DAILY ACTIVITY OF ANTS ASSOCIATED WITH THE EXTRAFLORAL NECTARIES OF *TURNERA ULMIFOLIA* L. (TURNERACEAE) IN A SUBURBAN AREA IN SOUTHEAST BRAZIL

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ABSTRACT

The ant fauna visiting the extrafloral nectaries (EFNs) of the weed Turnera ulmifolia L. (Turneraceae) was monitored day and night in a suburban area in Southeast Brazil. The ant density and number of occupied branches were both positively correlated with temperature, with the maximum activity of ants occurring between 12.00 and 15.00. A total of 16 ant species from four subfamilies were observed in the EFNs of Turnera, the Formicinae and Ponerinae comprising the vast majority of the species and individuals recorded during surveys. There was a clear daily turnover in ant species composition, with Brachymyrmex sp., Ectatomma quadridens (F.) and Camponotus aff. blandus dominating during the day, and Ectatomma spp. and a species of Camponotus at night. The differences in the foraging rhythms and the relatively low species overlap are proposed as promoting resource partitioning in ant assemblages.

INTRODUCTION

Extrafloral nectaries (EFNs) are sugar producing plant organs not directly related to pollination (Bentley, 1977; Elias, 1983). They are extremely variable anatomically and have evolved independently in many groups of plants, occurring in no fewer than sixty-eight families (Carrol & Janzen, 1973; Elias, 1983). Although EFNs can be visited by a variety of nectar-gathering insects (Hespenheide, 1985), ants are the most frequent visitors, occurring on plants both day and night (Beattie, 1985; Oliveira *et al.*, 1987; Oliveira & Brandão, 1991; Oliveira *et al.*, 1995). Ants have been seen to protect plants with EFNs against leaf and flower herbivores and seed predators (Buckley, 1982; Beattie, 1985; Koptur, 1992; Davidson & McKey, 1993).

Extrafioral nectar provides a predictable resource for ants and attracts a wide variety of ant taxa (Schemske, 1983; Oliveira & Brandão, 1991). Benefits to the plants depend largely on the protective abilities of the ant visitors (Koptur, 1992). Few studies have focused on the whole ant assemblage (Schemske, 1982; Oliveira & Brandão, 1991; Oliveira *et al.*, 1995), and even fewer have covered the nocturnal ant fauna (reviewed by Oliveira & Brandão, 1991).

Assemblages of ants visiting extrafloral nectaries are relatively poorly known in tropical areas, except in the cerrados (savanna-like vegetation) (Oliveira & Leitão-Filho, 1987; Oliveira & Brandão, 1991). There is strong evidence that ants may be effective anti-herbivore agents in this vegetation type (Oliveira *et al.*, 1987; Costa *et al.*, 1992).

The present study investigates the species composition and daily activity rhythms of the ant fauna visiting the EFNs of *Turnera ulmifolia* (Turneraceae), a plant species very common in suburban areas of SE Brazil.

MATERIALS AND METHODS

Field work was carried out from June to August 1998 (cold-dry season) on the suburban campus of the Universidade Estadual de Campinas (22°54'S, 47°03'W), São Paulo state, Southeast Brazil. The sites consisted of lawns with dispersed shrubs of *T. ulmifolia*, a perennial Neotropical weed that bears EFNs on the petiole near the lamina (Elias *et al.*, 1975).

In order to determine the ant assemblage visiting the EFNs of T. *ulmifolia*, ants were collected during both day (total of 40h) and night (total of 20h). Specimens were fixed in 70% ethanol for later determination.

Seventy-five stems of *T. ulmifolia* (12–32cm long) were tagged. Eight shifts of 3 hours were established in a 24h period. During each shift, each individual stem was searched for ants for 30s and the number of individuals of each ant species was recorded. In each shift, the air temperature near each stem was recorded. Three replicates were made for each daytime shift (06.00–18.00) and two in each nighttime shift (18.00–06.00). Ant nomenclature follows Bolton (1995).

