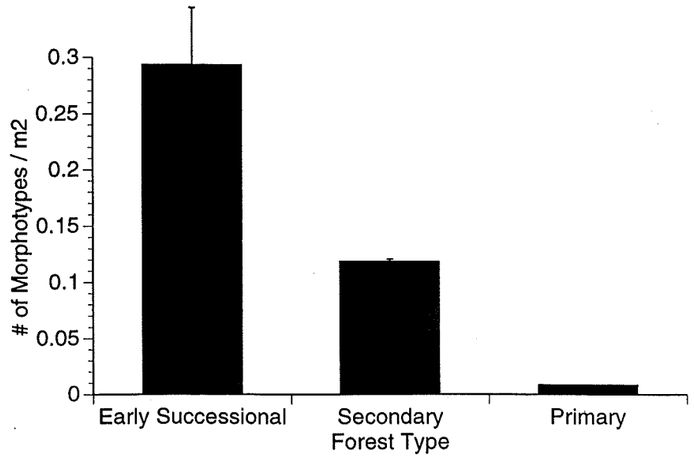

FIG. 2. Mean (±S.E.) number of flowering plant morphotypes/m^2 in early successional, secondary and primary forest types.

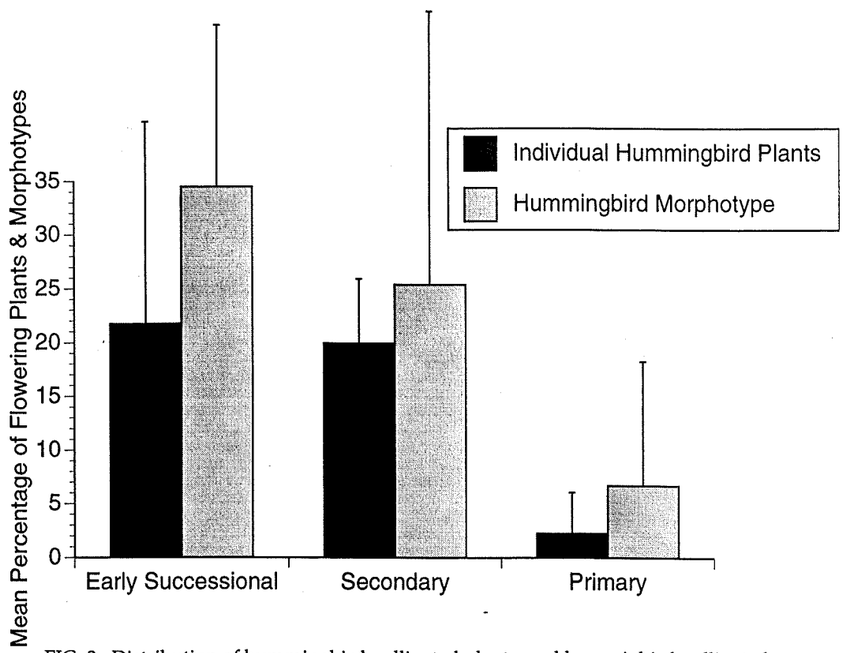

FIG. 3. Distribution of hummingbird pollinated plants and humminbird pollinated morphotypes in early successional, secondary, and primary forests. Data represent means ±S.E. percent freqency in three transects in each habitat.

EFFECTS OF TEMPERATURE AND LIGHT ON THE DISTRIBUTION OF LEAF PILES IN LEAF-CUTTING ANT TRAILS

WENDY A. COVER, PHUONG T. X. HANG, KARL R. KROENLEIN, AND ANDREW C. TOLONEN

Abstract. Light and temperature affect leaf-piling behavior of leaf-cutting ants, *Atta cephalotes*. We hypothesized that *A. cephalotes* only form leaf-piles in lighted and high ground temperature areas, and tested the hypothesis by measuring light and temperature along trails with leaf-piles. As predicted, leaf-piling behavior of *A. cephalotes* was connected with high light and ground temperature. However, we encountered several shaded trails without leaf-piles. Thus, leaf piling by ants could be either a physiological response of the ants to heat/temperature stress or an opportunistic behavior to facilitate leaf decomposition.

Key Words: Atta cephalotes, *heat stress*

INTRODUCTION

Leaf-cutting ants, *Atta cephalotes*, clear trails along the forest floor in tropical forests to transport leaves from forage sites to fungal gardens in their nests. On some trails, many ants collectively drop their leaves in the trail to form large piles of leaf fragments. We examined whether there is a pattern to the distribution of these accumulations of leaf fragments. We hypothesized that the mean light level and ground temperature in areas with piles would be higher than the mean light and temperature levels for the whole trail.

