Discussion

The greater abundance and diversity of soil fauna in new and old rubbish dumps indicates that these soil types provide a more favorable habitat than nest and forest soils for most soil organisms. The rubbish has a high content of decomposed plant material, ant feces and dead ants, which may provide readily available nutrients for soil organisms. Additionally, the loose packing and granular texture of the rubbish piles may induce better soil aeration than the densely packed, fine particulate clay material of forest soil.

The similarity in abundance and morphospecies richness between nest and forest soils was expected since composition of these soils appeared similar. The soil habitat in new and old rubbish dumps seem particularly suitable for insect larvae, Coleopterans, and Isopterans, which composed the majority of the morphospecies in our samples. The environment created by leaf-cutter ants through their rubbish disposal seems to improve the microhabitat for a greater diversity of soil fauna.

Literature Cited

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Removal of leaf obstacles from trails by leaf cutter ants

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Abstract. Leaf cutter ants, *Atta colombica*, maintain clear foraging trails by removing leaves and debris. We hypothesized that the response of *A. colombica* to introduced leaf obstructions would vary depending on leaf fragment size, with small fragments being pulled off the trail and large fragments cut up, then removed. Additionally, we hypothesized that soldiers would do most of the trail clearing and that ants would be recruited from the colony to help clear the obstruction. We found that the proportion of pulling decreased while the proportion of cutting increased with increasing leaf fragment size. Workers, not soldiers, did most (98%) of total pulling and cutting, and there was no increase in recruitment to the obstruction. Our findings demonstrate that ants employ different trail clearing strategies depending on the size of leaf fragments.

Key Words: Atta colombica, *recruitment, disturbance*

Introduction

Leaf cutter ants (*Atta colombica*) travel to and from their colonies on pheromone-marked trails cleared of litter. The ants harvest plant material and use it to maintain the basidiomycete fungus on which they feed (Martin 1969). Barriers on their trails, such as fallen leaves are often encountered and must be removed quickly, by either cutting or pulling, to allow ants carrying leaf pieces to return back to the colony. Since leaf obstacles differ in size, they might elicit different behavioral responses. To test this hypothesis, we predicted that, due to their size and weight, larger sized leaves will be cut into small pieces rather than being pulled from the trail intact. Similarly, we predicted that smaller leaves will be easier to pull, and will therefore be pulled off the trail rather than being cut and then removed, which would take longer.

We also hypothesized that ants will be recruited from the colony to the leaf obstruction in order to speed leaf removal from the trail. Finally, we hypothesized that soldiers, rather than workers, would remove most of the obstacles, as was shown by Bizzarro *et al.* (1992).

Methods

The first four foraging trails with active *A. colombica* along both the Sendero Rio Claro and Sendero Naranjos near Estación Sirena in Corcovado National Park, C.R., were surveyed on 4 February 1999 (n=8). Rectangular leaf fragments of three sizes [small: 3 x 4.5 cm (13.5 cm^2), medium: 7 x 5 cm (35 cm^2) and large: 8.5 x 11 cm (93.5 cm^2)] were cut from a single fresh, green leaf of *Heliconia sp.*, thus standardizing fragment density and toughness. On each foraging trail, leaf fragments were introduced separately (24 trials total), placed in the same position for each trial on a given trail.

In each trial, a randomly selected leaf size was introduced onto the trail. Every 30 sec for the first 3 min and every min for the rest of the 10 min trial, the caste of all ants (worker or soldier) and their action (cutting or pulling) were recorded. Since different numbers of ants responded in the trials, responses were quantified as percentage of total responses represented by each behavior type. In addition, the times of the first response to the leaf, removal of cut sections, and complete leaf removal from the trail were recorded. Each trail was allowed to recover for 15 to 20 min between trials.

Recruitment to the leaf was quantified by measuring ant abundance before and during the disturbance. Prior to the disturbance, the number of ants moving away from the nest was quantified in two 1 min intervals at a random point between the nest and the disturbance area. During the disturbance, the number of ants moving towards the leaf fragment was quantified every other minute.

