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【Research report】

甘薯螟蛾之交尾與性費洛蒙關係之研究【研究報告】

戴樂楷、胡文津、蘇富正、葉文彬、劉雅慧

*通訊作者E-mail :

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Abstract

摘要

甘藷螟蛾（Omphisa anastomasalis）為亞洲及太平洋地區甘薯之重要害蟲。本文乃研究甘薯螟蛾在室內及田間之交尾習性及對性費洛蒙之反應。甘薯螟蛾羽化時間主要在7:00 PM至12:00 PM，交尾高峰在1:30 PM至2:30 PM之間。1至5日齡處女蛾對雄蛾皆具誘引作用，其中以3至4日齡處女蛾之誘引數較多，而1至5日齡雄蛾皆可被誘引。誘蟲盒內處女數為2至6隻時，其誘引雄蛾數隨其數目之增加而增加。誘蟲盒內放兩隻處女蛾在距離20公尺內之標識雄蛾回收率為25 %，而有少數標識雄蛾在30至40公尺處仍可被誘引。七種不同螟蛾科之性費洛蒙對甘薯螟蛾並無誘引效果。甘薯螟蛾之產卵前期為30.3±10.4小時，而產卵期則為4至8日，且雌蛾平均一隻可產211±82粒卵。

Key words:
關鍵詞: 甘薯螟、交尾、性費洛蒙、產卵。

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Mating and Sex Pheromone Related Studies with Sweetpotato Vine Borer (Lepidoptera: Pyralidae)

Narayan S. Talekar, Wen-Jin Hu, Fu-Cheng Su, Wen-Bin Yeh and Ya-Hwei Lyou
Asian Vegetable Research and Development Center, P. O. Box 42, Shanhua, Tainan 741, Taiwan, R.O.C.

ABSTRACT

Laboratory and field studies were conducted to study the mating and presence of typical lepidopteran sex pheromone in sweetpotato vine borer (SPVB), *Omphisa anastomasalis* (Guenee), a pest of sweet potato in Asia and the Pacific. SPVB adults emerged from the pupae mainly between 7 PM and midnight. Mating peaked between 1:30 AM and 2:30 AM. One- to 5-day old virgin females attracted males but 3- to 4-day olds attracted more males than others. One- to 5-day old males were receptive to mating. Traps baited with virgin females attracted males and within a range of 2 to 6, the more the females per trap, the more males attracted. Traps baited with two virgin females attracted 25% of the intentionally released males from up to 20 m from the trap; lesser insects were attracted from 30 and 40 m. Sex pheromones of seven other pyralids were not active against SPVB. Preoviposition period lasted 30.3±10.4 hours and during the oviposition period of 4 to 8 days, the insect, on the average, laid 211±82 eggs.

Key words: *Omphisa anastomasalis*, mating, sex pheromone, oviposition.

甘薯螟蛾之交尾與性費洛蒙關係之研究

戴樂楷、胡文津、蘇富正、葉文彬、劉雅慧 亞洲蔬菜研究發展中心 善化郵政 42 號信箱

摘　要

甘薯螟蛾(*Omphisa anastomasalis*)為亞洲及太平洋地區甘薯之重要害蟲。本文乃研究甘薯螟蛾在室內及田間之交尾習性及對性費洛蒙之反應。甘薯螟蛾羽化時間主要在 7:00 PM 至 12:00 PM，交尾高峰在 1:30 PM 至 2:30 PM 之間。1 至 5 日齡處女蛾對雄蛾皆具誘引作用，其中以 3 至 4 日齡處女蛾之誘引數較多，而 1 至 5 日齡雄蛾皆可被誘引。誘蟲盒內處女蛾數為 2 至 6 隻時，其誘引雄蛾數隨其數目之增加而增加。誘蟲盒內放兩隻處女蛾在距離 20 公尺內之標識雄蛾回收率為 25%，而有少數標識雄蛾在 30 至 40 公尺處仍可被誘引。七種不同螟蛾科之性費洛蒙對甘薯螟蛾並無誘引效果。甘薯螟蛾之產卵前期為 30.3±10.4 小時，而產卵期則為 4 至 8 日，且雌蛾平均一隻可產 211 ±82 粒卵。

