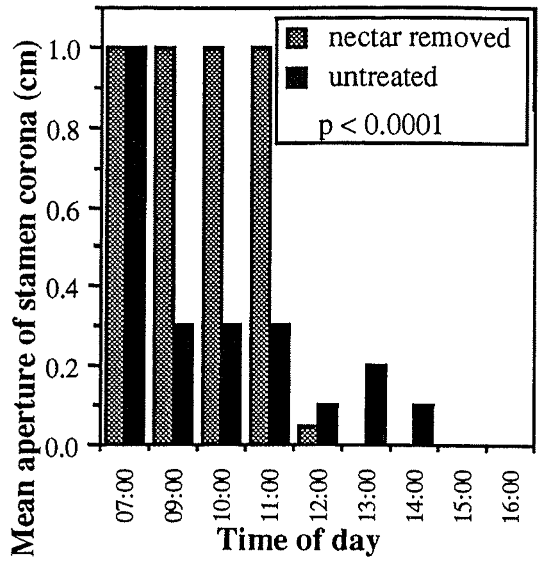

Figure 2. Effect of nectar removal on N.ampla stamen collapse (repeated measures ANOVA).

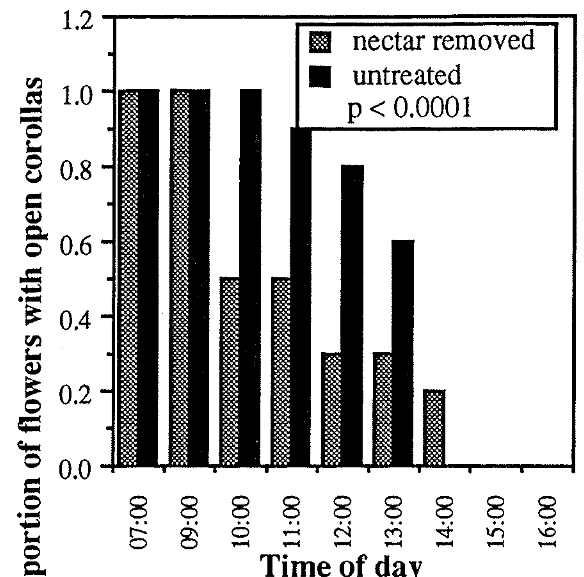

Figure 3. Effect of nectar removal on N. ampla corolla closure (repeated measures ANOVA).

open corolla in treated vs. untreated flowers. This suggests that two different mechanisms are at work.

We speculate that low nectar levels serve as a cue that enough pollinators have visited to pollinate the flower. If nectar levels are high, as in untreated flowers, visitation has not been sufficient to guarantee pollination. In this case, stamen coronas close earlier, forcing increased contact between pollinators and anthers and the ovary. This is consistent with the idea that cross-pollination is favorable to self pollination, but self-pollination is better than no pollination.

In contrast to stamen corona closure patterns, corolla closure is delayed in untreated flowers. We suggest that here also, as described above high nectar levels signal a lack of pollination, and the corolla is therefore left open to allow pollinators to enter. Both stamen coronas and corollas close by 14:00, possibly because the preferred pollinator is active in the morning.

Pollinator exclusion had no effect on time of stamen corona or corolla closure in either treatment. This suggests that mechanical disturbance or pollination does not affect the aperture of either the corolla or the stamen corona.

There still exist fundamental gaps in our knowledge of N. ampla pollination biology. Flowers are probably open for several days, and we do not know whether the trends we observed repeat every day. It would be interesting to study whether petal closure signals that pollination has occurred and triggers the development of the fruit. Manual pollination experiments could be used to test the effects of pollination on flower closure and determine whether the population is obligatorily outcrossing.

EFFECTS OF SUNLIGHT, LEAF LITTER, AND TEMPERATURE ON HABITAT SELECTION BY ANT LIONS (NEUROPTERA: CHRYSOPIDAE)

Andrew N. Swanson, Brendan M. Everett and Mark E. Berry

ABSTRACT (MEB)

We examined factors affecting pit location by ant lions placed in an artificial plot. In the field, we observed ant lion pits only in bare soil. We hypothesized that ant lions choose sunny locations over shady locations, and choose bare soil over soil covered by leaf litter. We found that ant lions prefer shady cooler soil to sunny hot soil, prefer bare soil to soil covered by leaf litter, and construct more pits at night than during the day, especially in sunny soil. Ant lions may be excluded from sites with leaf litter or high soil temperatures, however, nocturnal pit construction may permit utilization of some sites that would be too warm for daytime colonization.

Key Words: Myrmeleon, ant lion, habitat selection.

