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Field and experimental analysis of antlion dispersion patterns

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Abstract: Ecological theory predicts that individuals distribute themselves to minimize competition and maximize resource acquisition. We tested whether antlions minimize competition through active movement resulting in a particular pattern of dispersion. By recording antlion distributions in the field and by experimentally manipulating antlion dispersion in three treatments, we found that antlions actively distribute themselves uniformly within their habitats. In this way antlions minimize interference with conspecifics and probably maximize their access to prey.

Key Words: intraspecific competition, resource competition, site selection, spacing

Introduction

Many factors influence the spatial distribution of individuals in a population, including location and abundance of resources and competition for these resources. According to ecological theory, individuals should distribute themselves in ways that maximize their access to available resources while reducing competition (Begon et al. 1993).

In this study, we examined site selection and dispersion patterns of antlions (*Myrmeleon* spp.: order Neuroptera). Antlions burrow into sandy soil, creating pitfall traps to capture ants and other small insects (Janzen 1983, Beadell and Bird 1996). Antlion pitfall dispersion is strongly influenced by substrate temperature and texture (Topoff 1977) and probably serves to maximise prey capture (Wilson 1974, Simberloff et al. 1978). Given these findings, we hypothesized that antlions actively disperse themselves in a non-random pattern. Specifically, we predicted that antlions in the field would be overdispersed. We then used laboratory experiments to test whether displaced antlions would actively reposition themselves into non-random dispersion patterns.

Methods

To measure dispersion, we calculated an index of dispersion using the equation $I = \Sigma (n_I - n)^2 / [(m-1) n]$, where I = index of dispersion, m = number of quadrats, n_I = number of antlion pits in quadrat I, and n = mean number of antlion pits per quadrat. When $I = 1$, the antlion pits are randomly dispersed; when $I > 1$ the antlion pits are aggregated; and when $I < 1$ the antlion pits are uniformly dispersed.

To determine antlion spatial configuration under natural conditions, we collected data along footpaths in the forest southeast of the OTS field station in Palo Verde National Park, Costa Rica. We selected areas of high antlion density, assuming that these individuals would most likely experience intraspecific competition. We measured the distribution of antlions in 14 plots by placing a 1 x 1 m frame, divided into 100 quadrats (10 x 10 cm), over each selected area and recorded the number of antlion pits observed in each quadrat. The mean index of dispersion for the plots was compared to a random dispersion ($I = 1$) with a t-test.

For the lab experiments, we filled nine trays of equal size (0.25 m x 0.25 m) with 1 L of sand sieved through a 1.5 mm mesh. We assigned three trays to each of three treatments: aggregated, random or uniform distribution. We divided the trays into nine 8.33 x 8.33 cm quadrats based on the average observed antlion pit diameter (4 cm). We placed nine antlions in each tray to match the maximum densities observed in the field. The antlions were deposited gently on top of the sand in each tray in predetermined configurations: random, aggregated or uniform (*I* values of 2.5, 1.25, and 0, respectively), and left to form pits overnight (Fig. 1). After 12 h we recorded the number of occupied antlion pits in each quadrat. We assessed whether ant lions moved by comparing the final dispersion values to the initial dispersion values using t-tests. We also used t-tests to evaluate whether final dispersion patterns were aggregated, random or uniform. Data are presented as means ± SE.

Results

Antlions in the field were uniformly dispersed. The mean index of dispersion for the 14 plots sampled was $I = 0.94 \pm 0.02$, and was significantly different from random ($t = -3.16$, $df = 11$, $P = 0.009$). The density of antlions ranged from one to four antlions per 10 cm^2 quadrat. The median number of ants per quadrat was one.

