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EFFECTS OF DENSITY AND HUNGER ON THE SPATIAL DISTRIBUTION AND PIT CONSTRUCTION BEHAVIOUR OF THE ANTLION LARVAE (*MYRMELEON* SPP.)

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ABSTRACT

The antlion larvae are sessile predaceous larvae, which depend on active prey for their food. They dig conical pit in loose fine sand and remain at the bottom of their pits with their long piercing jaws from where they seize and remove the body fluids of the ant and other arthropods that slide into their trap. The effects of hunger and density on the spatial distribution and pit construction by the larvae were studied for the three instar stages in fine and coarse sand textures of particles size of <540 µm and <1200 µm respectively.Twenty four (24) Iron trays of 25cm^{2}each filled with sand to the depth of 20cmwere used in the study.The result of the findings reveals that with the increase in density, there was an increased in spatial uniformity and the pits became uniformly distributed. The diameters of the pit were not statistically affected by the changes in the larval density. There was difference between the total number of pits constructed between sand textures and not between the larval instars, in addition, nearest neighbor distance decreases with increase in density and with no effect on pit diameter. Pit diameter increases with hunger level and Antlion move pit to reducedisturbances and to improve food supply. The result analysis showed significant differences in the mean number of pits constructed between densities, sand texture and larval instars at P< 0.01 but none between fed and larval instar.

Keywords: Antlion, Construction, Density, Distribution, Hunger, Larvae, Pit.

INTRODUCTION

The use of traps for predation has evolved independently in a small number of animal groups (Alcock 1972; Foelix, 1996; Ruxton and Hansell, 2009). This strategy is energy and time consuming, but reduces the amount of energy expended in prey searching given that ambush predators invest no energy or time in prey searching but need only a suitable place for constructing a trap (Lucas 1985; Riechert 1992; Foelix, 1996 and Elitz, 1997). Antlion are metabolous insects whose reproductive cycles go through the egg, larva, pupa and to adult instar. They belong to the phylum Arthropoda, Class Insecta, Order Neuroptera, Sub-Order Planipeunica, Family *Myrmeleon tidae* and Genus *Mortar* (Orki, 2001). Antlion adults of *Myrmeloeon* have a worldwide distribution, represented by the greatest number of species in the tropical and subtropical regions (Wheeler, 1930). Antlion adults are a nocturnal insect that often attracted to light at night. The head capsule is characterized by prominent pair mandibles, which serves as a feeding apparatus during prey capture, as well as in pit construction. The abdominal region has nine distinct segments. Antlion larvae move just under the surface of the sand crawling backward in what appears to be random directions (Mc Gavin, 2009). Ituses two means of propulsion; the hind legs used to pull the antlion into the sand and contraction of the wedge-shape abdomen used to plough backwards through the sand (Lucas, 1982). The larvae continue moving until a suitable site for pit construction obtained (Botz*et al.,* 2003).Pit construction activity in Antlion is determined by a number of different factors including predator and prey size (Griffiths 1980; Scharf*et al.,*2009), availability of prey (Griffiths 1980; Scharf and Ovadio 2006), temperature, food and population density of the Antlions (Arnett and Gotelli, 2001), disturbance regime (Gotelli 1993; Barker *et al.,* 2010), microclimatic factors such as photoperiod (Scharf *et al*., 2008), substrates temperature (Marsh 1987), moisture (Gotelli 1993; Morrison 1994), and shade (scharf*et al.,* 2008). Pit construction is also affected by the physical properties of the substrate, such as the sand particle size (Griffiths 1980 Lucas 1982, 1986; Lomascolo and Farji-Brener 2001; Botz *et al*., 2003; Devetak*etal*., 2005) and density (Devetak*etal*., 2012).

Lucas (1982) detected four stages of pit construction behavior in the species *Myrmeleon crudelis*, while Tuculescu*etal*., (1975) and Topoff (1977) noted some variation in the construction behavior of *Myrmeleon immaculatus* larvae, which change direction while circling through the center of the truncated cone.

