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SOME ASPECTS OF MATING AND OVIPOSITION BEHAVIOUR OF THE SPOTTED BOLLWORM OF COTTON, EARIAS VITTELLA (F.)

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Abstract. Investigations were made on the mating and oviposition behaviour of the spotted bollworm of cotton, *Earias vittella* (F.) in the laboratory. The field-collected larvae when reared on natural diet showed a sex ratio of 49 males to 51 females. The females generally mated once and the maximum mating was observed on the fourth night after emergence. The mating was maximum between 2–3 a.m. and the duration of mating ranged from 30–105 min. It was also observed that males mate more often when confined with several females than with one.

The females started laying eggs on the second night after emergence or the first night following mating. The most active oviposition period was in the range of 2–7 days post-emergence. A mated female laid on an average 159 eggs. The majority of oviposition occurred during night hours.

The spotted bollworm of cotton, *Earias vittella* (F.) [*fabia* (Stoll)] is among the major destructive pests of cotton in Indo-Pakistan subcontinent. The damage is done by the caterpillars boring into the tender portions of the plant viz. the growing shoots, buds, flowers and bolls. In 1905 and 1906, there was a failure of the cotton crop in the Punjab and Sind, respectively, due to bollworms attack.¹ Experiments carried out by Deshpande and Nadkarny² in Punjab and Bombay Presidency showed that a crop protected against the attack of *E. fabia* yielded 15–80% more seed cotton than the control. Patel³ reported that the spotted bollworm (*E. fabia*) was mainly responsible for damage to the cotton crop and low yields in Baroda. According to Naqvi⁴ the spotted bollworms cause 10–15% loss in cotton yield in Sind.

Some information on the general habits of bollworm moths and oviposition behaviour has been reported by Deshpande and Nadkarny² and Ahmad and Ghulamullah.⁵ The study reported here on the reproductive biology of this pest is necessary for a better understanding of the population dynamics when sterile-insect release technique is being considered for control purposes.

Materials and Methods

The larvae were collected from cotton crop and also from okra (*Habiscus esculentus* L.) which is an alternate host of this pest. They were reared on buds, immature bolls of cotton and okra in the laboratory maintained at $27 \pm 2^{\circ}$ C, 70–80% R.H. and a photoperiod of 12 hr per day. The light was provided artificially through daylight flourescent tubes.

The pupae were kept individually in glass vials until emergence to obtain virgin adults. On emergence one male was confined with one female in each oviposition cage. Food was continually available to the adults in the form of 10% sucrose solution provided in a bottle equipped with a wick made of rolled cotton. Glass chimneys, the mouths of which were covered with muslin cloth, were used as cages in the current investigations. The fecundity and fertility was calculated by counting all the eggs laid during the life of each female and by incubating a portion of eggs for viability, respectively.

Results and Discussion

Emergence of Moths. Under laboratory conditions, adult emergence was recorded daily at 7 a.m. and 7 p.m. from a total of 1750 pupae. It was observed that a total of 1640 adults emerged, out of which 40 (2.4%) emerged in the day time (7 a.m.-7 p.m.) and 1600 (97.6%) during the night (7 p.m.-7 a.m.). Callahan⁶ found that in another Noctuid, *Heliothis zea* (Boddie) 94.6\% of emergence occurred between 7 p.m. and midnight.

Sex Ratio. Larvae collected in the field during the months of June to September 1971, and reared in the laboratory yielded males and females in the ratio of 49:51. Out of 1926 pupae 944 were males and 982 females.

Mating Behaviour

The observations on the mating behaviour of individual pairs were made during a period of almost equal darkness and daylight in the last week of September and first week of October. Similar photoperiod of 12-hr day and 12-hr night was created in the laboratory. Inspections were made at 15 min intervals through the day and night. During night a torch, the beam of which was subdued by means of a dense red filter over the lens, was used for observations. These inspections did not seem to disturb the activities of the moths in any way. The male and female were placed in a cage the morning after their emergence and all the activities observed from the time of pairing until death.

