TRAIL LENGTH AND FORAGING EFFICIENCY IN LEAF CUTTING ANTS

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Abstract. Leaf-cutting ants *(Atta columbica)* harvest leaf fragments from trees for their fungal gardens. A queen ant founds a stationary, central colony from which workers must travel varying distances to forage. Theoretically they should attempt to maximize leaf fragment acquisition. We hypothesized that leaf mass carried per ant per unit time would vary with distance of trees to the colony and that the proportion of ants returning to the colony without leaves would vary with distance traveled to forage. Contrary to our expectations, ants on long vs. short trails carried proportionally the same weight of leaf fragments relative to their body mass and were no less likely to be carrying leaf fragments. However, larger ants tended to carry heavier leaf loads and longer trails tended to have larger ants than short trails. This trend may represent an optimal foraging strategy. Measurements of ant velocity in relation to ant load and ant mass are necessary to test this hypothesis.

Key Words: Atta columbica

INTRODUCTION

Leaf cutting ants *(Atta columbica)* are eusocial insects that harvest leaf fragments on which they grow a fungus within their colony. The ants collect the swollen tips of the fungal hyphae (gongylidia) as food (Quilan and Cherrett 1977). These ant colonies can contain up to five million individuals (Stevens 1983) and therefore have considerable energetic demands that must be supported by the harvesting of leaf tissue. Selection should favor optimal foraging. Because ants are central-place foragers, optimal foraging strategies seem likely to vary with distance from the tree to the nest. We hypothesized that leaf load and the frequency of dropped leaves will vary with distance. We predicted that (1) ants would carry smaller loads over longer distances due to velocity decreases incurred by heavy loads and (2) frequency of dropped leaves would increase with distance given the simple prediction that dropped leaves per ant per unit time should be the same.

METHODS

We located the start and end of eight leaf cutter ant trails; four short trails (under 25 m) and four long trails (over 50 m) on 2 February 1998, at Serena Biological Station, Corcovado National Park, Costa Rica. We collected all leaf fragments, and the ants carrying them, that crossed a line ~ 5 m from each colony entrance for two separate five minute periods. We also counted ants returning to the colony without leaves. We measured the total biomass (± 1 mg) of ants and leaf fragments for each replicate and averaged these two measurements for each trail. These values were divided by ant mass to get leaf mass carried per unit ant mass. We used a one-way ANOVA to test for effects of trail length on (1) leaf mass carried per unit ant mass and (2) the proportion of ants returning to the colony without leaf fragments. We also used a regression to analyze the relationship between ant mass and the mass of leaf fragments.

RESULTS

Ants on long and short trails carried similar loads (mean ± SE = 3.24 ± 0.42 vs. 2.96 ± 0.35 mg leaf mass/mg ant mass respectively; $F_{1,6}$ = 0.25, P = 0.63). Bigger ants carried heavier loads (r^2 = 0.72, P = 0.008, Fig. 1) and ants tended to be larger on long trails than on short trails (mean mass ± SE = 5.93 ± 0.67 vs. 4.61 ± 0.09; $F_{1,6}$ = 3.90, P = 0.096; Fig. 1). Trail length had no effect on the proportion of ants returning to the colony without a leaf fragment ($F_{1,6}$ = 0.36, P = 0.57).

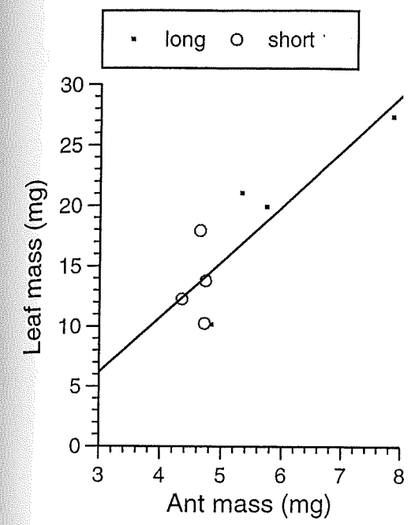

Fig. 1. Average leaf mass on a trail as a function of average ant mass on a trail. Function is fit to long and short trails combined.

DISCUSSION

Our first hypothesis was falsified by lack of difference between long and short trails in the leaf mass carried per unit ant mass. This suggests that ants may be imperfect foragers. Alternatively, foraging efficiency does not change with load size. The decreased velocity due to heavier leaf loads over long distances (Rudolph and Loudon 1986), or increased waiting time incurred by cutting larger leaf fragments (Burd 1996) may negate any potential gains of cutting large leaf fragments. Our second hypothesis was also refuted. There was no difference in the proportion of ants returning to the colony without a leaf fragment. This result was surprising because it refutes the simple expectation that there would be equal leaf fragment drops per ant per unit time. It may be that colonies send out a certain number of ants to repair the trail, scout, etc., irrespective of trail length.

Although our predictions were falsified, the ants displayed a solution that we had not envisioned. Larger ants carried heavier leaf loads than smaller ants and there were greater numbers of large ants on long trails. This mechanism could maximize leaf fragment harvesting for the colony. Similarly, Shutler and Mullie (1991) reported that *Atta columbica* colonies sent larger ants to more distant trees. Future studies could test the prediction that larger ants are more efficient than smaller ants at harvesting distant trees. Measurements of ant velocity as a function of ant load and ant mass would allow an empirical prediction of the optimal worker size as a function of trail length. Then the predicted optimal worker size could be compared to actual worker size. Figure 2 shows a preliminary graphical formulation that predicts (1) optimal ant size is greater on long trails than on short trails, (2) maximal returns are greater on short trails than long trails, and (3) ant size is more important to foraging efficiency on short trails than long trails.

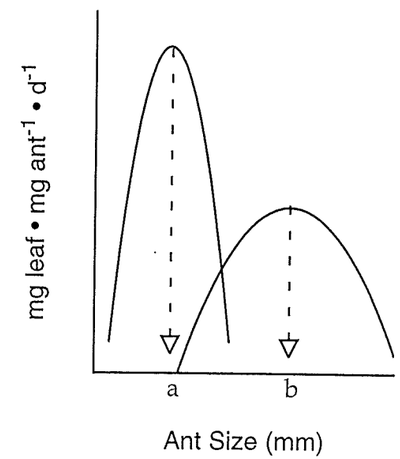

FIG. 2. Graphical representation of theoretical model: a indicates optimal ant size for short trails, and b indicates optimal ant size for long trails.

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