Results

As the size of introduced leaf fragments increased, there was a decrease in the proportion of pulling responses and a corresponding increase in the proportion of cutting responses (Fig. 1; Wilcoxon, X^2=11.7, df=2, P=0.003). On large leaf fragments the proportion of cutting responses was significantly higher than the proportion of

pulling responses (Wilcoxon, $X^2=12$, df=1, P=0.0005; Fig. 1). On small and medium fragments, there were no significant differences between proportions of pulling and cutting responses (Wilcoxon; small: $X^2=1.48$, df=1, P=0.22; medium: $X^2=0.025$, df=1, P=0.87; Fig. 1). Four of eight small leaves, three of eight medium leaves, and no large leaves were completely removed from the trail during the 10 min trial.

Worker ants performed 98% of all trail-clearing behavior observed (cutting and pulling). Also, there was no change in recruitment of ants from the colony over time after the introduction of small, medium, and large leaf fragments (Table 1; Least Squares/2-Way Anova: small fragments: P=0.80; medium fragments: P=0.95; large fragments: P=0.59).

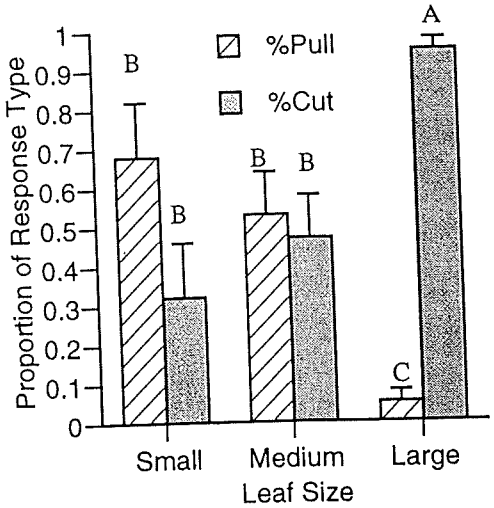

Fig. 1. Response (pull or cut) to introduced leaves of different sizes on *Atta colombica* trails at Corcovado National Park, Costa Rica. Letters indicate values which differ significantly.

Table 1 - Number of leaf-cutter ants/min (mean ± SE; n=4) crossing a designated point before and at intervals after introduction of obstructing leaf fragment to ant trails at Corcovado National Park, Costa Rica.

	Before	2 min	4 min	6 min	8 min	10 min
Small	35.3 ± 7.95	37.3 ± 8.32	33.7 ± 5.78	37.5 ± 10.9	39.2 ± 9.69	36.5 ± 6.65
Med	30.1 ± 8.92	31.2 ± 6.37	31.5 ± 8.7	27 ± 10.37	27.5 ± 7.96	27.3 ± 7.63
Large	44.9 ± 12.5	29.5 ± 5.12	35.2 ± 3.5	34 ± 8.88	28.8 ± 8.59	26.5 ± 7.15

Discussion

As leaf fragment size increased, *A. colombica* tended to cut rather than pull the obstructing leaf off the trail. This indicates that ants attempt to maximize leaf removal efficiency by trying to pull the leaf off the trail and then, if unsuccessful, cutting the leaf into smaller pieces which could then be removed. Pulling appears to be faster clearing trails because some small and medium fragments were completely pulled off the trails during the trials, while no leaves were completely removed by cutting.

Contrary to our second hypothesis and the observations of Bizzarro *et al.* (1992), soldiers did not contribute to the removal of leaf obstacles, suggesting that they do not always perform this function. Workers are more abundant both travelling to and from the colony, and are therefore more likely to encounter and possibly clear trail obstructions, despite their small size.

Our results indicate that *A. colombica* did not recruit more individuals to the site of an obstruction. Obstructions caused considerable back-ups of ants so there may have been sufficient individuals to remove leaf fragments. Alternatively, our trial length might not have been long enough to observe recruitment. Furthurmore our testing was done 24 hrs after a period of heavy rain, which had washed out many trails and kept ants from foraging. These circumstances might have led ants to ignore obstacles in favor of getting more leaves to the nest or because there were more serious repairs needed in the trail at other locations. Our results show, however, that *A. colombica* did distinguish between different sized leaf obstacles and employ different trail clearing strategies depending on the size of the leaf fragments.

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