Precopulation Period. The observations were made on 125 pairs caged individually after emergence. Twenty five females were dissected daily in order to note whether or not the females had mated. It was observed that 36, 48, 72, 88 and 84% females mated on first, second, third, fourth and fifth night respectively (Fig. 1). The maximum mating (88%) was recorded on the fourth night after emergence.

Time and Duration of Mating. Twenty six pairs that had mated were kept under continuous observation in order to note the time and duration of mating. The time when mating was initiated by different pairs was noted as follows: 2-3 a.m., 12 pairs; 3-4 a.m., 4 pairs; 4-5 a.m., 6 pairs; 5-6 a.m., 2 pairs; 6-7 a.m. 1 pair; 7-8 a.m., 1 pair.

All the copulations were observed after 2 a.m. Among the pairs under observation the earliest copulation was observed at 2 a.m. and latest at 7 a.m. The mating was maximum between 2–3 a.m. Squire⁷ reported that moths of pink bollworm, *Pectinophora* gossypiella (Saunders), were active from 1–5 a.m. and that matings were largely restricted to the last 2 hr of this period. Ouye *et al.*⁸ observed that first mating of the pink bollworm occurred between midnight and 6 a.m. Callahan⁶ found that all copulations of *H. zea* occurred after 1 a.m. Shorey *et al.*⁹ reported that the time of initiation of copulation of *Trichopulsia ni* (Hübner) observed in confinement was 2.10 a.m.

The time in copulation of 26 pairs was recorded from the time of initial attachment until separation. The pairs remained in copulation for an average of 68 min with a range of 30–105 min.

Number of Matings. The number of times a female mated successfully was determined by removing the bursa coupulatrix, carefully dissecting it and counting the number of spermatophores. To find out whether or not more than one spermatophore ever resulted from a single mating, 30 pairs of the newly emerged males and females kept separately were confined (single pair) in the cages. They were watched continuously day and night and as the pair mated, it was kept under observation till separation. The females were then dissected. It was observed that one spermatophore was transferred at each mating.

In order to determine the number of matings a female could accomplish, 25 individual pairs of newly emerged moths were kept in oviposition cages. Upon death the females were dissected to record the number of spermatophores present in the bursa copulatrix. The data thus collected revealed that 22 pairs had mated once and only 2 pairs mated twice. These behavioural observations showed that females mate no more than once if a normal spermatophore is received from the male. Anwar *et al.*¹⁰ reported that the females of another species of spotted bollworm, *E. insulana* Boisd, generally mate once during their life span.

Shape of Spermatophore. The newly formed spermatophore is white, oval-shaped with a small sinuous tube attached to it. It measured an average 2.2 ± 0.3 mm in length and 1.7 ± 0.2 mm in width.



Fig. 1. Accumulated per cent of mated females of spotted bollworm.

Effect of Sex Ratio on Number of Matings. To determine the effect of sex ratio on number of matings, virgin females and males were caged together in different ratios in 10 replicates. The females were dissected after death and the number of spermatophores produced were recorded.

5 X 1				Total	Average
5 Males and	0.1	0.0		1.1	per male
1 female 1 1	21	23		14	0.28
1 Male and					
1 female 0 1	1 1	1 1	1 1 1 1	9	0.9
1 Male and					
5 females 4 2	1 1	12	1 2 3 1	18	1.8

The data showed that when a single female was confined with 5 males, an average of 0.28 spermatophore was produced per male. With a single male and 5 females, an average of 1.8 spermatophores was recorded per male. The results of spermatophore counts in this species agree closely with those of Gehring and Madsen^{II} for the codling moth, *Carpocapsa pomonella* (L.), showing that males mate more often when confined with several females than with one. This is probably because the sex attraction of a mated female is less than of a virgin or the mated female refuses the male.

Oviposition Behaviour

Preoviposition Period. The females began egg laying on the second night after emergence or the first night following mating. As the mating took place in the first to fourth night after the emergence of moths, the preoviposition period under laboratory conditions was 2–5 days. Desphande and Nadkarny² noted that some moths of spotted bollworm, *E. fabia*, began laying eggs in the first night after mating and great majority of them commenced oviposition about the fourth night. They mentioned that the preoviposition period was 3–7 days under conditions in Bombay and 3–3.5 days at a temperature of 25–35°C.

