for these differences to be significant. Despite the possibility that predation on infants may be greater than adults, females with infants did not scan more than females without infants, and in fact, appeared to spend less time scanning (see Results). Therefore, troop size seemed to be the most important factor determining how much time an individual allocates to scanning.

Evidence linking vigilance and predation rate in primates is not well established (Hall and Fedigan 1997). Because we could not directly measure predation risk, our conclusions rest on the untested assumption that scanning in howlers reflects this danger. At our study site, the predation threat to adults appears to be low; no large monkey-eating eagles occur in Palo Verde (Stiles and Skutch 1989). Some resident hawks and large snakes, however, do occur and could potentially prey upon infant and juvenile monkeys.

If time spent vigilant is a valid indicator of predation risk, then our results suggest that living in a large group is a way for howler monkeys to find relative safety. In a more dangerous environment, this may be essential to monkey survival, and could have been an important factor in the evolution of group living in this primate species.

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Pseudomyrmex spinicola response to an arboreal fungus

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Abstract: Nests of several bird species are commonly found in acacia trees inhabited by the aggressive ant species *Pseudomyrmex spinicola*. These nests always incorporate hyphal strands of black arboreal fungus. We tested the reaction of ants to introduction of naturally occurring hyphae versus a control, grass, to determine if the presence of hyphae reduced ant response. No difference in ant response was observed between treatments. However, there was significant variation in ant responses from tree to tree. Birds may be able to nest on acacias inhabited by *P. spinicola* because they choose trees with more tolerant ant populations. Hyphae use in nest construction may be solely due to its pliability and availability in the dry forest.

Key Words: Acacia collinsii, *ant defense*, Campylorhynchus rufinucha, Icterus pustulatus, Tolmomyias sulphurescens, *vegetation clearing*

Introduction

The acacia ant species *Pseudomyrmex spinicola* is known to be an aggressive species, defending its host trees against insects, mammals, neighboring plants and even inert objects (Cook et al. 1993). However, when examining acacias inhabited by *P. spinicola*, one often finds the nests of bird species such as the rufous-naped wren (*Campylorhynchus rufinucha*), yellow olive flycatcher (*Tolmomyias sulphurescens*), and especially the streaked-backed oriole (*Icterus pustulatus*) (Stiles and Skutch 1989). These nests usually contain a high percentage of hyphae from a black arboreal fungus found on trunks of trees in the dry forest. The ants eventually allow the nest to remain, accepting it as part of the tree.

Conte and Macintosh (2000) hypothesized that the presence of the fungus itself could reduce the ant's defensive response, allowing the birds to nest in a safe location. They compared *P. spinicola* response to a control, grass, with that toward the fungal hyphae. They found no difference in ant response to the two materials, concluding that the hyphae did not play a part in reducing aggressive ant response. However, they used hyphae from an old *I. pustulatus* nest that had fallen from an acacia. In this study we performed a similar experiment by examining ant response to hyphae harvested directly from tree trunks. This material had not been modified during previous use by birds or by exposure to acacia ants.

We hypothesized that hyphae are used in nest construction because they may have properties that deter or reduce the defensive reaction of the acacia ants. To test this, we predicted that *P. spinicola* would react more strongly to the introduction of grass, a substance commonly cleared from the ground around the nest, than to the introduction of an equal quantity of hyphae. We also predicted that ant activity would increase upon the initial introduction of both materials and decrease in the following measurement period (Macintosh et al. 2002).

Methods

On 11 January 2002, we examined *P. spinicola* responses to grass and hyphae on 20 *Acacia collinisii* trees located ~0.25 km east of the OTS Biological Station in Palo Verde National Park, Costa Rica. Trees selected for study were between 3.5 – 4.5 m tall and had a cleared area beneath the tree, indicating an active resident ant population.

We collected grass from the side of the airstrip across from the research station and fungal hyphae from two trees along paths in the dry forest. These materials were handled with forceps to avoid introducing human

scent. In the lab, we constructed small bundles (~4 cm long, ~1 cm wide) of each type of material. On each acacia tree, we chose two similar branches at ~1.5 m above ground level, 1.25 - 1.75 m in length, and identified thorns approximately 6 cm from where the branch joined the trunk as bundle placement sites.