關鍵詞：甘薯螟蛾、交尾、性費洛蒙、產卵。

Introduction

Sweetpotato vine borer (SPVB), *Omphisa anastomasalis* (Guenee) (Lepidoptera: Pyralidae) is one of the most destructive pests of sweet potato, *Ipomoea batatas* Lam., in tropical to subtropical Asia and the Pacific (Talekar and Pollard, 1991). It is widespread in India, Sri Lanka, Malaysia, Indonesia, Taiwan and Hawaii (Zimmerman, 1958). In Taiwan, this insect is considered a serious pest, second in importance only to the sweetpotato weevil, *Cylas formicarius* (F.) (Hung and Lin, 1960). SPVB lays eggs on leaves and petioles and soon after hatching, larvae bore into the stems and gradually eat their way down the vines into the crown. Vines with severe tunnelling show weak growth and poor foliage development, later yellow and wilt (Chu, 1984). Such plants show poor root formation. In Malaysia, SPVB reduces sweet potato yields by about 30% (Ho, 1970); in Taiwan it ranges from 11 to 65% (Chu, 1984). On Penghu Island in Taiwan Straits, the yield loss approaches 50% (Talekar and Cheng, 1987).

Because of its concealed feeding habit, it is difficult to control SPVB without frequent insecticide applications which is not economical and sustainable. To control this pest economically, research at the Asian Vegetable Research and Development Center (AVRDC) in southern Taiwan emphasizes breeding of SPVB-resistant sweet potato cultivars. However, screening of AVRDC's entire sweet potato germplasm, consisting of over 1100 accessions has resulted in identification of only two accessions with moderate level of resistance (Talekar and Cheng, 1987). To help control the pest, research on supplementary control measures, especially sex pheromone, was initiated. Since sex pheromones have been developed for several other pyaralids, it was thought that a similar chemical might be present in SPVB. We, therefore, conducted a series of biological studies to detect the presence of sex pheromone activity before venturing into actual extraction and identification of the chemical.

Materials and Methods

Insect rearing

SPVB larvae were collected from sweet potato fields. The larvae were reared in the laboratory on sweet potato roots placed in a cage at 28±2°C. Pupae were collected by cutting roots open and were separated into males and females. Newly emerged unmated adults were used for the detection of sex pheromone and other related studies.

Morphology

A large number of SPVB pupae were observed to find distinguishing characters which could be used to separate males from females prior to their emergence into adults. Adult insects were also studied carefully to find out easily recognizable morphological characters of males and females.

Adult emergence periodicity

A large number of SPVB pupae were collected from laboratory rearing culture and separated into males and females. They were then placed individually in small plastic containers. Adult emergence was observed hourly during a 24-hour period and the number of adults emerging during each hour was recorded.

Mating periodicity

A large number of SPVB pupae were collected and placed individually in small plastic cups. Male and female pupae were maintained separately and when emerged, 1-day old adults were used for the mating periodicity study. One male and one female each was confined in an acrylic jar (15 cm diameter, 30 cm height), the top of which was covered with muslin cloth. A cotton plug dipped in sugar solution was placed inside the jar to serve as food source. Insects were observed once every 30 minutes during a 24-hour period and the number of them in copula was recorded. To facilitate observations during the dark, a dim red light lamp was used.

We also made observations on characteristics of calling behavior of SPVB female just before the mating.

Mating age study

This study was conducted for both female and male adults.

Females: Virgin females, ranging from 1 to 7 days old, were used in a field experiment. One female of each age group was placed in each of five sticky paper traps. The traps were placed 1 m above the soil surface in the field at 5 PM and the number of SPVB males captured in each trap was recorded the following morning. In the laboratory test, virgin females, ranging from 1 to 5 days old, were confined individually in acrylic jars (15 cm diameter, 30 cm height). One unmated 1- to 2-day old male was then introduced in each jar containing the female. The jars were covered with muslin cloth and a cotton plug dipped in sugar solution was placed inside to serve as food source. After 24 hours the females were dissected open to observe the presence of spermatophores to judge the mating.

Males: Every day for six consecutive days, we collected SPVB male adults from the laboratory colony. Each day's collection of moths was marked with different colors to identify their age. The insects were placed in a 30 cm × 30 cm × 30 cm cage and provided with sugar syrup as a food source. We placed a sticky paper trap baited with two virgin females 1 m above the soil surface in the center of a parcel of land. At 1:30 AM to 2:30 AM we released the males 4 to 5 m from the virgin female-baited trap. Next morning, we recorded the number of males of each age group caught in the trap. This experiment was repeated six times.

Pheromone "concentration" study

Several 1-day old virgin females were collected from routine laboratory culture. Two, four or six live females were placed

in sticky paper traps. These traps, along with one blank trap without any insect, were placed 1 m above soil surface in a sweet potato field late in the afternoon. The number of male moths captured in each trap was monitored the following morning. This experiment was done once each in 1988 and 1990.

