ISRAEL JOURNAL OF ENTOMOLOGY Vol. VIII 1973

BIOLOGY AND MASS BREEDING OF THE TOBACCO CATERPILLAR, *SPODOPTERA LITVRA* (F.)*

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A B S T R A C T

The eggs of *Spodoptera litura* (F.) hatch within 4 days at 26.7 + 1°C and the larvae pass through six instars to pupate in earthen cells in the soil. The larval periods of male and female adults were 12.8 and 13.1 days respectively, whereas the comparative pupal periods were 7.3 and 6.1 days, respectively, at a mean laboratory temperature of 28.6 C. The average egg laying capacity was 2,518 eggs per female with over 90% of the eggs being laid between the second and the fifth day after emergence. Infection of the culture by a microsporidium reduced the fecundity to 1,895 eggs per female. Daily placement of 10 pairs of freshly emerged moths in a wire screen oviposition cage measuring 30 x 30 x 30cm yielded the maximum number of eggs per female. The eggs laid on 25-30 cm x 3-5 cm plastic strips could. easily be scraped off and separated. Rearing freshly hatched larvae in glass jars on castor bean leaves until the third instar, and then on an artificial diet prepared from lucerne leaf powder, was quite satisfactory.
An optimum of 200 third-instar larvae could be reared in a galvanized iron cage of 35 cm diam, 10 cm height.

* This research has been financed in part by a grant made by the United States Department of Agriculture, Agricultural Research Service Under PL. 480.

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INTRODUCTION

The tobacco caterpillar, *Spodoptera litura* (F.), is a common pest of tobacco *(Nicotiana tabacum* L.), cauliflower *(Brassica oleracea (bostrytis)* L.), castor bean *(Ricinus communis* L.), Lucerne *(Medicago sativa* L.) etc. in this area. Moussa, Zaher and Kotby (1960) recorded 112 species of plants, belonging to 44 families, as food plants of this insect. Since the insect can be easily bred and reared in the laboratory and has a wide host range, it was thought to be a good laboratory host for mass-breeding parasites and predators. Some information on the biology of the insect and a mass rearing method, successfully used for over 3 years, are given in this paper.

MATERIALS AND METHODS

The culture of *S. litura* was started by collecting eggs and larvae from fields of castor, cauliflower, lucerne, tobacco etc. The larvae were reared on their natural host plants in glass jars during the early instars and then in round galvanized iron tin sheet cages (35 cm diam. 10 cm height) containing 3 to 5 cm deep moist soil. The pupae were collected from these trays 3-4 days after all larvae had entered the soil. They were buried in about 3 cm of moist soil in a glass jar containing a mass of wood-wool and covered with a piece of nylon cloth. The adults emerging from such jars were collected daily, sexed and released in an oviposition cage, to obtain the eggs.

Fifteen pairs of males and females were placed in an oviposition cage (Fig. 1) measuring 30 x 30 x 30 cm, made of 7 mesh wire screen with an open bottom fixed in moist soil on a tray. One of the sides of the cage was fitted with a snugly-fitting tin-plate lid. Cotton-wool plugs dipped in 5% honey solution were provided as food for the moths. Six to eight bunches of 25-30 cm long, 3-5 cm wide, transparent plastic strips were suspended in the cage for the moths to lay eggs on. Most of the eggs were laid in masses on the plastic strips which were taken out the following morning, the eggs being scraped off by a fine brush and gently worked with a brush through a suitable sieve so as to separate them. The number of eggs thus separated was determined by measuring them with a graduated narrow tube. The eggs were then held in a small plastic bag until hatching.

When these eggs hatched, the larvae were transferred to a wide-mouth glass jar containing a fresh castor leaf. The mouth of the jar was covered with a piece of plastic sheet having many pin pricks. The jar was then covered with a piece of black cloth so that the larvae readily settled on the leaf. On the following day, the plastic cover of the jar was replaced by a piece of nylon cloth and a fresh leaf placed below the older one. Most of the larvae developed into third instar within 4 days and were then reared further in 35 cm diam, 10 cm high, galvanized iron tin sheet cages. Although the larvae could be reared satisfactorily on castor leaves, it was necessary to develop an artificial diet because these leaves were not available in large quantities throughout the year and the larvae chewed out cloth covers of the cage if the quantity of leaves provided was inadequate. The artificial diet was prepared with the following ingredients:

Lucerne leaf power	...	600 g
Water	...	1,800 c c
Agar	...	6 g
Antimicrobial solution*	...	30 c c
Acetic acid	...	12 c c
Ascorbic acid	...	12 g
Vitamin solution**	...	30 c c
Formaldehyde	...	1 c c

Agar was dissolved in three-fourth quantity of water and thoroughly mixed with the leaf powder. Antimicrobial solution was added in some water and thoroughly mixed. The mixture was then cooked at 15 p.s.i. for 25 minutes in a pressure cooker.

