

SHORT COMMUNICATION

**Effect of herbivore deterrence by ants on the fruit set of an extrafloral nectary plant, *Qualea multiflora* (Vochysiaceae)**

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There are many definitions of extrafloral nectaries (EFNs), but those that define EFNs as nectaries that are not involved in pollination (e.g. Fiala & Maschwitz 1991) could be the most simple and correct- EFNs have been recorded from more than 93 angiosperm families (Elias 1983, Koptur 1992) in at least 2200 species (Keeler 1989). These glands secrete nectar that attracts many ant taxa, mainly Myrmicinae, Formicinae and Dolichoderinae (Oliveira & Brandão 1991). Many authors have demonstrated that the associations between ants and EFNs are beneficial to the plant. In these cases ants feed on nectar and protect the plants against several types of herbivores (Bentley 1977, Horvitz & Schemske 1984, Koptur 1984). Nevertheless, Boecklen (1984), O'Dowd & Catchpole (1983) and Rashbrook *et al.* (1992) showed that in some systems ants are ineffective anti-herbivore agents. The role of EFNs acting against herbivores is still under discussion (Bentley 1977, Koptur 1992).

Plants bearing EFNs may account for up to 31 % of the woody individuals and 25% of the woody species in the cerrado community of Brazil (Oliveira & Oliveira-Filho 1991). Although cerrado is a well-defined vegetation occupying one-fifth of the Brazilian territory, only a few studies have examined the relationships between plants and insects in this vegetation. Oliveira *et al.* (1987)

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provided the first experimental evidence suggesting that ants can potentially deter herbivores from plants with EFNs in the cerrado. More recently Costa *et al.* (1992) demonstrated that ants limit herbivore damage on leaves of the extrafloral nectary tree *Qualea grandiflora* Mart. In this study we worked with *Qualea multiflora* Mart. (Vochysiaceae), a common cerrado tree bearing paired EFNs on the stem next to the insertion of the leaves, and on the bud pedicels. To our knowledge, our study provides the first experimental evidence showing that herbivore deterrence by visiting ants can increase the reproductive output of a plant in the cerrado.

Field work was done between October 1993 and February 1994 in cerrado vegetation (*sensu stricto* Goodland 1971) in Uberlândia, Minas Gerais state, south-eastern Brazil (18° 57' S, 48° 12' W). *Qualea multiflora* is locally common and occurs at a density of nearly 73 individuals ha<sup>-1</sup>.

To evaluate whether ants attracted to the EFNs of *Q. multiflora* reduce the action of herbivorous insects on the plants, two experiments were performed. In the first experiment (October 1993, beginning of the rainy season), 30 trees (1-4 m tall) were tagged within a plot of 0.2 ha to form 15 plant pairs. The plants of each experimental pair had the same height and number of stems and were in the same phenological state. All individuals were producing young leaves. Plants in each pair were assigned randomly as treatment or control by the flip of a coin. Ants had free access to control plants. Treated trees had their trunks banded (30 cm above ground) with a sticky resin (Tanglefoot®) which impeded the access of ants. Everything that could be used by ants to climb on the treatment plant, such as grass bridges and stems of neighbouring plants, were also removed. Plants were checked weekly to ensure that ants were indeed being excluded from treated *Qualea*. During all field work we made observations on nectar-gathering behaviour by ants at EFNs of control plants. At each observation (weekly) of treated and control plants we also registered the number, species and behaviour of herbivorous insects on all plant parts. Herbivores and ants were also collected on non-experimental *Qualea* trees.

