DOI: 10.13102/scb11292 FIELD NOTE

When spiders take over: the expulsion of giant Amazonian ants from their nest

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Abstract – Spiders have been documented using nests of various ant species. In this study, we recorded the non-harmonious use of a nest and the expulsion of giant Amazonian ants from their nest by a *Diplura* spider. Both species inhabit South American forests, including the Amazon rainforest and Cerrado. This event took place in the northern Cerrado of Brazil during the rainy season. The expropriation process lasted 13 days, beginning with the simultaneous occupation of the anthill and culminating in the complete eviction of the ants. Over the last two days, we observed intense ant activity at a second entrance to the anthill and the construction of a new nest. We propose that the funnel-web spider was using the ant nest as shelter. However, the simultaneous coexistence may have been limited due to the spider web blocking an entrance and dietary overlap leading to competitive exclusion.

Additional keywords: territoriality, *Diplura*, *Dinoponera gigantea*, Cerrado.

Ant interactions with other animals are highly complex, often involving ants that construct structurally stable and long-lasting nests (Kronauer & Pierce 2011). These interactions range from non-mandatory nest occupation, as seen with *Strumigenys perparva* Brown, 1958, and *Pseudomyrmex pallidus* (Smith, 1855) in *Dinoponera gigantea* (Perty, 1833) nests (Moreira et al. 2020), to associations with earthworms, millipedes (both Chilopoda and Diplopoda), collembolans, acari, and other arthropods in *Formica rufa* (Perty, 1883) nests (Parmentier et al. 2014). Additionally, there are cases of simultaneous space use by ants, such as *Pheidole* Westwood, 1839, and *Dinoponera quadriceps* Kempf, 1971 (Vasconcelos et al. 2004). However, determining whether a species is a facultative or obligate associate can be challenging due to limited records of species occupying the nests (Parmentier et al. 2014).

Arthropods have been observed utilizing the nests of various ant species across different ecological contexts. Symbiotic associations include Isopoda and Acari in the detritus chambers of *Ectatomma brunneum* Smith, 1858 (Lapola et al. 2003), the spider *Masoncus pogonophilus* Cushing, 1995, with the Florida harvester ant, *Pogonomyrmex badius* (Latreille 1802) (Cushing 1997), and spiders, springtails, silverfish, and snails with *Leptogenys distinguenda* (Emery, 1887) (Witte et al. 2008). Additionally, parasitic associations are common between Ponerinae ants and the Strepsiptera insect *Myrmecolax incautus* Oliveira & Kogan, 1959 (De Bekker et al. 2018). Additional examples include the fly *Apocephalus paraponerae* Borgmeier, 1958, parasitizing deceased ants of *Paraponera clavata* (Fabricius, 1775) (Brown & Feener 1991) and the ant *Polyrhachis loweryi* Kohout, 1990, exploiting the nests of *Rhytidoponera* Mayr, 1862 (Maschwitz et al. 2003). Mutualistic associations between ants and other arthropods have been documented with Hemiptera (Way 1963; Mouratidis et al. 2021) and with trophobionts (Freitas & Rossi 2015). However, the expropriation of ants from their nests by other arthropods has not been previously described. In this study, we report the expulsion of a *Dinoponera gigantea* population from its nest by funnel-web spider (Araneae: Mygalomorphae).

Dinoponera Roger, 1861, ants are the largest known ants globally (Fourcassié et al. 1999), with worker ants in most species exceeding 3 cm in total body length (Lenhart et al. 2013). Native to South America, these ants are commonly referred to as giant Amazonian ants or tocandiras. They are generalist predators, feeding on small arthropods and plant material (Fourcassié & Oliveira 2002). In addition to their solitary foraging behavior and lack of recruitment among workers, *Dinoponera* ants primarily rely on visual cues from their environment to navigate foraging routes (Fourcassié et al. 1999).