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* Antimicrobial solution:4.0 g sorbic acid and 3.0 g methyl parahydroxybenzoate dissolved in 34 ml ethyl alcohol.

**Vitamin solution: Dissolve 12 mg biotin in 100 cc water and add nicotinic acid (Niacin) 600 mg; calcium pantothenate 600 mg; riboflavin 300 mg; thiamine hydrochloride 150 mg; folic acid 150 mg; pyridoxine hydrochloride 150 mg; and vitamin B-12, 1.2 mg.

The food was then allowed to cool and the remaining quantity of water with measured amounts of acetic acid, ascorbic acid, Vitamin solution and formaldehyde were thoroughly mixed. Three or four plastic dishes containing a thin layer of this diet were kept upside down on a wire screen support, half inch above the soil in the rearing cage. Third instar larvae were transferred to the cage and then covered by a piece of black cloth held in place by an elastic string. The larvae reached the food through the wire screen support and fed from below (Fig. 3). Their excrement dropping through the screen was removed and the food was supplemented as and when necessary. After completing their development, the larvae entered the soil for pupation. Such cages were left undisturbed for 3-4 days for the larvae to pupate. The soil was then sifted to obtain the pupae.

The optimum number of larvae that could be reared in a 35 cm diam, 10 cm high, rearing cage was determined by rearing several sets each with 200 to 500 larvae per cage and working out the percentage of pupation and the average weight per pupa in different sets. To determine the optimum number of moths to be released in an oviposition cage for maximum egg collection per female, 10 and 15 pairs of moths were released daily in respective cages for nearly 4 weeks. The number of eggs harvested from each of the two sets was recorded daily to calculate the average number of eggs collected per female per day.

To study the number of larval instars and the duration of the larval stages, 100 freshly hatched larvae were reared on castor leaves individually, in petri dishes. Each larva was examined daily in the morning to determine moulting as judged by measuring the size of the head capsule,moulting being confirmed by the presence of head exuviae. The pupae were sexed and held separately to determine the duration of pupal stage of male and female moths. To study the fecundity and longevity of the adults, each pair of adults was caged in a glass chimney containing a suspended plastic strip for oviposition and 5% honey solution as food.

RESULTS AND DISCUSSION

Larval development

The eggs of *S. litura* hatched in 4 days when held at 26.7 ± 1° C. Out of 100 larvae reared individually, 71 completed their larval development passing through six instars in an average of 12.98 days at a mean laboratory temperature of 28.6°C (Table 1). The average duration of these instars varied from 1.43 to 2.00 days for the first 5 instars and a little over 4 days for the last one including the prepupal period. The observation of Philip (1958)that the larvae pass through 5 instars seems to be incorrect. The individual rearing studies grouped on the basis of adult sex showed that male larvae had a shorter larval life (12.77 days) than the female larvae (13.13 days). On the other hand, male pupae took 1.22 days longer (7.3 days) than female pupae (6.08 days). However, when the time spent in both larval and pupal stages is combined, the males took about 0.86 days longer than the females. Jarczyk, Jarczyk and Flaschentraeger (1957) also observed that female pupae took less time to develop than male pupae.

Sex determination

The male thorax bears 3 wood-brown strips (Ridgway,1912) one along the mid-dorsal line and one on either side originating from near the base of each forewing and going dorsally backwards (Fig. 2). Similar strips are also present along the posterior margin of the forewings and therefore, when wings are folded, they form a wood-brown strip along the mid-dorsal line. In females, these areas are not coloured differently from the general brownish-drab colour of the body. Male forewings also bear a wood-brown strip from the middle of the costal margin to a similar strip along the posterior margin. In females, this strip is divided into narrow streaks by brownish-drab scales. Ventrally, the males are vinaceous-buff while females are smoke-grey in colour (Ridgway, 1912).

Table 1: Number and duration of larval instars of *Spodoptera litura* reared at an average laboratory temperature of 28.6°C on castor bean leaves.

Instar	Duration in days		
	Min.	Max.	Average*
I	2	2	2.00
II	1	2	1.63
III	1	3	1.43
IV	1	3	1.99
V	1	4	1.78
VI	1	3	2.15
Prepupa	2	2	2.00
Total			12.98

*Average of 71 individual observations.

Fecundity

The pre-oviposition, oviposition and post-oviposition periods averaged 1.6, 5.1 and 1.2 days respectively (Table 2). The fecundity data of 15 females studied individually revealed that the egg laying capacity varied from 1,900 to 3,197 eggs with an average of 2,518 eggs per female. Over 90 per cent of the eggs were laid between the second and the fifth day from emergence. The number of eggs laid by a female has been recorded to be 545.8 by Chin (1936), 400 - 1,600 by Sonan (1937), 578 by Basu (1945) and 403 by Philip (1958), all of which are very low figures, probably based on inadequate studies. When the culture was infected by a microsporidium, the egg laying capacity varied from 0 to 3,016 with an average of 1,895 eggs per female based on 25 females studied individually. Thus, the disease had a profound effect on the moth's fecundity.

