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Effect of Population Density on Larval Dispersion and Pit Construction of the Antlion, *Myrmeleon angustipennis* Banks (Neuroptera: Myrmeleontidae)

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ABSTRACT

Since its discovery in 1916, the dispersal pattern of *Myrmeleon angustipennis* Banks has never been documented. Spatial distribution of this species was illustrated and quantitatively analysed using nearest neighbour technique. The effect of population density on pit construction and dispersion of *M. angustipennis* larvae was also observed. This was accomplished by introducing 10 antlions at the center of a 30×30 cm wooden observation box filled with sandy soil (Set-up A). Set-up A represented low experimental population density (1.1 larvae per 100 cm^2). Meanwhile, set-up B had 20 antlions released at the middle of a 20×20 cm observation box; representing high population density (5 antlion larvae per 100 cm^2). Results showed that in both set-ups, *M. angustipennis* exhibited near uniform distribution based on the illustrationsas well as on the computed R and c values. Hence, population density had no effect on the dispersal pattern of this antlion species. However, it was noted that pit construction had decreased with increased population density. Set-up A had an average of 97% pit construction while set-up B had an average of 60% pit construction. Lastly, antlion size seemed to have more influence on pit location rather than population density.

Key words: Antlion, dispersion, *Myrmeleon angustipennis*, Myrmeleontidae, population density, spatial distribution

INTRODUCTION

Antlions or doodlebugs are Neuroptera larvae that derive their name from the manner by which they catch their prey. These sit-and-wait predatory insects construct conical pits as a means of capturing fallen prey like ants or any animal they can manage to subdue with their strongly-developed sickle-shaped mandibles. Meanwhile, the name doodlebug is probably descriptive of the way these insects disperse themselves; larvae dig through soil with their body half exposed, leaving behind shallow trenches that look like doodles on the soil (Wilson, 1974; Swenson *et al.*, 2007). These predaceous larvae also always move backward, very seldom forward.

Wilson (1974) recognized that antlions would be good subjects for ecological study but admitted that the interest in this kind of basic entomological research had waned when scientific attention had been turned toward applied studies. In the Philippines, particularly in Luzon, antlion studies were initiated by Banks (1916) when two *Myrmeleon* species from Mount Makiling were recorded, one of which was new. The species was described and named *M. angustipennis*. However, description was based on the adult form. Seventy years later, Zipagan (1986) described in detail the life history and certain aspects of the behavior of this species for the first time.

This study aims to continue the natural history studies done on *M. angustipennis* by describing the population dispersion or spatial distribution of this species. Specifically, this investigation aims to: (1) illustrate, quantitatively analyze and identify the population distribution pattern of *M. angustipennis* larvae and (2) determine the effect of population density on pit construction and dispersion of *M. angustipennis* larvae.

MATERIALS AND METHODS

Experimental set-up: The procedure for this laboratory study was modified from that of McClure (1976) on the spatial distribution of pit-making antlion larvae. A total of 30 antlion larvae of varying sizes (ranging from 5-10 mm) were collected around the University of the Philippines Los Baños campus. These were later identified as *M. angustipennis* based on the larval description of Zipagan (1986).

Two set-ups were made, each replicated 7 times with one wooden observation box per replicate. For the first, designated as set-up A, 10 antlion larvae were released at the center of a 30×30 cm observation box filled with sandy soil that is pre-sifted using a wire sifter with mesh size of 2 mm. Set-up A represented a low experimental population density of 1.1 larvae per 100 cm^2. For the second set-up, B, 20 antlion larvae were released at the center of a 20×20 cm observation box to represent a high population density of 5.0 antlion larvae per 100 cm^2. For both set-ups, the dry sandy soil had a maximum depth of 2.0 in or 5.08 cm.

All set-ups were observed after 24 h for signs of pit construction. The number of antlion larvae that successfully constructed pits was counted and the respective diameters of these pits were measured. The spatial distribution patterns of the antlion pits in each of the observation boxes are illustrated as Fig. 1. The illustrations were traced directly from digital photographs of the observation boxes for accuracy. Antlion pits at or near the center of the observation box were referred to as central pits whereas pits close to the box edge were called peripheral pits.

