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).

Extrafloral 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

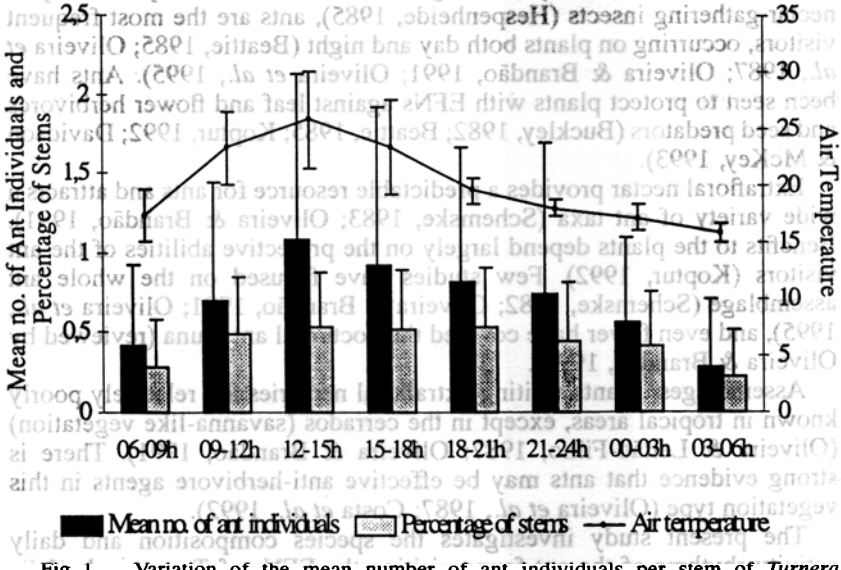

Fig. 1. — Variation of the mean number of ant individuals per stem of *Turnera ulmifolia*, the percentage of stems occupied by ants and the air temperature (°C) during the 24 hours of the day. Values are means of 75 tagged stems and three censuses during the day and two during the night. Vertical bars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

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				
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).

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.

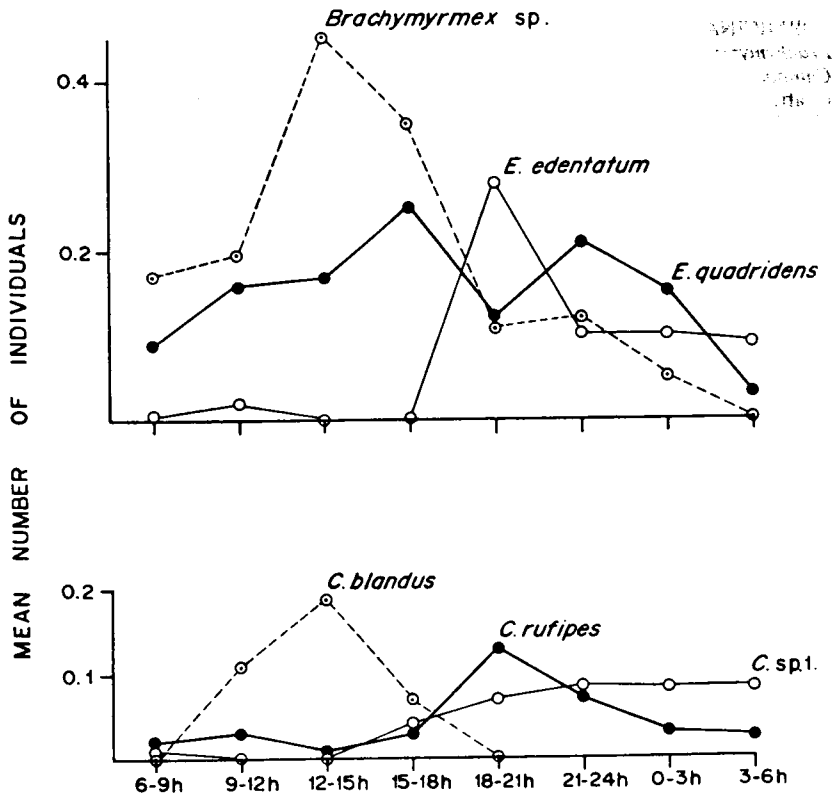

Fig. 2. — Activity rhythm of the most common species of ants visiting the EFNs of *Turnera ulmifolia*.

