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Mating Behaviour of *Crocidolomia pavonana* F.

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Abstract—The sequence and duration of mating behaviour Crocidolomia pavonana were observed and investigated by using ethogram time budgets. This research was conducted in the dark hours from 18:00 pm to 06.00 am. The results showed that C. pavonana mating behaviour consists of calling behaviour , courtship behaviour, copulation and oviposition behaviour. Behaviour of copulation was dominated among other behaviour. It took about 48% of on all mating steps behaviour. However, the frequency of the calling leaded by 70.8 times among other behaviour

Keywords: single copulation, calling, Crocidolomia pavonana,

INTRODUCTION

Crocidolomia pavonana F. is one of the damaging insect on cabbage.[1]. This insect was difficult to control because it has a high reproductive rate and resistance to various insecticides. To date, there is a promising control methods such as the intrusion of mating behaviour, or so-called mating disrupstion [2] [3]. It describes the strategy based on the knowledge that mating behaviour took place with duration and show preference to certain plant species [4]. Each insect species have specific mating behaviour. Therefore, it need to be observed in the form of stages and the duration on each steps within the mating cycles. The data is associated with the ability to reproduce insects[5]. Research on the mating behaviour of *C. pavonana* has never been done before. So we need a profound observation to determine the mating behaviour of *C. pavonana* on cabbage plants in order to provide some insight for *C.pavonana* biocontrol methods

METHODS

a. Time and Place

The study was conducted for 8 months starting in August 2015 to March 2016. The observations of behaviour, carried out at the dark period from 18:00 p.m. to 06:00 a.m. (following the mating behaviour of *C. pavonana*). Breeding *C. pavonana* and behavioural observations conducted at the Laboratory of Zoology, Department of Biology, Faculty of Mathematic and Natural Science, University of Jember.

b. Tools and materials

The tools used in this study include stopwatch, brushes, scissors, cage imago measuring 50 x 50 x 38 cm, container larvae diameter of 25 cm and a height of 16 cm, a measuring cup 10 ml, jars plastics, flashlight, tweezers, microscopes stereo, timer switches, hygrometer, video camera Sony Handycam DCR DVD 810, and a microscope camera OptiLab.

The materials used consisted of imago *C. pavonana*, a solution of honey, tissue, cotton, seeds F1 Hybrid Cabbage Green Coronet of PT. Takii Indonesia, distilled water, and sawdust.

c. Insect Collection

C. pavonana was taken from cabbage crops in the Bromo Tengger Mountains, Probolinggo and the Ijen Crater, Bondowoso, East Java. The collection was done on a cabbage crops with free pesticide application. The insect with all stadia was collected and then cultivated in the laboratory of Zoology, University of Jember.

d. Insect Rearing

Rearing is done by taking the larvae and eggs obtained from field into the plastic container. In each container put cabbage leaves that have been washed for *C. pavonana* larvae. Every day the container is cleaned and kept the moisture. The late instar 4 larvae were then transferred into a container containing sawdust as a media for pupation. Then, the pupae were transferred into cages with the cabbage seedling. After one week, the imago were eclosed. To feed the imago,10% solution of honey mixed with distilled water was applied . Once they mate, the female were layed eggs on cabbage seedling. Every day, the eggs was taken and transferred into smaller containers until hatched to be larvae, pupae and imago. We, then used the imago for the research. Insect breeding process carried out at a temperature between 21 - 27ºC and relative humidity between 62-96% , photoperiods of light and dark (L: D) 12 hours: 12 hours

e. Sex Determination on Pupa and Imago

Sex determination can be done on the pupal stage. Observation begins by taking 10 pupae at the same age (2 days before emergence. It can be done by examining the end of the ventral abdomen as shown in Figure 1. Male genital openings closer to each other and are located in two distinct segments, namely the ninth and tenth. Female genital and anal openings are wider and are located on the ninth and tenth segments are fused. Imago males have abdominal slim and conical, while females have a wider abdomen than the males and the edges are very sharp. This observations is generally similar to *Helulla undalis* that are currently on the family Pyralidae Kalbfleisch (2006)

Fig 1. *Crocidolomia pavonana* of Pupa Phase to Imago

f. Data collection for observation

The observations were made since the first day when imago eclosed from the pupa. Observations were made on a single pair of adult *C. pavonana* one-day-old female who is still virgin and imago *C. pavonana* males. One pair of adult *C. pavonana* were inserted into the cage (50 cm x 50 cm x 38 cm) and were given a 10% solution of honey. In the cage was also provides cabbage seedling in 2 polybags as a host plant. Furthermore, the observation of mating behaviour was made every hour throughout the night, starting at 18:00 to 6:00 pm.The mating started in the dark period 12 hours circadian rhythms (Karungi et al., 2010). Behavioural observations was conducted over four days with four repetitions. The flashlight and a red light were used for observation.