Quantitative analysis and definition of population dispersion patterns: The degree to which the observed distribution of antlion larvae departs from random expectation was measured. This measurement was with respect to the distance of their nearest neighbour. Calculation relied on the measure of spatial relationships developed by Clark and Evans (1954). Based on Clark and Evans (1954), the ratio, R, of the observed distance to the expected ranges from 0 (maximum aggregation) to 1 (random distribution) to 2.15 (perfectly uniform) can be used as a measure of the degree to which the observed distribution approaches or departs from random expectation. Values significantly different from 1 suggest approach toward uniform distribution (if R approaches 2.15) or clumped distribution (if R approaches 0).

Statistical analysis: Significant differences of R can be analysed by the statistical c test. The formula used for computing this is shown (Clark and Evans, 1954):

$$C = \frac{\bar{r}_A - \bar{r}_E}{\sigma_{\bar{r}_E}}$$

where, $\bar{r}_A$ is Mean of array of distances to the nearest neighbor $\bar{r}_E$ is Expected mean distance to the nearest neighbor $\sigma\bar{r}_E$ is standard error of the mean distance to the nearest neighbor in a ramdomly distributed population at a given population density.

Association between larval density and % pit construction was analysed using the chi square test while differences between average pit sizes of peripheral and central pits were determined using the t test. Both tests were done using statistical function of Microsoft Excel program.

RESULTS AND DISCUSSION

Figure 1 shows the spatial distribution of antlion larvae at two experimental densities. At both densities, the spatial distribution of *M. angustipennis* exhibits near uniform pattern. The computed R and c values indicate likewise (Table 1). Computed R values at experimental density of 1.1

Table 1: Quantitative analysis of population dispersion of *M. angustipennis* at two different experimental densities

	Computed Statistics from Set-ups											
	A 1.1 antlion larvae per 100 cm^2						B 5.0 antlion larvae per 100 cm^2					
Replicates	$\bar{r}_A$	ρ	$\bar{r}_E$	R	$\sigma\bar{r}_E$	c	$\bar{r}_A$	ρ	$\bar{r}_E$	R	$\sigma\bar{r}_E$	c
1	7.55	0.01	4.75	1.59	0.78	3.59	4.65	0.03	2.77	1.68	0.40	4.70
2	8.21	0.01	5.00	1.64	0.87	3.69	3.94	0.04	2.67	1.48	0.37	3.43
3	11.07	0.01	5.97	1.85	1.18	4.32	5.46	0.03	2.77	1.97	0.40	6.73
4	7.75	0.01	4.75	1.63	0.78	3.84	4.73	0.03	2.77	1.71	0.40	4.90
5	6.38	0.01	4.77	1.34	0.78	2.06	4.82	0.03	3.01	1.60	0.48	3.77
6	9.42	0.01	4.77	1.97	0.78	2.53	5.48	0.03	3.04	1.80	0.48	5.08
7	7.89	0.01	5.00	1.58	0.87	3.32	5.45	0.03	3.16	1.72	0.52	4.40

$\bar{r}_A$: Mean of array of distances to the nearest neighbor, ρ: No. of individuals per unit area, $\bar{r}_E$ = expected mean distance to the nearest neighbor, R: Measure of degree to which observed distribution deviates from random expectation, $\sigma\bar{r}_E$: Standard error of the mean distance to the nearest neighbor in a ramdomly distributed population at a given, population density, c: 1.96, significant departure from randomness at p = 0.05, c = 3.29 (p = 0.001)

