B. simaruba density was positively correlated with irradiance, but negatively correlated with soil moisture (Table 1). Soil moisture and irradiance among the three sites were also negatively correlated (Table 1).

DISCUSSION

Our results support the hypothesis that *B. simaruba* is more abundant in areas of high irradiance. In nature, irradience and soil moisture tend to covary. Thus, the south facing slopes on which *B. simaruba* was most abundant tended to be both sunny and dry. The increased abundance of *B. simaruba* on southerly aspects could be directly attributable to the positive effects of high sunlight, but it could also be that the competitive ability of *B. simaruba* is enhanced in areas of water stress. Most tree species in sunlit areas were deciduous and had lost their leaves. Without the benefit of photosynthetic bark these trees may incur a greater carbon debt during the dry season and accomplish less annual growth than *B. simaruba* . Conversely, the competitive ability of *B. simaruba* may be reduced in less water-stressed areas. Comparing tree growth rates across sites with different slope and aspect (e.g., between the limestone hills at Palo Verde) is one way to test this hypothesis.

Because all sites were not tested at the same time of day it is possible that some of the inter-site variation in irradiance was due to the sampling time. We suggest that similar studies in the future measure irradiance at the same time in each site.

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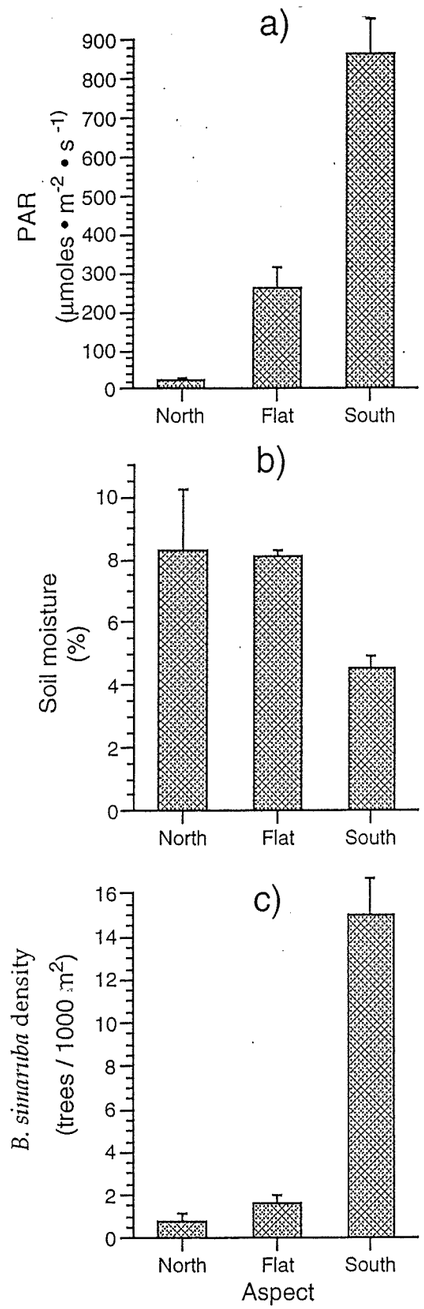

FIG. 1. Mean (±1SE) of a) photosynthetically active radiation b) soil moisture c) *B. simaruba* density.

THE EFFECTS OF SOIL TEXTURE AND ANT PHEROMONE TRAILS ON HABITAT SELECTION IN ANT-LIONS

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Abstract. Myrmeleon larvae, more commonly known as ant-lions, feed by building conical pits to capture ants and other small crawling insects. We hypothesized that soil texture and ant pheromone trails would play a role in where ant-lions built their traps. We predicted that ant-lions would build more traps in fine soil because fine soil is easier to manipulate by a small organism than coarse soil. We also predicted more traps in areas which had been treated with ant pheromones, assuming ant-lions are able to detect residual pheromone trails. We designed a multi-treatment grid to test the effects of soil texture, ant pheromones, and the combination of the two factors on trap placement. We found significantly more ant-lion traps in fine soil than in coarse soil, but that ant pheromones played no significant role in the placement of traps, perhaps because of the ephemeral nature of the ant trails.

Keywords: ant-lion distribution patterns, Myrmeleon, *pheromone detection*

INTRODUCTION

Myrmeleon larvae are an interesting example of sit and wait predators, building conical pits to capture ants and other small crawling prey. While these larvae are often found in dry loose soil, little is known about their habitat preference or method of dispersion (McClure 1983). It has been shown that ant-lions build cones faster in fine soil than coarse soil (Beadell et al. 1996) but an earlier study was unable to correlate soil type with feeding efficiency (Perlroth et al. 1995). Additionally, Guerrerio et al. (1992) found greater numbers of ant-lions beneath ant-inhabited *Acacia* trees than other cleared areas, suggesting that ant-lions may be capable of detecting ant pheromone trails.

We designed an experiment to examine the effect of soil texture and ant pheromones on distribution of ant-lion traps. We hypothesized that soil type and presence of ant pheromone trails would have an effect on ant-lion settling patterns. We predicted that ant-lions would prefer fine soil to coarse soil and would also preferentially settle in plots treated with ant pheromones.

