *Attacobius*, widely distributed in Brazil, is composed of the species *A. attarum*, *A. luederwaldti*, *A. nigripes*, *A. lamellatus*, *A. blakei*, *A. uiriri*, *A. tucuru*, *A. verhaagui*, *A. kitaе* and *A. carranca* (Brescovit and Bonaldo, 2005). These Neotropical spiders are called ground-running spiders because they dwell on the ground, and some species have a very unusual natural history. For example, *A. luederwaldti* and *A. attarum* exhibit a phoretic behaviour on leaf-cutting ants of the genus *Atta* spp. (Mello-Leitão 1923; Erthal and Tonhasca 2001; Ichninose et al. 2004; Brescovit and Bonaldo 2005). This behaviour is probably associated with dispersal, as seen in many other arachnids (Thomas and Jepson 1999). However, it is suggested that this behaviour is associated with parasitism in ant colonies; in other words, spiders prefer the winged female as they will establish new colonies, thus they can feed and breed.

This hypothesis is supported by the observations of Erthal and Tonhasca (2001), which state that the myrmecophytic spider is a predator of immature forms inside the nest of the host, *Atta sexdens*. However, no spider was found when the queens were...
founding their nests, or inside the initial nests of *Atta bisphaerica*, *Atta capiguara*, *Atta laevigata* or *Atta sexdens* (Ichninose et al. 2004). Surprisingly, *Attacobius sp.* was found inside the nest of *Solenopsis saevissima*, on males and females (Pesqueiro et al. 2011). However, the relationship of these spiders with ants remains unclear – whether it is just a phoretic dispersal behaviour of the species, or whether the spider is a predator of immature forms or a myrmecophile living inside the nests.

Here, we focus on the hypothesis that phoretic behaviour is commonly used for the dispersion of spiders, especially for females. Thus, a nest of *Atta sexdens* was monitored on the day of the mating flight, and the winged ants and the spiders were collected. Next, after the nuptial flight, the queens were observed during the foundation of the nest, to confirm the presence or absence of spiders. In addition, the sex of the spiders was determined and their body morphometry measured.

**Materials and methods**

A nest of *Atta sexdens* was monitored on the day of the mating flight (5 October 2013), from 13:00 to 17:00 h in a forest fragment located in Botucatu, SP, Brazil. A sample of 739 winged males and females, with and without spiders, were collected during this period, and then taken to the Laboratory of Social-Pest Insects of Faculdade de Ciências Agronômicas - Universidade Estadual Paulista – Botucatu. After the nuptial flight 350 queens that were collected in the beginning of digging process their nests.

The sexing was performed by direct observation, using a stereoscopic microscope, of male (palps) and female (epigyne) genital structures of the collected specimens. The H0 of equality of proportions between males and females was subjected to the Chi-square test (α = 0.05). The morphometric data included the body measurements of 64 spiders: the carapace (cp) and abdomen (ab) [length (Lcp) and width (Wcp) of the carapace, length (Lab) and width (Wab) of the abdomen]. They were then analysed with a hybrid clustering algorithm for multivariate observations composed of two steps. In the first step, the K-means clustering procedure was used to obtain a histogram of density estimate over the partition k of the sampled space. In the second step, the matrix of distances between k clusters was determined and the single linkage clustering algorithm was applied to the matrix to obtain the dendrogram of the cluster samplings (Wong 1982).

The specimens were deposited in the collection of spiders of the Butantan Institute (Curator: Y. Cury).

**Results**

Sixty-four individuals of *A. attarum* were collected, of which 62 were females (96.9%) and two were males (3.1%), which was a significant female bias ($\chi^2_{1,0.05} = 28.125$). For the females, the morphometric measurements were: carapace length of 1.55 ± 0.30 mm and width of 1.38 ± 0.26 mm, abdomen length of 1.98 ± 0.39 mm and width of 1.45 ± 0.22 mm (N = 62). For the males, the measurements were: carapace length of 1.56 ± 0.19 mm and width of 1.31 ± 0.06 mm, abdomen length of 2.31 ± 0.31 mm and width of 1.44 ± 0.06 mm (N = 2).