INTRODUCTION (MEB)

Larvae of the Neuropteran, Myrmeleon sp. (ant lion) prey on small insects that fall into conical pits constructed in loose soil (McClure, 1983). We observed that ant lion pits in a tropical dry forest were exclusively on bare soil and not under the adjacent leaf litter. We initially hypothesized that ant lions avoid soil covered by leaf litter by avoiding shaded soil. We gave ant lions a choice between sunny and shaded bare soil, and predicted more pit construction in the unshaded soil. The alternative hypothesis was that ant lions avoid leaf litter directly. We gave ant lions a choice between bare soil and soil covered by leaf litter, and predicted more pit construction in the bare soil. Observations of high soil temperatures in sun treatments led us to hypothesize that ant lions construct more pits at night when soil temperatures are lower.

METHODS (BME)

We assessed ant lion habitat selection within artificial plots, 1.75 m^2, constructed at Palo Verde National Wildlife Refuge, Costa Rica. Experiments were conducted on 13-14 January, 1994.

Shade treatments were produced by boards suspended 10cm above the plot. In some treatments, leaf litter gathered from the adjacent forest was laid over the soil substrate. We measured soil temperatures near natural ant lion pits and noticed that soil temperatures in the sun treatments were far higher than natural ant lion habitats (up to 60°C). To maintain temperatures within a natural range we covered "sun" treatments with a 4mm mesh screen that produced partial shade.

In the first experiment, 88 ant lions were added in the treatment plot, 44 to both sun and shade habitats at 09:00 on 13 January, 1994. Number of ant lion pits, light levels and soil temperatures were measured at 09:00, 11:00, 13:00 and 16:00.

The second experiment tested ant lion preferences for bare soil compared to soil covered by leaf litter. At 06:30 on 14 January, 1994, we thoroughly mixed the soil in the pit, which destroyed the existing pits, dispersed the 88 ant lions that were present, and homogenized soil temperatures. There we placed leaf litter on half the study plot, and removed the shading boards. The mesh screen was stretched over the entire plot. Ant lion pits were counted at 18:30.

Experiment 3 addressed our prediction that ant lion pit building rates would be higher at night, as compared with our data for Experiment 1. The experiment began at 18:00 on 13 January, 1994 by mixing the sandy plot soil, and ended at 06:30 on 14 January, 1994. Soil temperatures and ant lion pits were measured at 22:00 and 06:30. We used the same screening apparatus as in Experiment 1.

We tested ant lion habitat preferences using Chi-square analyses.

RESULTS (BME)

When given the choice between sun and shade, ant lions constructed 23 of 28 pits in the shade treatment ($X^2 = 15.1$, df = 1, $p < 0.001$; Figure 1A). High light intensity in the sun treatment of Experiment 1 (Figure 1B) produced soil temperature far above that in natural ant lion habitats: mean ± SE = 60.1 ± 0.4 vs. 39.0 ± 1.3°C at 13:15 on 13 January (n = 4 and 16, respectively; Figures 1B and 1C). Temperatures in the shade treatment were similar to those in natural habitats (44.3 ± 0.4%, n = 4). Temperatures >50°C proved to be lethal to ant lions placed on the soil surface.

In Experiment 2, 19 times as many pits were built in base soil as were in the litter portion of the arena ($X^2 = 31.4$, df = 1, $p < 0.001$, Figure 2).

Ant lions constructed more pits at night than during the day (Figure 3). Over a four hour period, 28 pits were constructed during the day compared to 60 during the night ($X^2 = 11.6$, df = 1, $p < 0.001$). Diurnal patterns

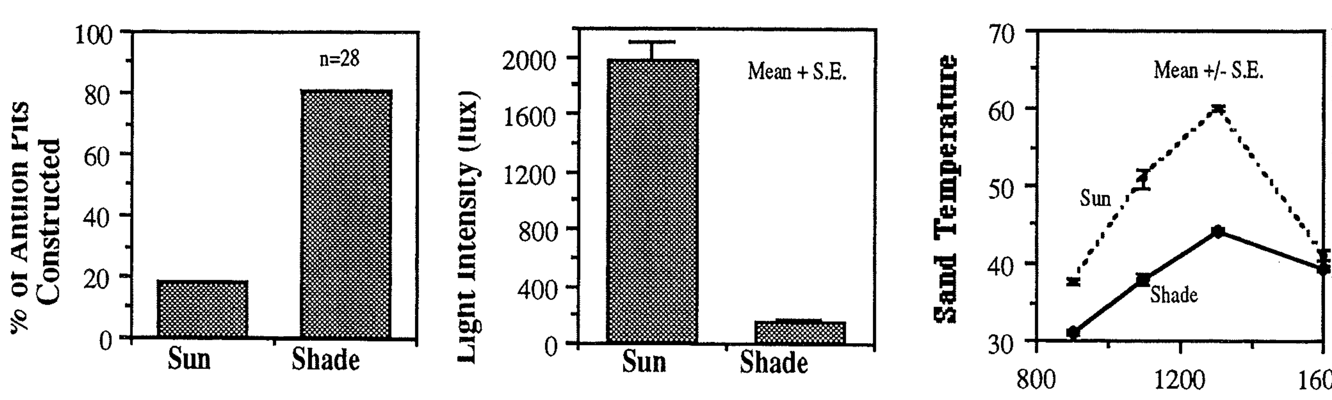

Figure 1: Comparison of (A) Ant lion pits dug from 09:00 to 16:00, (B) Light intensity at 13:00 (peak of day) and (C) Diurnal patterns of temperature in sun and shade habitats.

