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Article

Influence of the microhabitat on the trap construction of *Myrmeleon brasiliensis* (Neuroptera: Myrmeleontidae) larvae

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ABSTRACT. Antlion larvae of *Myrmeleon brasiliensis* (Návas, 1914) build their traps in a microenvironment with protection from the direct action of rain and other perturbations as well as microhabitats that are less protected from disturbances that can destroy the traps. Differences in microhabitats may affect the characteristics of the trap-building process due the high energy expenditure exerted in building and maintaining these traps, which led to the following question: Do antlion larvae of *M. brasiliensis* build larger traps in protected microhabitats? Considering the occurrence of *M. brasiliensis* larvae in two microhabitats and the measurements of the size of the larvae and their traps, the hypothesis was that larvae would occur in greater abundance and the trap size would be larger in more protected microhabitats. The results showed that antlions occurred in equal abundance in both microhabitats, but density was greater in the protected microhabitat. Even in months with more rainfall, *M. brasiliensis* larvae continued to forage throughout the year in the protected microhabitat and the investment in trap size was greater in this microhabitat. This suggests that the larvae of the protected microhabitat have an advantage, given that they have the possibility of foraging throughout the year.

KEYWORDS. Antlion, disturbance, foraging, traps.

RESUMO. Influência do microhabitat na construção de armadilhas de larvas de *Myrmeleon brasiliensis* (Neuroptera: Myrmeleontidae). Larvas de formiga-leão *Myrmeleon brasiliensis* (Návas, 1914) constroem suas armadilhas em microhabitat com proteção da ação direta da chuva e outros intempéries e em microhabitats menos protegidos de perturbações que podem destruir suas armadilhas. Dado o alto gasto energético para a construção e manutenção das armadilhas das larvas de formiga-leão, diferenças entre microhabitats podem afetar características da construção da armadilha. O que levantou a questão: larvas em microhabitats mais protegidos investem mais no tamanho de suas armadilhas de captura de presas? Através de medidas da ocorrência de larvas nos dois microhabitats e através de medidas do tamanho da larva *M. brasiliensis* e de sua armadilha, foi previsto que as larvas ocorreriam em maior abundância em microhabitats protegidos e que o investimento no tamanho da armadilha seria maior em microhabitats com maior proteção. Os resultados deste trabalho mostraram que as larvas de formiga-leão ocorrem em igual abundância nos dois microhabitats e a que densidade é maior no microhabitat protegido. Os dados demonstram que as larvas *M. brasiliensis* permaneceram forrageando durante todo o ano no microhabitat protegido, mesmo em meses mais chuvosos, e o investimento em tamanho de armadilha foi maior nesse microhabitat. O que sugere, que as larvas do microhabitat protegido apresentam vantagem, dado de fato de terem a possibilidade de forragear durante todo o ano.

PALAVRAS-CHAVE. Formiga-leão, perturbação, forrageamento, armadilhas.

Ecosystems vary in time and space, which affects the distribution of organisms (Wellnitz & Poff, 2001; Brown, 2003). Variations within a patch or microhabitat of an ecosystem (incidence of light, temperature, disturbances, and resource availability) can affect the individual behaviour of organisms (Lin & Shiraishi, 1992). According to the theory of optimum foraging, such variations in each environment lead predators to select patches in which the energy return is greater (Charnov, 1976; Brown & Kotler, 2004). The energy return of sit-and-wait trap-building predators must be calculated based on resource availability as well as the energy expended on the building and maintenance of the trap (Blackledge & Wenzel, 2001; Scharf *et al.*, 2009).

Larvae of some species of antlion (Neuroptera: Myrmeleontidae) build funnel-shaped traps in dry and sandy soil to capture their prey (Lucas & Stange,1981; New, 1991). Trap size and successful capture of prey is proportional to the larvae size (Klokočovnik & Devetak, 2013). Larvae of the antlion species *Myrmeleon brasiliensis* (Návas, 1914) were observed in Brazil in the state of Mato Grosso do Sul. *Myrmeleon brasiliensis* build traps ranging from 9.19 to 35.21 mm in diameter (Nonato & Lima, 2011) and pass through three instars (each lasting an average of 26 days) prior to the formation of the pupae (Missirian *et al.*, 2006).

In the natural environment, factors such as wind, falling vegetal matter, rainfall, and the transit of other animals can destroy the traps of antlion larvae (GOTELLI, 1993). The construction and maintenance of a trap requires the expenditure of energy (BURGESS, 2009; LIMA & SILVA, 2017) and larvae whose traps have been disturbed have a 50% lower growth rate compared to those whose traps have not been disturbed (GRIFFITHS, 1980).

Due to the influence of several factors at the trap construction of antlion larvae and the great abundance of *M. brasiliensis* in Mato Grosso do Sul State, the present study aiming to comprehend the influence of the microhabitat on the trap construction of *M. brasiliensis* larvae, as well as their density and abundance. For that were evaluated 1) the abundance of *M. brasiliensis* larvae, 2) the relation between larval abundance and rainfall, 3) the density of larvae, 4) the trap size build by larvae, and 5) the investment of the larvae in trap size in microhabitats with different degrees of disturbance, as well as their abundance.

