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Feeding behaviour of pit building of antlion *Myrmeleon pseudohyalinus,* Holzel 1972 (Neuroptera: Myrmeleontidae) in different mediums, instars and hunger levels

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ABSTRACT: Feeding behaviour of *Myrmeleon pseudohyalinus* (Holzel, 1972) larvae was studied in sand and soil media for second and third instars, and at two hunger levels (fed/starved) in laboratory conditions. Common ant *Anoplolepis gracilipes* (Smith, 1857) was used as prey in all the experiments. From the eight experiments, feeding time, prey escape and capture success were analysed. The predatory efficiency studied indicated that the capture success was high in second instar larvae irrespective of hunger level and medium. The relationships between selected behaviour, instar, medium and condition were studied and also the relationship between selected behaviour, instar, medium, condition and time period were analysed. From the Canonical Correspondence Analysis (CCA), it is clear that the prey beating, emergence and submergence behaviours were influenced by the larval instar (second and third) and quiescence, pit clearing and jaw set behaviour patterns were influenced by their condition (fed or starved). CCA also shows an influence of time period in the feeding behaviour pattern of antlion larvae. © 2022 Association for Advancement of Entomology

KEYWORDS: Predatory efficiency, Canonical Correspondence Analysis, antlion instars

INTRODUCTION

Neuropterans are mainly predators in both larval and adult stages, but in the case of Family Myrmeleontidae, the larval stages are more predaceous than adults and have interesting strategies for feeding, pit building and predation. Adult antlion's survival period is below one month when compared to the long larval period of up to two years. The larvae make conical pits in the substrate and wait for the prey to fall down in to it. Conical pits are dual purposed as it shelters the antlion from enemies and traps its unsuspecting prey too. Exceptions to pit building are the Mediterranean antlion species *Neuroleon microstenus* (McLachlan, 1898) which dig in sand backwards and wait for the prey (Devetak *et al*., 2010).

Pit building by antlion larvae in sand or dry soil is accomplished by a series of backward movements. After making the pit, they wait for the prey and once the larvae encounter a prey, many behaviours are exhibited followed by feeding. Predation helps to maintain the balance of animal populations and the predators selectively remove the young, old and diseased or injured individuals from prey populations (Southwick, 1976). Napotilano (1998) reported that

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twelve distinct behaviours were exhibited by antlions to accomplish feeding, namely attack, holding, submergence, emergence, prey beating, feeding, use pit clearing, head roll, prey clearing, grooming, quiescence and jaw set. Scharf *et al.* (2009) proved that *Myrmeleon hyalinus* larvae grow faster during the feeding phase and lost mass during starvation period. Ants are the common prey of antlion larvae. Sometimes, the ants bite antlions immediately after they have been caught and grasps the antlions mandible and dies without releasing the hold rendering the antlion unable to make its pit (Lucas and Brockmann, 1981). Eisner *et al.,* (1993) documented *Myrmeleon carolinus* (Banks, 1943) larvae sucking the body contents without puncturing the acid sac of the formic acid spraying ants (*Camponotus floridanus* Buckley, 1866*).* Studies on feeding behaviour of antlion larvae from India are negligible and the objective of the present study is to give a baseline data about the feeding behaviour of this least studied group in Kerala.

MATERIALS AND METHODS

Antlion larvae were collected by handpicking or by using a spoon (Maoge *et al*., 2014) and were transferred to a paper cup (diameter 6 cm and height 6 cm) filled with sand/soil. The collected specimens of antlion larvae were identified by using standard taxonomic keys (Stange, 2004 and Ghosh, 2000) and confirmed by molecular sequencing. *Myrmeleon pseudohyalinus* Holzel, 1972 was the species mostly found in Kerala. As it is a first report of the species from India, the sequence was deposited in NCBI with an accession number MN711710.

Eight experiments were conducted for understanding the feeding behaviour of *M. pseudohyalinus* larvae in various conditions (Table 1). For this plastic trays (23X23cm) were filled with sand or soil to a thickness of 5 cm and maintained at room temperature (28-32^{o}C). The fed larvae were given one prey per day and in the case of starved larvae, they were starved for 3 days prior to the experiment. A single larva was introduced into the centre of a tray and allowed to make its pit. The larvae were kept undisturbed for 3 days prior to experiment to get it acclimatised to that situation.

