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Scientific note

Predation behavior of the *Myrmeleon brasiliensis* (Neuroptera: Myrmeleontidae) larval instars

Comportamiento de depredación de los estadios larvales de *Myrmeleon brasiliensis* (Neuroptera: Myrmeleontidae)

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Abstract: *Myrmeleon brasiliensis* larvae are predators that use the sit-and-wait tactic to catch their prey, and to fulfill this pit-making funnel traps in the sandy soil and remain buried waiting for prey to slip. The objective of this study was to observe the predation behavior of larvae of *M. brasiliensis* in the three larval instars, for this leaf cut ant were collected manually and offered within the plastic pots as prey for 14 larvae of 1st instar larvae, 33 of 2nd and 3rd instar. It was counted the number of attacks of the predator to prey, the number of escapes from jail and the success of prey capture for each larva of *M. brasiliensis*. The larvae of *M. brasiliensis* 1st instar attacked more times its prey, followed by larvae of 2nd and 3rd instar. On the number of escape of prey, there was no significant difference in this behavior among larvae. Regarding the success in capturing prey, the larvae of 3rd instar were more successful, with a predation rate of 96.96%, followed by the larvae of 2nd (69.70%) and 1st instar (14.28 %).

Key words: Ant-lion. Foraging. Predator.

Resumen: Las larvas de *Myrmeleon brasiliensis* son depredadoras que utilizan la estrategia de forrajeo de tipo "sit-and-wait" para capturar a sus presas y así construyen trampas en forma de embudo en el suelo arenoso y permanecen enterradas esperando que caigan las presas. El objetivo de este trabajo fue observar el comportamiento de depredación de las larvas de *M. brasiliensis* en los tres instares larvales, para eso, se recolectaron hormigas cortadoras y se ofrecieron manualmente como presas a 14 larvas de 1° instar y 33 de 2° y 3° instar. Se contó el número de ataques del depredador a la presa, el número de escapes de la presa y el éxito de captura de presas de cada larva de *M. brasiliensis*. Las larvas de *M. brasiliensis* de 1° instar atacaron más a sus presas, seguidas por las larvas de segundo y tercer instar. En cuanto al número de escapes de las presas, no se observó diferencia significativa para ese comportamiento entre las larvas. En relación al éxito en la captura de las presas, las larvas de 3° instar presentaron más éxito, con una tasa de depredación de 96, 96%, seguida por las larvas de 2° (69,70%) y 1° instar (14,28%).

Palabras claves: Depredador. Forrajeo. Hormiga león.

Introduction

Several types of foraging strategies can be employed by predators in search for preys. These models may range from the ambush, in which the predator waits for its prey, to active search, when, as the name suggests, the predator hunts the prey (Nilsson 2006; Scharf *et al*. 2006). Depending on the behavior, the capture of preys may be determined by several factors, such as their morphology, the kind of prey, the structure of habitat, the presence of competitors, the physical conditions and the interactions among them (Endler 1991). In this context, a large array of tactics of capture and subjugation of preys arise; and, for the same species, adults and young specimens may adopt diverse strategies (Bekoff 1983).

Ant-lion (Neuroptera, Myrmeleontidae) larvae are predators that use the tactics of ambush for catching their preys. These larvae build funnel-shaped traps in the sandy soil and remain interred while waiting for their preys, arthropods that move on the soil surface, to fall into their traps (Crowley and Linton 1999; Lomáscolo and Farji-Brener 2001; Napolitano 1998). On falling into the traps, the preys find difficulty escaping because of the sand granulation and the inclination of the funnel walls, and are therefore easily subjugated by the larvae (Devetak 2005; Devetak *et al*. 2005). Other factors, such as the availability of sites with dry and sandy soil for the building of the funnels, the texture and temperature of soil, the abundance of preys and the competition for space between the larvae are variables that may affect the costs and benefits of foraging (Faria *et al*.1994; Heinrich and Heinrich 1984; MacClure 1976; Prado *et al*. 1993).

Larvae of ant-lion *Myrmeleon brasiliensis* (Návas, 1914) go through three instars before the formation of pupa. Each instar lasts about 26 days, depending on the diet of the larvae (Missirian *et al*. 2006). First-, second- and third-instar *M. brasiliensis* present a mean body size of 4.3 (S.D.: ± 0.55mm), 6.1 (± 0.92mm) and 9.9 (± 1.23mm), respectively (Missirian *et al*. 2006). Lima and Faria (2007) observed that there is a positive relation between body size of *M. brasiliensis* and trap size, and researchers who studied other ant-lion larvae species (e.g. Allen and Croft 1985; Day and Zalucki 2000; Faria *et al*. 1994; Griffths 1980, 1986; Heinrich and Heinrich 1984) observed that the increase in both body size and trap size are positively related to the success of capturing preys.

