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Research Article

# Identification of the Optimum Temperature of *Myrmeleon obscurus* (Rambur, 1842)

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## ABSTRACT

Terrestrial ectotherms are active between precise thermal tolerance values, from lower to upper limits that impacts their survival. Around the temperature range where the xerophilous antlion larvae are active, there is a temperature close to the upper thermal limit where vital functions are optimal. No research at our knowledge is done on the thermal tolerance of *Myrmeleon obscurus* (Rambur, 1842); the present investigation identifies the thermal optimum of each larval stage in a range of four temperatures: 22, 27, 35 and 40°C. It comes clear that 35°C is the temperature at which no mortality is observed resulting to 100% of adults all viable; at this temperature *M. obscurus* has the shortest life cycle 45.43 days.

**Keywords:** Antlion larvae; Thermal tolerance; Survival; Thermal optimum

## INTRODUCTION

Insects are ectothermic organisms and therefore have a very weak capacity to regulate their body temperature, so that the ambient one determines all the biological activities. Low temperature variation can alter the metabolic activity of organisms [1], resulting in significant changes in their development, survival, reproduction, and behavior [2-5]. A change in ambient temperature produces to the insect a proportional increase or decrease in all its metabolic processes [6].

Temperature is an essential resource for the development of insects, while adequate; it impacts positively its whole development and life. Variation in the amplitude of the thermal tolerance is specific and depends to the developmental stage and to the environmental conditions of insects [7]. Increasing the temperature to the thermal optimal level causes acceleration of the insect metabolism. Hence, it directly influences increase of their activity [8].

However, the optimal temperature is therefore considered as that of most efficient physiological insect functions. At the optimal temperature, le duration of development is shorter, live expand is longer, feeding and growing are at their maximum values [9]. For terrestrial insects, the thermal optimum is higher and most close to the upper thermal limit. In addition to temperature, other spatial and temporal changes in the environment, such as the availability of nutrients can influence growth and survival [10].

Antlions are xerophilic insects that the duration of developmental stages (larval, pupal and adult) depends on several factors such as photoperiod, temperature, prey availability and body size [11] and this developmental process can be accelerated or retarded. Some species of antlion larvae do construct pits in areas with high soil temperatures [12,13].

However building and cleaning of pit trap by larvae increases better under suitable temperatures [14,15] although some other studies have been done on the effect of temperature on activities of antlions larvae. [14-20]. But few works are focused on the influence of temperature on the development and even the understanding of the functioning of antlions and temperature on larval activity in their habitats generally dry and arid zones [21].

Works on the characterization of the *M. obscurus* habitats which is one of the most common species in the northern part of Cameroon [21-23] shown that larvae are encountered in shaded habitats under trees, protected from the direct sun light. Previous investigations situate their thermal tolerance limits within range of temperatures from 10°C to 42°C [21,24]. It is also in this range that is found the suitable temperature under which *M. obscurus* builds and cleans its funnels [25]. The present

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investigation makes a step forwards finding out the thermal optimum of *M. obscurus* at each stage of its development.

MATERIALS AND METHODS

## Collection, calibration and breeding of larvae development

*Myrmeleon obscurus* larvae were obtained by extraction from their funnels at the sites of their occurrence. Sampling was carrying out at the beginning of dry season in high Guinean savannahs of Adamawa in Cameroon. The larvae of the same batch were collected the same day and reared. A total of 87 larvae have been extracted and brought to the laboratory. Among them, 67 whose length was equal to 1.5 mm were considered stage I larvae and considered for the manipulation. Consideration of size (1.5 mm) as a stage 1 larva is based on our observations of laboratory hatched.

The larvae are introduced individually in cups of 33 cl filled to two-thirds of the marine sand sifted with a 500 microns of mesh sieve. The larvae are fed *ad libitum*, receiving each per day, one third instar larva of *Tribolium castaneum* (Coleoptera: Tenebrionidae). Four sets of 16 larvae were constituted and put in rearing in cages at fixed temperature. One rearing cage was monitoring at 22°C, a second one at 27°C a third one at 35°C and the last one at 40°C.

