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# 不同温度和土壤含水量对大斑芫菁生长发育的联合作用

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**摘要**: 在室内人工饲养大斑芫菁, 研究了不同温度、土壤含水量对大斑芫菁生长发育及其卵的孵化率的联合作用。结果表明: 大斑芫菁不同生长发育时期对温度、土壤含水量的要求有所不同, 1~6 龄幼虫发育速率最快时的温度和土壤含水量依次为: 32.6℃、6%; 35.6℃、6%; 36.3℃、6%; 38.0℃、6%; 35.6℃、6%; 38.0℃、7.1%, 蛹发育速率最快时的温度、土壤含水量为 37.1℃、6%。卵孵化率最高时的温度、土壤含水量为 34.0℃、12%, 卵发育速率最快时的温度、土壤含水量为 33.2℃、7%。

**关键词**: 大斑芫菁; 温度; 土壤含水量; 生长发育; 联合作用

# Joint effect of Different Combination of Temperature and Water-content in Soil on the Development of *Mylabris phalerata* Pall.

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**Abstract**: Mylabris is the dried body of the Chinese blister beetle (*Mylabris phalerata* Pallas). The use of Mylabris can be traced back to more than 2 000 years ago in the traditional Chinese medicine. Cantharidin (hexahydro-3aα, 7aα-dimethyl-4β, 7β-epoxyisobenzofuran-1, 3-dione) is the active ingredient of Mylabris. Mylabris is a potent vesicant and purported aphrodisiac used on human beings as well. If it is ingested, it will produce the congestion of the urethral mucosa, which may result in priapism in men and pelvic congestion in women. The other traditional uses of Mylabris include treatments of poor local blood circulation, dropsy, pleurisy, pericarditis and amenorrhea in the places of Europe and China. In recent studies, Cantharidin was discovered to possess anti-tumor activities and would increase the number of leucocytes.

For its extensive uses in medicine, the natural resources of Mylabris have been dramatically decreased. Therefore, the manual raise of Mylabris was become more important than before. Temperature and water-content in soil are the two of the most important factors that will effect the development of insects. So we have carried out an investigation about the development and hatchability of M. *phalerata* under the different conditions in combinations of temperature and water-content in soil.

The mylabris used in our investigations were taken from the soybean field in the campus farm of Huazhong Agricultural University. They were kept and raised in the Insects Resources Institute of Huazhong Agricultural University. The adult mylabris were raised in the cubic cages, at the bottoms of which, a certain amount of sand was put in. While the eggs, pupas and larvae were put into the plastic cups, in which there was a certain amount of sand, too. We used the flowers of bean-plants to feed the

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adult mylabris and changed their foods from time to time. And we used the eggs of locust to feed the larvae.

Then, we took the soil from the field and got rid off the stones and roots of grass, we put it into the oven and waited it to be dried and made its weight normal. When it was cooled to the temperature of the inside room, we put water in it and made it suitable, according to the water-content we needed in the experiments. After that, we put it into the fostering-box. For the measurements of the growing-rate of larvae, we settled 5 different temperatures in our JKDP-2 type Eternal Temperature Box, which were 22℃、26℃、30℃、34℃ and 38℃. At the same time, we set the amounts of water-content in soil, which were 6%、10% and 14%. Under the conditions of each combination of temperature and water-content in soil, we raised 10 larva mylabris; each of them was kept in a plastic cup. We repeated the same experiment for 4 times. Altogether we raised 40 larvae. Every day we observed them at 4 settled time (7:00、12:00、15:00 and 21:00). Each time we not only did the observations but also recorded the periods of time for instars at their different ages. At the same time, we paid attention to their growing-up process and also how well they grew. If we upset the numbers of the days that instars needed to be fully grown-up, we would get the rates of larva's growing-up development. At the last observation time (21:00) of each day, we not only took the record but also measured the weight of each plastic cup and filled in a certain amount of water. We did it in order to keep the water-content of soil constant.

