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Biological Studies on Microplitis plutellae (Hymenoptera: Braconidae), a Larval Parasitoid of Diamondback Moth, Plutella xylostella (Lepidoptera: Plutellidae)【Research report】

小菜蛾 (Plutella xylostella) 幼蟲之小菜蛾側溝繭蜂生物學研究【研究報告】

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Abstract

Laboratory studies were conducted to elucidate biological features of Microplitis plutellae (Muesebeck), a larval parasitoid of diamondback moth, Plutella xylostella (L.). M. plutellae was introduced from the United States to Taiwan in 1955 to assist the local braconid, including Cotesia plutellae to control Plutella xylostella. Normally M. plutellae is a solitary parasitoid laying one egg per host larva; however, at times, more than one egg were found in the same host. Although early instar larvae were present in the host larval hemocoel, only one parasitoid survived to come out of host larva for pupation, killing the larva in the process. M. plutellae had three larval instars, each with unique morphological characteristics. The larval period was 7-10 days at 25 – 30oC. Mature larva exited the host body and spun a spindle-shaped brown cocoon from which an adult emerged after 5-6 days of the pupation period. Majority of the adults emerged during 0300 – 0900 hours. Oviposition largely took place during the daylight hours. Adult longevity increased up to 16 days when provided with food, honey solution; however, it lasted less than 2 days in the absence of food. The total developmental time from egg to adult was 16-18 days at 25-30°C.

摘要

本實驗探討寄生小菜蛾 (Plutella xylostella) 幼蟲之小菜蛾側溝繭蜂(Microplitis plutellae) 之寄生現象。小菜蛾側溝繭蜂於1995年從美國引進台灣，期望藉以補強台灣現有的寄生蜂 - 小菜蛾小繭蜂 (Cotesia Plutellae)，以增進生物防治小菜蛾之效果。小菜蛾側溝繭蜂是單一擬寄生者，於每一寄主上產下一粒卵，但也曾發現產下數粒卵者；當多隻早齡幼蟲同時出現於寄主幼蟲的血腔中時，只有一隻擬寄生者能成功地脫離寄主發育成蛹，過程中會殺死其他寄生幼蟲。小菜蛾側溝繭蜂幼蟲分三齡，每一齡期有其形態特徵，在25-30℃下，幼蟲期7-10日。成熟的幼蟲離開寄主並結棕色的繭，經過5-6日蛹期後，羽化成蟲。大多數的成蟲在早上三時至九時羽化，其產卵時間主要在白天。給予食物蜜水使成蟲壽命可達十六日，若缺乏食物，則只能維持少於二日。在25-30℃下，從卵至成蟲的發育期需16-18日。

Key words: biological studies, parasitoid, Plutella xylostella, Microplitis plutellae
關鍵詞: 生物學研究、擬寄生者、小菜蛾、小菜蛾側溝繭蜂

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Biological Studies on *Microplitis plutellae* (Hymenoptera: Braconidae), a Larval Parasitoid of Diamondback Moth, *Plutella xylostella* (Lepidoptera: Plutellidae)

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ABSTRACT

Laboratory studies were conducted to elucidate biological features of *Microplitis plutellae* (Muesebeck), a larval parasitoid of diamondback moth, *Plutella xylostella* (L.). *M. plutellae* was introduced from the United States to Taiwan in 1955 to assist the local braconid, including *Cotesia plutellae* to control *Plutella xylostella*. Normally *M. plutellae* is a solitary parasitoid laying one egg per host larva; however, at times, more than one egg were found in the same host. Although early instar larvae were present in the host larval hemocoel, only one parasitoid survived to come out of host larva for pupation, killing the larva in the process. *M. plutellae* had three larval instars, each with unique morphological characteristics. The larval period was 7-10 days at 25 – 30ºC. Mature larva exited the host body and spun a spindle-shaped brown cocoon from which an adult emerged after 5-6 days of the pupation period. Majority of the adults emerged during 0300 – 0900 hours. Oviposition largely took place during the daylight hours. Adult longevity increased up to 16 days when provided with food, honey solution; however, it lasted less than 2 days in the absence of food. The total developmental time from egg to adult was 16-18 days at 25-30°C.