## Daily follow-up of rearing of larvae and cocoons

Activities of larvae as feeding, cleaning of funnels, molting were observed and noted on daily basis. After molting or formation of the silk cocoon, the sand was changed, and the newly emerged larva measured (length × width), the length was measured from the abdomen to the mandibles and the width at the thorax, and put in clear sand. If a cocoon is formed, its diameter is noted, and observations continue in the same cup.

When adults emerge from cocoons, their appearance and viability are noted (Tables 1 and 2). Data on development time and size of different larval stages and cocoons were analyzed by one-way ANOVA. In the post test a Duncan procedure was proceeding to access the less significant difference among means observed.

**Table 1:** Influence of temperature of breeding on the total duration of the development of *Myrmeleon obscurus* in condition of food ad libitum with a larvae of *Tribolium castaneum* per day (mean ± SE n=16). Within a line, values followed by the same letter are not significantly different (p ≤ 0.01) (n=16 larvae per treatment).

| | 22°C | 27°C | 35°C | 40°C | F(df) |
|---|---|---|---|---|---|
| Larva I | 17.25 ± 1.23d | 14.12 ± 0.34c | 6.0 ± 0.0 a | 10.81 ± 1.60b | 351.86 (3; 60)*** |
| Larva II | 17.85 ± 2.50c | 15.71 ± 2.36b | 8.0 ± 2.5a | 9.28 ± 2.05a | 59.81 (3; 54)*** |
| Larva III | 20.25 ± 4.09c | 16.0 ± 3.04b | 10.56 ± 5.11a | 10.21 ± 2.66a | 20.07 (3; 46)*** |
| Cocoon | 29.0 ± 8.39a | 27.0 ± 5.49b | 17.87 ± 5.87a | 26.25 ± 9.26b | 6.39 (3; 51)*** |
| Duration | 85.18 ± 11.07d | 74.63 ± 6.12c | 45.43 ± 6.06a | 59.75 ± 11.57b | 50.33 (3; 46)*** |

**Table 2:** Influence of the variation of the temperature on the size (Length width in mm 2) *Myrmeleon obscurus* larvae (n=16). In the line; value followed by the same letter are not different significantly (p ≤ 0.01).

| | 22°C | 27°C | 35°C | 40°C | F (df) |
|---|---|---|---|---|---|
| Larve I | 1.5 | 1.5 | 1.5 | 1.5 | |
| Larve II | 6.06 ± 2.42c | 10.28 ± 2.87b | 16.0 ± 1.06a | 11.41 ± 2.24b | 26.45 (3 ; 25)*** |
| Larve III | 14.07 ± 1.83c | 16.33 ± 2.33b | 19.5 ± 0.85a | 18.0 ± 0ba | 14.39 (3 ; 20)*** |
| Diameter of cocoon | 5.76 ± 0.59a | 6.07 ± 0.51b | 8.84 ± 0.96c | 8.32 ± 0.67c | 74.89 (3 ; 42)*** |

RESULTS

## Influence of temperature on the development of each larval stage time

The duration of larval stage of *M. obscurus* is under the control of the temperature (Figure 1). The stage of development which is the shortest is the stage 1 lasting for 6 to 17 days. The longest stage is the cocoon which last for 17 to 30 days. The 6 days, shortest duration of the stage 1 is observed in the cages where the temperature was monitor at 35°C.

The following duration, 11 days is observed in boxes where the temperature was monitor at 40°C. At 27°C and at 22°C the larval developmental duration is the longest: 14 days. Differences observed among these first stage delays are significant (F=351.86*** and df=3; 56; P=0.0001).

In stages II and III the larval life is grouped into three categories with the first which is the shortest at 35°C (8 days at second instar and 11days at the third one) and 40°C: (9 days at second instar and 11days at the third one).

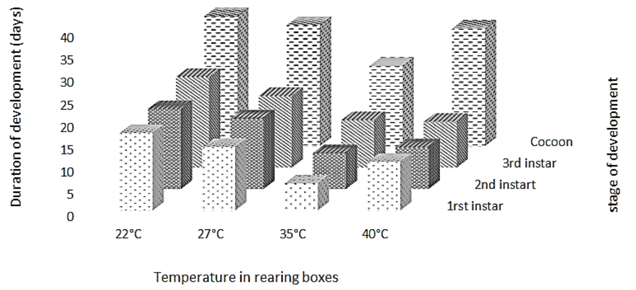


**Figure 1:** Influence of the temperature of rearing on the duration of the development of *Myrmeleon obscurus* fed ad libitum with third instar larvae of *Tribolium castaneum*

While at 27°C it is 15.71 for stage II and 16 days for stage III. The longest duration is at 22°C with 17.85 days at stage II and 20.25 days at stage III. A significant difference exists among these durations ($F=59.81^{***}$ and df=3; 56 for stage II P=0.0001) and for stage III ($F=20.07^{***}$ and df=3; 51 P=0.0001).

