A Contribution to the Biology of the Eggplant Borer Euzophera osseatella Tr.

(Pyralidae Lep.)

by

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Foreword

Euzophera osseatella is a Mediterranean insect. Records of its dis- tribution come from Italy, Dalmatia, Cyprus, Syria, Israel, Egypt, Tunis, Algeria and Morocco. In perusing the literature, including the "Review of Applied Entomology", one finds that this insect, except in Egypt (Willcocks, 1925) and in Israel (Bodenheimer, 1930; Klein, 1941), is little known as a pest.

In Egypt and Israel it has been reported as injuring eggplant, tomato, potato and pepper. It has also been found on Atropa belladona and, to a great extent, on the night-shade Solanum villosum (Klein, 1941). The biology of this pest has been but little and casually studied. This present work is an endeavour to add to the knowledge of this little-known insect.

The Status of Euzophera

Injury is caused by the larvae boring into stems. Eggs are laid on the stem, the newly-hatched larvae boring into it, and down toward the root. Boring generally starts close to the root crown, and may result in plant chlorosis, easily breakable stems, impaired general vigour, and reduced yields. Microorganisms may develop in the tunnels, causing rots which finally kill the already weakened plant.

Potatoes are attacked in early spring by the adults which emerged from winter larvae. The summer generations continue infestation of this crop. Tubers as well as stems may be tunnelled. According to Slomnicki (personal communication), in the Negev only potatoes which sprout in September escape attack. Summer generations attack tomatoes and egg- plants too. This pest may destroy 20-25 per cent of fruit-laden tomato plants. In eggplants , a few larvae may be found in one stem. Damage is generally accentuated in plants left for a second-year crop. According

to Bodenheimer, injury may be so great that it is not profitable to raise eggplants for a second season.

Rearing Methods

Potato tubers, a natural food, served as medium for the laboratory cultures. A potato tuber was placed in a dish on a layer of moist sand (Plate I, a) ; over it, a lamp-chimney was adjusted when necessary, its upper opening covered with cheese cloth. This simple, small cage enabled the rearing of larvae in various conditions.

The neonate larvae were placed on the tuber. They crawled in search of an entrance place and began boring into it. Their entrance was facilitated by a slight tangential cut in the tuber. Brown excrement served to indicate that the larvae had begun boring. The tuber was then kept under constant observation.

Pupation could be seen through the cocoon walls which the larvae spun. In some cases, the potato was opened toward the end of the rearing period ascertain the larvae's situation.

Moths were kept in 600 ml jars. Several males and females were often kept together for a day or two before being separated into pairs. They were fed a 7-8 per cent sugar solution.

Eggs were counted and removed every day or two. With the exception of rearings in which humidity effects were tested, the eggs were reared on wet blotting-paper in a closed Petri dish. Daily observations were made to ascertain the time of hatching.

RESULTS

The Egg

It is brown or rust-coloured, and rough-surfaced, oval 0.5mm long and about 0.4 mm wide.

Development and Threshold

Eggs were reared both in incubators at constant temperatures, at prevailing room temperature, and outdoors in an open hut. The incubators were set at 10, 15, 18, 22, 26 and 30°C. Outdoor temperatures throughout the

year varied from a daily average of 13°C in December-January to a daily average of 27-28°C in July-August. Incubation periods at various temperatures are presented in Table 1.

Table 1. - Length of development of Euzophera eggs at various temperatures

Temperature, in °C	Number of rearings	Number of eggs	Length of development in days	% of daily development (empiric)
13.5	3	359	32.83	3.04
18	15	2364	13.83	7.23
19	10	804	10.70	9.34
21	5	428	9.70	10.30
22	22	3569	9.11	10.97
22	9	956	9.30	10.75
23	11	1791	8.35	11.97
24	1	176	7.41	13.49
25	25	2992	7.20	13.88
26	20	2732	6.72	14.88
26	11	1879	6.56	15.24
27.5	34	5247	6.00	16.66
30	13	1201	5.92	16.89

From these data the eggs' threshold of development was calculated and the line of regression was drawn in graph form (Fig. I, a). The threshold of development lies near 9°C.

This incubation threshold was tested empirically. Eleven batches comprising 1140 eggs were kept at 10.3°C (10 - 10.5°C) for 40-45 days without hatching; by mishap the thermostat failed , and the temperature rose to 15°C for one day. This caused the hatching of 132 eggs (11.6%). The general percentage of hatching ranged from 43% (30°C) to 73% (19°C). No hatching took place while the temperature remained close to the threshold, although some eggs still lived.