Table 2: The longevity and fecundity of *Spodoptera litura* in the laboratory at 26.7°C.

Sr. No.	Duration (in days)	No. of individuals	Min.	Max.	Average	% of the total
1.	Longevity					
	(a) Female	15	5	10	7.87	
	(b) Male	15	3	14	9.26	
2.	Pre-oviposition	15	1	2	1.6	
3.	Oviposition	15	3	7	5.13	
4.	Post-oviposition	15	0	2	1.2	
5.	No. of eggs laid on on Ist day	15	0	0	0.0	-
	2nd day	15	0	1300	383.33	15.25
	3rd day	15	500	1300	896.67	35.60
	4th day	15	350	1100	693.33	27.53
	5th day	15	0	600	351.67	13.96
	6th day	15	0	300	66.67	2.64
	Other days	15	-	-	126.53	5.02
Total No. of eggs laid by a female			1900	3197	2518.20	100.00

Egg collection

Results of studies to determine the optimum number of moths that should be released in an oviposition cage for maximum egg collection showed that daily addition of 10 pairs of adults yielded 1,957 eggs per female as against 1,358 eggs when 15 pairs were added (Table 3). However, when the culture was infected with the microsporidium during January-February 1967, these averages were only 1,317 and 1,187 eggs per female, respectively. The lower egg harvest per female on daily adding 15 pairs may be due to moth overcrowding in the cage. Thus, for

mass-breeding purposes, it is better to release 10 pairs in the cage every day and maintain the culture free from microsporidial infection.

Table 3: Egg collection when *Spodoptera litura* moths were caged in different numbers in a 7-mesh wire screen oviposition cage.

Sr. No.	Period of study	Duration of study in days	No. of pairs of moths added in the cage every day	Daily egg collection from the cage			Average No. of eggs per female
				Min.	Max.	Average	
1.	Jan. - Feb. 1967	21	15	13,000	21,000	17,810	1,187
2.	" "	18	10	10,000	16,000	13,167	1,317
3.	Jan. - Feb. 1967	28	15	10,000	31,500	20,375	1,358
4.	" "	21	10	10,000	31,500	19,571	1,957

Mass rearing the larvae

When larvae were reared on castor bean leaves throughout their larval period, 80.7% developed into healthy pupae having an average weight of 0.360 g per pupa (Table 4). When they were reared only on the artificial diet, a large number died during their early instars and only 51.7% developed into healthy pupae. The larvae were therefore reared on castor leaves until their third instar and then transferred to the artificial diet of 3,750 first-instar larvae reared on castor leaves in 15 different sets, 3,255 (86.8%) third-instar larvae survived. The recovery of third-instar larvae as calculated for different sets varied from 77.2 to 96.0%. When the larvae were reared on castor leaves until their third instar and then transferred onto the artificial diet, 86.75% produced healthy pupae (Table 4). Thus, rearing on castor leaves yielded 86.6% third-instar larvae out of which 86.75% produced healthy pupae on lucerne leaf powder diet. This works out to 75.3% pupation

Table 4: Effect of different larval diets on the development of *Spodoptera litura* larvae.

Larvae reared from	Food	No. of sets studied	No. of larvae under observation	No. of pupae obtained	% pupation	Av.wt. per pupa in g.
First instar	Castor leaves	9	2250	1815	80.66	0.360
"	A.D. (Lucerne powder)	11	3650	1888	51.72	0.350
Third instar	A.D. (Lucerne powder)	22	4605	3995	86.75	0.311

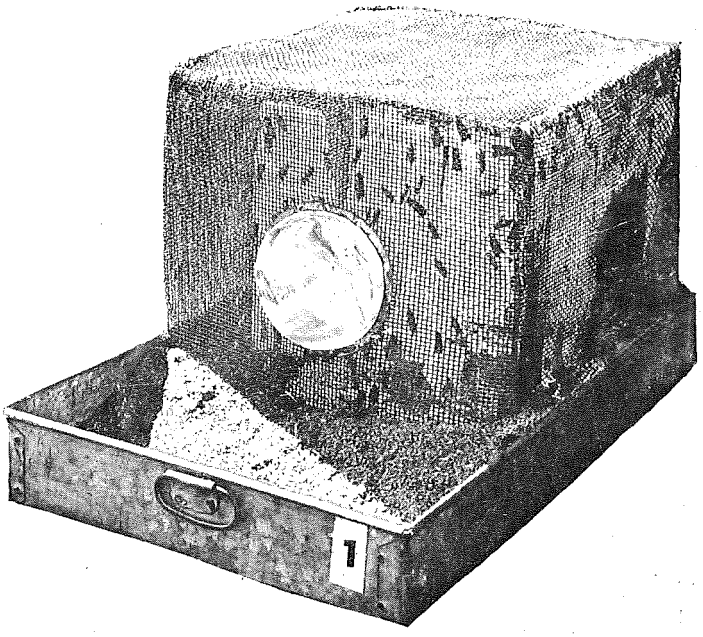
A.D. = artificial diet.