During the pit constructions behavior, the antlion moves under the surface of the sand, crawling backward randomly. It then moves in a circular path during which it flicks the sand to the outside circle by spiraling inward, these deepens the antlion and furrows and a conical pit is constructed (Youthed and Moran, 1969; Topoff, 1977;Matsura andKitching, 1993). Antlion as a predator using pit constructed as pit fall trap that enhances capture efficiency by retarding the escaping pray (Wilson, 1974),the pit fall trap increases the distance from antlion over which pray can be capture (Griffths, 1980). Lucas (1981) and Devetak (2005) observed that the antlion uses conical pit fall trap for the avoidance of antipredator tactics such as biting or spraying of noxious chemicals of potentially harmful. Pray are retreating under sand or by pulling them under the walls of the pit. How long a larva remains in a particular location is regulated by an internal hunger stimulus (Wheeler, 1930; Scharf and Ovadia,2006),which is governed by the frequency of prey encounter. A starved larva is likely to move its pit. Heinrich (1984) showed the probability of movement in *Myemeleon* or *immaculates* species was a function of hunger level. Variation in the motivation to eat is a well-known phenomenon in laboratory experiments on feeding behaviour, and controlling the food deprivation period before experiments is the most often-used (Sandre *et al.*, 2010).The antlion move its pit if the benefit of moving exceed the cost. The benefits are likely either to improved food supply or to reduce Level of disturbance from leaves, rain or nearest larvae. The costs are those of moving and constructing a new pit. Wilson, (1974) claimed that the pit size increases with hunger level but Griffiths, (1980) found no evidence for this. The density of spatially distributed pits increases with the antlion larval density. However, the uniform spatial arrangement of pits maximizes the distance between competitors (Scharf*et al.*, 2009).

The aim of this study is to focus on pit construction behavior of Antlion of a Family *Myrmeleont idae* under fed and starve condition in relation to the dry soil particle sizes.

Collection of samples

The experiment was carried out in the laboratory of the Department of Biological Science,Bayero University,Kano, Nigeria under ambient temperature. Twenty four (24) Iron trays of 25cm^{2}each were lined up in an undisturbed corner of the laboratory at the room temperature of 26-36^{0}C in a light and dark regime of day and night. Dry Fine sand of uniform texture of a particle size <540µm were put into 12 trays and dry coarse sand of particle size <1200µm of put into the other 12 trays to the depth of20cm to form 24experimental plots. Sieves of 1200µm and 540µm mesh sizeswere used to get the required texture of the sand.

Antlion larvae were identified following Insect Identification Guide ofOrkin (2001), and were collected from their constructed pits under trees within Biological Sciences Department, Bayero University, Kano Nigeria during the dry season in the month of February using silver spoon of about 2cm long and put into a tray containing sand. The antlions were carefully weighed on a Mettler balance to separate them into various instar stages in the laboratory following the protocol of Devetak(2005).

Experimental set up

The antlion larvae were then fed with worker ants of the species *Lasiusfuliginosus* to satiation for three days and starved for 24 hours before they were introduced into the experimental plots(trays). The aim of the feeding and starving them was to standardize the hunger level following Elitz(1997). The temperature range recorded during the experiment was between 26-36^{0}C, typically of the Sudan Savanna type of climate.

Randomized Block Design (RBD) was adopted in the experiment. In the first experimental plot of the fine sand, five first instar antlion larvae were introduced. In the second plot ten antlions and in the third fifteen antlions. The same procedure was followed for second instar, third instar and mixed instar antlion larvae. The same experiment was carried out in the other twelve trays but in coarse sand texture. The larvae were released at the centre of experimental arena in each case so that bias would be toward a clumped distribution. The larvae were fed continuously with ants (*Lasiusfuliginosus*).

Data collection

Five replicates of each larval density were made and mean number of pit constructed by fed and starved Antlions in fine and coarse was recorded after every 24hours, when the larvae must have constructed their pits. The nearest neighbor distance and pit diameter were recorded using a pair of divider and the length using ruler calibrated in centimeter (cm). Pits depth were measured using a long calibrated needle in centimeter (cm). The total number of pits constructed per plots was also recorded.