The common ant (*Anoplolepis gracilipes Smith, 1857*- worker) was used for the feeding purpose both in rearing and experiments, because it is the most abundant prey in the antlion larval pit irrespective of species (mean size 0.45±0.05 cm) and placed in the centre of the pit. The behavior of the antlion was noted by using a hand lens up to the completion of feeding without any interruption. From the observation data the capture success of the larvae were analyzed and the prey escapes were observed.

RESULTS AND DISCUSSION

Twelve distinct behaviours were identified. Seventy five percentage of the larvae took 0-35 minutes for the completion of its feeding process (attack to jaw set) and the remaining (25%) of the larvae took 0-45 minutes to complete its feeding irrespective of the conditions. Irrespective of the conditions, the second instar (95%) larvae were more successful than third instar (75 %) larvae. Predatory efficiency of *M. pseudohyalinus* larvae has been shown in Table 1. The highest prey escape was noted in the combination of third instar fed larvae in sand medium. The duration of feeding was lengthy in fed second instar larvae in sand medium and starved second instar larvae in sand. The capture success of the prey by antlion larvae were high in the medium soil compared with sand media.

CCA was performed to visualize the relationships between different behaviour and conditions. The Eigen values for Axis1 (87.61%) and 2 (12.38%) added upto 99.99 percent which indicates that 99 percent of the variance has been covered. Therefore robustness of the test is very high and can be used for interpretation. The prey beating, emergence and submergence behaviours are influenced by the larval instar (second and third). The following behaviour: quiescence, pit clearing and jaw set behaviour patterns were influenced by their condition of being fed or starved. Head roll behaviour was only related to the medium of the substrate in which the larva was inhabiting and it was more in soil media (Fig. 1).

CCA was performed to visualize the relationships between different behaviours, instars, medium,

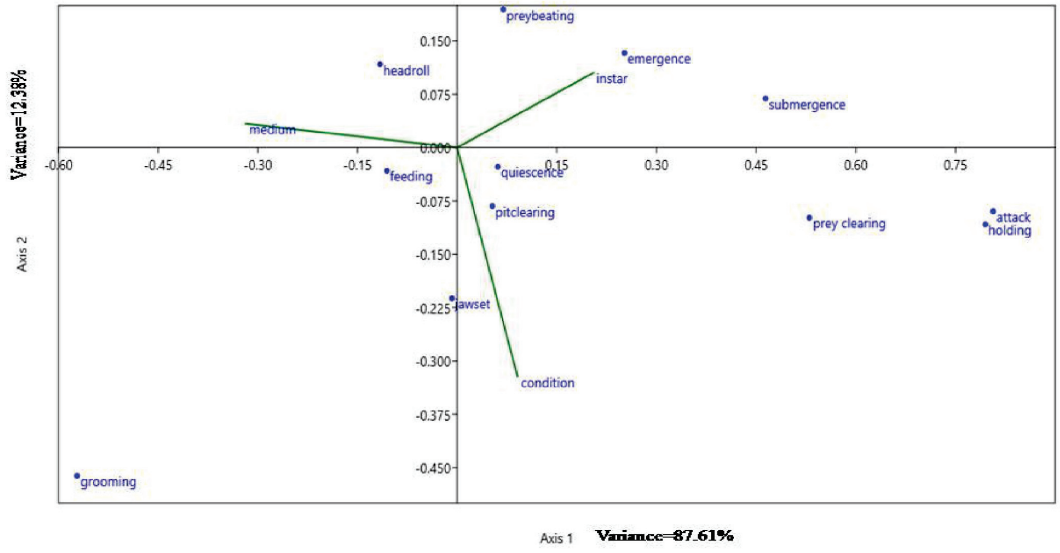

Fig. 1. CCA map showing relationships between selected behaviour and instar, medium and condition