Key words: biological studies, parasitoid, *Plutella xylostella, Microplitis plutellae*

Introduction

The diamondback moth, *Plutella xylostella* (L.) (Lepidoptera: Plutellidae), is an oligophagous insect and has been reported to feed mainly on plants belonging to the family Cruciferae; particularly in the genus Brassica (Hartcourt, 1986; Salinas, 1986), which contains sinigrin, a mustard oil glucoside

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(Feeny, 1975, 1976). It is considered the most destructive pest of crucifers throughout the world outside the European continent (Talekar and Shelton, 1993). Larvae of this pest feed on foliage, reducing its quantity and quality. In Europe, where the insect was known to originate, large numbers of natural enemies, particularly parasitoids, keep the pest population below a level where they can cause damage (Mustata, 1992). Some of these parasitoids have been introduced outside the Europe to combat this pest (Talekar and Shelton, 1993). In most of these cases, successful control of the pest has been achieved only in cool highland areas, where climate resembles temperate conditions in Europe. The diamondback moth, however, remains a serious pest in lowland and midlevel highlands where large portions of the crucifers are cultivated in the tropics. Locally established braconid, *Cotesia plutellae* (Kurdjumov), has not been as effective as *Diadegma semiclausum* (Hellen) was in the highlands (Talekar *et al*., 1992). Efforts are being made in various institutions in Taiwan and elsewhere to aid in the control of DBM (Lim, 1986; AVDRC, 1997). *Microplitis plutellae* (Muesebeck) (Hymenoptera: Braconidae) is one of the larval parasitoids that have been fortuitously introduced and commonly recovered from many areas in Canada and United States (Putnam, 1978; Anciso, 1990). This braconid was introduced from the United States to Taiwan's cool highland area in 1995 to combat the diamondback moth (AVRDC, 1998). We reported here the results of our studies on the biology of *M. plutellae* reared on the diamondback moth.

Materials and methods

Insect rearing

Diamondback moth larvae, on which the parasitoid was raised, were reared on 6-8-week old common cabbage plants. Second instar larvae of the diamondback moth were exposed for oviposition by *M. plutellae* adults and biological attributes of the various growth stages of the parasitoid were studied.

Morphology and life cycle study

The length and width of *M. plutellae* eggs, larvae, cocoon, prepupae, pupae and adults were measured. Measurements of eggs were made at 12 and 24 hours after the oviposition. Dimensions of parasitoid larvae within the host larvae were measured daily from 1 to 10 days after the oviposition; this covered the entire larval period. Simultaneously, the length and width of the cocoon, prepupae, pupae and adults were measured. Whenever the adults emerged, body length from the front end of the head to the distal end of the last abdominal segment was recorded. Width was measured as the maximum distance between two stretched fore-wings. Measurements were taken from 30 insects from egg to adult stages, except the larval instars; for which, 15 larvae from each instar were measured. While studying the morphology of various developmental stages, we also recorded the duration of each stage at room temperature (25-30°C) and occasionally at constant temperature of 25°C.

Periodicity of oviposition

The number of eggs laid by *M. plutellae* females at different hours during the day was observed by exposing a group of 20 2nd instar diamondback moth larvae to 3 pairs of mated *M. plutellae* adults in a clear acrylic cylinder (30cm in length, 15cm in diameter) at an hourly interval during 0600 to 1800 hour. Each group of the diamondback moth larvae was exposed to the parasitoids for 1 hour and then removed for rearing up to pupation. The numbers of *P. xylostella* and *M. plutellae* pupae developed were recorded separately for each group and data were analyzed by ANOVA followed by Duncan's multiple range test.

In a separate experiment, the number of eggs laid by individual *M. plutellae* female during the photophase (0600–1800 hour) was determined by exposing 100 2nd instar larvae of the diamondback moth to one mated parasitoid female in an acrylic cylinder. The parasitoid female was allowed to oviposit in the host larvae for 12 hours and then discarded. Immediately after the oviposition, the diamondback moth larvae were dissected and examined microscopically for the presence of parasitoid eggs. This experiment was conducted twice at room temperature (25 – 30°C) and each test was replicated four times. The number of eggs laid by each *M. plutellae* female was calculated separately at the end of the dissection.

A similar experiment was also conducted at night (1800-0600 hour) in the absence of light. However, the number of the diamondback moth larvae exposed to one mated parasitoid female was reduced to 20 and the cylinder holding the insects was covered with a piece of black cloth to prevent any influence of light.

Periodicity of adult emergence and sex ratio

This test was conducted in the laboratory at room temperature 25°C – 30°C. A total of 200 newly developed *M. plutellae* pupae were used. They were divided into 4 groups of 50 pupae and placed in 4 separate Petri dishes. Each Petri dish was treated as one replicate. Beginning at 3 hours after the start of the test, observation was made at 3-hour intervals to determine the time of emergence, rate of adult emergence, and sex ratio of the emerged adults. At every observation, the emerged adults were collected and observed under the microscope to determine their sexes, then released into the rearing cage. Sexing of the adults was based on physical characteristics, showing females with long ovipositors at the end of the abdomens and males with blunt abdomens. The observation continued for 21 days until no more adults emerged. The percentage of pupae that emerged into adults at different time intervals was calculated. Data were analyzed by Student's t test.