Thus, because the changes of instars of *M. brasiliensis* larvae yield an increase in their body size and, consequently, in their trap size, the larvae's changes of phases may eventually affect their foraging behavior. The objective of this note was to describe the way different larval stages of *M. brasiliensis* behave during the capture of preys. This study presents

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three specific objectives: 1) to compare the number of times *M. brasiliensis* ant-lions attack their preys in the three instars; 2) to compare the number of times the preys of *M. brasiliensis* manage to escape in the three instars; and 3) to compare the prey capture success by *M. brasiliensis* in the three instars.

Materials and Methods

M. brasiliensis larvae were collected in the municipality of Aquidauana, Mato Grosso do Sul, in a permanent protection area - Área de Proteção Permanente (APP) (20º26’25”S, 55º39’21”W) - belonging to the State University of Mato Grosso do Sul, in October 2008. The experiments were conducted in the Zoology Laboratory of the Federal University of Mato Grosso do Sul, campus of Campo Grande, from October 2008 to May 2009.

The larvae had their funnel diameter noted and were later collected with the help of a spoon and stored in plastic bags with some sand from the site of origin to be transported to the laboratory. In order to differentiate the instars, the larvae had their body length (head-abdomen) and cephalic capsule width measured with the help of a digital caliper (resolution 0.01mm). After the trial they were stored individually in transparent plastic pots (13cm in length and 10cm in diameter) with sand.

To assess the predation behavior, the following experiment was performed: workers of leaf-cutting ant, *Atta laevigata* (S. Smith, 1858), with mean size of 5.78±1.09mm, were collected and manually offered in the plastic pots as preys for 14 first-instar larvae and 33 second- and third-instar larvae. Each larvae was fed only once with only one ant. During the experiment the larvae were observed for five minutes and then three variables were counted: the number of attacks of the predator on the preys (attack was so considered when there was a rapid movement of jaws throwing sand, in an attempt to reach the preys for them to fall into the bottom of the trap); the number of prey escapes (escape was so considered when the larva releases its prey for it to leave or not the trap); and the successful capture of preys for each *M. brasiliensis* larva (successful capture was so considered when the larva seizes the prey with its jaws and submerges it in sand).

Kruskal-Wallis test (followed by Dunn test) was used to compare the number of attacks of *M. brasiliensis* larvae on their preys and the number of escapes of preys in the three larval instars. The comparison among the successful capture of preys throughout the three instars was assessed by the 3X2 contingence table utilizing G Test.

Results

The diameter of the funnels varied from 14.7 to 27.9mm; the larvae’s body length, from 1.91 to 10.17mm; and the cephalic capsule, from 0.48 to 1.44mm. The variations in size among the instars can be observed in Table 1.

When the preys were offered to *M. brasiliensis* larvae, they all tried to seize them by moving head and mandible. The pattern of capture of first-instar larvae was to attack their preys with assaults on the legs and, later, on the abdomen, whereas second- and third-instar larvae would attack their preys directly on the abdomen, which made capture and manipulation easy.

First-instar *M. brasiliensis* larvae attack their preys more often, followed by second-and third-instar larvae (Kruskal-Wallis, df = 2, $p < 0.001$). Dunn test, performed later, showed that this difference occurred among first- and third-instar larvae. The mean number of attacks observed for first-, second- and third- instar larvae was 38.0 (minimum 1-maximum 171), 18.3 (min. 1 – max. 84) and 7.6 (min.1 – max. 32) (Fig. 1), respectively.

No significant difference was seen regarding the number of escapes of the preys, although first-instar larvae had a higher average of escapes (2.6 ± 3.20, against 1.81 ± 1.46 and 1.3 ± 1.45 for second and third-instar larvae, respectively). First-instar larvae, even attacking their preys more often, did not manage to seize them effectively, that is, the attack did not involve any kind of contact with the preys, which therefore is not characterized as an escape. On the other hand, other instar larvae (especially third) attacked less often and, when the attack occurred, *M. brasiliensis* managed to capture their preys in an efficient way, which contributed for the sharp decrease in number of escaping.

Third-instar larvae were more successful in capturing preys (96.96%) whereas first- and second-instar larvae capturing 14.28 % and 69.7 % respectively.