RESULTS

Ants were observed visiting the EFNs throughout 24 hours of the day. They were present on 95% of the stems during the day, and in 92% of them at night. Most of the stems had a mean of less than one ant per shift



Mean no. of ant individuals 🔤 Percentage of stems ---- Air temperature

Fig. 1. — Variation of the mean number of ant individuals per stem of *Turnera ulmifolia*, the percentage of stems occupied by ants and the air temperature (°C) during the 24 hours of the day. Values are means of 75 tagged stems and three censuses during the day and two during the night. Vertical bars show the standard deviation.

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both day (n = 54, 72%) and night (n = 64, 85%). Both the number of ant individuals in each shift and the percentage of stems with ants were positively correlated with air temperature (number of ants and of stems: Spearman $r_s = 0.905$). Mean air temperature varied daily from 17°C to 28°C (fig. 1). The percentage of stems on which ants were present remained relatively constant (40–60%) between 09.00 and 03.00, decreasing only in the period of lower air temperature (03.00 to 09.00) (fig. 1).

TABLE 1. — ANT SPECIES VISITING THE EXTRAFLORAL NECTARIES OF TURNERA ULMIFOLIA IN A SUBURBAN AREA IN SE BRAZIL. Day/night differences were significant in both cases (G test, P <0.001).

Ant species	Mean number of individuals per stem		Percent of stems occupied by each species	
	Day	Night	Day	Night
FORMICINAE	2 the second second			
Brachymyrmex sp.	0.297	0.072	12.3	4.2
Camponotus abdominalis	0.000	0.055	0.0	5.0
C. aff. blandus	0.098	0.000	9.6	0.0
C. rufipes	0.026	0.067	2.0	5.5
Camponotus sp. 1	0.016	0.080	0.9	6.3
Camponotus sp. 2	0.031	0.002	2.9	0.2
Camponotus sp. 3	0.001	0.000	0.1	0.0
Camponotus sp. 4	0.000	0.044	0.0	1.5
Camponotus sp. 5	0.009	0.007	0.9	0.7
MYRMICINAE				
Pheidole sp.	0.004	0.000	0.2	0.0
Solenopsis sp.	0.062	0.002	3.1	0.2
Cephalotes pusillus	0.040	0.000	2.7	0.0
PONERINAE				
Ectatomma edentatum	0.009	0.148	6.6	12.0
E. quadridens	0.172	0.130	13.3	9.8
Odontomachus sp.	0.000	0.017	0.0	0.2
PSEUDOMYRMECINAE				
Pseudomyrmex termitarius	0.024	0.000	2.1	0.0

Sixteen ant species in four subfamilies were recorded visiting the EFNs of *T. ulmifolia*. Seven species were observed exclusively during the day, six during the night and three occurred in both periods (Table 1). The best represented subfamilies were Formicinae and Ponerinae, with three genera – *Camponotus*, *Brachymyrmex* and *Ectatomma* – representing 83% of the individuals recorded during the day and 97% at night. Between 21.00 and 06.00, only individuals of these three genera were recorded on the stems. The mean number of species recorded in each shift was relatively constant during both day (range 7.0–8.3 species) and night (range 6.0–8.0 species).

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The most common species (in order of abundance) were Brachymyrmex sp., Ectatomma quadridens F. and Camponotus aff. blandus during the day and E. edentatum Orger, E. quadridens and Camponotus sp. 1 during the night (Table 1). The principal species were most active in short time periods, with relatively low overlap (fig. 2). Even though E. quadridens was active during 24h, it was less active between 18.00-21.00, the time in which E. edentatum showed highest activity (fig. 2A). The same pattern was observed among Camponotus spp. visiting the EFNs of T. ulmifolia. Although Camponotus sp. 1. and C. rufipes (F.) are present on the plants during all 24h of the day, their activity increased at night, when workers of C. aff. blandus were not present on the shrubs (fig. 2B). Additionally, the decrease in the frequency of Brachymyrmex during the night corresponds with the increase in the activity of three different species, mainly E. edentatum and Camponotus sp. 1.