Effect of food on adult longevity

This experiment was conducted in the laboratory at two different temperatures. The first test was done at 25±1°C, and the second was at room temperature varying between 25 to 30°C. There were two treatments, "with food" and "without food", in each test. A total of 20 pairs of *M. plutellae* were used in each treatment, and each adult was observed until it died. In the first test two clear acrylic cylinders were used, each holding 20 pairs of adults. The parasitoid adults with food were supplied with 10% honey solution as food source, which was replaced once every other day, and those in "without food" were deprived of any food, throughout the test. A fresh excised cabbage leaf was placed in each cylinder. The leaf was also replaced once every other day. The parasitoid adults were observed daily for mortality. The dead parasitoid adults were observed under the microscope to determine their sexes. Daily observations continued until all adults died. The second test was done using exactly the same method as was Test 1, except that the parasitoid adults were kept at room temperature. The data were analyzed by Student's t test to compare the longevity of adults between the treatments as well as between the two temperatures tested.

Results

Morphology and life cycle: Egg stage

The hymenopteriform egg of *M.*

表一　小菜蛾側溝繭蜂在室溫下各生長期的體型大小（平均值±SD)

Table 1. Some physical measurements (Mean±SD) of various life stages of *Microplitis plutellae* at room temperature (25-30℃)

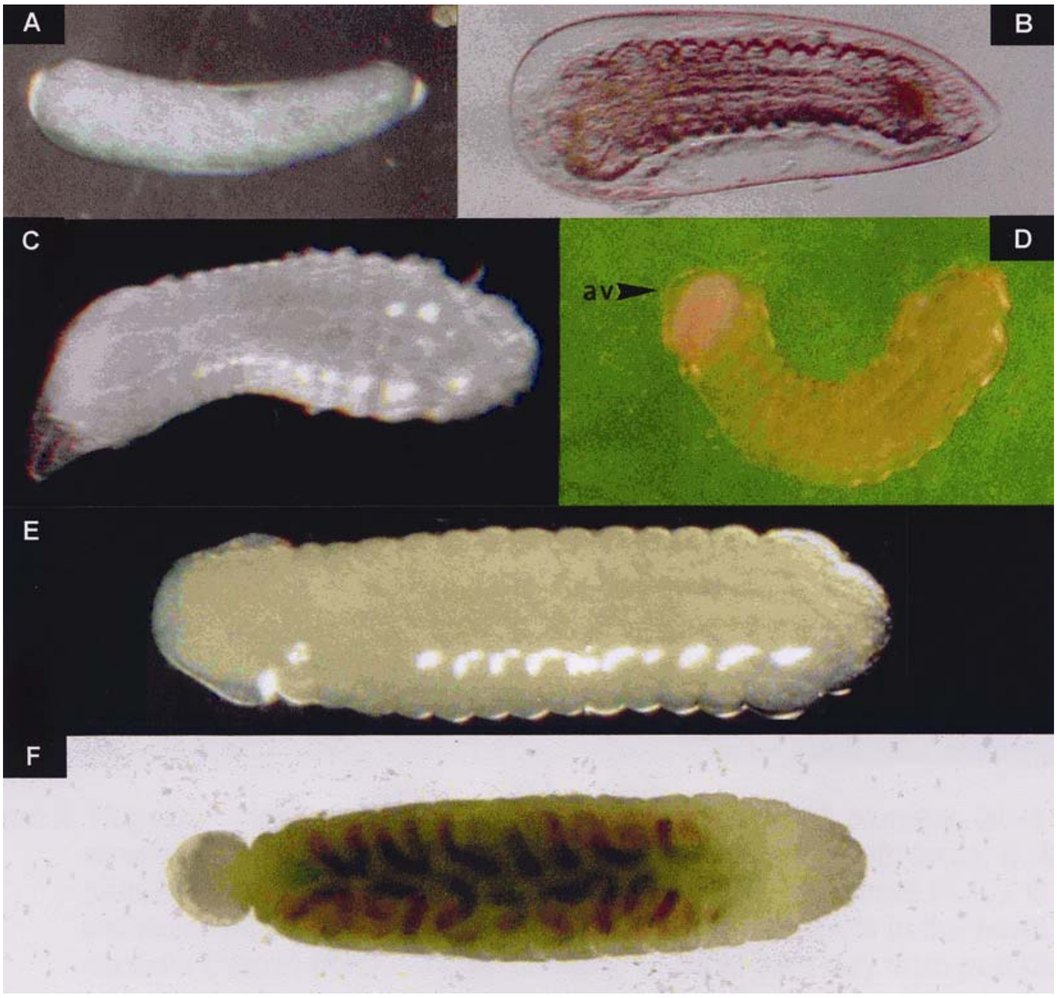
Period after Oviposition	Stage	Numbers observed	Length (mm)	Width (mm)	Head Width (mm)	Anal vesicle (mm)
12 hours	Egg	30	0.47±0.08	0.09±0.02		
1 day	Egg	30	0.50±0.04	0.14±0.02		
2 – 3 days	1st instar larva	15	0.52±0.06	0.12±0.01	0.07±0.01	0.06±0.01
4 – 6 days	2nd instar larva	15	1.99±0.55	0.42±0.14	0.28±0.08	0.36±0.10
7 – 10 days	3rd instar larva	15	3.67±0.30	0.83±0.05	0.39±0.07	0.54±0.06
10 – 12 days	Cocoon	30	3.18±0.14	1.20±0.07		
11 – 12 days	Prepupa	30	3.14±0.21	0.80±0.06		
12 – 16 days	Pupa	30	2.35±0.25	0.60±0.21		
16 – 18 days	Adult emergence					
	- male	30	2.36±0.17	4.80±0.59		
	- female	30	2.54±0.17	4.80±0.48		