MATERIALS AND METHODS

Observations were carried out in a forest reserve (800 ha) in the municipality of Aquidauana in the state of Mato Grosso do Sul, Brazil (20°26'25"S, 55°39'21"W). The reserve is situated in the Maracaju Hills, which extend in the north-south direction throughout nearly the entire state, with the southern limit near Aquidauana and the northern limit in the proximities of the municipality of Rondonópolis in the state of Mato Grosso (BOGGIANI*et al.*, 1998). The Maracaju Hills are covered mainly by forested savanna, semi-deciduous seasonal forests, riparian vegetation, and plains (DAMASCENO *et al.*, 2000). Altitude ranges from 240 to 700 m (ZEE-MS, 2008).

Larvae of *Myrmelon brasiliensis* (Návas, 1914) are found in two microhabitats areas of the Maracaju Hills in the municipality of Aquidauana, Brazil; in which the observation occurred: 1) a trail that cuts through the reserve which is characterized as an exposed microhabitat, as the larvae have no protection from the direct action of the rain and where *M. brasiliensis* larvae are seen building their traps below plantlets and near tree trunks; and 2) on the slope of the rocky cliffs of the Maracaju Hills – reaching approximately 100 meters in height and are composed of sandstone of eolian sedimentation (BRASIL, 1982; ZEE-MS, 2008) –, which is characterized as a protected microhabitat where the action of the rain does not destroy the traps due to the slope of the cliff.

Monthly observations were carried out from August 2016 to July 2017. Antlion larvae of *M. brasiliensis* collected in the area were identified by the researcher Lionel Stange (University of Florida).

Four sampling points were established at both environment (trail and cliff). Each sampling point measured approximately 2 m² (four quadrants of 2 m²), in which the abundance of the larvae and trap diameters were determined. The abundance was calculated by counting all the traps within the each quadrant. Within each sampling point, quadrants measuring 0.25 m² were established for the estimation of larval density. The density was calculated by counting the number of larvae per 0.25 m². At the end of the monthly observations in each microhabitat, the diameter of the traps of 50 larvae was measured and the larvae were collected and taken to the Laboratório de Estudos da Biodiverside of the Universidade Federal de Mato Grosso do Sul for the measurement of body size (head-abdomen). All measurements were performed with the aid of digital calipers (precision: 0.01 mm). Rainfall data were obtained from a meteorological station situated in the study location belonging to the Universidade Estadual de Mato Grosso do Sul.

The t-test was used for the comparison of larval abundance; the Mann-Whitney test was used for the comparison of larval density as well as trap sizes in the two microhabitats. The correlation between abundance and rainfall in the two microhabitats was determined using Pearson's correlation test. The association between larval size (head-abdomen) and trap size in the two microhabitats was determined using linear regression analysis. All analyses were performed using the MyStat free software (https://systatsoftware.com/downloads/download-mystat/).

RESULTS

Nine hundred eighty five *Myrmelon brasiliensis* larvae were counted building traps (500 in the protected microhabitat and 485 on the trail). No difference in abundance was found between the two microhabitats (t_{22} = 0.07; P = 0.47). Mean larval density was higher in the protected microhabitat (7.8 larvae/0.25 m) than the exposed microhabitat (3.8 larvae/0.25 m²) (t_{22} = -2.90; P = 0.01), with the highest density (12 larvae/0.25 cm²) occurring in the protected environment in June 2017. Larval density on the trail was zero in the period of March and April (no larvae counted) due to rainfall.

No significant correlation was found between the larval abundance and rainfall in the protected microhabitat (r = -0.4559; P = 0.13), while the larval abundance was negatively affected by rainfall on the trail (r = -0.5866; P = 0.04) (Fig. 1).

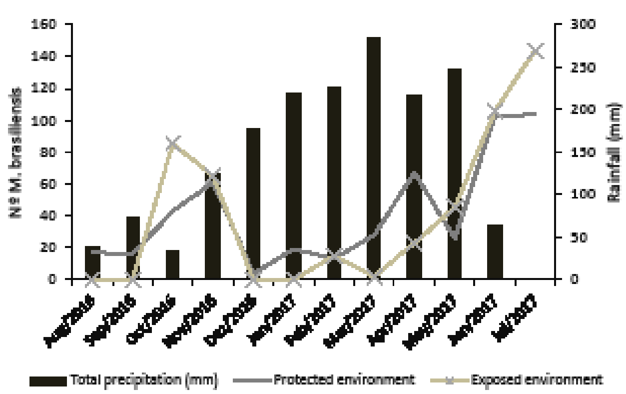

Fig. 1. Abundance of *Myrmelon brasiliensis* (Návas, 1914) (Neuroptera: Myrmeleontidae) larvae and rainfall (mm) registered in the period from August 2016 to July 2017 in exposed and protected microhabitats, Aquidauana, MS, Brazil.