METHODS

We collected ants and ant-lions within a 0.5 km radius of the OTS Field Station at Palo Verde National Park, Costa Rica on 13 January 1998. We used a two-factor experimental design with two levels of soil type, fine and coarse, crossed with two levels of ant pheromone, present and absent (Fig. 1). In each of the four treatment types, ant-lions had a choice of a treated side and an untreated side which contained fine sand with no ant pheromones. We assembled a multi-treatment testing grid of wood with walls 5 cm high divided into four test plots, each 50 x 100 cm. To obtain fine sand, we sifted dirt through 1 mm screen, and to obtain coarse sand we used a 5 mm screen. To treat subplots with ant pheromones, we released ten ants on each subplot and removed them five minutes later. We lined the walls with Tanglefoot® to prevent ants from disturbing our control plots and to prevent ants from escaping. Immediately after removing ants, we released ten ant-lions into the middle of each of the four plots. This number of ant-lions per subplot represents maximum ant-lion densities observed in the field.

We allowed five hours for the ant-lions to construct their traps and then recorded the proportion of ants in each subplot. For each of six replications, we collected and mixed all the ant-lions from test plots, added 10 new individuals to the pool, and randomly selected a new 10 for each plot. Because the data were proportional, we performed an arcsin transformation. After testing for homogeneity of variance, we analyzed our data using a two-way ANOVA to test for effects of sand quality, ant pheromones, and their interaction in determining ant-lion distribution.

	CONTROL	Sand Texture	Pheromone	Multi-Variable
Untreated	Fine Sand No Ants	Fine Sand No Ants	Fine Sand No Ants	Fine Sand No Ants
Treated	Fine Sand No Ants	Coarse Sand No Ants	Fine Sand Ants	Coarse Sand Ants

FIG. 1. Multi-variable test plot, with different treatments described

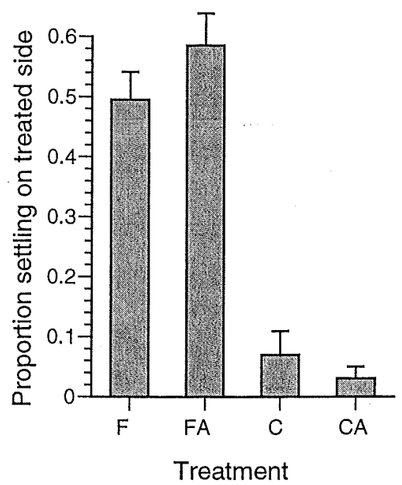

FIG. 2. Mean proportion of *Myrmeleon* larvae building traps on the treated side of test plots when given a choice between the control side,"fine sand, no ants" (F) and the treated side: fine sand, no ants (F); fine sand with ants (FA); coarse sand, no ants (C); and coarse sand with ants (CA) (mean ± 1 SE).

RESULTS

When given an option of fine or coarse textured soil, a significantly higher proportion of ant-lions chose to build their traps in the fine soil ($F_{3,20} = 106.6$, $P = 0.000$). Ant pheromones did not significantly affect ant-lion choice of trap location ($F_{3,20} = 0.007$, $P = 0.932$), and there was no interaction between soil type and the presence of ant pheromones ($F_{3,20} = 1.78$, $P = 0.197$) (Fig. 2).

DISCUSSION

Soil texture was a significant factor in determining the location of ant-lion traps, with most choosing to settle in fine soil. For their survival and foraging success, ant-lions rely on their ability to manipulate their environment and set traps (Beadell et al. 1996). Fine textured soil is inherently easier to manipulate by small organisms than coarse soil. Residual pheromone trails left behind by ants did not influence ant-lion settling patterns. Either the pheromone trails had dissipated by the time the ant-lions began to settle, or ant-lions do not change their behavior based on residual ant pheromones. Our conclusions about the relative importance of soil texture and ant pheromones are further supported by the fact that ant-lions settled almost entirely in fine untreated sand even when presented with coarse ant-treated sand.

The results of the ant pheromone test lead us to two possible conclusions. If our attempt to replicate the situation ant-lions face in the wild was successful, then we may conclude that ant-lions do not sense ant pheromones. If ant pheromones dissipate very quickly, then it may be unlikely that ant-lions would have evolved the ability to detect ant pheromones. Ant-lions might instead set traps in soil they can easily manipulate, and only move if they are unsuccessful in foraging. Another possibility is

that our simulation failed to replicate nature in that in the five hour experimental settling time, ants were only present for the first five minutes, and the pheromones may have dissipated quickly thereafter. Perhaps a constant presence of ants in a region, and therefore "fresh" trails, is necessary for an adequate test of this hypothesis.

Our study examined only two factors which may affect ant-lion settlement. Placement of ant-lion larvae by mature female *Myrmeleon* might play a role that was not considered in this experiment. To more fully understand factors affecting ant-lion distribution, more study into their ability to distinguish between habitats is necessary.

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