To estimate the leaf damage caused by insects, 10 leaves of the same size were collected from each treated and control plant (three leaves from the top, four from the middle and three from the lower branches). Folivory was evaluated prior to ant exclusion (October), and then three months later (January). Measurements of herbivory rates on leaves were assessed by placing them on a transparent grid (divided into millimetres). An index of herbivory from each leaf was estimated as the proportion of points in the grid falling within damaged and undamaged areas of the leaf blade. A mean herbivory index for each tree was calculated. The results showed that plants of each experimental category did not exhibit significant differences in degree of folivory in October. After 90 d, herbivory increased significantly in both control and treated groups. Antexcluded plants, however, showed higher leaf damage than did plants with free ant access (Figure 1). We observed many species of leaf herbivores, mainly Coleoptera, Homoptera and Hemiptera. We did not observe ant-Homoptera

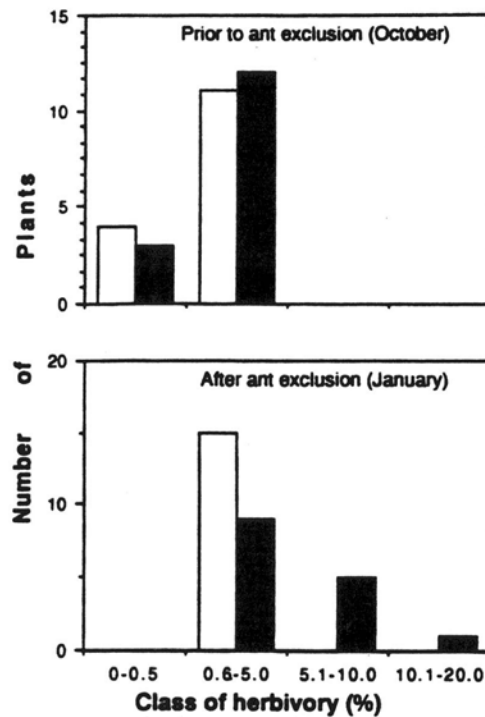


Figure 1. Amount of leaf damage to control (open) and treated (shaded) *Qualea multiflora* trees ( $n = 15$  trees in each experimental group). Prior to ant exclusion there was no statistical difference in the amount of leaf damage between control and treated plants ( $P > 0.05$ ), but after the ants had been excluded from treated trees this was significantly different ( $P < 0.001$ ). Leaf damage increased from October to January within both control ( $P < 0.001$ ) and treated ( $P < 0.001$ ) trees, Mann-Whitney U-tests.

interactions on plants during the study. So ants were attracted to *Qualea* trees only by the presence of EFNS. Leaf herbivores were significantly more abundant on plants without ants than on plants with ants (Table 1).

In a second experiment we investigated the effect of ant visitation to *Q. multiflora* on the reproductive output of the plant. Using the same 15 experimental plant pairs, we tagged one inflorescence on each plant of the 10 experimental pairs that flowered during November. Nearly the same number of buds were marked in each plant of a pair. In February we registered the number of fruits formed per buds produced in each experimental group. In *Q. multiflora*, the fruits are loculicide capsules with between 10 and 18 samaroid winddispersed seeds. The results showed that damage to buds and flowers was also significantly greater on ant-excluded plants. Plants with free ant access produced almost twice as many (1.7 times) fruits per buds than did treatment plants (Table 1). The beetle *Macrodactylus pamilio* Burm. (Scarabaeidae: Melolontinae) was the main herbivore on buds and flowers of *Q. multiflora*. This beetle eats petals and other floral parts and was significantly more abundant

Table 1. Number of herbivores (mean  $\pm$ SD) observed during experiments of ant exclusion and fruits formed per buds produced on experimental groups of *Qualea multiflora*.

	Plants with ants	Plants with ant excluded	P
Herbivores found on leaves (n = 15)	10.8 $\pm$ 1.93	17.7 $\pm$ 4.46	<0.001 <sup>a</sup>
Herbivores found on buds and flowom (n = 15)	0.87 $\pm$ 0.92	2.27 $\pm$ 0.96	<0.005 <sup>a</sup>
Fruits per buds (n = 10)	107/222 0.48 $\pm$ 0.17	76/292 0.27 $\pm$ 0.14	<0.005 <sup>b</sup>

<sup>a</sup> Wilcoxon signed ranks test.

<sup>b</sup> Mann-Whitney U-test.

on ant-excluded plants (72% of observations) than on control plants (28%,  $\chi^2$ ,  $P < 0.005$ ).