Fig. 2. — Activity rhythm of the most common species of ants visiting the EFNs of *Turnera ulmifolia*.

Ants of different species showed different behaviour patterns when visiting the EFNs. For instance, *Ectatomma* spp. foragers are solitary and were observed especially on new leaves, moving slowly from one EFN to another. *Brachymyrmex* sp. foragers were observed visiting the EFNs with many individuals in the same stem near the new leaves. *Camponotus* spp. were observed visiting EFNs alone and patrolling the whole plant.

DISCUSSION

The number of species visiting the EFNs of *T. ulmifolia* (16) is similar to that observed in other tropical habitats (reviewed by Oliveira & Brandão, 1991), surprisingly high considering that the present study was conducted in a disturbed suburban area. Some species that were recorded visiting the EFNs of *T. ulmifolia* were also found visiting the EFNs of other plants in cerrado vegetation in Brazil, for example *C. rufipes*, *C.* aff. *blandus*, *Cephalotes* (= *Zacryptocerus*) *pusillus* (Klug) (see Andrade & Baronl-Urbani, 1999) and *E. quadridens* (see Oliveira & Brandão, 1991; Oliveira *et al.*, 1995). This corroborates the facultative nature of this mutualism, with a wide variety of ant taxa being attracted to many different nectar-bearing plants, with no apparent specialization being required.

In the dry-cold season the foraging activity of ants at the EFNs was not limited by higher temperature, in spite of being limited by minimum temperature at night. Similar decreases in ant activity during the night have been recorded in other studies (Oliveira *et al.*, 1995). Thus it could be interesting to investigate if the activity of the herbivores of *T. ulmifolia* is higher in the periods of lower ant activity (when only 20–30% of the stems have ants).

Species of the genera Camponotus, Crematogaster and Pheidole occur at high local abundance and exhibit a large number of species in tropical habitats (Wilson, 1987). These genera are known as the most common visitors of EFNs in both tropical and temperature regions (Oliveira & Brandão, 1991). However, the ant assemblage visiting the EFNs of T. ulmifolia presented two species of Ectatomma as numerically dominant species throughout a round-the-clock period (similar predominance of Ectatomma species were found in Costus spp. in Panama by Schemske, 1982). We suggest that in urban areas, where the contact among the plants is strongly reduced, it may be impossible for the arboreal ants to access the EFNs, and thus the dominance orders in ant assemblages visiting the nectaries may be altered. One fact corroborating this hypothesis is that the only Pseudomyrmex species recorded in the present study was P. termitarius (Fr. Smith) which is known as one of the few terrestrial species of this genus. On the other hand, terrestrial Ponerinae, such as Ectatomma quadridens and E. edentatum, are usually found foraging in open areas in the study site and may benefit from the absence of species with mass recruitment, which possibly are best able to reach and dominate the EFNs

of *T. ulmifolia*. Comparative studies between urban and natural areas are needed to elucidate this question.

The benefits to the plant in attracting ants should not be exclusively in relation to protection against herbivores. As an example, ants can disperse seeds of *T. ulmifolia*, as showed by Lock (1904). Additionally, several times during the work, *Ectatomma* and *Camponotus* species were observed removing seeds from the stems and could probably act as seed dispersors of this species.

Even if differences in foraging rhythms among sympatric ant species are based mainly on different humidity and temperature ranges tolerated by each taxon (and not on competitive interactions), the resulting pattern of species replacement (Table 1, fig. 2) could promote resource partitioning in this assemblage.

ACKNOWLEDGEMENTS

We are grateful to I.R. Leal for helping with ant species determination and to G. Machado, M.R. Pie, P.S. Oliveira and K.S. Brown, Jr. for critical reading of the manuscript. We also thank the night guards of the Campus, who helped to maintain high spirits in the research personnel.

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