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 & Baroni-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.

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REFERENCES

Andrade, M.L. & Baroni-Urbani, C., 1999, Diversity and adaptation in the ant genus *Cephalotes*, Past and Present, *Stuttg. Beitr. Naturk.*, B, **271**: 1–889. **Beattie, A.J.**, 1985, *The Evolutionary Ecology of Ant-Plant Mutualisms*, Cambridge University Press, Cambridge. **Bentley, B.L.**, 1977, Extrafloral nectaries and protection by pugnacious bodyguards, *A. Rev. Ecol. Syst.*, **8**: 407–428. **Bolton, B.**, 1995, *A new general catalogue of the ants of the world*, Harvard University Press, Cambridge, Massachusetts. **Buckley, R.C.**, 1982, Ant-plant interactions: a world review (pp.111–141) in R.C. Buckley (ed.), *Ant-Plant Interactions in Australia*, W. Junk, The Hague. **Carrol, C.R. & Janzen, D.H.**, 1973, Ecology of foraging by ants, *A. Rev. Ecol. Syst.*, **4**: 231–257. **Costa, F.M.C.B., Oliveira-Filho, A.T. & Oliveira, P.S.**, 1992, The role of extrafloral nectaries in *Qualea grandiflora* (Vochysiaceae) in limiting herbivory: an experiment of ant protection in cerrado vegetation, *Ecol. Ent.*, **17**: 362–365. **Davidson, D.W. & McKey, D.**, 1993, The evolutionary ecology of symbiotic ant-plant relationships, *J. Hym. Res.*, **2**: 13–83. **Elias, T.S.**, 1983, Extrafloral nectaries: their structure and distribution, pp. 174–203, *in* Bentley, B.L. & Elias, T.S. (eds), *The Biology of Nectaries*, Columbia Univ. Press, New York. **Elias, T.S., Rozich, W.R. & Newcombe, L.**, 1975, The foliar and floral nectaries of *Turnera ulmifolia* L., *Am. J. Bot.*, **62**: 570–576. **Hespenheide, H.A.**, 1985, Insect visitors to extrafloral nectaries of *Byttneria aculeata* (Sterculiaceae): relative importance and roles, *Ecol. Ent.*, **10**: 191–204. **Koptur, S.**, 1992, Extrafloral nectary-mediated interactions between insects and plants, *in* E. Bernays (ed.), *Insect-Plant Interactions*, CRC Press, Boca Raton, **4**: 81–129. **Lock, R.H.**, 1904, Ecological notes on *Turnera ulmifolia* L., var. *elegans*. *Urban. Ann. R. bot. Gdns Peradeniya*, **2**: 107–119. **Oliveira, P.S. & Brandão, C.R.F.**, 1991, The ant community associated with extrafloral nectaries in the Brazilian cerrados pp. 198–212, in Cutler, D.F. & Huxley, C.R. (eds), *Ant-Plant Interactions*, Oxford University Press, Oxford. **Oliveira, P.S., Klitzke, C. & Vieira, E.**, 1995, The ant fauna associated with the extrafloral nectaries of *Ouratea hexasperma* (Ochnaceae) in an area of cerrado vegetation in Central Brazil, *Entomologist's mon. Mag.*, **131**: 77–82. **Oliveira, P.S. & Leitão-Filho, H.F.**, 1987, Extrafloral nectaries: Their taxonomic distribution and abundance in the woody flora of cerrado vegetation in Southeast Brazil, *Biotropica*, **19**: 140–148. **Oliveira, P.S., Silva, A.F.**