Discussion

Larvae at the beginning of development attacked more often than third-instar ones. Heinrich and Heinrich (1984) observed that first-instar *Myrmeleon immaculatus* DeGeer, 1773 larvae did not consume ants (*Camponotus herculeanus* L. 1758) whose body size ranges from 9 and 10mm. Missirian *et al*. (2006) observed that first-instar *M. brasiliensis* did not attack leaf-cutting ants (*Atta* spp) with body size bigger than 5.24±1.91 mm. In this paper, working with preys with mean body size of 5.78±1.09 mm, it was seen that most larvae attacked only once or twice and, in not being successful, ignored the prey whereas a minority (three larvae) attacked their preys many times (more than 100). This behavior represents a laboratory situation, in which the prey size was standardized to different sizes of *M. brasiliensis*. Probably if the prey size varies positively with size ant-lion larvae, the number of attacks at the preys would not vary between different instars of *M. brasiliensis*.

The animals are susceptible to decisions such as where to forage and what to eat (Scharf *et al*. 2010). Furthermore, predators tend to have a more efficient foraging behavior if, after attacking their preys, they begin to adjust their behavior in order to enhance their success rate (Dall *et al*. 2005; Iwasa and Higashi 1981). First-instar *M. brasiliensis* larvae may have ignored the preys because they do not represent a suitable energy return, as the cost of capture is very high. Also, the bigger the prey, the more significant the destruction caused to the trap during the attempt to capture (Griffiths 1980). The building and maintenance of traps require energy (Griffiths 1986); larvae having their trap disturbed present a growth rate reduced in 50% when compared with the ones whose trap was not disturbed (Griffiths 1980). Thus, smaller larvae would tend to ignore large preys, avoiding the expenditure with capture and a later trap re-building.

There was no significant difference in the number of prey escape among the instars. Smaller larvae did not manage to seize their preys, therefore no escape was seen (see methodology). On the other hand, when bigger larvae managed to do it, the attack was successful and, in this case, no escape occurred either. In the field, the capture rate of ant-lion larvae is quite reduced (Heinrich and Heinrich 1984) and, since smaller larvae do not manage to efficiently seize their prey in the first attack, they start suffering from inanition. Faria *et al*. (1994) observed that, in a population of *Myrmeleon uniformis* (Návas, 1936) smaller individuals tend to disappear more often than bigger individuals, which, besides being more successful during foraging, also bear a longer period without food. Coelho *et al*. (2008) and Cohen (1998) draw the attention to the fact that, for predators with extra-oral digestion (bugs, spiders and ant-lion larvae), the predator-prey contact is extremely relevant. It should occur in such a way that the predator manages to immobilize the prey so as to inject the toxins of digestion in the tissues and, then, perform the ingestion of liquefied content.

Third-instar bigger larvae present an efficient predation behavior, demonstrated by few attacks to the prey and highly successful capture (96.96%). For these larvae, the higher success in capture of preys is due to both body size and trap characteristics, since bigger larvae manage to use their long mandible to seize the prey directly at the abdomen, unlike smaller larvae that tend to seize preys at legs, and then at the abdomen. On seizing the prey at the abdomen, ant-lion larvae shake them to break their exoskeleton and then release digestive enzymes (Devetak 2005).

Regarding the relation between trap size and successful capture, it can be observed that, on falling into the traps, the prey has more difficulty escaping due to the greater depth of the trap and also because the larvae use their mandibles to throw sand against the prey. This makes its escape difficult, causing it to slide more easily downwards the trap, where the larva can seize it. Dias *et al*. (2006) observed that the probability of escape of *Myrmeleon* sp. preys decreases as the funnel diameter enlarges, and predicted that when funnels have diameters about eight times larger than the prey size, the probability of escape decreases in 50%. Moreover, this efficiency may also be associated with the knowledge "older" larvae have of vibration signal on the sand and availability of preys going together (Devetak 1998; Guillette *et al*. 2009).

Thus, through of laboratory experiments, in which the prey size was standardized, it can be concluded that changes in the larval stage of *M. brasiliensis* affect its predation behavior. Larvae at the beginning of development attack their preys many times, generating greater investment in capture of preys; this larger investment, though, does not yield an increase in the accomplishment of predation. On the other hand, larvae at the end of development present a more efficient predation behavior, occurring few attacks to preys and a highly successful predation. Probably under field conditions, in which, the prey size varies, the larvae efficiency of first instar in the capture of small preys, it would be similar to larvae of second instar, and principally of the third instar in the capture of the big preys.

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