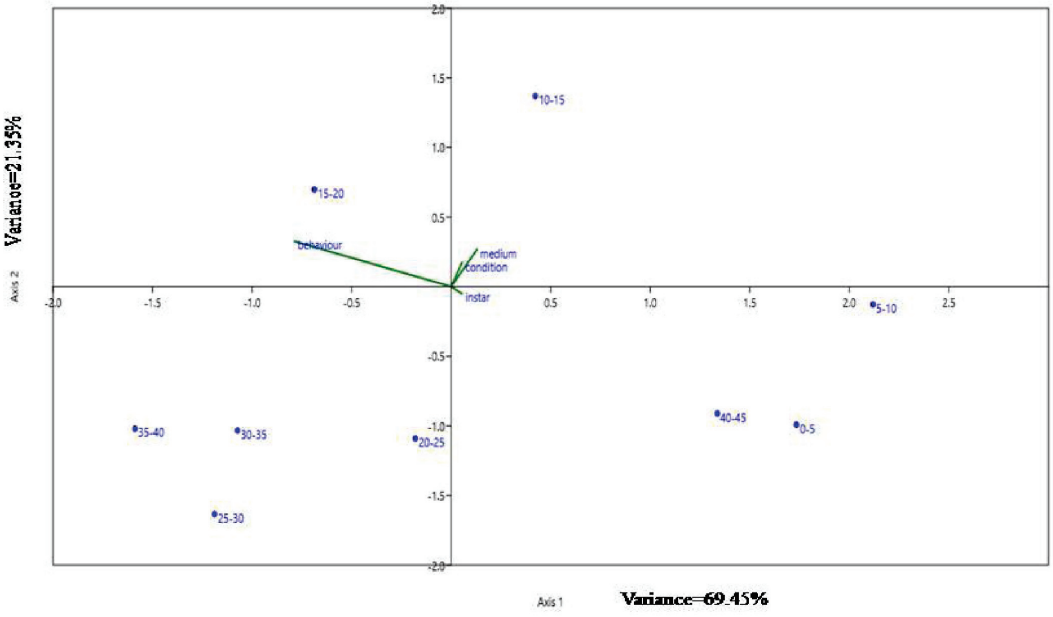

Fig. 2. CCA map showing relationships between selected behaviour and instar, medium and condition & time period

Table 1. Predatory behaviour of *M. pseudohyalinus* antlion larvae in different medium, instars and at hunger levels

Medium	Instars	Fed/ Starved	Feeding time (Min)	Prey escape (%)	Capture success (%)
Sand	Second	Fed	0-45	20	80
Sand	Third	Fed	0-35	50	50
Dry soil	Second	Fed	0-35	0	100
Dry soil	Third	Fed	0-35	0	100
Sand	Second	Starved	0-45	0	100
Sand	Third	Starved	0-35	33	67
Dry soil	Second	Starved	0-35	0	100
Dry soil	Third	Starved	0-35	18	82

(n=15 to 17 replications)

condition and time period. The Eigen values for Axis 1 and 2 per cent added up to 90.8 perceent which indicates that 90 percent of the variance has been covered. Medium (sand and soil), condition (fed and starved) or instar (second and third) did not seem to play much of a role in the behaviour but, time period seemed to affect behaviour. The behaviour in the first five and last five minutes of observation seemed very similar (mainly inactivity). Behaviour of 5-10 minutes duration also showed similarity to this group. Behaviour during and after 10-15 minutes was very unique and therefore lay in different quadrats. Rest of the five minute windows showed similar behaviour (Fig. 2).

In all the conditions, the larvae show similar behaviour in the first five minutes. Attack, holding, submergence, emergence, prey beating and feeding are the six behaviour patterns shown in this time period. In addition to this, head roll behaviour pattern is present in 5-10 minutes period of feeding except in the combination starved second instar larvae in sand medium. Starved second instar larvae in soil medium shows pit clearing behaviour in addition to this head roll.

The 10-15 minute period of fed second instar larvae, third instar larvae and starved third instar larvae shows similarity in behaviour patterns and the starved second instar larvae in sand media, pit clearing and prey clearing were found in addition to the common behaviour (prey beating, feeding and head roll) in this time period. In soil media, the second instar fed larvae shows quiescence and jaw set behaviour pattern in this period and the third instar fed larvae shows similar behaviour pattern of second and third instar fed larvae in sand media.

During 15-20, 20-25 and 25-30 minutes *M. pseudohyalinus* larvae showed prey beating, feeding, pit clearing, head roll, prey clearing, grooming, quiescence and jaw set activities. During 30-35 minutes, the jaw set and quiescence are the main patterns and considered as the end point of feeding behaviour. The behaviour patterns of fed second instar larvae in sand medium (Fig. 3) and fed third instar larvae in soil medium (Fig. 6) showed that the maximum feeding activity was present in 15 to 30 minutes. In the fed third instar larvae in sand medium (Fig. 4) and starved third instar larvae in sand medium (Fig. 4) two peaks were present in the activity patterns (0-15 minutes and 15-30 minutes). The remaining experiments such as starved second instar larvae in sand medium (Fig. 3), fed second instar larvae in soil medium, starved second instar larvae in soil medium (Fig. 5) and starved third instar larvae in soil medium (Fig. 6) did not show a prominent pattern of feeding activity with respect to time period.