Effective distance study

Sixty 2-day old unmated male adults were obtained from laboratory culture. They were divided into six batches of 10 insects each. The insects in each batch were marked lightly on the thorax with different colors. A trap baited with four live virgin females was erected 1 m above soil surface in the middle of an empty field. Small nylon net cages containing the marked males were placed 1, 5, 10, 20, 30 or 40 m from the trap in a straight line along the direction of the wind. At 1:30 AM to 2:30 AM the males were released from the cages. Next morning the number of marked males trapped in the virgin female-baited trap was recorded. This experiment was conducted twice, once each in 1987 and 1990.

Synthetic sex pheromone test

Sex pheromone chemicals of the following pyralids were bought from Sigma Chemical Company, St. Louis, USA: *Ostrinia nubilalis* (Hübner) (Kochansky *et al.*, 1975), *Chilo suppressalis* (Walker) (Nesbitt *et al.*, 1975), *Galleria mellonella* (L.) (Leyrer and Monroe, 1973), and one common to *Ephestia kuehniella* (Zeller) (Kuwahara *et al.*, 1971) , *Ephestia cautella* (Walker) (Brady *et al.*, 1971), *Ephestia elutella* (Hübner) (Brady and Nordlund, 1971), *Ephestia figulilella* (Gregson) (Brady and Caley, 1972) and *Plodia interpunctella* (Hübner) (Kuwahara *et al.*, 1971). The chemicals (100 μg) were individually dispensed on rubber septa. Sticky paper traps baited with sex pheromone of individual species were placed 1 m above soil surface in a sweet potato field. Traps baited with four 1-day old virgin females were also placed in the same field. Next morning the number of males captured in the traps was recorded. This experiment was conducted every day for one week.

A bioassay with these same chemicals was also conducted in the laboratory. For this bioassay, 2- to 5-day old unmated males were confined into 30-cm diameter 50-cm high acrylic cylinder. One open end of the cylinder was wrapped in muslin cloth and the other end was placed on a flat bench top. Each sex pheromone dispensed on individual rubber septum was inserted 2 cm inside the cylinder through a 2 cm $\times$ 2 cm hole made 3 cm above the bottom of the cylinder. A gentle stream of air was blown through the hole so that it will pass directly over the pheromone inside the cylinder. The number of males exhibiting movement of antennae, fluttering of wings or attempting to mate with the pheromone-baited septum was recorded. The whole experiment was conducted at 1:30 PM to 2:30 PM in a specialized darkroom where photoperiod was reversed to coincide natural daytime with darkness and vice versa.

Oviposition studies

In one study we placed one newly-emerged female in each of 14 acrylic jars (15 cm diameter, 30 cm height) lined with tissue paper on the inside. A cotton plug dipped in sugar solution served as a food source. We observed the insect containing jars once every 3 to 4 hours for the presence of eggs. As soon as eggs were laid the observations were discontinued.

In another study we placed one newly-emerged female and one similar aged male inside each of eight acrylic cylinders described above. A cotton plug dipped in sugar solution served as a food source. We recorded the number of eggs laid every day until insects stopped laying eggs.

Results and Discussion

Morphology

The distinguishing features of male and female pupae and adults are presented in Fig. 1. The male and female pupae of the SPVB can be distinguished easily by observing the ventral side of the 9th and 10th abdominal segment. In both sexes an anal opening notch is present on the 10th segments. In female pupa an additional prominent notch is present on the 9th segment. This notch is absent in males. Female adults have relatively broader abdomen compared to males. SPVB male adults have a pair of clasper like structure on the last abdominal segment which is absent in females. These easily recognizable characters were used in separating the pupae and adults for sex pheromone studies.

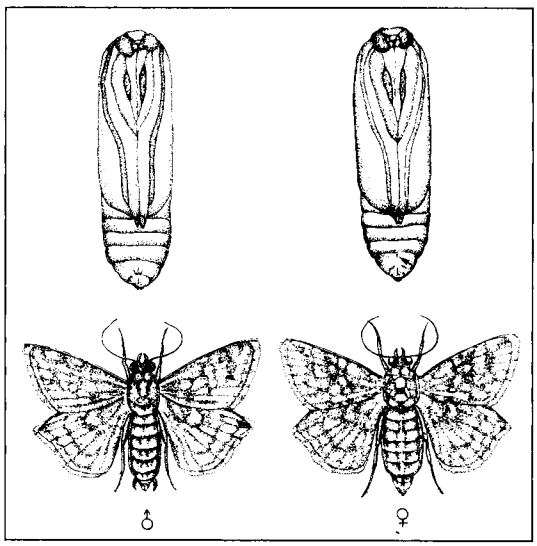

Fig. 1. External features of male and female pupae and adults of SPVB. Arrow shows the additional prominent notch on the 9th segment of female pupa.