According Shirai (1995) *C. pavonana* have pre reproductive period for 2-3 days and the peak occurrence of oviposition on the fourth day until the fifth day after leaving the pupa. Pre reproductive period in question is the period of time required for the process of egg maturation. Observation of mating behaviour performed until oviposition occurs

Data observed included: Mating behaviour includes systematic order of phase behaviour; The duration of the whole activity of mating behaviour ;Characteristics of each

mating behaviour; Measurements of air temperature, humidity, and age of imago.

g. Data Analysis

Data were analyzed descriptively to know the characteristics of mating behaviour *C. pavonana*. The data is then shaped in ethogram time budgets that records every behaviour that occurs within the duration of one cycle of mating behaviour and made in the form of graphs and tables to explain each category of mating behaviour that goes with time constraints.

RESULTS AND DISCUSSION

The results obtained through observations of mating behaviour in C. pavonana in one cycle of mating behaviour gained an average duration of the behaviour of the calling was 19.3 minutes, the duration is longer than the courtship behaviour during 17.7 minutes. Copulation behaviour has an average duration of 103.3 minutes and oviposition behaviour has an average duration of 73.5 minutes. The total average duration of the entire mating behaviour C. pavonana as much as 213.8 minutes (Table 1). In the study, Lee., et al [6] The average total time duration that is shorter than the moth Tuta absoluta 400 minutes for the entire mating behaviour. Other research Lopez., et al [7] The average total duration of Sesamia nonagrioides moth mating behaviour as much as 288 minutes is calculated without the time duration of oviposition behaviour.

Table 1. Mating behaviour *Crocidolomia pavonana* F. during the mating cycle starting at 6 p.m. to 6:00 a.m.* ° C with a humidity of 72% RH (Relative Humidity). The data obtained in the form of observations of mating behaviour *C. pavonana* during the mating cycle of 12 hours of night in 4 days (Table 1).

Behavior	Average in duration (min)	Average the behavioural frequency (times)	The ratio in each step (%)
Calling Partner	19,3	65,5	9%
Courtship	17,7	70,8	8%
Copulation	103,3	1	48%
Oviposition	73,5	1	35%

* The observation of mating behaviour carried out for 4 days in 4 replications.

The average duration of mating behaviour *C. pavonana* when set in percentage one cycle of mating behaviour. Calling and courtship behaviour of the calling partner's percentage of each as much as 9% and 8%. Copulation behaviour as much as 48% and the percentage of oviposition behaviour of 35%. But the courtship behaviour has a frequency value of 70.8 times, rather than calling the behaviour of couples who have a frequency value of 65.5 times. Meanwhile, copulation and oviposition behaviour both have a frequency of once in one cycle. It shows that the mating behaviour of *C. pavonana* has a value inversely proportional to the duration of time with frequencies that occur in one cycle of observation. Also in the observations did not reveal any post copulation behaviour, it happens because after copulation the female imago *C. pavonana* not show a characteristic behaviour other than oviposition behaviour.

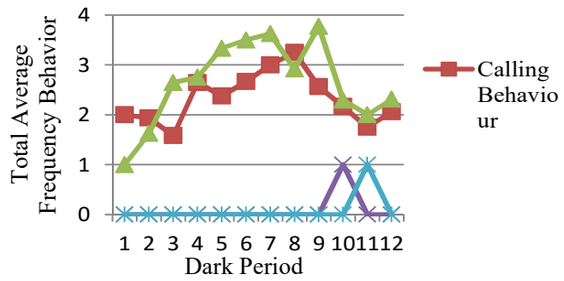

Fig 2. Graph *Crocidolomia pavonana* F. mating behaviour in a cycle of mating for 4 days (6 p.m. to 6 a.m.).

Based on Figure 2. appears that the calling behaviour have a total average of highest frequency in the dark periods of the ninth and tenth decline in hours until the eleventh hour. Courtship behaviour has a total average of highest frequency in the dark periods of the eighth and fell to the dark periods of the ninth to the eleventh hour. Copulation behaviour has a total average of highest frequency in the dark periods of the tenth and oviposition behaviour has a total average of highest frequency in the eleventh period

Calling behaviour *C. pavonana* has dark period peak on the seventh day of the second and eighth hours of day one. So that the calling behaviour of the highest pair on the first day and the second day of observation. But on the third day and the fourth day of the calling behaviour experience a decrease in the average number of behaviours. On the fourth day of the tenth and eleventh dark periods not encountered calling behaviour. In the courtship behaviour has a peak period in the dark hours of the sixth to tenth. Many courtship behaviour occurred on day one, the second and third. Courtship behaviour has decreased to zero at the tenth hour to twelve hours. copulation behaviour has a peak period in the dark hours of the tenth. In the copulation behaviour occurs on the fourth day and the time of copulation at around 04.00. Then, oviposition behaviour of *C. pavonana* has a peak period at the eleventh dark periods. Oviposition behaviour occurs on the fourth day and the time of oviposition at around 05.00. The distance between the oviposition behaviour of copulation with up to 1 hour. This is compared with a distance of copulation with *Ephestia kuehniella* oviposition takes as much as four days [8].