The Silk cocoon that protects against thermal variations can also be affected by changes in temperature; because the duration of the cocoons in different temperature conditions are not the same. However, the shorter duration is 35°C (17.85 days) and in other conditions seems to have no difference.

Analysis of variance shows that the observed difference is significant ($F=6.39^{***}$ and df=3; 46 P=0.0010). The duration of the silk cocoon at 35°C is therefore smaller than that observed at other temperatures. The larval life cycle from the stage I to the adult stage is 45.43 days at 35°C.

This is the shortest cycle, followed by the duration of 59.75 observed at 40°C; a long period of 74.63 days is observed at 27°C; the duration of 85.18 days at 22°C is the longest (Figure 1). Analysis of variance of the larval life shows that the observed difference is highly significant ($F=50.33^{***}$ and df=3; 46 P=0.0001).

## Influence of temperature on the growth of the larvae of *Myrmeleon obscurus*

Larvae that at the first stage had the same length, 1.5 mm, reared at different temperatures, as soon as they pass the second instar larvae show a great variation in their size.

At 22°C, the lowest temperature, second instar larvae reached the size width×length of 6.06 $mm^2$ and 14.07 $mm^2$ at the third instar. At the temperature 35°C the second instar larva reached the size of 16.0 $mm^2$ and third instar 19.5 $mm^2$.

At 40°C the second instar was 11.41 $mm^2$ and the third 18.0 $mm^2$. Analysis of variance shows that differences observed are significant ($F=26.45^{***}$, df=3; 25 p=0.0000 for the second instar and $F=14.39^{***}$, df=3 p=0.0000; 20 for the third instar).

## Influence of the temperature on the mortality of larvae

Mortality during larval and pupal stages decreases when the temperature increases from 22°C (initial strength) to 27°C, and is zero at 35°C, then observed at 40°C. At 22°C the mortality expressed in relation to the numbers of individuals present at the beginning of each stage, intervene at all stages with a dominance at the nymphal stage (stage I: 3/16 (18.75%) stage II 2/13 (15.38%) stage III: 1/11 (9.09%) and nymphs 2/10 (20%).

However, at 27 and 40°C no mortality was observed at the third instar larva. At 27°C 2/16 (12.5%) of larvae died at the first instar 1/14 (7.14%), at the second and 9 finally 2/13 (15.38%) of cocoon still barren.

At 40°C only 1/16 (6.25%) of larval mortality was observed at the first instar, 1/16 (6.66%) at the second and 2/14 (14, 28%) of cocoons were barren (Figure 2). The total mortality rate of first stage to adults was high at 22°C (50%), but relatively low at 40°C (25%), 27°C (31,25%).

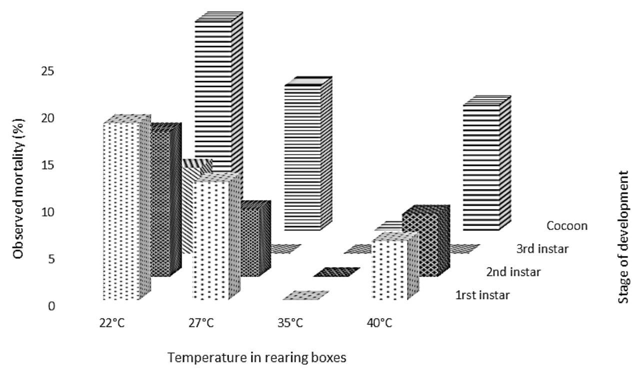


**Figure 2:** Larval mortality of *Myrmeleon obscurus* in relationship with the variation of rearing temperature.

## Effect of temperature on the construction, maintenance of pitfall traps and predation

Construction, cleaning of the pitfall traps and predation are the main parameters through whose antlion larvae exhibit their vitality. The temperature has an important impact on these activities.