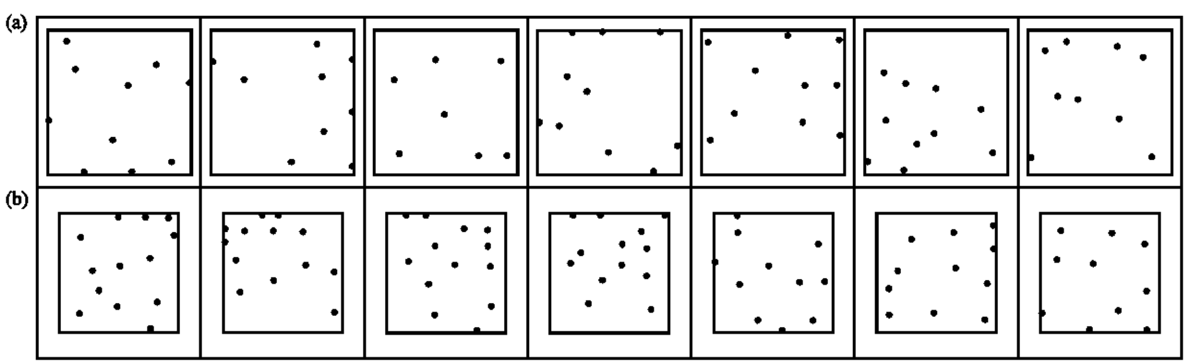

Fig. 1(a-b): The spatial distribution of antlion, *M. angustipennis*, larval pits in observation plots or boxes, (a) 30×30 cm plot with initial 10 antlion larvae introduced (1.1 larvae per 100 cm^2), (b) 20×20 cm plot with initial 20 antlion larvae introduced (5.0 larvae per 100 cm^2)

Table 2: Number and per cent of antlion (*M. angustipennis*) pits constructed at different population densities (based on 7 replicates per set-up)

Density (No. of larvae 100 cm^{-2})	No. of antlion larvae introduced	No. of antlion pits constructed	Percent larval pits constructed
Set up A: 1.1	10	Range: 9-10	Range: 90-100
		Average: 9.7	Average: 97
Set up B: 5.0	20	Range: 10-13	Range: 50-65
		Average: 12.0	Average: 60

Highly significant chi square test results indicate that % pit constructed is related/associated with larval population density ($p<0.001$)

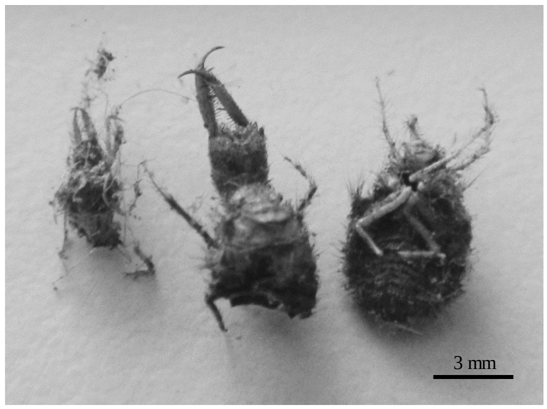

Fig. 2: Some dead antlion (*M. angustipennis*) larvae recovered from the observation boxes: with pinched thorax (left); with abdomen partly crushed (middle); and decapitated (right)

antlion larvae per 100 cm^2, ranged from 1.34-1.97 while, the R values at 5.0 antlion larvae per 100 cm^2 ranged from 1.48-1.97; both approaching perfectly uniform distribution (R = 2.15). The c values (test of significance) on the other hand, confirm that the distribution patterns exhibited at these experimental densities indicate highly significant departure from a random distribution at $p<0.001$ except for reps 5 and 6 in Set-up A which indicate significant departure from a random distribution at $p<0.05$. Hence, population density in this case had no effect on the dispersal pattern of *M. angustipennis*. Intraspecific competition for space (McClure, 1976), food availability, microhabitat conditions and differences in prey capturing abilities between different larval instars (Wilson, 1974; Prado *et al*., 1993) as well as the energy costs of pit construction and relocation McClure (1976) are possible factors affecting the spatial distribution of *M. angustipennis* that warrant further investigation.

Table 2 shows that the number of pits made or constructed tend to decrease with increasing antlion larval population. Set-up A with an antlion larval population density of 1.1 larvae per 100 cm^2 had an average of 97% antlion pit construction while set-up B with an antlion larval population density of 5.0 larvae per 100 cm^2 had an average of 60% antlion pit construction. The chi square test showed that % pit construction is highly significantly associated with antlion population density ($p<0.01$).

Sifting through the observation boxes did not recover all of the antlions initially introduced. Only around 2-3 dead antlions were retrieved. All the dead antlions were the small ones. Close inspection under the microscope revealed that these dead antlions showed indications of being attacked by other antlions as they appeared to either have pinched abdomens or were decapitated (Fig. 2). Day and Zalucki (2000) observed that in *Myrmeleon acer*, cannibalism was only recorded at population densities greater than 5.0 antlions per 100 cm^2.

