Formosan Entomologist
Journal Homepage: entsocjournal.yabee.com.tw

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【Research report】

溫濕度對夾竹桃天蛾幼蟲發育之影響【研究報告】

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Received: Accepted: 1996/12/19 Available online: 1997/06/01

Abstract

Effect of 4 constant temperatures ranging from 20 to 35℃ on development of immature oleander hawk moth, Daphnis nerii (L.) was studied. Development occurred at all temperatures, however, survival was lowest at 20 and 30℃. The proportion of time spent in each life stage from hatch to adult about 10.3% for 1st instars, 6.8% for 2nd instars, 7.6% for 3rd instars, 9.5% for 4th instars, 13.4% for 5th instars, 7.8% for pre-pupal stage, and 44.6% for pupal stage. A developmental threshold of 1.35℃ was estimated for development from hatch to adult emergence. Development from hatch to adult emergence was fastest at 30℃, taking about 23 days, and slowest at 20℃ taking about 60 days.

摘要

本報告在實驗室中研究4種定溫對夾竹桃天蛾幼蟲發育之影響。天蛾幼蟲在所測試的定溫下均能發育，唯在20℃及35℃時存活率最低。幼蟲孵化至成蟲羽化所耗費時間的百分比如下：第一齡幼蟲佔10.3﹪、第二齡幼蟲佔6.8﹪、第三齡幼蟲佔44.6﹪、第四齡幼蟲佔9.5﹪、第五齡幼蟲佔13.4﹪、前蛹期佔7.8﹪、蛹期佔44.6﹪。幼蟲孵化至成蟲羽化的發育在30℃時最快，約需23天，在20℃時最慢，約需60天。發育的臨界溫度是1.35℃。

Key words: Sphingids, developemtn, thermal threshold, degree-days.

關鍵詞: 天蛾、發育、臨界溫度、日度。

Full Text: PDF(0.29 MB)

Effect of Temperature on Development of the Oleander Hawk Moth, *Daphnis nerii* (L., 1775)

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ABSTRACT

Effect of 4 constant temperatures ranging from 20 to 35 ℃ on development of immature oleander hawk moth, *Daphnis nerii* (L.) was studied. Development occurred at all temperatures, however, survival was lowest at 20 and 35 ℃. The proportion of time spent in each life stage from hatch to adult about 10.3% for 1st instars, 6.8% for 2nd instars, 7.6% for 3rd instars, 9.5% for 4th instars, 13.4% for 5th instars, 7.8% for prepupal stage, and 44.6% for pupal stage. A developmental threshold of 1.35 ℃ was estimated for development from hatch to adult emergence. Development from hatch to adult emergence was fastest at 30 ℃, taking about 23 days, and slowest at 20 ℃ taking about 60 days.
Key words: Sphingids, development, thermal threshold, degree-days

Introduction

The oleander hawk moth, *Daphnis nerii* (L., 1775), is a native of Africa and Europe, but can also be found throughout the Pacific area including Hawaii, and Asia including Taiwan. The insects can be found from January to May, June to August, and October to December and distributed at the lower elevation of Taiwan.

The larval stage consists of five instars, mainly feeding on oleander (*Nerium indicum* Mill.) and closely related plants such as *Tabernaemontana divaricata* (L.) R. Br. ex Roem, *Alstonia schloaris* (L.) R. Br., and *Vinca rosea* L. (Chen, 1994). Larvae also fed on *Dissolaena verticillata* Lour., and *Adenium obesum* Forsk (Yeh *et al.* 1997). In Okinawa the larvae also fed on *Catharanthus roseus*, *T. divaricata*, and *Cerbera manghas* (Kimura, 1996).

Lin (unpublished data) reared *D. nerii* larvae by using *Nerium indicum* Mill and reported that the developmen-

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tal times were as follows: egg stage 4 days, 1st instar 4 days, 2nd instar 3 days, 3rd instar 3 days, 4th instar 4 days, 5th instar 5 days, prepupa to pupa 3 days, pupal stage 16-17 days, egg to pupa 44-45 days in growth chamber (25-26 ℃). Yeh *et al*. (1997) reared *D. nerii* larvae by using *Adenium obesum* Fork leaves and reported that the developmental times were as follows: egg stage 3-4 days, 1st instar 3 days, 2nd instar 3 days, 3rd instar 3 days, 4th instar 2-3 days, 5th instar 11-12 days, pupal stage 11-12 days, egg to pupa 26-28 days during October-November (room temperature about 27-29 ℃); and egg stage 7-9 days,1st instar 6-9 days, 2nd instar 3-6 days, 3rd instar 5 days, 4th instar 4-5 days, 5th instar 8-11 days, pupal stage 27 days, egg to pupa 61 days during December-January (room temperature about 18-22 ℃).

