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Research article

Relationships between the ant *Brachymyrmex obscurior* (Hymenoptera, Formicidae) and *Acacia pennatula* (Fabaceae)

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Summary. In central Mexico, the ant *Brachymyrmex obscurior* Forel feeds on nectar produced by extrafloral nectaries of *Acacia pennatula* (Schlecht. & Cham.) Benth. However, no studies have determined whether the ant´s visitation is related to plant nectar availability and whether ants protect *A. pennatula* from herbivory. The objectives of this 2-yr study (2000–2001) were to assess whether seasonal changes in ant visitation coincide with extrafloral nectar productivity in *A. pennatula* and to determine whether ants protect the plant. At the end of the dry season (April–June) *B. obscurior* was the only ant species on *A. pennatula* and extrafloral nectar production is limited to this period. Exclusion experiments, performed at the end of the dry season showed that *A. pennatula* did not receive a protective benefit when visited by ants. Branches with ants and branches where ants are excluded had similar numbers of the nonmyrmecophile leafhopper *Sibovia* sp. which was the only herbivore observed under natural conditions.

Key words: *Brachymyrmex*, *Acacia*, ants, extrafloral nectaries, nectar.

Introduction

In central Mexico, during the wet season the ant *Brachymyrmex obscurior* Forel (Hymenoptera: Formicidae) is associated with the myrmecophilous leafhopper *Dalbulus quinquenotatus* Delong & Nault (Hemiptera: Cicadellidae) on the basal green leaves of the gammagrass *Tripsacum dactyloides* L. (Moya-Raygoza and Larsen, 2001). At the end of the dry season, tending ants moved to nearby plants of *Acacia pennatula* (Schlecht. & Cham.) with extrafloral nectaries, because all *T. dactyloides* had died and *D. quinquenotatus* dispersed. However, Moya-Raygoza and Larsen (2001) did not describe whether the ants´ switch to extrafloral nectaries was associated with plant nectar availability. Therefore, the first objective of this study was to correlate the visitation of *B. obscurior* with the phenology of extrafloral nectaries produced by *A. pennatula*.

Previous studies showed that nymphs and adults of *D. quinquenotatus* provide honeydew to ants, which in return protect the leafhoppers from predators (Moya-Raygoza and Nault, 2000; Larsen et al., 2001). But possible protection for *A. pennatula* against herbivory at the end of the dry season, when *B. obscurior* visits the extrafloral nectaries, has not been examined. To understand the ant-extrafloral nectary interaction, one of the first steps is to determine whether ants protect the plant from herbivory, because in some insect-plant relationships this protection may not occur (Cushman and Beattie, 1991). Buckley (1983), Heads (1986), Oliveira et al. (1999), and Ruhren (2003) determined that ants obtain food from plants with extrafloral nectaries but that ants do not protect the plants against some herbivores. Consequently, the second objective of this study was to determine whether *B. obscurior* protects *A. pennatula* in order to study the nature of the interaction between the plant bearing extrafloral nectaries and ants during the end of the dry season.

Materials and methods

This 2-year study (2000 and 2001) was conducted in San Agustin, Jalisco state, Mexico. The study site was at 969 m, latitude 20°30′ N, longitude 103°28′ W, and 20 km south of Guadalajara City, in central Mexico. In San Agustin, a population of *T. dactyloides* grows among several other species of herbs and trees, including *A. pennatula*. San Agustin has two seasons per year. The wet season generally spans from June to September and the dry season from October to May (Moya-Raygoza, 1995). April and May are the driest months, reaching temperatures close to 25 °C. No rainfall occurred in these two months during 2000 and 2001. The wet season begun the first week of June in both years, reaching an average of 5 mm of rainfall per month.

There were only five *A. pennatula* trees located at my field site. Mean (minimum; maximum) height of the trees was 3.3 m (2.5; 4.2),

trunk diameter of 7.6 cm (4.2; 10.0) and, distance between neighboring trees 21.2 m (5.0; 53.0). Four branches per tree (total of 20 branches) were selected using a random numbers table. Each of these branches was marked 20 cm from the apex and ants (*B. obscurior*) had unrestricted access to them. The study site was selected because *B. obscurior* was the only ant present and *A. pennatula* the only plant with extrafloral nectaries. The mark was made with an indelible marker pent and the mark did not affect ant behavior (pers. obs.). Counts were made for the distal 20 cm of each selected branch so as to have similarly sized measurement units for each branch.

The *A. pennatula* branches were selected on 1 January, 2000, and the number of leaves, extrafloral nectaries and ants was recorded every two weeks between 14:00 and 18:00 h from January to July 2000 and 2001. No data were taken between August and December 2000 and 2001 because during this period, ants tend *D. quinquenotatus* but do not visit extrafloral nectaries of *A. pennatula* (Moya-Raygoza and Larsen, 2001). *Acacia pennatula* starts producing active extrafloral nectaries on the young leaves in April (McVaugh, 1987), thus such plants may be attractive to ants during this time.