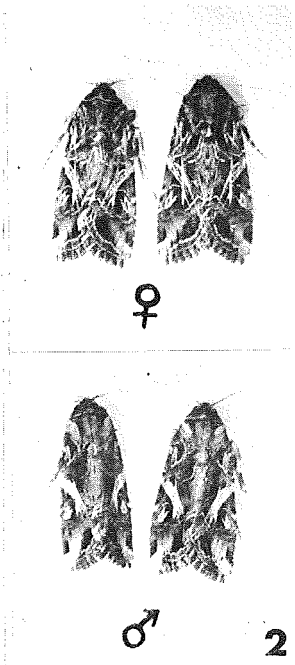
when the larvae are reared in two phases. This is a quite satisfactory development for mass-rearing the larvae considering the difficulties in rearing either on castor leaves alone or on the artificial diet.

The optimum number of third-instar larvae that could be reared in a 35 cm diam. 10 cm high, galvanized iron sheet rearing cage was found to be 200 per cage which yielded 86.2% pupae, each weighing 0.325 g (Table 5). When the number was increased up to 500 per cage, the percentage of pupation as well as the weight per pupa declined appreciably.

Table 5: Development of *Spodoptera litura* larvae on lucerne leaf powder diet in a 35 cm diam. 10 cm high, rearing cage

No. of third instar larvae per set	No. of sets studied	Total No. No. of larvae reared	No. of healthy pupae obtained	% of pupation	Average weight per pupae in g.
200	6	1200	1034	86.17	0.325
300	13	3900	3161	81.05	0.279
400	10	4000	2673	66.82	0.261
500	6	3000	2081	69.36	0.266





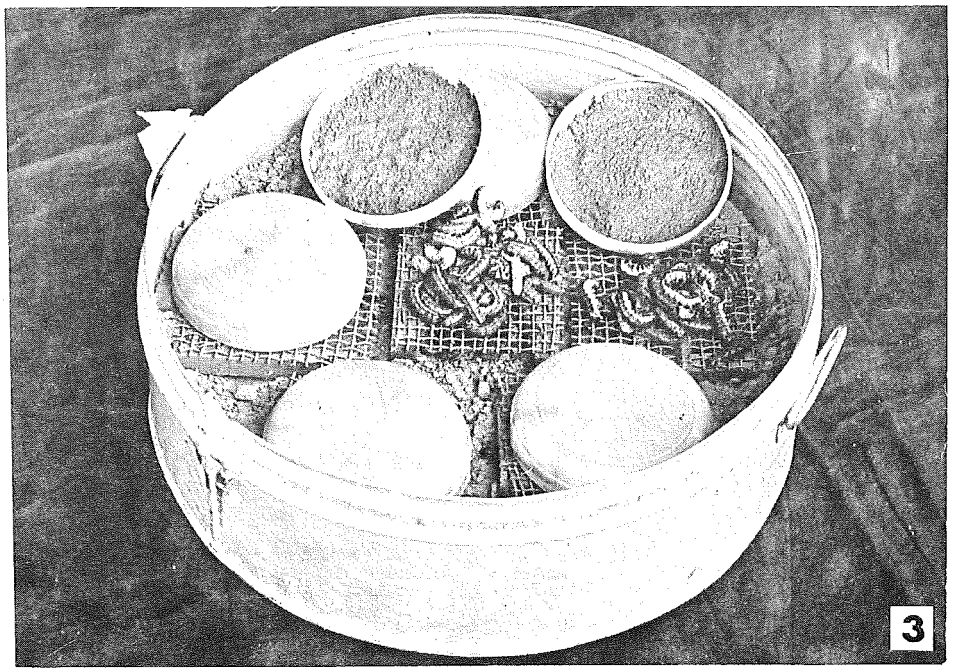


Fig. 1: Oviposition cage for *Spodoptera litura*.

Fig. 2: Female and male moths of *Spodoptera litura*.

Fig. 3: *Spodoptera litura* larvae feeding on artificial diet.

ACKNOWLEDGEMENTS

The authors are grateful to Dr. R.M.Patel, Director, Institute of Agriculture, Anand for providing necessary facilities and to Drs.P.B.Dowden and C.F.Rainwater of the U.S.D.A. for their valuable suggestions and interest in the work.

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