plutellae was transparent and cylindrical, measured 0.47 ± 0.08mm in length, with rounded ends (Fig. 1A). One end of the egg was broader (0.08 ± 0.02mm) than the other (0.06 ± 0.01mm) at 12 hours after the oviposition. The size of the egg increased to 0.50 ± 0.04mm long and 0.14 ± 0.02mm wide just before hatching. These measurements were consistent with the report that the egg doubled in size just before hatching (Bolter and Laing, 1983). At temperatures ranging from 25 to 30ºC, the incubation period of an egg lasted 29 to 40 hours with a mean of 32 hours (Table 1). The egg with transparent and thin chorion, was normally found free floating in the hemocoeal of the host larva. The developing embryo or larva within the egg was usually visible through transparent chorion (Fig. 1B). More than one egg could be found in a single host larva if the latter was exposed to the parasitoid for a longer period or to a large number of parasitoid females. In our study when the exposure to the parasitoid females was only for 1 hour, only one egg could be found per host larva. During the hatching, the 1st instar larva usually emerged at the side of the egg towards the broader end.

Larval stage

The 1st instar larva was transparent in caudate mandibulate form (Fig. 1C). It was found in the posterior part of the host's hemocoel, and did not attach to the host tissue. It had distinct mandible and anal vesicle, which increased in size with successive instars (Fig. 1D). Twelve body segments were clearly evident. First instar larva measured 0.52 ± 0.06mm by 0.12 ± 0.01mm and lasted for 1.53 ± 0.050 days at 25-30ºC. In this instar, the sclerotized head was bigger than anal vesicle. Occasionally, more than one 1st instar larva were found within a host, but only one continued to develop further to final instar; the remaining developed to 2nd instar before dying.

The 2nd instar larva was opaque and very different in morphology from the 1st instar. The sclerotized head was no longer distinctive, and smaller than the anal vesicle, which had increased in size.



圖一　*Microplitis plutellae* 的卵及幼蟲期。A. *M. plutellae* 的卵在小菜蛾(X900)第二齡幼蟲裡的情形；B. 一天後 *M. plutellae* 的卵(X900)；C. 孵化後的第一齡幼蟲(X900)；D. 孵化後幾個小時內的第一齡幼蟲；E.第二齡幼蟲身軀結實且不透光(X630)；F.孵化後第八天的第三齡幼蟲，其帶有顯著紅棕色長條體，像在身上著色一樣(X250)。

Fig. 1. Egg and larval stages of *Microplitis plutellae*. A. *M. plutellae* egg inside the second instar larva of diamondbck moth (X900), B. one-day-old *M. plutellae* egg (X900), C. first instar larva soon after hatching (X900), D. first instar larva a few hours after hatching (av = anal vesicle), E. second instar larva with robust opaque body (X630), and F. third instar larva at eighth day after oviposition with conspicuous reddish brown spindle like coloration on the body (X250).

The larva had a well-segmented body with 13 clearly visible segments. The larval body gradually became opaque due to the deposition of fatty tissues, increasing ramification and greater development of the tracheal system. From 4 to 8 days after the oviposition, the 2nd instar larva developed rapidly and almost tripled its initial size to 1.99 ± 0.55mm in length and 0.42 ± 0.14mm in width (Fig. 1E).