METHODS

Five *Atta cephalotes* trails were selected from the marked trails surrounding the Sirena Station in Corcovado National Park, Costa Rica. The trails were selected based on the presence of active piles of cut leaf fragments. Active piles were defined as those leaf piles with ants actively adding leaf fragments to an already existing pile. We measured the distribution of leaf piles along a 50 m section of trail, starting at the nest. If the total trail length was less than 50 m, the entire trail was sampled. We measured the presence or absence of sun (recorded as light or no light) and ground temperature (°C) every two meters and at every active patch encountered along the drag line.

A chi-square contingency table was used to test for the relationships between presence or absence of light and presence or absence of an active patch. A t-test was used to examine a potential relationship between mean ground temperature in sites with and without piles.

Qualitative observations of pile formation were also recorded at each site.

RESULTS

We found that leaf-piling behavior of *A. cephalotes* was not random at all. In fact, ants were very specific as to where to they formed leaf-piles. Piles occurred in 17 of the 29 lighted patches, while none was found in 73 shaded sites (Likelihood Ratio=52.58, df=101, P<0.001; Table 1). In addition, leaf-piles occurred significantly more often in areas with higher temperature (T=70.10, df=102, P<0.001; Fig. 1).

Table 1: Number of leaf piles in sun or shade

	Pile	No Pile	Total
Light (sun)	17	12	29
No light (shade)	0	73	73
Total	17	85	102

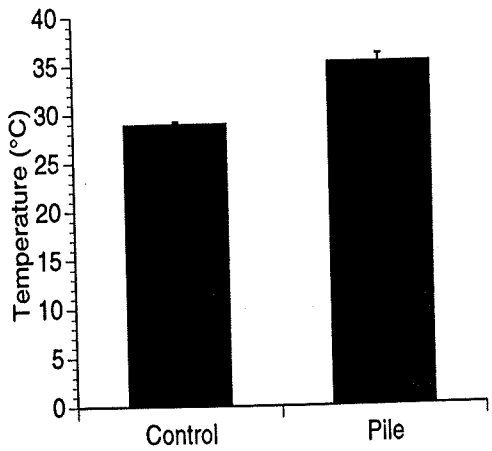

Fig. 1. Mean ground temperature at sites containing leaf piles and at sites located at 2m. intervals along the same ant trails (control). (n=85, control and n=17, piles)

Discussion

Accumulations of leaf fragments occurred only in sunny, warm areas along ant trails. This occurrence and distribution of leaf piles could be accounted for either as a physiological response of the ants to thermal stress or as an opportunistic behavior the ants use to facilitate decomposition.

Heat or light stress could induce a physiological response in the ants that causes them to drop the leaves. If the temperature or light levels exceed some threshold, ants may drop leaves to ease their load and pick them up later when conditions improve. This seems unlikely, however, since there were many patches of sunlight along the highways that did not have leaf piles (see Table 1). Additionally, there were many tiny patches of sunlight amid the shade that would seem too small to induce a physiological response, and yet contained leaf piles.

Leaf dropping could also be an opportunistic behavior of the ants to facilitate leaf decomposition. This behavior would benefit the leaf-cutters in two ways: either to allow evaporation to lighten the load of the leaves for future carriers, or to facilitate the decomposition of the leaf fragments. Further studies on both dry leaf weight and on the fungal processes would lend more insight into this phenomenon.

Several active trails we encountered were shaded and lacked leaf-piles. This suggests that leaf piling behavior is environmentally induced and any benefits from it, such as leaf decomposition, are not essential for normal colony functions. Furthermore, we observed that every time the shade encroached upon a leaf pile, the ants moved the fragments either to another sunny area along the trail or on to the nest. Further experiments using artificial shading on leaf piles would be useful to quantify these observations.

The majority of the ants that dropped their leaves on a pile immediately turned around and returned in the direction they came instead of continuing on to the nest. This suggested to us two hypotheses. The "way station" hypothesis entails a further division of labor, where there are certain ants that specialize in cutting and depositing, and others who specialize in picking up the fragments and transporting them to the nest. For this idea, the leaf piles might serve as a way station between the two divisions. A second hypothesis is that the workers maintain the leaf piles in the sun for a certain period, possibly for decomposition purposes, before taking them to the nest and therefore do not continue on their path to the nest after dropping off a leaf, but instead return to collect more leaves. This is the more likely hypothesis since the piles are found only in patches of sun, and if the piles served only as way stations they could just as easily be located in the shade.