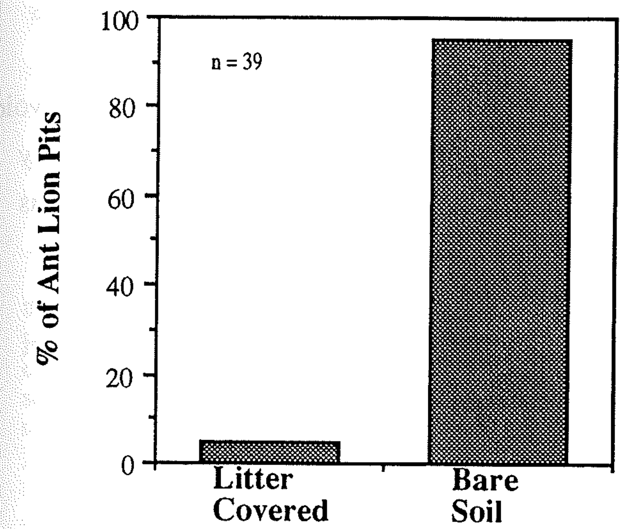

Figure 2: Comparison of ant lion pit locations for bare soil and leaf litter during one day in an experimental test plot.

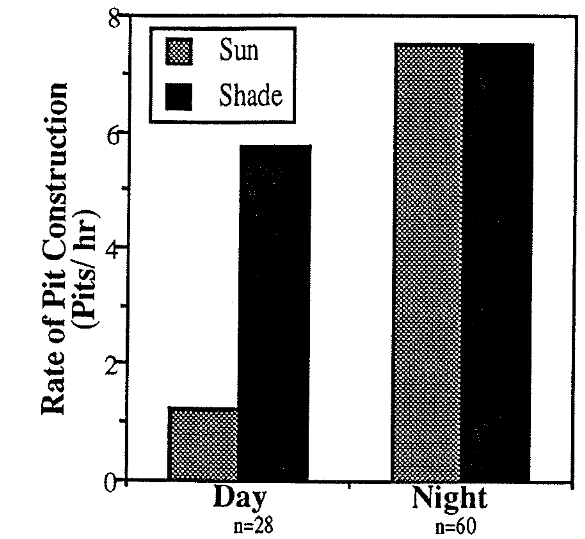

Figure 4. Comparison of ant lion pit construction rates in sun and shade treatments during the day and night. Rates were calculated over a 4hr period

were much more pronounced in the "sun" treatment (6 day pits vs. 30 night pits) than in the shade treatment (22 day pits vs. 30 night pits).

DISCUSSION (ANS)

Natural populations of ant lions appeared to have strong habitat preferences for pit construction. We only found ant lion pits on bare forest soils, never under leaf litter. In addition, pits usually occurred under the canopy, and were only rarely found in areas devoid of larger trees.

We hypothesized that use of litter free soils was due to a preference for warm, sunny sites. We found, however, that ant lions do not prefer the sun, but avoid it. In the day, soils in the sun treatment were very warm, in fact, potentially lethal. Ant lions showed a preference for shaded soils that were the same temperature as soils adjacent to natural pits. Light levels, however, were only 1/10 as great in the shade compared to light levels around natural pits. We thus hypothesize that ant lions are precluded from some sites by high soil temperatures.

In our second experiment, we hypothesized that ant lions may select habitats by avoiding leaf litter. In fact, we found ant lions strongly avoided constructing pits in leaf litter. Alternatively, ant lions may have preferred leaf litter because it buffers soil temperature (daytime soil temperatures under the litter in the field were ≈6°C lower than bare soil temperatures). Ant lions preferred sunny, warm soils (which were potentially lethal in the day) over litter. We speculate that ant lion traps do not work in the presence of leaf litter.

In Experiment 3, we found ant lion pit construction increases at night, especially in warm sunny sites. Presumably, at night, soil surface temperatures become moderate enough to allow pit construction in "sunny" areas. By 22:00, soil temperatures in both sites were equal (26°C). It is likely that soil temperatures at the depth of pit construction are tolerable, even when surface temperatures are not. Nocturnal pit building may allow ant lions to exploit some habitats that would otherwise be unusuable.

We suggest that ant lions construct pits under the canopy to avoid high light and excessive temperatures, but must at the time avoid leaf litter. Bare soils beneath the canopy may be a limiting resource for ant lion populations at Palo Verde. Future work is required to assess prey abundance, light, temperature, and litter as independent variables that may affect ant lion habitat preference