On each branch, we chose a point between the bundle placement site and the trunk, and recorded baseline ant activity for 2 min by noting the number of ants passing in either direction. After 2 min, we simultaneously placed a bundle of grass on one branch and a bundle of hyphae on the other, then rapped each branch three times with a pen in order to ensure a uniform disturbance at each site and to alert the ants to the presence of foreign material. For the next 10 min we recorded the number of ants passing the fixed point at 1 min intervals.

We tested for differences in ant activity between treatments with a repeated measures ANOVA. Because baseline activity levels differed significantly among trees ($F_{19,20}$ = 4.50, $P < 0.001$), analyses were based on standardized measures of ant activity (number of ants at time *t* on branch *x* minus average predisturbance activity for branch *x*). We used a series of paired t-tests to compare ant response to treatment at each individual measurement time.

Results

P. spinicola activity in response to hyphae and grass control treatments did not differ over time ($F_{1,19} = 0.48$, $P = 0.49$; Fig. 1), nor was there an interaction between time and treatment ($F_{9,11} = 0.79$, $P = 0.63$). Ant activity in both experimental (fungus) and control (grass) treatments decreased significantly during the 10 min after bundle placement ($F_{9,11} = 4.21$, $P = 0.01$), but there was no difference in activity between the two treatments ($t < 3.42$, df = 19, $P > 0.19$).

Discussion

Although *P. spinicola* activity increased upon introduction of both hyphae and grass, we found no difference in their response to these two treatments, supporting the results of Conte and Macintosh (2000). In the short term, ant response is not lessened by the presence of fungal hyphae. Ants are efficient at removing vegetation surrounding their resident trees, so had we monitored long-term response to fungus and grass, our findings might have been different.

The significant variation in ant response between populations suggests that birds could be choosing to nest in acacias inhabited by less aggressive ants, and overwhelm them with quick and persistent nest construction. It is also possible that birds use hyphae in nest construction for other reasons such as its availability, durability, strength and/or ease of manipulation. The latter is consistent with observations that species not nesting in acacias also use hyphae in the construction of their nests (Stiles and Skutch 1989).

Current evidence indicates that hyphae do not reduce *P. spinicola* aggression. A combination of factors seem to work together to determine the tolerance of *P. spinicola* to foreign materials near their homes. Further research could examine bird nest site choice, for example testing whether ants in trees containing bird nests respond less to disturbances than ants in trees not containing nests.

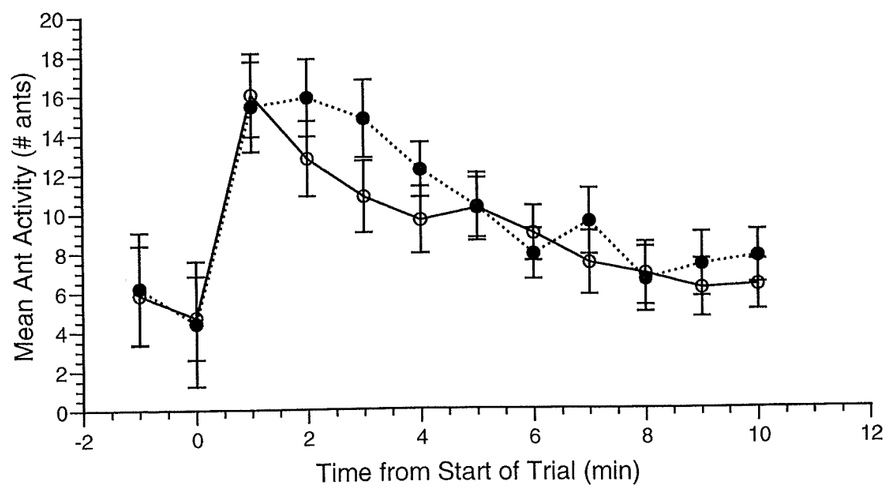

FIG. 1. Mean (± SE) ant activity before and after placement of grass bundles (open circles) and black fungal hyphae (closed circles) on branches of *A. collinsii*..

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