When we were dealing with the pupae, the number of pupae, the conditions of temperature, water-content in soil were the same as we did in the experiment of larvae. Every day we observed them at settled time (7:00、15:00 and 21:00). Every time when we took records, we noted down the time that different pupae needed to grow up fully and the situations of their growing-up process. The way we treated with the water-content in soil to make it constant was the same as we did in our previous experiments. Then, we came to the measurement of the growing-up rates of the eggs. We settled the same 5 temperatures. Meanwhile, we set the amounts of water-content in soil, which were 7%、12% and 17%. Under each combination of temperature and water-content in soil, we used 50 eggs of mylabris. The process of the observation and the way to keep the water-content constant were same as the mentioned above, too. The results are presented the following:

The combinations of 32.6℃、6%; 35.6℃、6%; 36.3℃、6%; 38.0℃、6%; 35.6℃、6%; 38.0℃、7.1% were optimal for the duration of development of 1～6 instars larvae. While the combination of 37.1℃、6% was optimal for the duration of development of pupa. The combination of 33.2℃、7% was optimal for the duration of development of egg. In the combination of 34.0℃、12%, the hatchability of egg was optimal.

Obviously, the temperature and the water-content in soil have their strong affections to the growing-up of eggs, larvae and pupae of mylabris. And they have effects to the hatchability of eggs as well. What is more, between the temperature and water-content in soil, they have their own interactions, which are also obvious. According to the results of our experiments in the room, during the range between 22～34℃, the growing-up rates of eggs, larvae and pupae increase together with the temperature's increasing. When the water-content in soil increase during the rang between 6%～14%, the rate will follow the parabola regular pattern. As we have observed, under the combinations of high temperature and low water-content, or the combinations of low temperature and high water-content, the larva's fetching food ability decreases. They don't have the necessary energy they need to grow up, thus they grow up rather slowly. What is even worse, some of them may even die soon. Moreover, under the combinations of low temperature and high water-content in soil, the eggs are easy to get infected by the mildews. Therefore,

the rate of their death is rather high. On the other hand, under the combinations of high temperature and low water-content in soil, the eggs are easy to lose the water in them. If they lose too much water, they will get shrunk and dry. So the rate of their death is very high, too.

As a conclusion, different combinations of temperature and water-content in soil play a significant role in the development of *Mylabris phalerata*. In comparison, the temperature range of 32～38℃ and the water-content in soil range of 6%～7% are shown to be most suitable conditions for the growth of *M. phalerata*.

**Key words**:*Mylabris phalerata* Pall.; temperature; water-content in soil; development; joint effect

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大斑芫菁(*Mylabris phalerata* Pall.)又名南方大斑蝥,属鞘翅目芫菁科(Meloidate)斑蝥属的昆虫。因其成虫和幼虫体内均含有斑蝥素(Cantharidin $C_{10}H_{12}O_4$)而受到广泛的重视。芫菁外用能蚀死肌,敷疥癣恶疮;内服有攻毒,逐瘀散结,抗肿瘤的作用。我国是最早认识芫菁药用价值的国家,已有二千年历史。如《神农本草经》、《名医别录》、《日华子本草》、《大观本草》、《本草纲目》等古代文献对芫菁的形态、习性和药用价值均有记载。由于过量捕捉,野生斑蝥资源越来越少[1,2]。

关于芫菁的生物学、斑蝥素的结构和提取、斑蝥素的药用价值[3~5]等方面的研究已有大量报道,有关环境条件对其生物学影响的研究似嫌不足,温度和土壤含水量是影响大斑芫菁生长发育的主要因子,张含藻等分别在室内、外不同环境条件下,观察了大斑芫菁交配、产卵、卵孵化率等与温、湿度等单因子之间的关系[6,7],胡周强等报道了芫菁幼虫的生长与土壤含水量的关系[8],胡周强等又报道了在恒定的温、湿度条件下,芫菁幼虫的捕食习性[9]。本文着重探讨了不同温度、土壤含水量的组合对大斑芫菁卵、幼虫及蛹的生长发育的联合效应,旨在为人工大量饲养大斑芫菁,从而科学的保护和利用芫菁资源提供科学依据。