Temperature is the most important environmental factor affecting poikilotherms and has a pervasive effect on physiological processes and on almost all aspects of organisms performance. Growth of caterpillars is strongly temperature dependent (Sharpe and DeMichele, 1977; Scriber and Slansky, 1981) and the degree of temperature dependence varies from species to species and the optimal temperature for growth is also variable (Taylor, 1981).

The temperature-dependent developmental rate curve of an insect is an important feature of its life history (Taylor, 1981). Using degree-day accumulations to predict a wide variety of events such as egg hatch, adult emergence, or migratory flights may be feasible for pest management. Degree-day accumulations need knowledge of both insect developmental response to temperature and lower developmental threshold (Woodson and Jackson, 1996).

Our study was conducted to determine the temperature-dependent development and developmental thresholds of the immature stages of the oleander hawk moth over different ranges of temperature.

Materials and methods

Eggs of *D. nerii* were collected from the oleander plants in the campus of Chung-Hsing University, Taichung, Taiwan. Upon hatching, larvae were placed individually in a capped 15 ml plastic container with a 1.5 cm^2 sheet of paper on the bottom, and reared on cut leaves of oleander. Containers were prepared and placed in a growth chamber and the rearing and test conditions were set at a constant photoperiod of 16:8 (L:D) under 20 ℃ , 25 ℃ ,30 ℃ , and 35 ℃ . Body weight, and head-capsule width were measured for each instars. Days of development were recorded. Body weight was obtained by using alive larvae. Fecal weights were calculated on dry weight basis. Each treatment had 10 larvae and with 5 replicates. Experimental design was using Randomized Complete Block Design (RCBD).

Analysis of variance (ANOVA) was used to examine the effects of temperature on developmental times, head-capsule width and log body weight. Since the standard deviation in the original scale of body weight varied directly as the mean, logarithms transformation were used to stabilized the variance. The analytical procedure used was the Statistical Analysis System (SAS) package (SAS Institute, 1988).

Calculation of developmental threshold temperature (Tb) and degree-day estimation for development of each life stage was followed the method described by Woodson and Jackson, 1996). According to Gilbert and

Raworth(1996) the effect of temperature on development rate was effectively linear in more than 300 species of insects, and the measure of day-degrees based on that linearity. Degree-days were calculated using data from the 20-35 ℃ range, where the relationship between temperature and development was approximately linear. A common estimate of Tb was used in all estimates of degree-day. This estimate of Tb was the average of Tb for development from hatch to adult emergence.

Results

Development from egg hatch to the adult stage occurred at all temperature tested; survival declined above 30 ℃ or below 25 ℃ . There was a decrease in developmental time with increasing temperature for most life stage up to 25 ℃ , above which development without significant difference (Table 1). The proportion of time spent in each stadium relative to the total time from hatch to adult as temperature increased did not change with all life stage. Averaged over all temperatures the proportion of developmental time spent in the 1st stadium was 10.3%, in the 2nd 6.8 %, in the 3rd 7.6%, in the 4th 9.5%, in the 5th 13.4%, in the prepupal stage 7.8%, and in the pupal stage 44.6%.

A two-way ANOVA on developmental time versus life stage and temperature showed significant effects as a result of stage (F= 515.31; df = 6, 112; p<0.0001) and to temperature (F = 378.47; df = 3, 112; p<0.0001), and there is a significant effect caused by their interaction (F = 49.84; df = 18, 112; p<0.0001). A two-way ANOVA on log body weight versus life stage and temperature indicated significant effect as a result of life stage (F = 2838.36; df = 6, 112; P< 0.0001), and to temperature (F = 5.25; df = 3, 112; P< 0.0001) (Table 2). There was a decrease in body weight with increasing temperature for most life stages. The exception was the 1st instar, whose body weight without significant change, and was the 4th instar, whose body weight increased from 20 ℃ up to 35 ℃ .