The activity budget of *D. gigantea* is negatively correlated with external temperature (Silva et al. 2017). Their nests in the Amazon are typically located at the base of palm trees or thick lianas, usually featuring eight entrances with diameters ranging from 3 to 8 cm, and varying numbers of chambers. There are also records of polydomic nests (Fourcassié & Oliveira 2002). These nests can cohabit with various arthropods, including other insects and arachnids (Moreira et al., 2020).

The genus *Diplura* C. L. Koch, 1850 consists of mygalomorph spiders belonging to the family

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Corresponding editor: Alessandro Rapini
Submitted: 1 Sep. 2024; accepted: 29 Oct. 2024
First published: 8 Nov. 2024; final version: 18 Nov. 2024

Dipluridae, with a Neotropical distribution extending from southern Panama to northern Argentina (Pedroso et al. 2016). This family includes species of various colors and sizes that prey on beetles, crickets, ants, millipedes, and occasionally on the remains of other animals, such as frogs (Vollrath 1978). According to Raven (1985), a key diagnostic feature of *Diplura* is the maxilla with lyra, formed by a single row of clavate setae (see Pedroso et al. 2016: Figs 10–12).

During a study on the feeding behavior of *D. gigantea*, we documented the process of ant expropriation by *Diplura* sp. The research was conducted in the northern Cerrado of Brazil, specifically in Chapadinha, Maranhão, Brazil (03°44'01.1"S, 43°19'12.0"W), from January 5 to December 5, 2019. Weekly observations were made of five ant colonies during this period, with each colony being observed once a week in alternate weeks from 7:00 to 8:30 AM using *ad libitum* observations (Bateson & Martin 2021). The simultaneous occupation of a nest by both taxa began on April 2, 2019, at 7:20 AM and continued for 13 consecutive days. Following the initial occupancy, we conducted daily observations until the ants completely vacated the nest. During this period, the spider acted as a tenant while the ants accessed the nest through a secondary entrance (Figure 1A). The total observation time for the ants' diet in the five colonies was 180 hours, with the observation of the nest expropriation by the spider spanning from April 2 to April 14, 2019, amounting to approximately 17 hours. We calculated the daily number of foraging ants before the spider occupation using the median from January to March 2019, and we counted the maximum number of ants per day from the first day of occupation, from April 2 until the total evacuation of the nest.

Before the spider occupied the nest, there was a median of 7 (Minimum: 6; Maximum: 10; 25º percentile: 6; 75º percentile: 8; N=13) ants foraging. The process of expropriating *D. gigantea* nests is described in the following timeline:

Day 1. We observed the spider at one of the entrances to the *D. gigantea* nest, where it remained motionless on the ground. Meanwhile, the ants could freely access the nest through other adjacent entrances and foraged around the nest without any interference from the spider. Number of ants: 7.

Days 2–5. The spider remains at the entrance of the nest, making small movements, occasionally entering the nest, and then returning to the entrance, leaving only its first pair of legs and thorax exposed outside the anthill. Number of ants: 9, 7, 7, 8 between second to fifth day, respectively.

Day 6. The spider was not observed at the nest entrance or around *D. gigantea* during the daytime; however, we did not access the deeper parts of the anthill. Number of ants: 10.

Days 7–8. The spider returns to the nest entrance and exhibits more active behavior, briefly leaving the entrance to remain inactive about 5 cm away, but quickly returning. Number of ants: 7 and 6, respectively.

Day 9. The activity rate of *D. gigantea* workers entering and leaving the nest decreased compared to previous occupation of the spider. Meanwhile, the spider remained at the nest entrance and began constructing a web around it. Number of ants: 3.

Days 10–11. The activity rate of *D. gigantea* dropped, with only two workers entering and leaving the nest over these two days. The spider's web covered the entire entrance and surrounding area of the nest (Figure 1B). When ants touched the web, the spider would emerge from the nest entrance, quickly approach the ant without touching it, raise the front legs defensively, and then return to the nest.