Same procedure was followed as above but in this case, the antlions were starved for three days before being introduced into the experimental arenas where they remained under the starvation condition until after the experiment. Nearest neighbor distance number of pits, pit depth volume and were recorded.The analysis was performed using the statistical package SPSS 14.0 (SPSS Inc., Chicago, IL, USA).

RESULTS AND DISCUSSION

Tables 1a and 1b show the mean number of pits constructed by fed and starved antlions larvae of various instar covering the completely experimental arena at three different densities in coarse and fine sand textures respectively. The mean number of pit constructed in fine sand was higher than in coarse sand (Table 3), and increased with increase in density, but remained about the same for all larval instars (Table 5) and between fed and starved larvae.The results from this research showed antlions of various instars in satiation and starved condition prefer sands with fine particle size to construct their pits (Farji-Brener 2003).

The spatial distribution pattern of the antlion larvae in the plots depends upon their own density and prey availability. As density increases the space becomes limiting, the diameter of larval pit and their spatial distribution were that each larvae optimizes its prey capture, this was observed in Table 1b at fifteenth larval densities in the first instar stage. The diameter and volumes of pits constructed were not significantly affected by changes in larval density;however, there was significant reduction in the number of larvae constructing pits in the densest experimental plots (Wheeler, 1930 and Lucas, 1982).Observation made on this study conformed the Scharf*etal.*, (2009) and Vesna*et al*., (2012) findings that at high density often and fifteen larvae, there was uniform arrangement of pits and many of the larvae failed to construct pits due to spatial limitation. There was no significant difference in diameter between the larval densities confirming that density has noeffect on pit diameter. There was variation in pit diameter between the larval instars. The third had the largest diameter followed by the second and finally the first.Lucas (1982) also observed pit construction activity in three other species: *Myrmeleon carolinus*, *Myrmeleon mobilis*, and *Myrmeleon immaculatus*. Pit building was virtually the same in all three instar, and no variations in pit construction detected.Heinrich and Heinrich (1984) showed that the probability of larval movement was a function of hunger level. Wilson (1974) claimed that pit size increases with the increase in hunger level but Griffith found no evidence for this. The results from the research showed that pit diameter increased with the increase in hunger or starvation. The spatial distribution of the antlion larvae was affected by the size of the sand particles. The antlions were able to construct their pits more easily in fine than coarse sandBotz*et. al.* (2003), because of the Analysis of variance (ANOVA) of Table 1a and bshowed significant differences in the mean number of pits constructed between densities, between sand texture and between larval instars but none between fed and larvae at 10% probabilities. Duncan's Multiple Range Test (DMRT) was carried out to find the significant differences between the mean number of pit constructed at the different density, sand textures and larval instars.The ANOVA for the mean diameter, reveal significant differences between textures and between instars, however, none-between the three densities (Table 7). The sand particles sizehave influence at least on two aspects of the antlions behavior; total distance moved and choice of sand particles for pit construction (Lucas, 1985). In addition, studies reveal that more pits were constructed in fine sand than in coarse sand in the compared experimental plots.

Table 1a: Mean Number of Pit constructed by Fed Antlions First (I), Second (II), Third (III) and Mixed (M) instar at three densities in fine and coarse sand textures.

Larval Density/Tray	Fine				Coarse			
	I	II	III	M	I	П	III	M
5	4.0	4.6	4.6	4.2	4.6	4.8	4.0	3.6
10	9.0	8.6	7.2	9.2	8.6	8.4	6.6	8.4
15	11.0	10.2	10.6	10.2	10.2	8.4	10.2	10.6

Table 1b:Mean Number of Pit constructed by starvedAnlion First (I), Second (II), Third (III) and Mixed (M) instar at three densities in fine and coarse sand textures.

Larval Density/Tray	Fine				Coarse			
	I	II	III	M	I	II	III	M
5	4.6	4.0	4.0	4.6	4.2	3.6	3.8	4.2
10	8.6	8.0	8.0	9.0	8.4	7.6	7.4	8.6
15	11.0	9.2	10.8	11.6	8.6	9.0	7.6	10.8

Table 2: ANOVA for the mean number of pits constructed by fed and starved AntlionFirst (I), Second (II), Third (III) and Mixed (M) antlion larvae at three different densities in fine and coarse sand texture.