At 35°C a maximum activity of larvae is carry out, 80% of pitfall traps are regularly cleaned up at the first instar larva. At the second and third instar, 100% of pitfalls are cleaned the predation rate is also maximal.

At lowest temperature, 22°C for example, larval activities are reduced only 22.22% of pit fall are cleaned at the first instar larva, in stage 75% at the second and 83.33% at the third one. The predation rate is also reduced (Figure 3).

## Impact of the temperature during larval stages on the morphology of emerging adults

All larvae reared at the temperature 35°C leaded to 100% of normal and living adults of M. *obscurus*. At 40°C, 66.66% (8/12) of emerged adults were normal but 25.01% (3/12) have their wings crumpled and finally 8.33% (1/12) were abnormal and did not survive.

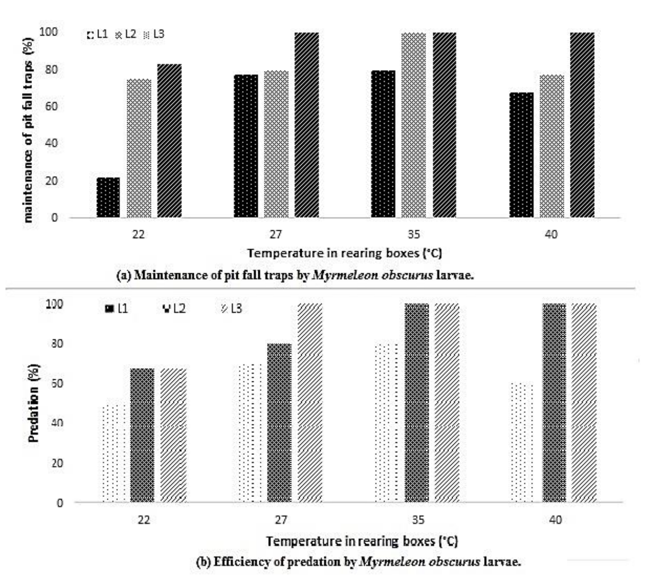


**Figure 3:** Influence of temperature on cleaning of pit fall traps (a) and the efficiency of the predation (b) in larvae of *Myrmeleon obscurus*.

At 27°C, 45.45% (5/11) of adults were normal, 36.36% (4/11) had their wings crumpled, 18% (2/11) of adults were abnormal and did not survive. At 22°C, 37.50% (3/8) of adults are abnormal and not viable only 25% (2/8) of adults are normal with also 37.50% (3/8) adults are abnormal. Temperature therefore has a significant effect on the development of the wings and the viability of adults of *M. obscurus* (Figures 4 and 5).

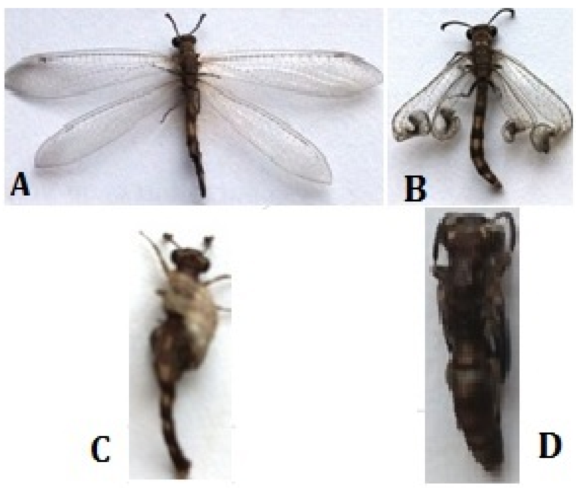


**Figure 4:** a=normal living adults; b=normal adults having crumpled wings; c=adults having extended abdomen but folded wings; d=adults with compacted abdomen and folded wings.