In the same five *A. pennatula* trees, four additional branches per tree (total of 20 branches) were selected on 1 January 2000. Each of these branches was adjacent and similar in size to branches with ants. Ant were excluded from these branches by applying a band of Fluon ADI (ICI Company, Charolette, NC) 20 cm from the apex of the branch.

In the 20 branches with ants present and in the 20 branches with ants absent, the number of herbivores was recorded every two weeks between 14:00 and 18:00 h from January to July 2000 and 2001. Statistical evaluation of the number of herbivores on branches with ants and without ants was made by Wilcoxon matched pairs test.

Results and discussion

In the driest months (April–June), *A. pennatula* produced young green leaves with active extrafloral nectaries (Fig. 1A, B), and the number of ants (*B. obscurior*) averaged two per branch in 2000 and three per branch in 2001 (Fig. 1C). *Brachymyrmex obscurior* was the only ant species observed visiting extrafloral nectaries of young leaves on all the trees and not only on the sampled branches. The first days of July, after the wet season began, *A. pennatula* extrafloral nectaries stopped producing nectar and ants started to abandon *A. pennatula*. This 3 months (April–June) period is the more likely time when ants can protect *A. pennatula* because it does not produce food resource (nectar) for attracting ants the rest of the year. Also, a short period of extrafloral nectary activity has been found in *Acacia decurrens* (Wendl.) Willd. (Buckley, 1983) and in *Populus* (Tilman, 1978).

Exclusion experiments conducted on *A. pennatula* showed that ants did not protect the plant from the herbivorous leafhopper *Sibovia* sp., even on young leaves with active extrafloral nectaries. Numbers of adult *Sibovia* sp. were similar during the driest months of 2000 (Wilcoxon matched pairs test; T = 49.50, Z = 0.18, $P = 0.85$) and 2001 (T = 59.00, Z = 0.46, $P = 0.64$) whether ants were present or excluded (Fig. 2). *Sibovia* sp. was the only herbivore found on the branches sampled, and no chewing insects were observed during the first and second year of the study. Also, no chewing insects could attack the plant during a 24 h cycle, because no chewing damage was observed on the sampled branches. I observed that *Sibovia* sp. is a non tended leafhopper without gregarious and sedentary behavior. *Sibovia* sp. is a xylem-feeding hemipteran and does not produce honedew suggesting that there is no mutualism between ants and *Sibovia* sp. (C. Dietrich, pers. comm.).

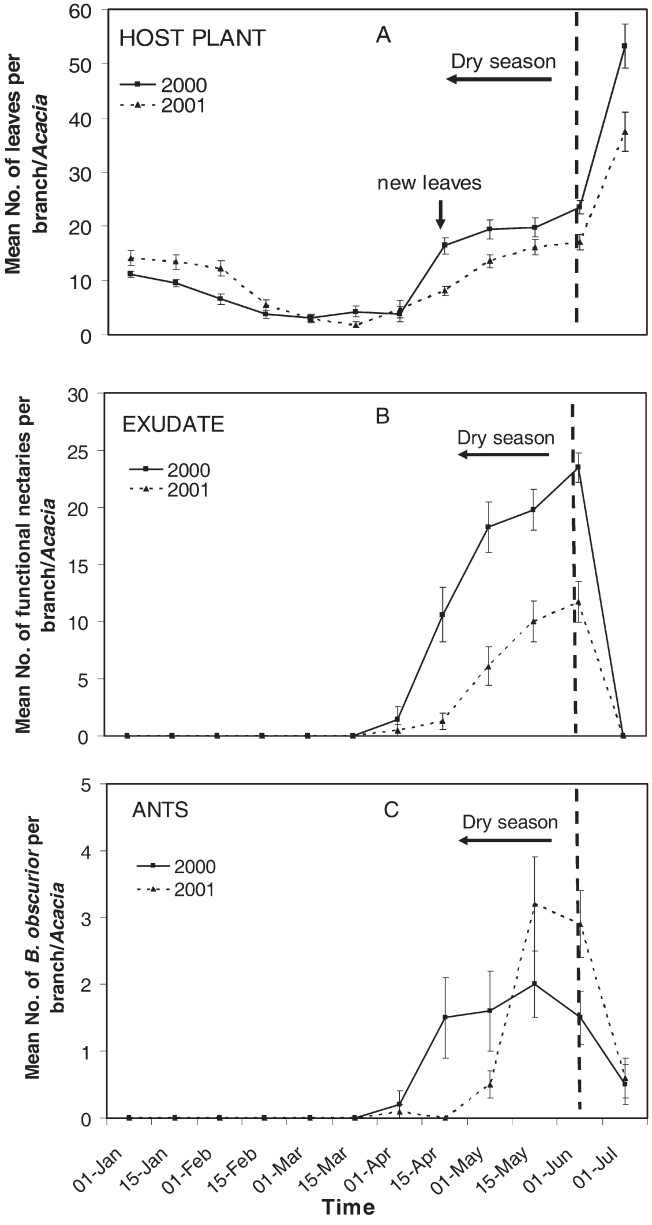

Fig. 1. Mean number of leaves (A), functional nectaries (B), and visiting ants (C) on *A. pennatula* during 2000 and 2001. Bars show standard error. Dashed line shows the division between dry and wet season. n = 20 branches.