## 1　材料与方法

### 1.1　试虫来源

大斑芫菁成虫采自华中农业大学校园农场大豆田,采后置于华中农业大学昆虫资源研究所养虫室内饲养。

成虫饲养于高 2m、长 1.5m、宽 1m 的立体笼中(周围附上沙网),底部放置一定量的沙子。卵、幼虫、蛹均放于高 10cm、上口直径 7cm、下口直径 4.5cm,内置一定量沙的塑料杯中。以豆科植物的花饲养大斑芫菁的成虫,并定时更换饲料。以棉蝗的卵块饲养大斑芫菁的幼虫。

### 1.2　实验方法

(1)土壤含水量的设定方法　将野外取回的土壤除去石块、草根的杂质,放入烘箱中烘干至恒重。冷至室温后,加水分别配制成试验所需的含水量。放置在培养箱中待试验用。

(2)幼虫发育速率的测定　用 JKDP-2 型恒温箱设置 22℃、26℃、30℃、34℃、38℃ 5 个温度,同时设置土壤含水量为 6%、10%、14%。每个温度、土壤含水量条件下,饲养大斑芫菁幼虫 10 头(一头幼虫置于一个塑料杯中),重复 4 次,每个处理共计饲养幼虫 40 头。每天定时(7:00、12:00、15:00 和 21:00)观察 4 次,每次观察并记录各龄幼虫的历期及生长发育进度等情况。各龄幼虫发育历期(天数)的倒数即为发育速率。21:00 观察记录的同时,对每个塑料杯进行称重,并补足相应重量的水分,以保持土壤含水量的稳定。

(3)蛹发育速率的测定　温度、土壤含水量条件及每个处理饲养的大斑芫菁蛹数的设置与幼虫相同。每天定时(7:00、15:00 和 21:00)观察 3 次,每次观察时均记录不同处理中蛹的发育历期及发育进度等情况。保持土壤含水量的稳定的方法同卵。

(4)卵发育速率的测定　用 JKDP-2 型恒温箱设置 22℃、26℃、30℃、34℃、38℃ 5 个温度,同时设置土壤含水量为 7%、12%、17%。每个温度、土壤含水量条件下,设置大斑芫菁卵 50 粒。观察记录和保持土壤含水量的方法同卵。



(5)结果计算方法　根据测定结果,利用二因素随机区组试验方差分析及新复极差多重比较的生物统

计方法对相关资料进行分析，并建立二元二次回归模型[10,11]。

## 2　结果与分析

### 2.1　不同温度、土壤含水量对大斑芫菁卵的发育速率及卵孵化率的影响

实验表明，不同温度、土壤含水量对大斑芫菁卵的发育速率及卵孵化率有明显的影响。从方差分析可知（表 1，表 2），不同温度、土壤含水量的处理下，大斑芫菁卵的发育及孵化率均达到了显著水平。总体来看，大斑芫菁卵的发育速率和孵化率随温度升高而增加，但温度过高时（38℃），其发育速率和孵化率反而降低；随土壤含水量的升高呈抛物线变化。在温度位于 30～34℃、土壤含水量为 7%～12%的范围内比较适宜大斑芫菁卵的发育。在 15 个不同温度、土壤含水量组合中，34℃、12%这个温度、土壤含水量组合最利于大斑芫菁卵的发育，在这种温度、土壤含水量的条件下，大斑芫菁卵的发育速率为0.043545，孵化率为86.9%。其次是 34℃、7%的温度、土壤含水量组合，其发育速率为 0.040186，孵化率为 63.9%。但在低温、高土壤含水量（22℃、12%～17%）和高温、低土壤含水量（38℃、7%）的情况下，大斑芫菁卵完全不能发育。