The 3rd instar larva was much

different from the previous two instars, especially in body size. In general, the body was broader than the head and anal vesicle. Early 3rd instar larva had a greenish tinge, possibly due to the accumulation of chlorophyll materials from ingested food in the diamondback moth. From 8 to 10 days after the oviposition, the 3rd instar larva formed conspicuous brown-reddish spindle-shaped patterns on its body (Fig. 1F). The body segments were distinct and the body itself was slightly curved. At this stage, the spiracles were also distinctly visible. Just before *M. plutellae* larva exited the host for pupation, a few silken threads could also be seen on the body of the larva. The larva measured 3.67 ± 0.30mm by 0.83 ± 0.05mm. The 3rd instar larva of *M. plutellae* usually emerged from the lateral side of the 3rd instar larva of the host at approximately 7th and 8th segments (Fig. 2A). Putnam (1978) made a similar observation in Canada. The parasitoid larva squeezed through the hole in the host larva by peristaltic movement and took 45-60 minutes to emerge fully.

Pupal stage: Cocoon

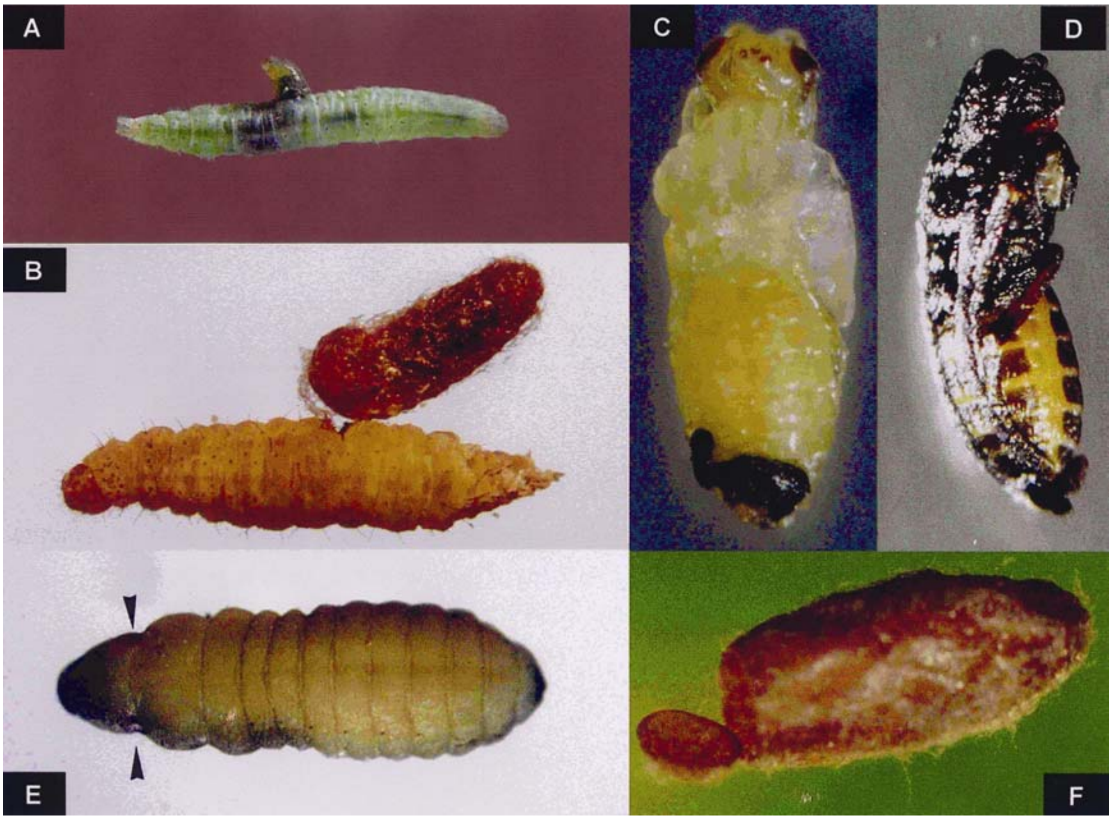
The parasitoid cocoon was spun from the silky thread released from the oral cavity of a mature larva. The parasitoid larva, soon after coming out of the host, started constructing a loose lacy and one-sided crescent-shaped cocoon and moved its posterior end into it first. Similar to *C. plutellae* (Lim, 1982), the cocoon was shaped by rippling motions of the body, with parasitoid often reversing its position within the cocoon. After the body was firmly fitted in the cocoon, the larva began closing the open side of the case. Generally, spinning movements were up and down at first, followed by cross spinning to enforce the sides. After 3-4 hours, parasitoid larva was barely visible through the pupal case. It, however, continued to construct the cocoon. The newly-spun cocoon was spindle-shaped light brown (Fig. 2B), which became harder and darker brown with the passage of time. On an average the cocoon measured 3.18 ± 0.14mm by 1.2 ± 0.07mm. In the field the cocoon was usually found under the leaf surface where the last instar host larva fed. In laboratory rearing, the cocoon could be found anywhere including the upper leaf surface, walls of rearing cage, pots used for growing host plant or bedding material inside the cage. The cocoons attached firmly to all surfaces with the use of silken thread, making it difficult to dislodge.