This is the first study that shows a plant with extrafloral nectaries provides food for ants but the ants do not protect the plant against a sucking nonmyrmecophile leafhopper as *Sibovia* sp. A lack of protection of plants has been found in other studies with several types of herbivores as well. For example, the aphid *Macrosiphum ptericolens* Patch and internally feeding miners and gall formers were immune to ants that visited extrafloral nectaries of bracken fern (Heads, 1986). Similarly, ants are ineffective against gall wasps in *A. decurrens* with extrafloral nectaries (Buckley, 1983). Cladodes of

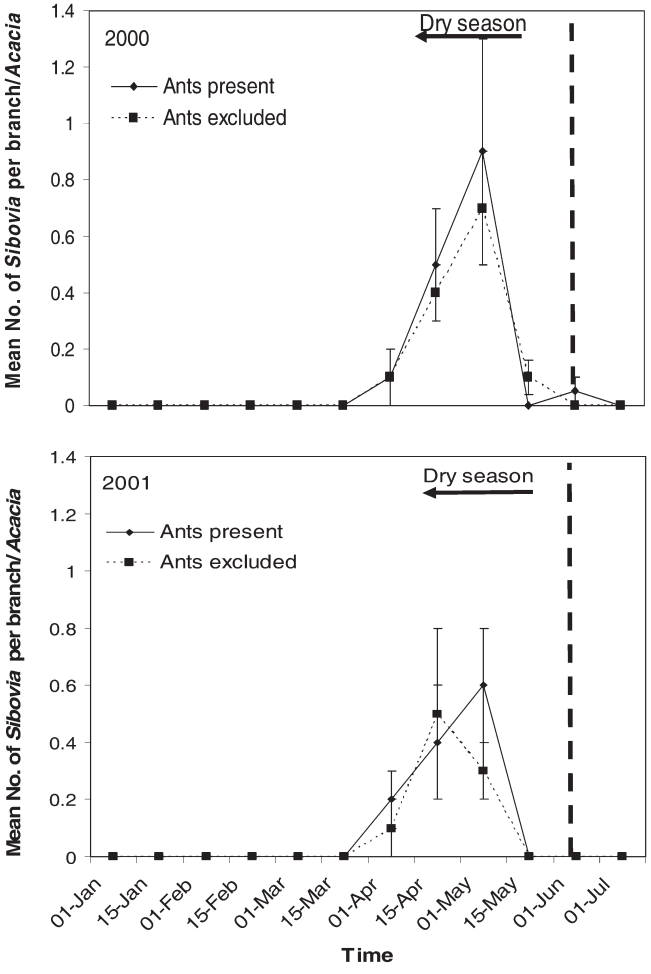

Fig. 2. Mean number of nonmyrmecophilous leafhoppers (*Sibovia* sp.) on *A. pennatula* when ants (*B. obscurior*) are present or excluded (2000 and 2001). Bars show standard error. Dashed line shows the division between dry and wet season. n = 20 branches.

Opuntia bearing extrafloral nectaries were equally infested by sucking bugs and mining dipterans when ants were present or excluded (Oliveira et al., 1999). Thus, the interaction between the plant with extrafloral nectaries and ants is highly variable. Ants that receive food from a plant may or may not provide protective benefits (i.e., against herbivores) (Koptur and Lawton, 1988; Hölldobler and Wilson, 1990; Del-Claro and Oliveira, 1993; Speight et al., 1999).

The contrast between the ant-*D. quinquenotatus* interaction (where ants provide protection against leafhopper predators) and the ant-*A. pennatula* interaction (where ants evidently do not produce protection against *Sibovia* sp.) could be because honeydew secretion by *D. quinquenotatus* is more continuous throughout an annual cycle. Ants interact with the leafhopper from July to March, whereas ants visited *A. pennatula* between April and June. Fiala (1990) and Blüthgen et al. (2000) concluded that honeydew is more constant throughout time than nectar; therefore the permanency of the ant colony is influenced positively when ants tend the leafhopper. Other explanation for observed relationships is that the honeydew produced by *D. quinquenotaus* is concentrated at the basal two or three leaves of *T. dactyloides*, so the food resource concentration offered by the leafhopper favors ant protection. Although the nectar produced by *A. pennatula* nectaries is distributed throughout the tree, ants are unable to patrol the larger surface area of the tree at a level high enough to limit herbivory.

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