表 1　方差分析结果

Table 1　Result of ANOVA

| 变异来源 Source | 自由度 *DF* | 方差平方和 Sum of squares | 平均值 Mean square | *F* 值 *F* value | 显著性 *Pr*>*F* |
|---|---|---|---|---|---|
| 模型 Model | 6 | 0.00631418 | 0.00105236 | 6.48 | <0.0001 |
| 误差 Error | 38 | 0.00617122 | 0.00016240 | | |
| 总变异 Corrected total | 44 | 0.01248539 | | | |

表 2　不同温度、土壤含水量对大斑芫菁卵的发育速率及孵化率的影响

Table 2　The influence of different combinations of temperatures and water-content in soil for the growth rate and hatchability of eggs of *M. phalerata*

| 温度（℃） Temperature | 土壤含水量（%） Water-content in soil | 发育速率 Growth rate | 差异显著性 Significance | 卵孵化率（%） Hatchability of egg | 差异显著性 Significance |
|---|---|---|---|---|---|
| 22 | 7 | 0.027799 | E | 12.3 | F |
| | 12 | 0 | F | 0 | G |
| | 17 | 0 | F | 0 | G |
| 26 | 7 | 0.034524 | D | 26.6 | E |
| | 12 | 0.035817 | CD | 36.7 | D |
| | 17 | 0 | F | 0 | G |
| 30 | 7 | 0.040064 | AB | 54.4 | C |
| | 12 | 0.037088 | BCD | 62.0 | BC |
| | 17 | 0.035916 | CD | 63.3 | B |
| 34 | 7 | 0.040186 | AB | 63.9 | B |
| | 12 | 0.043545 | A | 86.9 | A |
| | 17 | 0.038519 | BC | 79.3 | A |
| 38 | 7 | 0 | F | 0 | G |
| | 12 | 0.035039 | CD | 28.7 | DE |
| | 17 | 0.036376 | CD | 16.6 | F |

### 2.2　不同温度、土壤含水量对大斑芫菁幼虫及蛹的发育速率的影响。

实验表明，不同温度、土壤含水量对大斑芫菁幼虫及蛹的发育速率有明显的影响。经方差分析可知（表 3、4），大斑芫菁 1～6 龄幼虫及蛹的发育速率在不同温度、土壤含水量的处理下均达到了显著水平。从总体来看，大斑芫菁幼虫及蛹的发育速率随温度升高而加快，而随土壤含水量的升高呈抛物线变化规律。在温度 30～38℃、土壤含水量为 10%的范围内比较适宜大斑芫菁幼虫及蛹的发育。在 15 个不同温度、土壤含水量组合中，34℃、10%这个温度比较利于大斑芫菁幼虫及蛹的发育，在这种温度、土壤含水量的条件下，大斑芫菁 1～6 龄幼虫及蛹的发育速率分别为 0.62269、0.48280、0.32280、0.33558、0.0077529、0.190293、0.21005，显著高于其他组合。其次是 34℃、14%的温度、土壤含水量组合，2～6 龄幼虫及蛹的发育速率与前者接近或相差无几。但在低温、低土壤含水量（22℃、6%）和低温、高土壤含水量（22℃、14%）的条件下，大斑芫菁 1～6 龄幼虫及蛹的发育速率受到明显影响。说明适温（或高温）、土壤含水量适中的环境条件有利于大斑芫菁幼虫及蛹的生长发育。

### 2.3　不同温度、土壤含水量对大斑芫菁各虫态发育的联合效应



根据试验所测得的数据求得的温度（$x_1$）、土壤含水量（$x_2$）二因子联合效应对大斑芫菁卵、各龄幼虫及

表 3　方差分析结果

Table 3　Result of ANOVA

| 变异来源 Source | 自由度 *DF* | 方差平方和 Sum of squares | 平均值 Mean square | *F* 值 *F* value | 显著性 *Pr*>*F* |
|---|---|---|---|---|---|
| 模型 Model | 6 | 0.51767558 | 0.08627926 | 5.47 | <0.0001 |
| 误差 Error | 308 | 4.85905444 | 0.01577615 | | |
| 总变异 Corrected total | 314 | 5.37673002 | | | |