Time of Oviposition. The results indicated that the ovipositing females were active mainly during nocturnal periods and majority of the eggs were laid during night hours. Our studies on 14 pairs kept in the individual cages until death showed that 4%of the total eggs were laid between 6 a.m.-6 p.m. while 96% of them were laid between 6 p.m.-6 a.m. (Table 1). The findings of Deshpande and Nadkarny² that oviposition did not take place at all during the daytime was not true under our conditions. There were a few females that laid eggs during the day. However, the results of Ahmad and Ghulamullahs are in accordance with our results, they indicated that many females of *E. fabia* laid a small percentage of eggs during the daytime.

Oviposition. Experiments were conducted on 40 individual pairs of newly emerged adults to record the daily egg production of each female during its entire life span. The eggs were laid singly on muslin cloth. The most active oviposition period was in 2-7 days post-emergence. The total eggs laid by a single female varied from 28-340 with a mean of 159 during the life span of 7-14 days. The maximum number of eggs laid by a female on one day was 100. An average egg hatch of 92.9% was recorded under laboratory conditions. Tests run with caged virgin females indicated that 60% unmated females oviposited during their lifetime (7-20 days) but egg production was very low with an average of 3 eggs per female. Deshpande and Nadkarny² reported that the average number of eggs laid in Surat (India) during August-September was 432 per female under field conditions. They mentioned that oviposition declined considerably during December and January due to cold weather. Our observations showed that oviposition was predominantly on the top of the cage during first few days. As the females became older and weaker we observed that they no longer were able to climb up the cage and more eggs were deposited on the muslin cloth provided at the bottom of the cage. There was no definite trend in daily egg deposition and the number of eggs laid each day varied. Ahmad and Ghulamullah⁵ reported that egg laying in the spotted bollworm started with the least numbers of eggs on the first day, gradually increased until the maximum number of eggs per day was reached during the third to fifth day. Some typical cases showing the oviposition pattern of mated and virgin female are presented in Table 2.

Cage No.	Eggs laid during indicated time period									
	6 a.m6 p.m.	6 p.m.–6 a.m.								
1		69								
2		103								
3	34	322								
4	3	208								
5	13	267								
6	_	351								
7	3	47								
8	27	248								
9	17	222								
10	7	231								
11	11	198								
12		244								
13		106								
14	-	147								
Total	115	2763								
Percentage	4	96								

 TABLE 1.
 NUMBER OF EGGS LAID DURING DIFFERENT

 TIMES OF THE DAY AND NIGHT.

 TABLE 2.
 Some Typical Cases Showing Oviposition Pattern of Mated and Virgin Females of E. vittella.

	No. of eggs laid (days after emergence)										Total	Life				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14-20	'number of eggs laid	span (days)
Mated females 1 2 3 4 5 6 7 8 9 10		25 65 90 10 2	5 5 35 4 	$ \begin{array}{r} 6 \\ 54 \\ 1 \\ 20 \\ 4 \\ 20 \\ 8 \\ 11 $	2 28 2 8 51 3 59 11 51	$ \begin{array}{r} \hline 10 \\ 26 \\ 37 \\ 52 \\ 6 \\ 10 \\ 32 \\ 24 \\ 17 \\ \end{array} $	$ \begin{array}{r} 11 \\ 5 \\ 16 \\ 9 \\ \hline 0 \\ \hline 7 \\ 11 \\ 30 \\ 42 \\ \end{array} $	$ \begin{array}{r} 15 \\ 55 \\ 24 \\ 69 \\ \hline 2 \\ 1 \\ 9 \\ 8 \end{array} $	$ \begin{array}{c} 3\\ 40\\ 7\\ 49\\ 8\\ -\\ -\\ -\\ -\\ -\\ -\\ -\\ -\\ -\\ -\\ -\\ -\\ -\\$						61 28 319 84 340 260 44 223 98 129	13 7 9 11 14 7 13 10 10 9
Virgin females 1 2 3 4 5 6 7 8 9 10			5					2 3 2 	8						$\frac{1}{2}$ 7 10 9 1 1 1	10 7 12 12 11 20 13 14 14 16

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