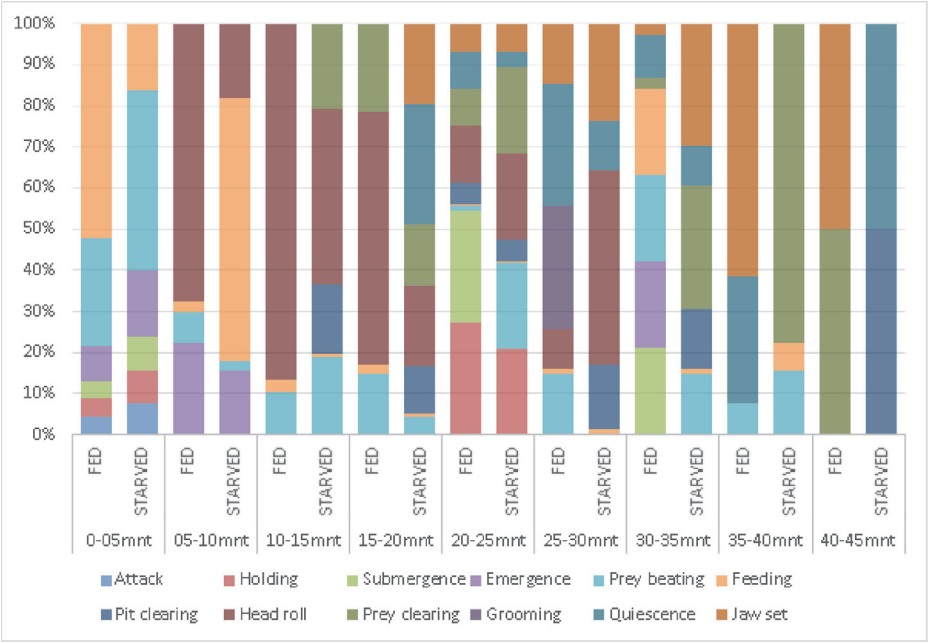

Fig 3. Feeding behaviour pattern of *Myrmeleon pseudohyalinus* fed and starved second instar larvae in each time interval in sand medium (y axis shows % occurrence of behaviour patterns)

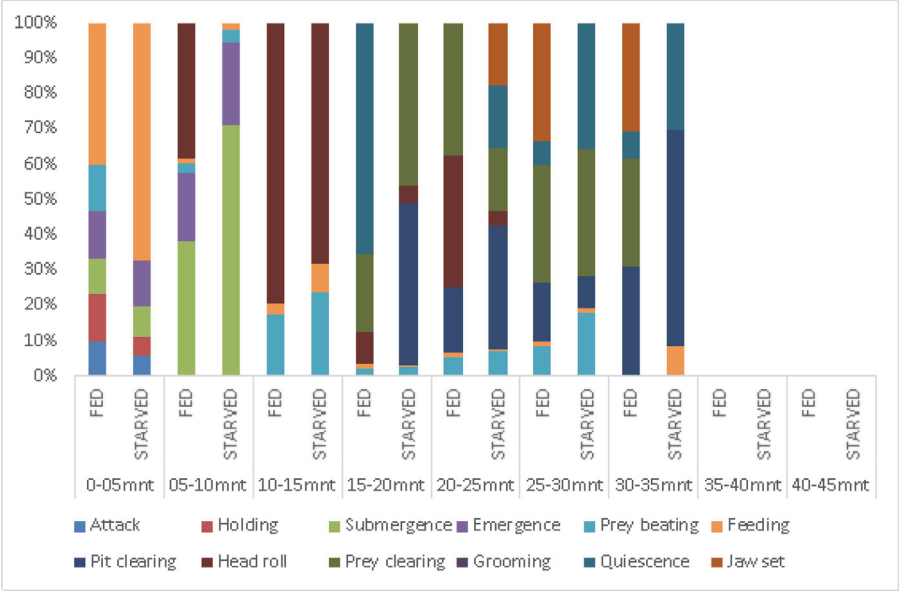

Fig 4. Feeding behaviour pattern of *Myrmeleon pseudohyalinus* fed and starved third instar larvae in each time interval in sand medium (y axis shows % occurrence of behaviour patterns)