表 4　不同温度、土壤含水量对大斑芫菁幼虫、蛹的发育速率的影响

Table 4　The influencef of different combinations of temperatures and water-content in soil for the growth rate of larvae and pupae of *M. phalerata*

| 温度(℃) Temperature | 土壤含水量(%) Water-content in soil | 发育速率 Growth rate | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 1 龄 1st instar | 2 龄 2nd instar | 3 龄 3rd instar | 4 龄 4th instar | 5 龄 5th instar | 6 龄 6th instar | 蛹 Pupa |
| 22 | 6 | 0.24746DE | 0.25384EFG | 0.18908F | 0.20480FG | 0.0058034E | 0.111194EF | 0.12900H |
| | 10 | 0.25743DE | 0.26426EFG | 0.20431EF | 0.23282DE | 0.0062306CDE | 0.119526DEF | 0.13889GH |
| | 14 | 0.22340E | 0.22288G | 0.19689EF | 0.19399G | 0.0059991DE | 0.109890F | 0.12548H |
| 26 | 6 | 0.33558CDE | 0.27907EFG | 0.21567EF | 0.24429CDE | 0.0064974CD | 0.117201DEF | 0.15288FG |
| | 10 | 0.40701C | 0.29480DEFG | 0.22252E | 0.25717CD | 0.0067278C | 0.127967BCD | 0.16129EFG |
| | 14 | 0.37591CD | 0.24546FG | 0.20086EF | 0.18632G | 0.0065944CD | 0.125913CDE | 0.13839GH |
| 30 | 6 | 0.45707BC | 0.32348DE | 0.26404CD | 0.25743CD | 0.0075197B | 0.137003BC | 0.15906EFG |
| | 10 | 0.56019AB | 0.40348BC | 0.27212CD | 0.31332AB | 0.0081784A | 0.141984B | 0.17845CDE |
| | 14 | 0.46491BC | 0.30471DEF | 0.27958BCD | 0.22272EF | 0.0075290B | 0.136986BC | 0.17351DEF |
| 34 | 6 | 0.45516BC | 0.32461DE | 0.28784BCD | 0.26353C | 0.0074832B | 0.179954A | 0.23316A |
| | 10 | 0.62269A | 0.48280A | 0.32280A | 0.33558A | 0.0077529AB | 0.190293A | 0.21005B |
| | 14 | 0.40701C | 0.45707AB | 0.30361AB | 0.30693B | 0.0076357AB | 0.176336A | 0.19613BCD |
| 38 | 6 | 0.36210CDE | 0.28824DEFG | 0.25686D | 0.24420CDE | 0.0068029C | 0.178687A | 0.20097BC |
| | 10 | 0.42108BC | 0.32348DE | 0.26404CD | 0.24460CDE | 0.0076643AB | 0.188986A | 0.20016BC |
| | 14 | 0.39083CD | 0.35991CD | 0.29527ABC | 0.22759EF | 0.0078753AB | 0.190123A | 0.17905CDE |

蛹的发育速率($y$)的二元二次回归方程如下:

卵　$$y = -0.076654 + 0.006246x_1 + 0.001897x_2 - 0.000085629x_1^2 + 0.000012952x_2^2 - 0.000079145x_1x_2 \pm 0.00233$$

$$(y_{\max} = 0.03185 \quad x_1 = 33.20 \quad x_2 = 7 \quad R = 0.9232^{**})$$

1 龄

$$y = -2.563288 + 0.171221x_1 + 0.050056x_2 - 0.002451x_1^2 - 0.000422x_2^2 - 0.001938x_1x_2 \pm 0.03748$$

$$(y_{\max} = 0.3069 \quad x_1 = 32.60 \quad x_2 = 6 \quad R = 0.9619^{**})$$

2 龄

$$y = -0.955710 + 0.069496x_1 + 0.022004x_2 - 0.000890x_1^2 - 0.00023708x_2^2 - 0.000963x_1x_2 \pm 0.06247$$

$$(y_{\max} = 0.3159 \quad x_1 = 35.60 \quad x_2 = 6 \quad R = 0.8176^{**})$$

3 龄

$$y = -0.478605 + 0.03784x_1 + 0.011739x_2 - 0.000490x_1^2 - 0.000161x_2^2 - 0.000312x_1x_2 \pm 0.02689$$

$$(y_{\max} = 0.2381 \quad x_1 = 36.60 \quad x_2 = 6 \quad R = 0.9033^{**})$$

4 龄

$$y = 0.006322 + 0.191344x_1 - 0.006169x_2 - 0.000270x_1^2 - 0.000963x_2^2 + 0.000266x_1x_2 \pm 0.03353$$

$$(y_{\max} = 0.3325 \quad x_1 = 38.00 \quad x_2 = 6 \quad R = 0.8966^{**})$$

5 龄

$$y = -0.008228 + 0.00820x_1 + 0.000272x_2 - 0.00001046x_1^2 + 0.00000263x_2^2 - 0.000011868x_1x_2 \pm 0.00043$$

$$(y_{\max} = 0.006899 \quad x_1 = 35.60 \quad x_2 = 6 \quad R = 0.9119^{**})$$

6 龄

$$y = 0.069157 + 0.001573x_1 - 0.001828x_2 + 0.000042519x_1^2 - 0.000192x_2^2 + 0.00012x_1x_2 \pm 0.01035$$

$$(y_{\max} = 0.20004692 \quad x_1 = 38.00 \quad x_2 = 7.1 \quad R = 0.9751^{**})$$

蛹

$$y = -0.231283 + 0.02268x_1 + 0.002765x_2 - 0.0000305x_1^2 - 0.000385x_2^2 - 0.000011457x_1x_2 \pm 0.01$$

$$(y_{\max} = 0.1905 \quad x_1 = 37.10 \quad x_2 = 6 \quad R = 0.9350^{**})$$

对以上各回归方程进行分析和计算，得到发育速率最快时的温度、土壤含水量分别为：卵期为33.20℃、7%；1 龄为 32.60℃、6%；2 龄为 35.60℃、6%；3 龄为 36.30℃、6%；4 龄为 38℃、6%；5 龄为 35.60℃、6%；6 龄为 38℃、7.1%；蛹期为 37.10℃、6%。通过以上数据不难看出，大斑芫菁发育速率最快时的温度、土壤含水量的环境是：32～38℃，6%～7%。可以说，高温和低土壤含水量的环境是最适宜大斑芫菁生长发育的。

## 3 讨论

**3.1** 温度与土壤含水量对大斑芫菁的卵、幼虫及蛹的发育和卵的孵化率均有明显的影响，而且两者有显著的交互作用。根据室内试验的结果来看，大斑芫菁卵、幼虫及蛹的发育速率，在 22～34℃的范围内随温度增加而加快，在 6%～14%的范围内随土壤含水量的的增加而呈抛物线规律。据观察，在高温、低土壤含水量和低温、高土壤含水量的情况下，大斑芫菁幼虫取食能力下降，生长发育所需要的能量供应不足，生长发育延缓，甚至死亡。另外，低温、高土壤含水量的条件下，卵块容易受霉菌感染，死亡率高；而在高温、低土壤含水量的条件下，卵容易失水导致干缩，死亡率也很高。