A two-way ANOVA on immature head capsule width versus temperature and life stage showed significant effects as a result of life stage (F = 493.11; df = 4, 60; P< 0.0001), but no significant effect were caused by temperature (F = 0.62; df = 6, 112; P = 0.546) no signifi-

Table 1. Mean developmental time (d) ± SD required for *D. nerii* at four constant temperatures

	Temp. ℃			
	20	25	30	35
n	12	20	15	5
1st instar	5.9 ± 0.9	3.4 ± 0.8	2.6 ± 0.5	2.6 ± 0.5
2nd instar	4.8 ± 0.5	2.3 ± 0.7	1.5 ± 0.7	1.6 ± 0.5
3rd instar	6.2 ± 0.6	2.3 ± 0.5	1.7 ± 0.5	1.6 ± 0.5
4th instar	5.5 ± 0.7	3.2 ± 0.4	2.2 ± 0.4	2.6 ± 0.9
5th instar	6.7 ± 0.8	4.4 ± 0.7	3.2 ± 0.4	4.0 ± 0.9
Prepupa	5.4 ± 0.5	3.0 ± 0.0	2.0 ± 0.0	1.3 ± 0.5
Pupa	25.7 ± 0.8	16.4 ± 2.0	10.1 ± 0.5	11.0 ± 1.7
Hatch to adult	60.7 ± 1.4	34.9 ± 2.2	23.2 ± 0.1	24.4 ± 3.6
% survival	20 %	85 %	80 %	40 %

Table 2. Estimated lower developmental thresholds and developmental time in degree-days for *D. nerii*

Stage	Threshold equation	n	r^2	Tb(℃)	DD ± SD
1st instar	y=0.073x+0.124	4	0.869	1.68	88.17 ± 15.68
2nd instar	y=0.148x+0.112	4	0.835	0.75	60.15 ± 20.26
3rd instar	y=0.154x+0.065	4	0.895	0.42	68.81 ± 29.40
4th instar	y=0.075x+0.145	4	0.691	1.93	82.19 ± 16.86
5th instar	y=0.038x+0.137	4	0.552	3.54	113.95 ± 19.41
Prepupa	y=0.191x+0.033	4	0.978	0.17	68.15 ± 24.36
Pupa	y=0.019x+0.023	4	0.808	1.17	381.53 ± 77.96
Hatch to adult	y=0.008x+0.010	4	0.828	1.14	860.72 ± 175.69

cant effect by their interaction ($F = 0.67$; $df = 3, 112$; $P = 0.712$).

Estimate of Tb were not similar for all developmental stages (Table 2). Averaged over all stadia, a pooled Tb was estimated to be 1.35 ℃. The development from hatch to adult emergence took about 860 DD.

Discussion

The optimal growth of the oleander hawk moths occurred between 25 to 30 ℃. The extreme temperature had detrimental effect on immature growth and caused high mortality. The mortality was caused by unable finishing larval stage, unable pupating or by deformed adults with misshapen wings.

The developmental threshold of the oleander hawk moth is quite low, 1.35 ℃, which is lower than *Pieris rapae*, 9 ℃ (Gilbert and Reworth, 1996). Prolonged exposure to extreme temperature dislocate the physiological kinetics was reported by Williams (1956). Prolonged exposure of pupae of *Samia walkeri* to 2.5 ℃ induces winter sickness which is caused by an inability to precipitate waste products from the blood. Nielsen and Evans (1960) consider that developmental thresholds are determined by temperatures that stop certain vital chemical reactions.

There was a decrease in developmental time with increasing temperature for most life stages of the oleander hawk moth. And the results of the proportion of developmental time spent in each stadia were similar to several sphingid moths of Taiwan (Lin, unpublished data). When eggs were kept individually, reared to adult and having sex determination. There is no substantial differences between male and female developmental times for any life stages.

The development from hatch to adult took about 34 days in 25 ℃, which was shorter than the other sphingids such as *Dolbina inexacta* took 56 days, *Langia zenzeroides formosana* took 63 days, *Phyllosphingia dissimilis hoenei* took 41 days (Lin, unpublished data). Developmental thresholds and degree-day requirements will provide information about life stage events and may aid in developing management strategies.

Acknowledgements

The authors are grateful to Mr. G. P. Huang for graphing. Sincere thanks also go to anonymous reviewers who provided valuable comments on this manuscript.

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Received for publication July. 16, 1996
Revised manuscript accepted Dec. 19, 1996

温度對夾竹桃天蛾幼蟲發育之影響

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摘 要

本報告在實驗室中研究 4 種定溫對夾竹桃天蛾幼蟲發育之影響。天蛾幼蟲在所測試的定溫下均能發育，唯在 20 ℃及 35 ℃時存活率最低。幼蟲孵化至成蟲羽化所耗費時間的百分比如下：第一齡幼蟲佔 10.3% 、第二齡幼蟲佔 6.8% 、第三齡幼蟲佔 7.6% 、第四齡幼蟲佔 9.5% 、第五齡幼蟲佔 13.4% 、前蛹期佔 7.8% 、蛹期佔 44.6% 。幼蟲孵化至成蟲羽化的發育在 30 ℃時最快，約需 23 天，在 20 ℃時最慢，約需 60 天。發育的臨界溫度是 1.35 ℃。

關鍵詞：天蛾、發育、臨界溫度、日度

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