Pre-pupa

The pre-pupa inside the cocoon lasted for about 2 days. It had discernible head, thorax and abdomen. The segmentation on the abdomen was more distinct than in the 3rd instar larva (Fig. 2C). Antennae, appendages, or wing pads were not present, but two reddish brown and oval-shaped eyespots were dorso-laterally present on the head. The pre-pupa was bright yellow and measured 3.16 ± 0.21 mm by 0.80 ± 0.06 mm.

Pupa

At the end of third day after the pupation, the pupa had a distinct head, thorax, and abdomen. The eyes turned dark brown and the head had three reddish brown ocelli (Fig. 2D). A pair of antennae was folded ventrally towards the posterior end. Legs and wing pads were light yellow. The excretory material was pushed down to the posterior end of the pupa. On the fourth day after the pupation, the head, thorax, dorsal and ventral surfaces of the abdomen, femur, eyes, and ocelli changed to black, while the antennae still remained yellow though slightly darker. By the end of the 4th day after the pupation, the antennae turned black, while legs, except for some yellow portions, were generally brownish



圖二 *Microplitis plutellae* 化蛹之特色。A. *Microplitis plutellae* 從第四齡小菜蛾幼蟲側邊出現；B. *M. plutellae* 幼蟲靠近已受傷的寄主結繭(X70)；C.前蛹期在頭部(箭頭處)有棕紅色橢圓形眼睛(X200)；D. *M. plutellae* 進入蛹期第三天可見明顯的頭部、胸部及腹部；E.進入蛹期第五天後發展成完全的蛹；F.繭的另一端開啟 *M. plutellae* 成蟲脫殼而出。

Fig. 2. Pupation characteristics of *Microplitis plutellae*. A. *M. plutellae* larva emerging from the side of fourth instar diamondback moth larva, B. *M. plutellae* larva forming cocoon near the wounded host larva (X70), C. pre-pupa with two reddish brown, oval shaped eye spots in the head capsule (arrow) (X200), D. *M. plutellae* pupa at third day from pupation with distinct head, thorax, and abdomen, E. fully developed pupa at fifth day from pupation, and F. cocoon with an open end through which *M. plutellae* adults emerged.

black. On the 5^{th} day from the initiation of pupation, the pupa reached its full development. The wings were fully developed and free, with most other adult features clearly visible (Fig. 2E). The pupa at this stage measured 2.35 ± 0.25 mm by 0.60 ± 0.21mm.

The adult emerged from the cocoon through one of the two pointed ends where a uniformly round cap was cut (Fig. 2E). The cap always remained hinged to the cocoon after the adult emergence.

Adult

The adults began emerging on the fifth day after the pupation. The adult was black and had a pair of light brown mandibles, yellow palpi, black antennae with 17 segments, and hyaline wings

表二　小菜蛾側溝繭蜂在日照十二小時下寄生於小菜蛾幼蟲的生殖力*

Table 2. Fecundity of *M. plutellae* when exposed to DBM larvae for 12 hours during the photoperiod*

Test	No. of DBM larvae used	Egg laid per female	Parasitism (%)
1	100	41.00±8.06	39.50±7.50
2	100	41.00±8.06	40.25±7.56

* 資料是四重複的平均值。Data are means of 4 replicates.

表三　小菜蛾側溝繭蜂在無光照十二小時下寄生於小菜蛾幼蟲的生殖力*

Table 3. Fecundity of *M. plutellae* when exposed to DBM larvae for 12 hours during the night in the absence of light*

Test	No. of DBM larvae used	Egg laid per female	Parasitism (%)
1	20	0.25±0.43	1.25±2.17
2	20	1.00±0.71	5.00±3.54

* 資料是四重複的平均值。Data are means of 4 replicates.

with blackish pterostigma and fuscuous veins. Most morphological characters were similar to those observed by Muesebeck (1922). The male and female adults can be differentiated by the presence of ovipositor at the posterior end of the body. Female adults were slightly bigger than the male (Table 1). The male adult measured 2.36 ± 0.17mm in body length and 4.80 ± 0.59mm in the wing span of forewings. The body length and forewing span of the female adults were 2.54 ± 0.18mm and 4.80 ± 0.48mm, respectively.