& Martins, A.B., 1987, Ant foraging on extrafloral nectaries of *Qualea grandiflora* (Vochysiaceae) in cerrado vegetation: ants as potential antiherbivore agents, *Oecologia*, **74**: 228–230. **Schemske, D.W.**, 1982, Ecological correlates of a neotropical mutualism: Ant assemblages at *Costus* extrafloral nectaries, *Ecology, Brooklyn*, **63**: 932–941; 1983, Limits to specialization and coevolution in plant-animal mutualism pp.67–109, *in* Nitecki, M.H. (ed.), *Coevolution*, University of Chicago Press, Chicago. **Wilson, E.O.**, 1987, Causes of ecological success: The case of the ants, *J. anim. Ecol.*, **56**: 1–9.

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July 5th, 1999.

An aggregation of Parasitic Hymenoptera. — On 29.v.1999, just after mid-day, walking along the top of the south-west facing slopes of the Great Orme, Gwynedd (SH 757835), very large numbers of microhymenoptera accompanied by small Diptera (Empididae, Sciomyzidae, Sepsidae, Chloropidae), Coleoptera (Staphylinidae, Coccinellidae) and Heteroptera (*Orthops kalmi* (L.), *Anthocoris nemoralis* (F.)) were flying and settling on our persons. They seemed to be particularly attracted to the mustard coloured sweater worn by my son, from which a sample of the parasitic Hymenoptera was collected in a pooter. Conditions were cool and overcast with a moderate north-westerly breeze, and the temperature was estimated at about 15°C. The sample, collected in about 15 minutes, comprised 252 individuals of 38 species:

ICHNEUMONIDAE: 1♀ *Adelognathus nigriceps* Thomson, 1♀ *Diplazon tibiatorius* (Thunberg), 2♂♂ *Syrphophilus tricinctorius* (Thunberg), 15♀♀ (1 Campopleginae, 3 Ichneumoninae, 1 Orthocentrinae, 10 Cryptinae) of ?12 unidentified species.

BRACONIDAE: 1♀ *Blacus* sp., 1♀ *Bracon* sp.

PROCTOTRUPIDAE: 1♀ *Codrus niger* Panzer, 1♀ *Phaenoserphus viator* (Haliday).

EUCOILIDAE: 1♀ *Kleidotoma truncata* Cameron.

TORYMIDAE: 1♀ *Torymus affinis* (Fonscolombe), 25♀♀ *Torymus flavipes* (Walker).

PTEROMALIDAE: 6♀♀ *Asaphes vulgaris* Walker, 1♀ *Miscogaster maculata* Walker, 1♂ 2♀♀ *Halticoptera aenea* (Walker), 1♂ 4♀♀ *Mesopolobus sericeus* (Förster), 1♀ *M. fasciiventris* Westwood, 1♂ 167♀♀ *M. tibialis* (Westwood), 1♂ 2♀♀ *M. dubius* (Walker), 1♀ *M. xanthocerus* (Thomson), 1♀ *M. amaenus* (Walker), 3♀♀ *Mesopolobus* sp., 1♀ *Pteromalus chrysos* Walker, 1♀ *Trichomalus bracteatus* (Walker), 1♀ *Pachyneuron muscarum* (L.).

EULOPHIDAE: 2♀♀ *Aulogymnus arsames* (Walker), 1♀ *Chrysocharis nitetis* (Walker).

APHELINIDAE: 4♀♀ *Coccophagus obscurus* Westwood.

Mesopolobus tibialis made up exactly two-thirds of the sample. This species and the other identified *Mesopolobus*, the two *Torymus* and *Aulogymnus arsames* are all parasitoids in galls of Cynipidae on oak. The nearest woodland is about 2km south-east of the place where the sample was collected, on the northern fringe of Llandudno, and contrary to the direction from which the wind was blowing. Their presence on the grazed turf of the Great Orme is an indication that females, which dominated the sample as a whole (97.6%), are highly dispersive. Ten female *M. tibialis* were dissected and all contained from between 7 and 22 mature ova.

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