Extrafloral nectaries occur more commonly on vegetative parts of plants (Koptur 1992, Oliveira & Leitão-Filho 1987). However, demonstrations of ant defence against herbivores are associated more frequently with nectaries that occur near flowers and fruits by representing a strong relationship with plant fitness (Keeler 1989, but see also O'Dowd & Catchpole 1983). Our results showed that ants attracted to the EFNs of *Q. multiflora* effectively reduced herbivore damage to leaves and reproductive parts of the trees, increasing the fruit set of this plant species. An analysis of the floristic composition of 26 cerrado areas in Brazil (Ratter & Dargie 1992) showed that the *Qualea* genus was the most widespread with 23 records (*Q. multiflora*, 16 records). We believe that the association with ants could be one of the most important factors in the success of *Qualea*. In the case of *Q. multiflora*, the sixth most abundant tree in the cerrado of Uberlândia, the main factor in maintaining its abundance could be a good production of seeds which is a result of the floral herbivore deterrence of the beetle *M. pumilio* by visiting ants. The increase of the rate of folivory on *Qualea* trees in January was related to an increase in the insect fauna in summer. The herbivore fauna can change (in species composition and number) between localities and seasons at the same areas (Marquis & Braker 1994).

We observed a total of 435 ants gathering nectar at extrafloral nectaries of *Q. multiflora*. The most abundant ants belong to the genus *Camponotus* (three species, 42.3% of the individuals). *Zacryptocerus pusillus* Klug was the second most abundant ant observed (19.8%), followed by *Pseudomyrmex* sp. (16.5%), *Solenopsis* sp. (13.1%), *Crematogaster* sp. (7.1%) and *Ectatomma permagnum* Fabr. (1.2%). The observation that *Camponotus* ants were the most frequent visitors at *Qualea* EFNs confirms the superiority of this ant genus as visitors to EFN bearing plants in many tropical areas (Costa et al. 1992, Oliveira & Brandão 1991, Oliveira et al. 1987, Rico-Gmy 1993). We know that *Camponotus* is also the most common genus in ant-homoptera interactions in cerrado vegetation (Del-Claro & Oliveira 1993). Three factors may have favoured the higher frequency of *Camponotus* on *Q. multiflora*. First, high abundance could have been

caused by the ant's natural abundance in cerrado vegetation. Second, the density of homopterans tended by ants in cerrado is small between October and February (Del-Claro 1995). Ants that use plant liquid food resources (floral and extrafloral nectar, homopteran honeydew) can change their sources in different seasons (Rico-Gray 1993). Third, the *Camponotus* abundance in EFNs of *Qualea* trees could also be the result of the competitive superiority of this ant genus. The *Camponotus* genus in the New World are generalists, feeding on plants, homopteran honeydew and carrion. Thus, they could compete intensively for resources with a variety of other ants (Davidson & McKey 1993).

During the reproductive season of *Q. multiflora* the richness and abundance of ants increased on flowering individuals. The ants climb in greater numbers to inflorescences, where there are more active EFNs than on branches, which could be a plant strategy to obtain better protection to the reproductive structures. Also, the nectar of bud pedicel EFNs could be of better quality than that of leaves. Parts of a same plant can differ in quality and attractiveness to herbivorous insects (Risebrow & Dixon 1987). Schemske (1982) discussed that differences in ant species richness on extrafloral nectary plants were not a function of plant distribution, the volume or composition of extrafloral nectar or the duration of nectar flow, but were positively correlated with inflorescence height.

Many studies have shown that ants protect EFN-bearing plants against herbivores, increasing their reproductive success in different parts of the world (Bentley 1977, Davidson & McKey 1993, Keeler 1989, Koptur 1992). However, we must be careful when generalizing about the protective function of extrafloral nectaries. O'Dowd & Catchpole (1983) working with ant-exclusion experiments in an EFN-bearing plant *Helichrysum* spp. did not find evidence for plant protection with ant interactions. They suggested that generalization of the protection hypothesis to all plants with EFNs is premature (see also Heads 1986). New investigations in different ecosystems will contribute to a better understanding of this type of ant-plant interaction.

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