Periodicity of oviposition

M. plutellae female laid eggs mainly during the day, depositing about 41 eggs during the day as compared to just 1 egg laid at night. The parasitism rate was 39 to 40% in the photophase (Table 2) and only about 1 to 5% during the scotophase (Table 3). There was no significant difference in the number of eggs laid at different hours during the day. The average number of eggs laid during the day was 6.46 ± 3.48 eggs/hour. The number of eggs laid generally increased between the early morning hours and noon, then declined towards the evening. The highest number of eggs was laid between 1300 to 1500 hours.

Periodicity of adult emergence and sex ratio

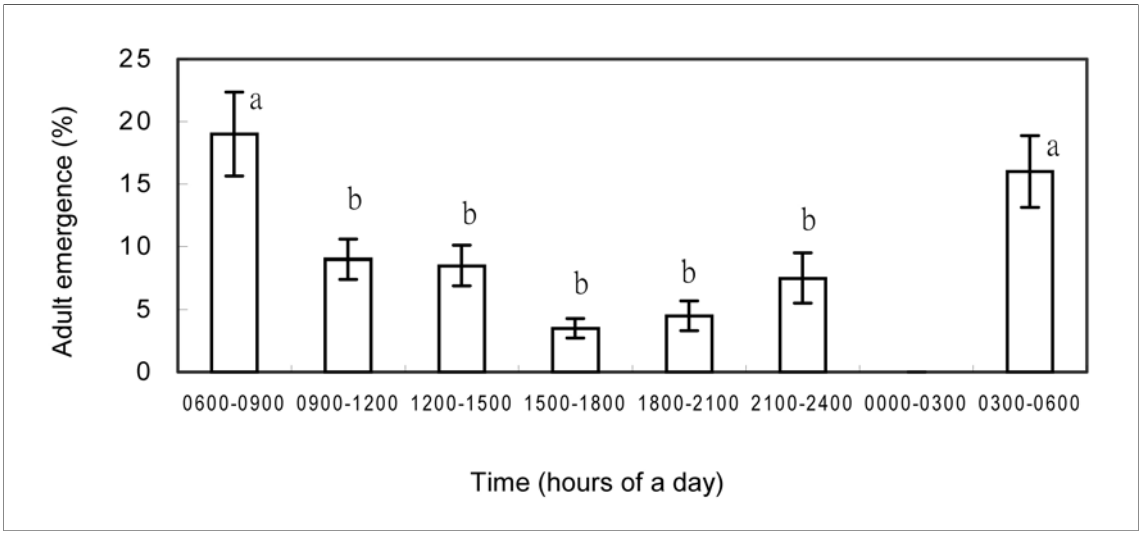
M. plutellae adults emerged from pupae steadily throughout the day, except between midnight and 0300 hours. Early morning hours of 0300 to 0900 were more favorable for adult emergence with almost 40% of the adults emerged during that period (Fig. 3). At fluctuating temperatures between 25 and 30°C, relatively more males were produced with a ratio of M:F = 2.5:1.

Effect of food on adult longevity

The longevity of *M. plutellae* adult was influenced by the availability of food. Adults without food source died within 0.9 to 1.75 days, whereas those provided with honey lived up to more than 15 days (Table 4). When the adults were held with or without honey solution, there was no significant difference in the longevity of male and female at either temperature regime.

Discussion

Since the introduction of *M. plutellae*



圖三　一天當中，*M. plutellae* 在不同時間從蛹羽化成成蟲的情形。

Fig. 3. Emergence pattern of *M. plutellae* adults from pupae at different times during a day. Bars with the same letter are not significantly different (P>0.05) according to Duncan's multiple range test.

表四　雄性與雌性小菜蛾側溝繭蜂成蟲在恆溫及變溫下給予或不給予食物的存活天數

Table 4. Longevity of male and female *Microplitis plutellae* when held with or without food at fixed and fluctuating room temperature

Sex	Rearing Temperature (ºC)	Longevity (days) (Mean ± SD) With food	Without food
Male	25	11.25±2.53	1.75±0.85
	25 – 30	14.00±4.77	0.90±0.55
Female	25	11.70±4.35	1.50±0.61
	25 – 30	15.75±6.11	1.25±0.72

資料爲二十隻昆蟲之平均值。Data are mean of 20 insects.