Mean trap size was significantly larger in the microhabitat protected by the rocky cliffs of the Maracaju Hills in comparison to that of the trail (U = 18.00; P = 0.02) (Fig. 2). The investment of the larvae in trap size was positively correlated with body size in both microhabitats (protected: $r^2 = 0.35$; P = 0.000; exposed: $r^2 = 0.15$; P = 0.01). However, the coefficient of variation (r^2) was higher in the protected environment, demonstrating that trap size was better explained by the size of the larvae in this environment than those on the trail.

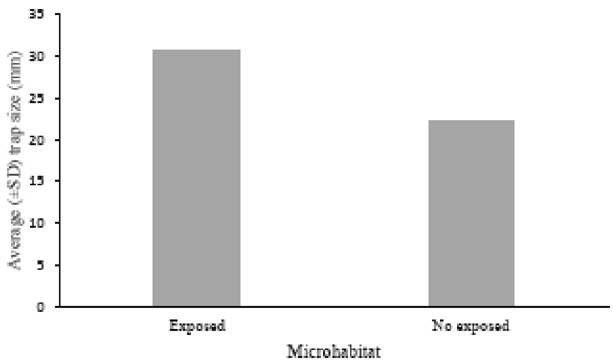

Fig. 2. Average trap size (±SD) of *Myrmelon brasiliensis* (Návas, 1914) (Neuroptera: Myrmeleontidae) larvae registered in the period from Agust 2016 to July 2017 in exposed and protected microhabitats, Aquidauana, MS, Brazil.

DISCUSSION

The results demonstrated that *Myrmelon brasiliensis* larvae occur throughout the entire year, with no difference in their abundance between microhabitats with different degrees of disturbance. Nevertheless, larvae in protected environments invest more in the size of their traps. Traps build by larvae on the trail (exposed environment) were destroyed in rainy periods, impeding the larvae from foraging until the soil dried out again. In the area near the rocky cliff of the hill (protected environment), only larvae in the more peripheral portion of the area were affected by rainfall, whereas those closer to the sandstone cliff wall continued foraging throughout the year. Laboratory experiments have been demonstrated that *M. brasiliensis* larvae rebuild their smaller size traps after the rain, when the soil dries out again (within five days, on average) (Freire & Lima, 2019).

The disturbance caused by the rain increases the cost of trap maintenance. The foraging strategy adopted by some species of antlion larvae and other trap builders (*e.g.*, spiders and worm lion larvae) reduces the energy expended on the search for and capture of prey, but not in the trap building itself (Blackledge & Wenzel, 2001; Devetak & Arnett, 2015; Adar *et al.*, 2016; Miler *et al.*, 2018). Thus, being in an environment that causes less destruction to the traps can diminish energy expenditure. Moreover, development time is longer for larvae that do not forage (Lima & Silva, 2017).Therefore, the lifecycle of the larvae on the trail could be longer than that among the larvae on the slope of the cliff, which implies that larvae on the slope of the hill can become more abundant in the environment in a given moment due to natural selection. For example, in years with more rainfall, larvae in the protected microhabitat can maintain the emergence rate of adults and the laying of eggs, whereas those in the exposed environment may remain in the larval phase for a longer period of time, thereby contributing less to the population size in the area.

The density of the antlion larvae was greater in the protected microhabitat than on the trail. Studies have demonstrated that density affects the movements of larvae and the occurrence of cannibalism (Lima, 2016; Lima & Lopes, 2016). In the present study, despite the greater density in the protected microhabitat, mean trap size and the investment of the larvae in trap size were greater. Thus, the protection of the rain and other perturbations (*e.g.*, wind and trampling of humans who use the trails) that the microhabitat offers enables a greater investment in trap size, which may result to greater success in the capture of prey (Nonato & Lima, 2011).

The lifecycle of antlions ranges from six months to two years, depending on the availability of food resources (quantity and quality of prey items), photoperiod, temperature, and metabolic rate (Fisher 1989; Arnett & Gotelli, 1999, 2001; Missiran *et al.*, 2006). Moreover, environments will high disturbance levels can exert an influence on the characteristics of the emerging adults (body size and wingspan). As there is a positive correlation between body size and fecundity in insects (Honek, 1993; Sokolovska *et al.*, 2000), larvae who undergo situations of high energy expenditure due to the maintenance of their traps may become smaller and less fecund adults.

In general, predators select locations with a greater energy return during the search for prey (Charnov,1976; Pyke *et al.*,1977). In the case of trap-building predators, however, the prey comes to them and greater energy is expended on the building and maintenance of traps rather than searching for prey (Beachly *et al.*,1995). The present findings demonstrate that the level of disturbance in microhabitats in which *M. brasiliensis* larvae build traps affects the foraging characteristics of these larvae, such as the investment in trap size for the capture of prey. Therefore, protected environments constitute an advantaged for pit-building antlion larvae, as the maintenance of foraging ensures the continual capture of prey and, consequently, a shorter lifecycle time and greater storage of energy for adult forms.

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