AVOIDING ANT-POLLINATOR CONFLICT ON *ACACIA COLLINSII*

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Abstract. In the ant-acacia mutualism, a resident colony of aggressive ants provides defense for the acacia against herbivory, mainly by insects. The question addressed in this study concerned how insects that pollinate acacias are able to avoid attack by ants. Through observation of the responses of acacia-ants (*Pseudomyrmex* spp.) towards flowers and towards applications of pollen on bark, we determined that these ants will patrol unopened flower buds but avoid pollen from flowers in anthesis and senescing flowers. Thus, insect pollinators are allowed access to acacia flowers unhindered. Whether or not pollen from flowers in anthesis contains a specific chemical ant repellent remains to be determined.

Key Words: Acacia flowers, ant-plant mutualism, pollen, Pseudomyrmex *sp., symbiosis*

INTRODUCTION

The mutualistic relationship between *Acacia* spp. and the ant genus *Pseudomyrmex* is a classic example of plant animal mutualism (Janzen 1983). The ants gain shelter from hollow thorns and food from nectaries and proteinaceous Beltian bodies. From the ants, the acacias receive protection from herbivores and, in some cases, from competing plants. While acacias are protected from herbivory by aggressive ants, they also require visits by bee pollinators during anthesis for cross-pollination. Willmer and Stone (1997) reported that ants are deterred from patrolling young flowers by a chemical substance in pollen on two African *Acacia* species, allowing pollinators to freely visit acacia flowers. To determine whether a similar relationship exists in Costa Rica, we studied *Pseudomyrmex spinicola, P. nigrocincta,* and *P. flavicornis* on *Acacia collinsii*. We hypothesized that pollen from acacia flowers inhibits ant patrolling. We predicted that ants would patrol flower buds and old flowers, but avoid flowers in anthesis. We also predicted that ants would avoid areas rubbed with chemicals of pollen-bearing flowers, while they would not respond to chemicals of flower buds. In this way, flower buds would receive protection from herbivory, but flowers reaching anthesis will be unguarded, allowing pollination by insects.

METHODS

On 9 January 1998 we located 17 flowering acacia trees, five with *P. flavicornis*, five with *P. nigrocincta*, and seven with *P. spinicola*, all near the road, west of the OTS field station in Palo Verde National Park, Guanacaste Province, Costa Rica. On a branch from each tree, we located a set of flowers including a flower bud, a flower in anthesis, and a senescent flower, and tapped the branch at the base of these flowers three times every 30 s for 5 min to elicit ant responses. We recorded how many ants visited each flower structure within the 5 min period. This was done for three different sets of flowers on each tree. For the data from *P. flavicornis* and *P. nigrocincta* , we performed a two-way ANOVA with flower stage and ant species as fixed effects to analyze the frequency of ant visits to each type of flower part.

In a second experiment, we observed *P. flavicornis, P. nigrocincta* and *P. spinicola* at "gates" on the main stem, consisting of two pen dots, 2 cm apart. After kicking the base of the tree several times to agitate the ants, we counted the number of ants that crossed through a gate and the number of ants that avoided the gate for 1 min. We defined "avoid" as either stopping at the gate or approaching it then changing direction to run around it. These pre-treatment data were considered to be the controls. Next we scraped a flower in anthesis across the gate until a band of yellow pollen was visible across the gate, re-agitated the base of the tree, and counted the number of ants that crossed and avoided the gate following treatment for 1 min. We repeated the process with a gate on a separate part of the trunk, but rubbed them with a flower bud hard enough to produce a visible mark across the gate. We performed a total of five replicates of each treatment on three different trees for *P. nigrocincta*, four replicates on two different trees

for *P. spinicola*, and three replicates on two different trees for *P. flavicornis*. We used a Chi-square test to analyze changes in ant behavior due to pollen or bud treatments.

RESULTS

We found that both *P. nigrocincta* and *P. flavicornis* patrolled flower buds more often than they did flowers in anthesis or senescing flowers ($F_{5,24}$ = 7.27, P = 0.003; Fig. 1). There was no difference in patrolling behavior between *P. nigrocincta* and *P. flavicornis* ($F_{5,24}$ = 0.04, P = 0.84), and no interaction between flower stages and ant species in determining the frequency of ant visits ($F_{5,24}$ = 0.06, P = 0.94). Only 35 *P. spinicola* visited floral parts of the tree.

All three ant species tended to avoid regions of the trunk (gates) that were rubbed with a flower in anthesis (X^2 = 148.90, 89.55 and 56.50, for *P. flavicornis*, *P. nigrocincta*, and *P. spinicola* respectively, all P < 0.001; Fig. 2).

Both *P. flavicornis* and *P. nigrocincta* avoided applications of flower bud to sections of the tree trunk (X^2 = 42.19 and 27.66, P < 0.001 and P < 0.001, for *P. flavicornis* and *P. nigrocincta* respectively) (Figs. 2a and 2b). *P. spinicola*, in contrast, did not exhibit a significant change in behavior when the tree was treated with buds (X^2 = 1.28, P = 0.26; Fig. 2c).