In the laboratory, antlions moved from their initial distributions and became

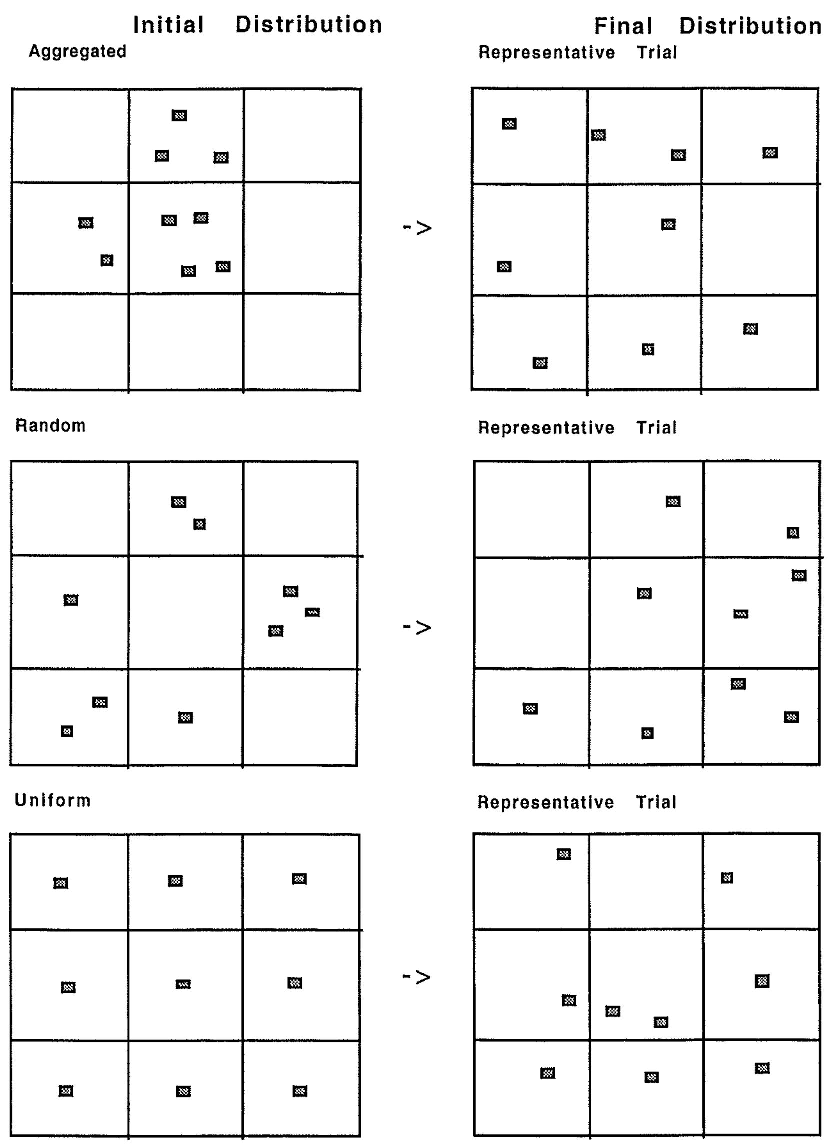

FIG.1. Results from 12 h antlion displacement experiment. Nine antlions were placed in three trays in three treatments: aggregated, random and uniform distributions. "Initial Distribution" replicate indicates initial placement with *I* values of 2.5, 1.25 and 0: "After" indicates antlion positions in one replicate after 12 h. Dots represent antlion locations.

uniformly dispersed ($I < 1.0$). The initially aggregated individuals ($I = 2.5$), moved to a mean distribution of $I = 0.5 \pm 0.14$ (n = 3). This mean final distribution differed significantly from the initial distribution ($t = -13.86$, $df = 2.0$, $P = 0.005$), and marginally from a random distribution ($t = -3.46$, $df = 2.00$, $P = 0.074$). The antlions intially placed in a random pattern ($I = 1.25$) had a final distribution of $I = 0.67 \pm 0.08$ that differed significantly from the initial distribution ($t = -7.00$, $df = 2$, $P = 0.02$) and marginally from a random distribution ($t = -4.00$, $df = 2$, $P = 0.057$). The initially uniformly dispersed antlions ($I = 0.0$) moved to a mean distribution value of $I = 0.5 \pm 0.14$ ($t = 3.46$, $df = 2$, $P = 0.037$). The mean value was consistent with a uniform distribution, and differed marginally from a random distribution ($t = -3.46$, $df = 2$, $P = 0.074$).

Discussion

Both the field and experimental studies demonstrated that antlions distribute themselves uniformly across patches of suitable substrate. An earlier study by Dickinson et al. (1998) showed that increasing antlion density decreases individual foraging success. A uniform distribution maximizes nearest neighbor distance and thereby minimizes local interference. Our results suggest that, when displaced, antlion larvae moved to a uniform distribution, which probably minimizes interference with other antlions and may increase prey capture rates.

The nearest neighbor distance for antlions is constrained by the spatial limits of substrate suitable for their pits. Antlions demonstrate a strong preference for fine sand substrate (Beadell and Bird 1996) that is free of leaf litter and has a lower temperature (Berry et al. 1994). Within suitable habitats, antlions seem to distribute themselves away from neighbors. Our results indicate that strong intraspecific competition may lead to a uniform distribution. We speculate that competition is a major factor affecting how individuals are dispersed in their environments.

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