Table 3: Location and mean diameter of pits constructed by antlion (*M. angustipennis*) larvae at population density, 1.1 larvae per 100 cm^2

	Peripheral pits		Central pits	
Replicates	No. of pits	Mean pit diameter (cm)	No. of Pits	Mean pit diameter (cm)
1	4	1.72	6	2.51
2	4	1.20	5	2.14
3	3	1.14	7	2.97
4	6	1.49	4	2.41
5	6	1.05	4	1.82
6	2	1.32	8	2.76
7	1	1.62	8	1.91
Average		1.36±0.25		2.36±0.43

*Treatment means are significantly different at $p<0.01$ using the t test for equality of means

Table 4: Location and mean diameter of pits constructed by antlion (*M. angustipennis*) larvae at population density, 5.0 larvae per 100 cm^2

	Peripheral pits		Central pits	
Replicates (cm)	No. of pits	Mean pit diameter (cm)	No. of pits	Mean pit diameter
1	5	1.19	8	2.70
2	4	0.85	9	1.93
3	3	0.71	10	2.24
4	3	1.47	10	2.45
5	3	1.10	8	2.46
6	2	1.04	9	2.10
7	3	1.10	7	2.57
Average		1.07±0.24		2.35±0.27

*Treatment means are highly significantly different at $p<0.001$ using the t test for equality of means

The rest of the unaccounted antlion larvae are believed to have escaped from the observation boxes. According to McClure (1976), it is not uncommon for antlion larvae to escape predation by other antlions at high population densities. In this case, some antlions may have left the observation boxes at the population density of 5.0 antlions per 100 cm^2. It is also possible for smaller larvae to be tossed together with sand particles during pit construction by the larger antlions. Those that did not form pits at 1.1 antlions per 100 cm^2 may not have left the observation boxes but were instead possibly cannibalized.

Assuming antlion size is directly related to pit size according to a previous study by Zipagan (1986) pit location seems to be more influenced by antlion size rather than population density. The average size of peripheral pits in set-up A (1.1 larvae per 100 cm^2) of Table 3 ranged from 1.05-1.72 cm while the average central pit size ranged from 1.91-2.97. On the other hand, average size of peripheral pits in set-up B (5.0 larvae per 100 cm^2) ranged from 0.71-1.19 cm while the average central pit size ranged from 1.93-2.70 (Table 4). In both set-ups, peripheral pits are significantly smaller than central pits ($p<0.01$). Assuming the positive correlation between pit size and antlion size, then both set-ups showed that the smaller antlions in each replicate were pushed to make pits at the sides and corners of observation box. These findings agree with McClure (1976) observations in *Myrmeleon* sp. He observed that the larger antlions chose sites in the first favorable area encountered (i.e., in the center of the plot where all larvae were introduced) thereby pushing the smaller antlions to the less favorable areas. Furthermore, pit-making is an energy-intensive activity so it will be favorable for the antlions to select optimal sites where prey shall be caught (Prado *et al.*, 1993; Swenson *et al.*, 2007).

In contrast, the study of Day and Zalucki (2000) showed that species redistribution is not the result of selecting sites for prey capturing optimization. Rather, it happens because antlions simply actively avoid each other and the associated sand-throwing activities of nearby antlions. Day and Zalucki (2000) also noted that the size of the pit could also be attributed to the lack of time to construct a completed one. In the present study, meanwhile, the basic assumption has been limited to the association of pit size with the size of the antlion which occupied it, similar to that observed by Zipagan (1986). Hence, this warrants further investigation incorporating size of larvae as treatments and *M. angustipennis* antlions of uniform size or instar for each treatment. The observed similarities and differences of *M. angustipennis* with/from other antlion species studied elsewhere e.g., Australia (Day and Zalucki, 2000), Costa Rica (Swenson *et al.*, 2007) etc. in terms of spatial distribution and pit construction also make studies focusing on other Philippine *Myrmeleon* species interesting.

CONCLUSION

Based on the computed R and c values, *M. angustipennis* exhibits near uniform distribution regardless of experimental density (high or low). Population density, in this case, had no effect on the dispersal pattern of this antlion species. This brings attention to the need to look at the effect of the following factors on the dispersal of *M. angustipennis*: intraspecific competition for space, food availability, microhabitat conditions, differences in prey capturing abilities between different larval instars and energy costs of pit construction. However, the results of this study revealed that pit construction had decreased with increased population density. Some antlions were able to escape predation by leaving the observation box, whereas those that were unable were cannibalized.

This investigation also demonstrated that antlion pit location seemed to be more influenced by antlion size rather than population density. If population density had any effect, it would have been indirect through the creation of spatial limitations that aggravated intraspecific competition for space. Such a claim shall also entail quantitative analysis.

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