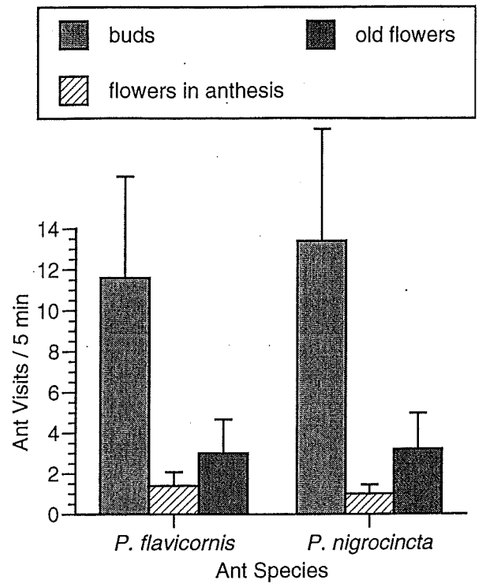

FIG. 1. Mean ant visits at different flower buds, flowers in anthesis and old flowers for *Pseudomyrmex nigrocincta* and *P. flavicornis* on *Acacia collinsii* at Palo VerdeField Station, Guanacaste Province, Costa Rica.

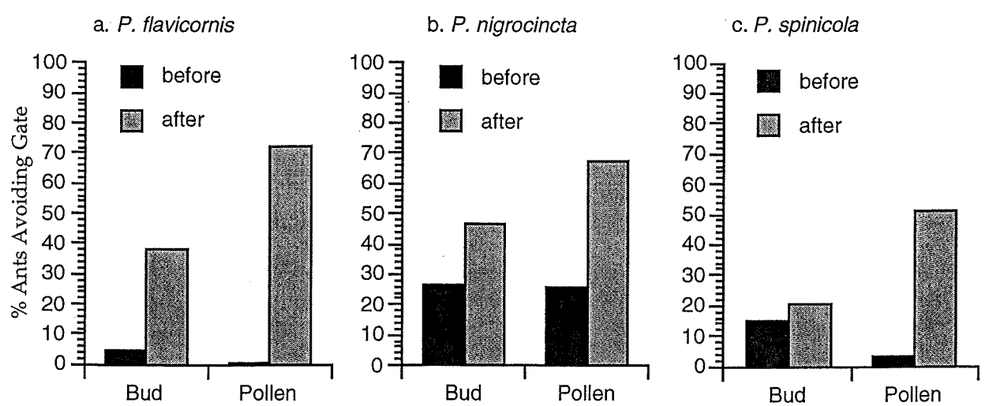

FIG. 2. Response by three species of *Pseudomyrmex* ants to flower buds or pollen rubbed onto *Acacia* trunks. Total ants observed = 132, 92, 110, and 112 for *P. flavicornis*; 283, 314, 277, and 219 for *P. nigrocincta*; and 108, 127, 132, and 94 for *P. spinicola*.

DISCUSSION

P. nigrocincta and *P. flavicornis* patrolled flower buds more often than flowers in anthesis and old flowers. Such frequent patrolling of flower buds may increase the acacia's reproductive potential by deterring herbivory. However, by avoiding flowers in anthesis, ants do not attack potential pollinators and allow pollination to occur unhindered. Contrary to the results of Willmer and Stone (1997), we found that ants avoided senescing flowers as well as flowers in anthesis. It is possible that flowers of *A. collinsii* maintain detectable quantities of pollen for a longer time than the senescing flowers observed in the African study. The flowers on the African acacia are viable for one day, and then quickly shed flower parts, exposing the ovule, whereas anthers remained on *A. collinsii* flowers for several days.

The finding that *P. spinicola* only infrequently patrolled any flower parts suggests that acacia-ant species may differ in their patrolling behavior and their responses to insect pollinators. Further study is needed to confirm these differences and their consequences to the pollination biology of acacias occupied by different species of ants.

Our second analysis investigated the mechanisms that might cause ants to avoid open flowers while still allowing them to patrol buds. We found that all three species of ants tended to avoid areas of the tree trunk treated with pollen-containing flowers. This suggests that the presence of some substance from these flowers, probably pollen, deters ants.

We did find that two of the three ant species also avoided regions rubbed with flower buds, which lacked pollen, suggesting that other chemical cues associated with flowers might influence ant patrolling. It is also possible that we altered the ant's chemical signals already present on the bark by rubbing pollen and buds on the tree. In this case, ants in our experiments could have been responding to disruptions of their own chemical signals on the bark. Thus, even though our results support the role of pollen in restricting ant visits to open flowers, other mechanisms and explanations for these findings require further investigation.

LITERATURE CITED

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