to combat the diamondback moth, no information on its life history and measurements of its different stages has been available. This study made a detail investigation of the different stages of *M. plutellae* to facilitate a better understanding of this parasitoid. Without the presence of identifiable exuvia and shed head capsule after each molt, it was difficult to determine the exact number of instars that *M. plutellae* larva has. Bolter and Laing (1983) reported that *M. plutellae* had four larval instars. However, we could not confirm this finding because both the exuviae and head capsule were quite unreliable indicators to judge the number of instars. At times the presence of more than one egg or larva made it more difficult to judge the exact number of exuviae. However, based on the physical appearance and body measurements, we concluded that *M. plutellae* has three larval instars. Hagen (1973) stressed that there may be varied in the number of larval instars within a genus. For *M. plutellae* our observations supports Punam's observation in 1978 that this braconid has three larval instars.

The number of eggs laid by *M. plutellae females* generally increased between the early morning hours and noon, and then declined towards the evening. The highest number of eggs was laid between 1300 to 1500 hours. This could be due to the influence of light and temperature on the activity of the parasitoids. Velasco (1982), in the study of the life history of *C. plutellae,* mentioned that photoperiod and temperature had a pronounced influence on the efficiency of *C. plutellae* as a parasitoid.

M. plutellae females were not active at night; hence, they hardly laid eggs during evening hours, making the parasitoid not a nocturnal insect. The adults obviously needed light to aid in their search for hosts. The antennae, as a sense organ, may be useful to find the host in the absence of light; however, they were not adequate to aid in the parasitism. Bolter and Laing (1983) mentioned that frass produced by feeding of host larvae also attracted parasitoid females, thus making it easier to locate the host for oviposition. However, we found that in addition to the claims made by Bolter and Laing (1983), *M. plutellae* females, provided with adequate light and suitable temperatures (25 – 30ºC), could have higher parasitism. Lim (1982) also stated that temperature was one of the most important parameters that influenced the ability of *C. plutellae* to persist and multiply in any location.

Light and possibly temperature at 30ºC during the day influenced the emergence of *M. plutellae* adults from pupae. This was evident from this study that most of the adults emerged during the day. Temperature at 30ºC also favored the emergence of more males than females. High temperatures have also been reported to favor production of males in another hymenopteran family, Ichneumonidae (Yang *et al.*, 1993).

This comparative study of the survivability of *M. plutellae* with or without honey as a food source showed that both male and female lived much longer with the honey solution. This finding was similar to that for *C. plutellae* reported by Lim in 1982. Temperature also influenced the longevity of the parasitoid, especially when fed. At temperatures ranging from 25º to 30ºC, both male and female adults lived significantly longer than at a fixed temperature of 25ºC. However, when not fed, the pattern of adult longevity was opposite, yet not very distinct. Because the adults did not survive beyond 1.75 days, a fair comparison between two temperature regimes was probably not possible.

Based on the temperature study, *M. plutellae* has demonstrated its ability to survive and perform well in a range of 25º to 30ºC, indicating that *M. plutellae* could better tolerate higher temperature than *C. plutellae*. Therefore, *M. plutellae* could be more suitable for use to control the diamondback moth in the warmer lowlands in Taiwan.

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小菜蛾 (*Plutella xylostella*) 幼蟲之小菜蛾側溝繭蜂生物學研究

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摘 要

本實驗探討寄生小菜蛾 (*Plutella xylostella*) 幼蟲之小菜蛾側溝繭蜂 (*Microplitis plutellae*) 之寄生現象。小菜蛾側溝繭蜂於 1995 年從美國引進台灣，期望藉以補強台灣現有的寄生蜂－小菜蛾小繭蜂 (*Cotesia Plutellae*)，以增進生物防治小菜蛾之效果。小菜蛾側溝繭蜂是單一擬寄生者，於每一寄主上產下一粒卵，但也曾發現產下數粒卵者；當多隻早齡幼蟲同時出現於寄主幼蟲的血腔中時，只有一隻擬寄生者能成功地脫離寄主發育成蛹，過程中會殺死其他寄生幼蟲。小菜蛾側溝繭蜂幼蟲分三齡，每一齡期有其形態特徵，在 25-30℃下，幼蟲期 7-10 日。成熟的幼蟲離開寄主並結棕色的繭，經過 5-6 日蛹期後，羽化成蟲。大多數的成蟲在早上三時至九時羽化，其產卵時間主要在白天。給予食物蜜水使成蟲壽命可達十六日，若缺乏食物，則只能維持少於二日。在 25-30℃下，從卵至成蟲的發育期需 16-18 日。

關鍵詞：生物學研究、擬寄生者、小菜蛾、小菜蛾側溝繭蜂