Days 12–13. On the 12th, a *D. gigantea* worker was observed getting caught in the web, which prompted the spider to approach the ant. However, the ant quickly freed itself from the web and moved away, while the spider returned to the entrance of the nest. The spider continued to stay at the entrance, which remained heavily covered with webs. During this time, no worker activity of *D. gigantea* was observed at the entrance of the nest occupied by *Diplura* sp. In contrast, the second entrance of the nest showed intense worker activity as they began constructing a new nest 2.5 meters away (Figure 1C). Over these two days, the ants were actively involved in building the new nest, forming lines, and transporting branches and pieces of clay.

Days 14–16. The nest was exclusively occupied by the spider, and from that point on, the ants were only observed being active in the new nest.

Over the four years leading up to this record, we monitored several *D. gigantea* nests in the Yellow Latosols of the Cerrado in northeastern Brazil. We observed that these ants remain in their nests for extended periods, with the exact duration still unknown but surpassing four years of fidelity. During this time, the ants not only maintain their nests but, in some cases, also expand them by constructing additional polydomic structures.

The spider *Diplura* occupied the first chamber of the nest, displacing the ants and remaining there until June 2022, when the nest was excavated. Although the spider could not be collected during the excavation, it was confirmed that it had occupied and used the first chamber. During the excavation, the spider moved to deeper chambers when it was found again. Some chambers and galleries were likely filled in due to a lack of maintenance and the influx of rainwater-carrying sediment.

Interactions between ants and other arthropods, particularly spiders, suggest that these animals often use ant nests as shelters. For instance, Fourcassié et al. (1999) reported the presence of small spiders and other arthropods in *D. gigantea* nests. Similarly, Moreira et al. (2020) observed a strong presence of mites and spiders in nests of *D. gigantea*, *D. lucida* Emery, 1901, and *Paraponera clavata*. The ant-associated spider

Figure 1. *Diplura* spider and *Dinoponera gigantea* ant nest in the leaf litter of the Cerrado in Northeast Brazil: **A-** spider positioned at one of the nest entrances (the red arrow indicates the secondary entrance); **B-** complex silk refuge constructed by the spider at an ant nest entrance; **C-** second ant nest, established and inhabited after the spider occupied the initial site.

Gamasomorpha maschwitzi Wunderlich, 1995, found in nests of *Leptogenys distinguenda*, preys on insects captured by the ants and has a minor negative impact on the ants' feeding (Witte et al. 1999; Witte et al. 2008). In *D. lucida* nests, Peixoto et al. (2010) also documented a harmonious presence of spiders within the colony. Conversely, Mendonça et al. (2019), studying the myrmecophily and myrmecophagy of *Attacobius* Mello-Leitão, 1925, in *Solenopsis saevissima* (Smith, 1855) colonies, observed that spiders preyed on the eggs, larvae, and pupae of this ant species. Additionally, larvae of *Oecophylla smaragdina* (Fabricius, 1775) are consumed by *Cosmophasis bitaeniata* (Keyserling, 1882) spiders (Allan & Elgar 2001). *Diplura* can also take advantage of shelters within the nests of other animals, such as birds (Gouveia et al. 2012), as well as plants (Brescovit et al. 2021: Fig. 3E, F).

The generalist diet of *D. gigantea*, combined with its predatory behavior (Fourcassié et al. 1999), may overlap with the diet of *Diplura* sp., potentially leading to competitive exclusion. Another hypothesis is that the spider's construction of a tube-shaped web at the nest entrance may create a physical barrier, thereby limiting and disrupting the ants' activity.

The coexistence of spiders and ants—whether sharing resources, occupying nests in a tenant-like manner, or competing for territory—illustrates the vast diversity of ecological relationships between these groups that remains to be explored. We suggest that future research should investigate these hypotheses to understand why giant Amazonian ants do not coexist with funnel-web spiders in the long term.

ACKNOWLEDGEMENTS

We are grateful to Dr Rogério Bertani from the Laboratory of Ecology and Evolution at Instituto Butantã, Brazil, for identifying the genus of the *Diplura* spider. We also thank two anonymous reviewers for their insightful comments and suggestions. The research was financed by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior-Brasil (CAPES: Finance Code 001).

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