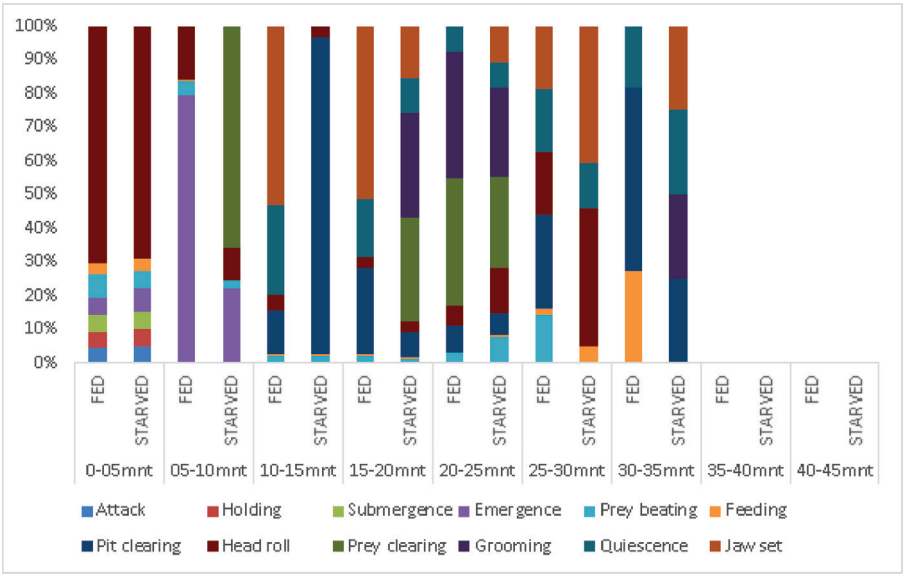

Fig 5. Feeding behaviour pattern of *Myrmeleon pseudohyalinus* fed and starved second instar larvae in each time interval in soil medium (y axis shows % occurrence of behaviour patterns)

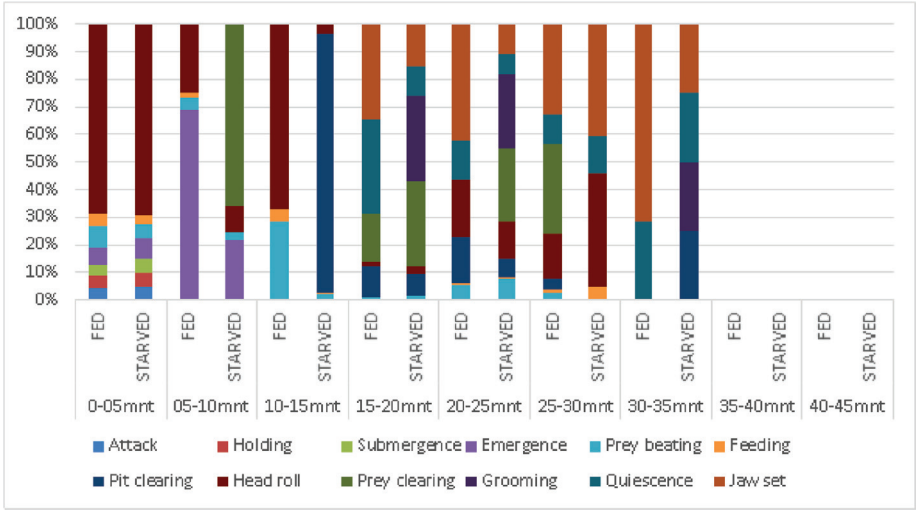

Fig 6. Feeding behaviour pattern of *Myrmeleon pseudohyalinus* fed and starved third instar larvae in each time interval in soil medium (y axis shows % occurrence of behaviour patterns)

Antlion larvae build its pit for predation and shelter. The predatory efficiency was described by examining the predatory behaviour patterns. From these experiments, the prey escape and capture success were calculated. Capture success of prey irrespective of different conditions, hunger level and instars are 50-100 per cent. Prey escape was noticed in fed second instar larvae in sand medium, fed third instar larvae in sand medium, starved third instar larvae in sand medium and starved third instar larvae in soil medium. The highest percentage of prey escape was found in fed third instar larvae in sand medium. It may be because of the lowest hunger level decreased its need and the final instar caused the larvae to pupate and emerge as adult. The prey escape was highest in sand medium due to the larger particle size which may help the prey to fill the pit by disturbing the medium easily, hence the highest capture success was observed in soil medium. The larval pit in soil medium has more stability due to its small particle size compared to sand medium.

Myrmeleon pseudohyalinus larvae took 35 to 45 minutes to feed its prey in laboratory conditions. The capture success noted from the study was 50-100 per cent and the capture success rate (95%) was higher in second instar larvae than third instar larvae (75%). This is different from Nonato and Lima (2011) who noted that the third instar (96.96%) larvae are more successful than second instar larvae (69.70%).