**3.2** 大斑芫菁的交配、产卵期一般在 7 月份至 8 月份，此时武汉地区平均温度在 30℃以上，所以在设置温度时采用了较高的温度组合，从本试验结果来看，在 34℃下大斑芫菁幼虫的发育速率最快。温度 34℃，土壤含水量 10%的组合是最适宜大斑芫菁幼虫生长的。胡周强、张含藻[8]认为在 26℃的恒温下，17%的土壤含水量是大斑芫菁幼虫生长的适宜土壤含水量。认为产生这种差异的原因有以下二点：一是在胡周强的试验中恒定了温度，所以无法比较不同温度对大斑芫菁发育的影响。二是武汉与南川（胡周强的试验地）的气候差异造成了两地的大斑芫菁在长期适应各自环境后所产生的地域差异。

**3.3** 结合本试验结果和人工饲养的经验，人工大量饲养大斑芫菁应注意以下几个问题：①要保持人工饲养箱空间宽敞，通风透气。②野外采回的食物应挂在饲养箱上部，以利于大斑芫菁的取食。③在芫菁成虫交

配期应在饲养箱底部放置沙盘，并注意保持一定湿度，为成虫产卵做好准备。④幼虫宜取出单个饲养，并注意保持温度和土壤含水量。除了温度和土壤含水量外，光照、食物等环境条件也是影响大斑芫菁生长发育的重要因子，在研究大斑芫菁的生长发育和人工饲养时，必须对上述因素综合加以考虑。

## 参考文献


[1] Zhang Z Y(张志勇), Yuan F(袁峰). A review on the research of cantharidin resource and its utilization. *Acta Agriculture Boreali-occidentalis Sinica*(in Chinese)(西北农业学报), 1996, **5**(4): 89～92.

[2] Xia G C(夏光成). Application of Meloidae resource. *Chinese Traditional and Herbal Drugs News*(in Chinese)(中草药通讯), 1978, **12**: 30～32.

[3] Dauben W G, Kessel C R and Takemura K H. Simple efficient total synthesis of cantharidin via a high-pressure Diels-Alder reaction. *J. Am. Chem. Soc.*, 1980, **102**: 6893～6894.

[4] Yang S J(杨素娟). Research progress of cantharidin an its clinical application. *Chinese Traditional and Herbal Drugs Information*(in Chinese)(中草药信息), 1992, **1**: 33～35.

[5] Wang G S(王广生). Antitumor effect and development of cantharidin. *Chinese Pharmaceutical Bulletin*(in Chinese)(药学通报), 1980, **15**(3): 23～27.

[6] Zhang H Z(张含藻), Hu Z Q(胡周强). Priliminary study of population dynamics of *Mylabris phalerata*. *Chinese Pharmaceutical Bulletin*(in Chinese)(中药通报), 1988, **23**(2): 11～19.

[7] Zhang H Z(张含藻), Hu Z Q(胡周强). Biological characteristic of Mylabris. *Journal of Chinese Medical Materials* (in Chinese)(中药材), 1988, **11**(3): 15～19.

[8] Hu Z Q(胡周强), Zhang H Z(张含藻), Wei B(韦波). Relation between the growth of *Mylabris phalerata* larvae and the moisture of soil. *Journal of Chinese Medical Materials* (in Chinese)(中药材), 1993, **16**(2):9～12.

[9] Hu Z Q(胡周强), Zhang H Z(张含藻). Relationship between *Mylabris phalerata* larvae and feeding capacity. *Journal of Chinese Medical Materials* (in Chinese)(中药材), 1994, **17**(5): 9～11.

[10] Zhu H F(朱弘复), Wang L Y(王林瑶). On the life-history of the legume blister beetle, *Epicauta gorhami* Marseul, with a discussion on hypermetamorphosis. *Acta Entomologica Sinica* (in Chinese)(昆虫学报), 1956, **6**(1): 61～73.

[11] Ding Y Q(丁岩钦). *Insect mathematical ecology*(in Chinese). Beijing: Science Press, 1994, 82～110.