Regarding the winged cutting ants sampled, 378 females and 361 males were collected, totaling 739 individuals. Of these, 64 individuals (8.7%), queens, had spiders phoretically attached on their back (Figure 2). The grouping of the variables
demonstrated the existence of only one population. The presence of an outlier (individual 20) is the appropriate hypothesis to explain the existence of a single group composed of a single individual.

The spiders were on the mound nest made of soil, then climbed onto the queen’s back and then attached to the pronotum region (Figure 1). Three hundred and fifty queens were collected after the nuptial flight, and none had a spider on their back, as the spiders were probably dispersed during the removal of the queen’s wings, or possibly during the mating flight (Figure 2).

**Discussion**

Undoubtedly, the *A. attarum* spiders perform phoretic dispersal in the environment attached to winged leaf-cutting ants. It was observed that about 9% of the winged ant samples had a spider attached onto its back, similar to the 11.1% reported by Ichninose et al. (2004). In general, the dispersal of spiders by ballooning is quite effective, as observed in linyphiid spiders (Linyphiidae) which can reach up to 30 km distance (Thomas et al. 2003).
From an evolutionary perspective, phoresy represents energy savings (in silk production) and reduces the risk of predation, because it is an association between individuals of different species in which one uses the other for transport, without harming it (Dajos 2005). However, leaf-cutting ant sexuals suffer a high mortality during their mating flight from bird predators (Autuori 1942).

In the literature, it is known that the distance traveled by winged leaf-cutting ants varies according to the species and to the speed they reach in the air flow. For example, Jutsum and Quinlan (1978) observed that females of *Atta texana* flew at a speed of 5.33 ms\(^{-1}\), suggesting a distance of 10.4 km; *Atta sexdens* at a speed of 1.57 ms\(^{-1}\), with a possible distance of 11.1 km; and field observations have shown dispersal of the queens of 9.6 km for the same species (Cherrett 1968).

Figure 2. Behavioural repertoire of *Attacobius attarum* for dispersion in *Atta sexdens*: (A) female spider in bunch of loose soil from the nest of leaf-cutting ant, in search of a winged male; (B) approximation of female of leaf-cutting ants before the mating flight; (C) climbing of the spider to the dorsal region of winged female; (D) spider detail on the back of the queen; (E, F) winged male and female of leaf-cutting ants are preparing for the mating flight with phoretic spiders on their pronota.
Another interesting result was the higher frequency of females collected (97%) than of males (3%) performing phoresy on winged leaf-cutting ants. It is known that females require a high-quality habitat, new resources and a stable microclimate for the production of eggs and for the survival of immatures, as opposed to the males that are just looking for a mating partner (Thomas and Jepson 1999). This observation supports the hypothesis discussed by Decae (1987) regarding the founder hypothesis, which suggests that natural selection will favour an individual that leaves a fairly crowded habitat to colonise an empty one, with its descendants.

However, the aerial dispersion of immatures is more often known among spiders because they seek new, less populous locations, and also because they have a tendency to cannibalise other individuals after hatching (Duffey 1956; Bishop 1990).

Regarding predation, in our study, no queens were found after the mating flight to have a spider attached, suggesting that spiders probably dispersed during the removal of the wings of the queen, or during the mating flight. This report contradicts the findings of Erthal and Tonhasca (2001), which state that the myrmecophytic spider is a predator of immature forms inside the nest of the host, *Atta sexdens*. However, our results support the results obtained by Ichinose et al. (2004), who found no spiders in the initial 100 nests excavated, suggesting that the spiders jump from the winged ants during the flight and are dispersed by the wind to colonise new habitats.

In our study, the spiders (*Attacobius attarum*), especially the females, performed phoretic dispersal in the environment, attached to winged leaf-cutting ants. However, new studies should be performed in order to investigate the natural history of these organisms.

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