Adult emergence periodicity

The results of the periodicity of emergence of SPVB adults over a seven-day period are summarized in Fig. 2. There were two peaks per 24-hour cycle; the major peak occurred one hour after sunset and the minor one 8 hours later. Most of the insects emerged between 7 PM and midnight; a small portion emerged between 4 AM and 6 AM. Emergence of males and females was synchronized.

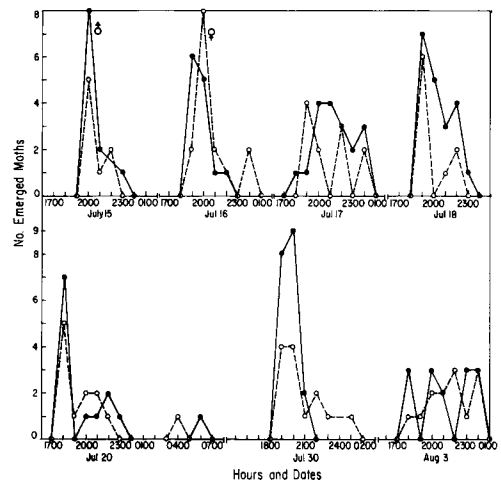

Fig. 2. Periodicity of emergence of SPVB adults.

Mating periodicity

During daytime the SPVB adult remained motionless. Adult activity began at the onset of darkness at 7 PM. The moth started to move its antennae backward and forward and took short flights around the insect rearing cage. The female initiated the calling behavior to attract the males about 3 hours after the onset of the darkness. The calling behavior observed is illustrated in Fig. 3. The tip of the abdomen was raised slightly during the night (Fig. 3A). A glandular section flexed from the tip of the abdomen and remained exposed for a period of time (Fig. 3B). The female then curved its abdominal tip with the flexed glandular section still exposed (Fig. 3C) and wiggled it right and left (Fig. 3D). We assume that this behavior is associated with release of sex pheromone.

The mating periodicity of SPVB adu-

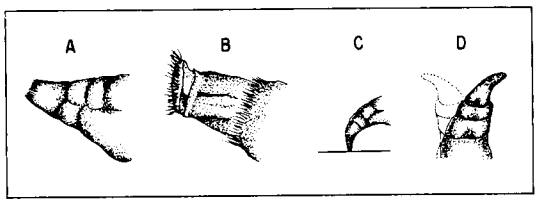

Fig. 3. Calling behavior of SPVB female. Please refer to the text for details.

lts is illustrated in Fig. 4. In the first experiment, the mating began 6.5 hours after initiation of darkness, with peak activity occurring 7 to 7.5 hours after the beginning of darkness. In the second experiment, mating started slightly earlier; 4 hours after the beginning of darkness, but it still peaked at about the same time as in the first experiment – 7 hours after the onset of darkness at 1:30 AM to 2:30 AM. It is possible that due to the larger number of insects used in the second test, the mating period was slightly widely distributed than in the first experiment. It can be concluded that the mating period of SPVB ranges between four to seven hours after initiation of darkness.

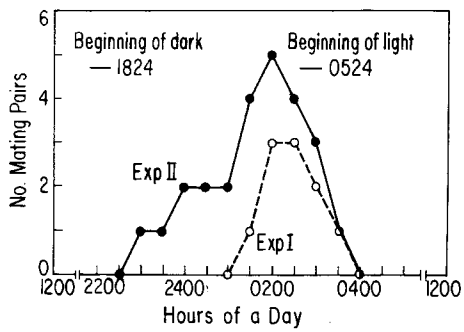

Fig. 4. Periodicity of SPVB mating.

Mating age study

The results of the study on the virgin female's age at which it attracts males for mating, presumably by the release of sex pheromone, are summarized in Fig. 5. One- to 5-day old males were attracted to the virgin female-baited traps. Six and 7-day old females failed to attract any males. These results, obtained from the field study, were also corroborated by observations in the laboratory where it was found that only 1- to 5-day old females mated successfully. In general, 3- to 4-day old females attracted more males. It is possible that 3- to 4-day old virgin females produce a maximum amount of sex pheromone. This age group is, therefore, ideal for extraction of pheromone to establish its identity or for comparing its effectiveness to synthetic pheromone.