Sources of variation	Df	SS	MS	F	P
Larval Density	2	293.9	147	496	<0.001
Sand texture	1	4.3	4.3	14.3	<0.001
Larval instar	3	5.5	1.8	6	<0.001
Hunger level	1	0.3	0.3	1	NS
Residual	40	10	0.3	-	-
Total	**47**	**314**	-	-	-

Table 3: The effects ofFine and Coarse sand texture on the mean number of pits constructed by all larval instar in various locations of the experimental plots.

Sand Texture	Whole Arena	Center	Periphery
Coarse	7.2a	2.6a	4.6b
Fine	7.8a	2.8a	5.0b

*Pairs of treatments that are not significantly different from one another share the same letter a or b at 10% confidence level using LSD

Table 4: The effects of larval densities on the mean number of pits constructed by all instars in various location of the experimental plots.

Larval densities	Whole Arena	Center	Periphery
5	4.2b	1.8a	2.4b
10	8.1a	2.9a	5.2a
15	10.2a	3.4b	6.8a

*Pairs of treatments that are not significantly different from one another share the same letter a, b or c at 10% confidence level using LSD

Table 5: The effects of larval instars on the mean number of pits constructed at various location in the experimental plots.

Larval instars	Whole Arena	Center	Periphery
I	7.66b	2.8 a	4.9a
II	7.15 b	2.4 a	4.7a
III	7.23 b	2.7 a	4.5a
M	7.9 b	2.9 a	4.9a

*Pairs of treatments that are not significantly different from one another share the same letter a or b at 10% confidence level using LSD

Table 6a: Mean pit diameter (cm) constructed by fedantlion by first (I), Second (II), Third (III) and mixed (M) instar in fine and coarse sand textures at three different densities.

Larval Density/Tray	Fine				Coarse			
	I	**II**	**III**	**M**	**I**	**II**	**III**	**M**
5	2.5	3.8	4.3	3.2	2.4	3.2	3.5	3.5
10	2.7	3.4	4.0	3.5	2.2	3.2	3.6	3.4
15	2.6	3.4	3.7	3.51	93.0	3.2	3.5	

Table 6b:Mean pit diameter constructed by starvedantlion larvae first (I), Second (II), Third (III) and mixed (M) instar in fine and coarse sand textures at three different densities.

Larval Density/Tray	Fine				Coarse			
	I	**II**	**III**	**M**	**I**	**II**	**III**	**M**
5	3.4	4.3	4.13	5.33.	0	3.9	3.7	3.7
10	3.03	9 4.	13.8	3.0	3.7	3.6	3.6	
15	3.3	4.1	4.03	62.9	4.0	3.7	3.7	

Table 7: ANOVA for the mean number of pits diameter constructed by fed and starved antlion instars at three different densities and sand textures.

Sources of variation	Df	SS	MS	F	P
Larval Density	2	0.1	0.05	1.3	<0.001
Sand texture	1	0.9	0.9	22.5	<0.001
Larval instar	3	8.0	2.7	67.5	<0.001
Hunger level	1	2.3	2.3	57.5NS	
Residual	40	1.7	0.04	-	-
Total	47	13	-	-	-

Conclusion and Recommendations

The pit-building behaviour of antlions in the study showed a distinct dependence on the sand particle size. As the antlion density increases, the spatial distribution becomes uniform.Spatial distribution was affected by sand texture.Antlion density had no effect on pit diameter and volume.

High density of antlion larvae affected the total number of pits constructed. Hunger had no effect on the total number of pits constructed and spatial distribution. However, antlion moves its pits to optimize the prey capture. Pit diameter and volume were found to increase in the starved condition.

It is therefore recommended that pit construction behaviors and alternative prey capture strategy in antlion larvae should be study in different sizes of soil particles containing different degree of moisture.

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