acacias combat increased herbivory pressure as overall leaf foliage decreases.

The importance of the presence of high quality foliage in determining ant distribution within plants is further supported by the lack of correlation between numbers of ants and the size, abundance, and position of nectaries, thorns, leaves, and branches. Thus these other factors do not appear to affect ant distribution. The lack of correlation between ant density and nectaries was particularly surprising, considering that nectaries are an important source of food for adult ants. However, we only quantified number of nectaries rather than nectar production or quality, so that these results may be inconclusive. We also expected a correlation between the number of larvae and the presence of Beltian bodies, as Beltian bodies provide the major source of protein, lipid and carbohydrates for the larvae (Janzen 1974). The data on larval abundance , however, had a high variance, and the lack of a significant correlation may have been due to the presence of one outlier data point from a branch with old foliage. Repeating our study with a larger sample size might reveal such a relationship.

Additional studies are necessary to fully explain the relationship between valuable plant foliage and increased ant defense. The results of our study suggest that new foliage, which is probably most valuable to *A. collinsii* , is also important to *Pseudomyrex spinicola*, leading ants to allocate more defense to these regions of their host plant.

LITERATURE CITED

Abram, E.H., M.P. Ayres, H.M. Fouts, P. L. Cans, A. E. Liberts and J.J. Ruel. 1994. Resource allocation in *Acacia collinsii*: plant growth and ant colony maintenance. Pp. 1-3 *in* J.L. Bykowski, editor, Dartmouth Studies in Tropical Ecology 1994. Dartmouth College: Hanover, New Hampshire, USA.

Janzen, D. H. 1974. Swollen-thorn acacias of Central America. Smithsonian Contribution to Botany **13**: 1-43.

EFFECTS OF DENSITY AND STRUCTURAL COMPLEXITY ON ANTLION CAPTURE EFFICIENCY

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Abstract. There are conflicting hypothesis regarding the optimal distribution of foraging antlions (*Myrmeleon* sp.). We studied the effects of antlion density and landscape structural complexity on several measures of antlion foraging success. We placed different densities of antlions into basins of low or high structural complexity and released ants (prey) into the arenas for timed intervals. We found that increasing antlion density increased total prey captures for the group, but decreased individual predation success. There was no effect of structural complexity. These findings suggest that interactions among antlions represent competition rather than facilitation, but further studies are needed to determine the exact nature of these interactions and what factors affect them.

Key Words: foraging efficiency, food availability , habitat complexity, Myrmeleon

INTRODUCTION

Antlions, larvae of *Myrmeleon* (Neuroptera: Myrmeleontidae), construct conical pits in loose dry soil that capture ants and other small crawling insects. Wilson (1974) and Simberloff et al. (1978) proposed that antlions distribute themselves to limit intraspecific competition and maximize capture success. Our preliminary observations suggested that antlions at Palo Verde were distributed randomly with respect to other antlions, although the pits seemed to be preferentially situated near rocks. High local densities of antlions could reduce individual capture success because of competition for prey. In this case, antlions should be overdispersed rather than randomly dispersed. However, it is possible that increased densities of antlions could enhance individual capture success because ants are likely to fall into multiple pits and be gradually weakened by the protease injected by antlions. Landscape complexity (e.g. rocks) could increase antlion capture success by creating vertical surfaces that hinder ants from escaping pits. We tested these hypotheses in experimental chambers at the OTS field station, Palo Verde National Park, Costa Rica.

METHODS

We used three basins (66 x 41.5 cm) with fine sifted sand (~ 5 cm deep) as antlion arenas. Each basin was used for one of three treatments: (1) low antlion density with low structural complexity, (2) low antlion density with high structural complexity, and (3) high antlion density with low structural complexity. Low density arenas were stocked with 11 antlions and high density arenas with 41 antlions. High complexity arenas contained 16 rocks of various sizes implanted into the sand.

Antlions and small black foraging ants (~8 mm long) were collected from the road and airstrip near the OTS station. Antlions were placed in the middle of each arena and allowed to construct pits. For each trial, we released 10 ants into each arena and recorded the number of times ants fell into each trap and whether or not they were captured and eaten. Tanglefoot paste prevented ants from escaping the arenas. After 5 min, any remaining ants were removed. New ants were used for each successive trial. This process was replicated six times for each basin (with new ants for each trial and ~ 30 min intervals between trials).

We compared the mean numbers of ant falls per arena, ant falls per individual antlion, and ant kills/fall between density and structural complexity treatments using Student's T-test.

RESULTS

Antlion density affected capture success. Ant falls per trial were highest in the high density treatment ($t_{10} = 4.03$, $P = 0.002$), but there were more falls per antlion pit in the low density treatment ($t_{10} = 2.28$, $P = 0.046$). There was no effect of antlion density on the probability that an ant falling into a pit would be killed (ant

kills/ant falls; $t_{10} = 0.31$, $P = 0.76$; Table 1).

Structural complexity had no effect on ant falls per trial, ant falls per antlion, or the ratio of ant kills to ant falls (all $P > 0.5$; Table 1).

DISCUSSION

Antlions in low density treatments were more successful predators than those in the high density treatment. Given equal prey abundance, individual antlions in the low density patch tended to receive more ant falls than those in a high density patch. Because the probability of an ant fall becoming an ant kill did not vary with antlion density, it follows that individuals in low density patches will have more kills than individuals in high density patches. Because capture efficiency was similar in both high and low density treatments, it appears that ants are not affected by falls into multiple pits.

For optimal capture success, antlion pits should be over-dispersed as proposed by Simberloff (1978). If antlion distribution is indeed random with respect to each other (preliminary observation), then individual antlions in a given population will have different capture success as a result of their local densities.

Structural complexity did not increase capture success. It is possible that rather than increasing capture success, rocks lend structural stability to antlion pits, reducing effects of disturbance and maintenance costs.

Our study was limited by time constraints and number of basins. Future explorations into the effect of density on predation success, including a broader range of densities, may reveal additional complexity in the relationships between antlion density, prey abundance, and capture success. For example, there could be thresholds or nonlinearities in the effects of antlion density on capture success, and there could be interactions among antlion density, prey abundance, and structural complexity.

LITERATURE CITED

McClure, M. S. 1983. *Myrmeleon* (Hormiga León, Antlions). Pages 762-76 *in* D. H. Janzen, editor. Costa Rican Natural History. University of Chicago Press, Chicago, IL., U.S.A.

Simberloff, D., et al. 1978. Holes in the doughnut theory: the dispersion of antlions. Brenesia **14-15**: 13-46.

Wilson, D.S. 1974. Prey capture and competition in the antlion. Biotropica 6:187- 93.

TABLE 1. Prey capture success in arenas with low and high antlion density and low and high structural complexity at Palo Verde National Park. Data obtained from six 5 min trials.

Antlion density	Structural complexity	Means (SE)		
		Ant falls/trial	Ant falls /antlion	Ant kills/ ant fall
high	low	48.67 (4.96)	1.19 (0.12)	0.053 (0.012)
low	low	22.83 (4.07)	2.08 (0.37)	0.060 (0.017)
low	high	19.00 (4.94)	1.73 (0.45)	0.071 (0.025)