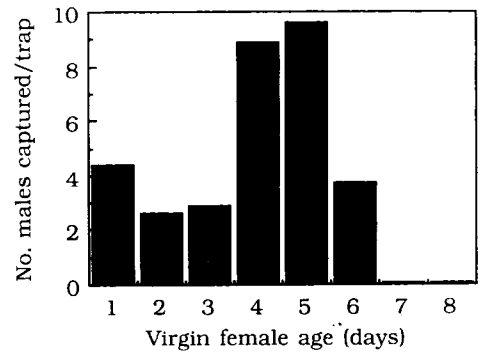

Fig. 5. Influence of SPVB virgin female age on the number of males trapped.

In general, males of 1 to 4 days old were receptive to sex pheromone emitted by virgin females (Fig. 6). Their response to sex pheromone declined steadily after four days. Like females, 1-day old (18-30 hours) males were mature enough to be attracted to sex pheromone. Therefore, 1- to 5-day old SPVB male adults can be used for bioassay of sex pheromone.

Pheromone "concentration" study

Traps baited with two virgin females attracted three males, one with four females also attracted three males but the one with six attracted nine SPVB males. Blank traps without anyVirgin female did not attract any males. Similar results were obtained in an earlier test conducted in 1988 where a trap baited with

four females attracted five males as against two males in a trap baited with only two females (AVRDC unpublished data). These results show that virgin females emit sex pheromone, and within the range of 2 to 6 the more the females per trap (which imply higher concentration of sex pheromone) the greater were the number of males attracted.

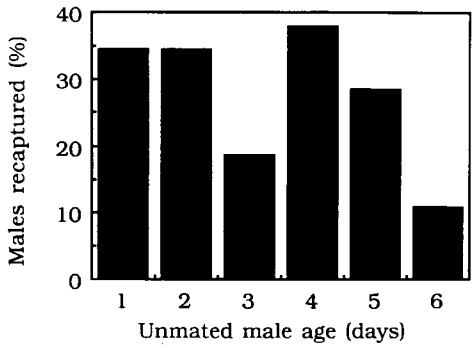

Fig. 6. Effects of unmated male age on the number of males trapped in virgin female-baited traps.

Effective distance study

Results of recapture of males released at distances of 2, 5, 10, 20, 30 and 40 m from virgin female-baited trap are summarized in Table 1. There was no difference between the number of insects recaptured from 1 to 20 m but the recapture declined sharply 30 and 40 m from the trap. These data further show the presence of sex pheromone in SPVB virgin female. Like a typical sex pheromone its effectiveness declines as the distance from pheromone source increases. This chemical(s) seems to be quite effective as it attracted a substantial number of released insects from up to 20 m from the trap.

Synthetic sex pheromone test

None of the traps baited with 100 μg sex pheromone or major component of the pheromone of *O. nubilalis, C. suppressalis, G. mellonella, E. kuehniella, E. cautella, E. elutella, E. figulilella* or *P. interpunctella* attracted any male SPVB adults when they could be trapped in virgin femalebaited traps. We realize that sex pheromones are specific to each insect species. However, certain pheromone components are common to more than one species. For example, cis-9, trans-12-tetradecenyl acetate acts as a pheromone of at least five pyralids: *E. kuehniella, E. cautella, E. elutella, E. figulilella* and *P. interpunctella* (Kuwahara *et al.*, 1971; Brady and Nordlund, 1971; Brady and Caley, 1972, Brady *et al.*, 1971). We hoped one of these synthetic pheromone could elicit some response in SPVB males which would have given us a headstart on developing synthetic sex pheromone for this insect. However, none of the chemicals tested elicited any response. The sex pheromone of SPVB is probably different than the sex pheromone of any of the above-listed pyralids.

Oviposition study

Preoviposition period for 14 females averaged 30.3±10.4 hours. The female started laying eggs soon after mating. The number of eggs laid per female among eight females ranged from 91 to 323 with an average of 211±82. Oviposition period ranged from 4 to 8 days.

Table 1. Recapture of marked SPVB males from various distances from virgin female-baited trap

	Distance from virgin female-baited trap (m)					
	1	5	10	20	30	40
No. males trapped	4	4	4	4	1	1
% recaptured	25	.25	25	25	6.3	6.3

There was no correlation between the longevity of the female and number of eggs laid. In general, a female with high fecundity, had tendency of depositing majority of the eggs within first three days of their oviposition period. No published information exists on the oviposition of SPVB elsewhere.

Acknowledgment

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