Mating behaviours had related among families of moths Pyralidae very varied, starting from simple to complex and diverse. Behaviour calling who do have the characteristic that when imago females produce a sex pheromone that is attractive to the male imago. *C. pavonana* male imago have similarity behaviour with *Ephestia kuehniella* it when sex pheromones produced by the females responded by imago imago male with a fly randomly to find the location of adult females [9]. Imago sex pheromones released by the females when the area abdomen protrudes out the end of the reverse, after the sex pheromone glands secrete pheromones (Figure 3). After that imago males will fly following the female, then male imago antenna moves simultaneously and rhythmically followed by imago females.

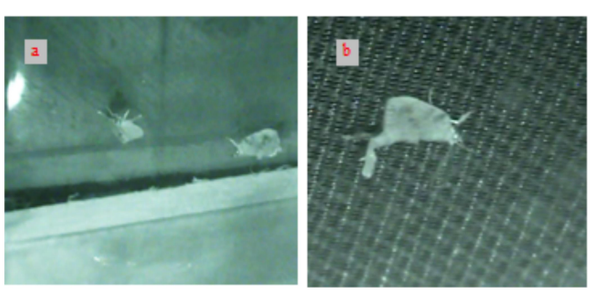

Fig 3. Calling behaviour Crocidolomia pavonana *F. a) Antenna of adult males and females move in same rhythm and b) Imago female pheromone glands secrete*

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Courtship behaviour in male imago C.pavonana started when a female fly followed and responded by moving the location of adult females antennanya. Courtship behaviour in C.pavonana also have similarities with A. transitella is much simpler. However, C.pavonana alone has the distinction of two kinds of characteristic that is in visual contact and physical contact. Visual contact began after a male imago C.pavonana responded and found the location of the female sex pheromones. Imago male approached from behind female imago, then landed with a parallel position and looked in the same direction with the female imago. Furthermore, when physical contact with female imago, the imago male cast forth and reverse its abdomen upward and elongate body organ klaspernya. In the process of this courtship female imago silent waiting for contact from imago males (Figure 4).

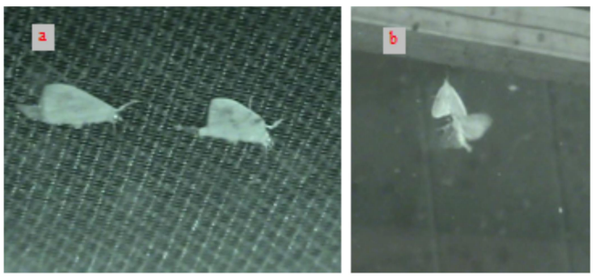

Fig 4 Courtship behaviour *Crocidolomia pavonana* F. a) Visual contact b) Physical contact.

C. pavonana copulation behaviour occurs when the valve clasper imago male contact and sticking closely with the tip of abdominal segments in imago female (Figure 5). Aedeagus in imago male organ into the bursa copulatriks females, when the place where the sperm is channeled. Initially sperm will move from the male spermatophore to the seminal ducts and then pass through the vestibule females and last heading on the female spermatheca stored [10]. In addition copulation behaviour is also accompanied by movement of the antenna with the same rhythm simultaneously.

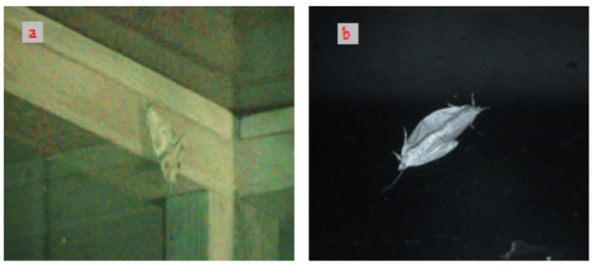

Fig 5. Copulation behaviour *Crocidolomia pavonana* F. copulation. a) Dorsal b) Ventral.

Oviposition or Lepidoptera moths lay eggs on a majority of less than 24 hours after copulation. Oviposition occurs after fertilization that occurs in the female vestibule. Fertilization occurs because the sperm in spermatheca toward the vestibule and then fertilize the egg. Time oviposition occurs when the evenings and span longer periods of time depending on the number of eggs released. Oviposition behaviour occurs when the female imago fly randomly approached and touched the surface location of oviposition candidate with antenna. Furthermore, female imago issued ovipositor organ towards nesting and raising the abdomen and then spawn (Figure 6).

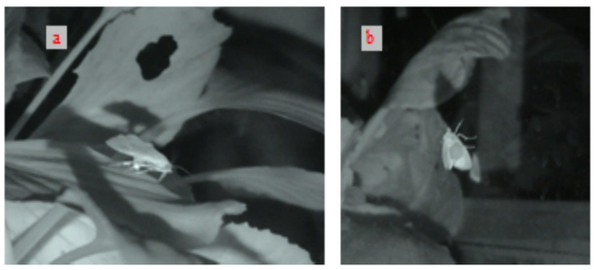

Fig 6. Oviposition behaviour *Crocidolomia pavonana* F. a) The initiation before oviposition and b) After oviposition produce eggs.

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