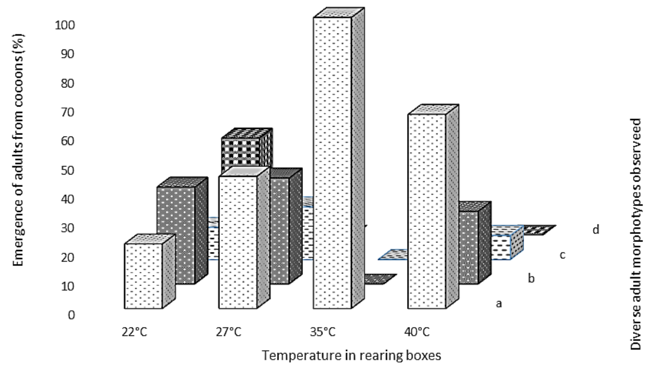


**Figure 5:** Variation of temperature during larval stages on the morphology of emerging adults.

## DISCUSSION

The results of this study indicated that temperature is an important factor, which exerts a profound influence on the development of insects. The effects of temperature on insect development may vary among species, but lower temperatures typically result in a decrease in the rate of development and increase in the duration of the time spent in each developmental stage. Results from this study indicated that the developmental time of different *M. obscurus* declined with increasing temperature. Within the thermal tolerance limits of *M. obscurus*, 35°C appears as the thermal optimum value; the temperature of 22°C is close to the lower tolerance limit and 40°C the upper one. At the thermal optimum, as described by Brodeur [26], the rate of development of *M. obscurus* is expressed as the inverse function of the time required to move from one stage of development to another. The temperature of 35°C considered as that which leads to a good development (thermal optimum) is generally lethal or considered as the upper limit not allowing the development of insects. This is the case, for example, of several other Neuroptera, such as the Hemerobiidae, where the thermal optimum is at 25°C [27,28]. Similarly, for chrysopids [29] the duration of each of these stages decreased with increasing temperature, whilst the viabilities of all forms attained 100% at 20 and 25°C.

Our study shows that from the optimal temperature, emergence of poorly formed adults with wrinkled wings that does not allow them the flight or to still live increases. Moreover, larval mortality that increases in the same way. Investigations on other insects [30] shown that far from the favorable thermal zone, mortality increases, death occurs at early stages. In general, most imago's emerging at sublethal temperatures is not viable. In the sub-lethal and lethal temperature zone, pre-pupae die without being able to reach the nymphal stage or, if they succeed, the few adults trained fail in living. Concerning our investigations, antlions in unfavorable temperatures do not feed normally but rather seek to relocate their funnels [31] observed that adult antlions have a short life span and some do not even feed, only mate and die. Thus, to complete its life cycle they depend crucially on the body mass of larvae before pupation.

Temperature during the larval stage is responsible for some characteristics of the adults.

Our study showed that body size of larvae is highly correlated with temperature this fund in previous experiments on Arthropods. The larvae have a larger size when the temperatures are more favorable. In eastern North America, larval and adult body size of the ant lion *Myrmeleon immaculatus* (DeGeer) increases weakly with latitude [32].

The predation and the maintenance of pit fall traps, show that temperatures below or above the thermal optimum (35°C), have negative impact. The soil temperature to positively affect pitfall trap volume and maintenance found in *Myrmeleon pictifrons* [14], *Myrmeleon immaculatus* [15] and *E. nostras* [16]. However, other studies showed contrasting effects of temperature on trap building. For example, in another study on *M. immaculatus*, the trap building frequency was negatively correlated with temperature [18]. It is likely that studies demonstrating a positive effect of temperature on trap building focused on a lower range of temperatures than studies demonstrating a negative effect. Furthermore, given that optimal body temperatures might differ between species that prefer shaded areas and species that are unresponsive to shade [19]. The same thermal range could result in contrasting thermal responses between such species. Some evidence supports this view. For example, it is shown that the intensity of hunting behaviors in *M. immaculatus* larvae (mandible extensions, body movements or direct prey capture attempts) increased with temperature to some point, but decreased with further increases in temperature [33]. Antlion larvae of the same species increased their trap-building frequency at lower temperatures [16], thermal range (38°C-47°C) may be above the thermal tolerance limit of this species [33]. On field conditions, it appears that larval density of larvae under the trees is higher than in March and April where the temperature is about 32°C [24].

## CONCLUSION

Temperatures under which larvae are reared have real impact on the issue and the viability of the emerging adults. Within the interval of thermal tolerance of *M. obscurus*, the temperature 35°C causes optimal development rate leading to normal and viable adults.

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