Drosophila melanogaster Meigen, 1830 (Lima, 2016), *Formica cinerea* Mayr, 1853 (Turza *et al*., 2020), *Tribolium castaneum* Herbst, 1797 (Bakoidi *et al*., 2019) were used for feeding antlion larvae in previous studies. Cain (1987) studied the prey capture behaviour of *Brachynemurus* larvae of Florida. *Brachynemurus* larvae lying in the pit by exposing only its mandibles above sand. It took 15-50 minutes to feed and throw away the prey in laboratory conditions. Kross and Pilgrim (2012) studied the predation rate of *M. brasiliensis* larvae by offering leaf cut ant and the third instar larvae with a predation rate of 96.96 per cent, second instar larvae with 69.7 per cent and first instar larvae with 14.28 per cent. In all the experiments the dominant behaviour pattern observed was feeding (47.8 - 77.8%). Prey beating was the behaviour noticed followed by feeding except in starved third instar larvae in sand medium. Here the attack and holding were the two dominant patterns followed by feeding. The feeding behaviour defines the success of an organism in a habitat. This study gave a base line data about feeding behaviour and predatory efficiency of *M. pseudohyalinus* larvae and the influencing components like time period, different conditions, and instars from India.

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REFERENCES

Bakoidi A., Djibo I., Dobo F., Maoge J. and Tinkeu L.S.N. (2019) Identification of the Optimum Temperature of *Myrmeleon obscurus* (Rambur, 1842). Entomology Ornithology Herpetology 8(216):1-4.

Cain M.L. (1987) Prey capture beaviour and diel movement of Brachynemurus (Neuroptera: Myrmeleontidae) Antlion larvae in South Central Florida. The Florida Entomologist 70(3): 397-400.

Devetak D., Lipovsek S. and Pabst M. A. (2010) Larval morphology of the antlion *Neurolon microstenus*. Zootaxa 2428: 55-63.

Eisner T., Baldwin I.T. and Conner J. (1993) Circumvention of prey defence by a predator: Ant lion vs. Ant. Proceedings of the National Academy of Sciences, USA 90: 6716-6720.

Ghosh S.K. (2000) Neuroptera fauna of North-East India (Records of Zoological Survey of India). Occassional Paper no.184. Zoological Survey of India, Culcutta. pp 1-179.

Kross C. and Pilgrim M. (2012) Blending Teaching and Research in the Ecology Laboratory: The Biology of Antlions as a Case Study. USC Upstate Undergraduate Research Journal V: 50-56.

Lima T.N. (2016) Cannibalism among *Myrmeleon brasiliensis* larvae (Návas, 1914) (Neuroptera, Myrmeleontidae). Acta Scientiarum Biological Sciences 38(4): 447-450.

Lucas J.R. and Brockman H.J. (1981) Predatory interactions between ants and antlions (Hymenoptera: Formicidae and Neuroptera: Myrmeleontidae). Journal of Kansas entomological society 54: 228-232.

Maoge J., Ngamo L.T., Michel B., and Prost A. (2014) Spatial distribution of the pit builders antlion's larvae (Neuroptera: Myrmeleontidae) in the serpentorial regions of Cameroon (Central Africa). International journal of scientific and research publications 4(9): 1-10.

Napolitano J.F. (1998) Predatory Behavior of a Pit-Making Antlion, *Myrmeleon mobilis* (Neuroptera: Myrmeleontidae). Florida Entomologist 81(4): 562

Nonato L.M and Lima T.N. (2011) Predation behavior of the *Myrmeleon brasiliensis* (Neuroptera: Myrmeleontidae) larval instars. Revista Colombiana de Entomología 37 (1): 354-356.

Scharf I., Filin I. and Ovadia O. (2009) A trade off between growth and starvation endurance in a pit building antlion. Oecologia 160: 453-460.

Southwick C.H. (1976) Ecology and the quality of our environment. Second edition. D. Van Nostrand Company, Item PA 3/5/3/162 - New York. pp 302-307.

Stange L. A. (2004) A Systematic catalog, Bibliography and classification of the World Antlions (Insecta: Neuroptera: Myrmeleontidae). Memoirs, Catalogue No : 9460, The American entomological Institute 74: 565.

Turza F., Zuber G., Bzoma M., Prus M., Filipiak M and Miler K. (2020) Ants Co-Occurring with Predatory Antlions Show Unsuccessful Rescue Behavior towards Captured Nestmates. Journal of Insect Behaviour 33: 1–6.

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