Effects of Humidity

The effect of humidity upon egg mortality was investigated. Eggs were placed in small tubes open at both ends, one end being covered with perforated tin foil. These were suspended just above various saturated salt solutions in a test tube, and kept at various temperatures in incubators.

The solutions employed are listed in Table 2, which also shows at which combinations of temperatures and humidity the eggs were incubated, and their respective survivals.

Table 2. - Percentage of Euzophera eggs hatched at various temperatures and various relative humidities

Saturated solutions	% relative humidity	Percentage of hatching at: 22-24°C 235 eggs	26°C 80 eggs	30°C 75 eggs
H_2O	over 95	79.1	63.7	65.3
K_2CrO_7	87	58.7	67.5	40
NaCl	76	59.1	25	48
Na_2CrO_7	55	51	67.5	33.3
$CaCl_2$	32	54.5	55	33.3

Table 2 shows that the highest hatching percentage occurred at a relative humidity above 95%. There was little difference between mortality at a RH of 87% or 76%; that at 26°C was an exception, this may have been due to an experimental error or other accidental cause.

The Larva

The larva is 13-15 mm long, with a reddish-brown head, inconspicuous prothoracic plate, and ivory-white body (this distinguishes it from the larva of the potato tuber moth Gnorimoschema operculella, whose head and prothoracic plate are black, and body colour variable from whitish-grey to greenish-purple).

Habits

After wandering about freely (often for as long as a day), the young larva penetrates into tissue. Entrance is easier when made at an axil of a side shoot, in a fold or groove, or in the "eye" of the potato. It feeds on internal tissues, and thus bores into stem or tuber. The tunnel may be lined with sparse silken threads. Should conditions in the tunnel become irritating to the larva, it apparently secretes a protective layer around itself, to separate itself from the tunnel walls. This happened when infested potato tubers were dipped in a systemic insecticide; the tunnel walls

were compact and brown. When humidities and temperatures within it become insupportable, the larva spins out a tube which may extend as much as 30 mm beyond the stem or tuber (see Plate I, a). Similar observations were also made by Klein. These tubes should not be confused with the fore-mentioned, nor with the pupal cocoon.

No true diapause was observed. Larval development could be accelerated at a higher temperature, but others of the same batch were retarded at a lower temperature.

When ready to pupate the larva spins a cocoon, either outside or inside the stem, or in the tube; the pupa is often found in above-ground parts of the stem (Plate I, b).

Development and Threshold

Potato tubers containing Euzophera larvae were kept, at various temperatures in incubators, in the room, and outdoors. The length of development under all these conditions was studied. This was no simple matter; the larvae were inside the tubers and these, or the silken tubes, had to be opened to ascertain development. Length of the development varied with individuals of the same batch reared under the same conditions. For the purpose of calculations, that period at which the majority of the larvae matured was considered.

Average larval development periods for the various conditions are given in Table 3, and the regression line drawn from these data in Plate I c; this shows that the line cuts the temperature axis at the point corresponding to 11.3°C; this, therefore, should be considered the threshold for larval development.

The optimal range of temperature probably lies between 22 and 28°C. At temperatures of 18°C or below, the larva is inclined to move into the fore-mentioned silken tube and to remain within it, apparently inactive, until the temperature rises. At temperatures above 30°C, larval mortality increased and development rates were retarded.

Table 3. - Development rate of Euzophera larvae at various temperatures

Temperature in °C	Number of rearings	Total number of individuals	Average development period in days	% of daily development (empiric)	% of daily development (calculated)
14.5*	3	9	100.2	0.99	-
16*	4	16	85.6	1.16	-
17	17	128	74.9	1.33	1.33
18	10	63	63.9	1.56	1.55
19.5	4	19	51.7	1.93	1.86
22	22	195	41.2	2.42	2.47
23*	9	23	41	2.44	-
25	48	312	32.6	3.06	3.16
27	18	44	26.9	3.71	3.62
30*	5	22	32	3.1	-

* Were not incorporated in the calculation of the line of regression.

The Pupa

The pupa is thin, 8-10 mm long, and enclosed in a loose cocoon about 15 mm long (Plate I, b).

Development and Threshold

Pupation may , as previously noted, occur either inside or outside the plant; it may also occur in the tube previously spun outside the plant, often not necessarily for the purpose of pupation. In such cases, the time of pupation could be accurately established. When pupation took place inside the plant, the tuber had to be opened; in such cases errors could be made in establishing the exact time of pupation. The effect of such errors was probably minimized by the large number of data involved. The term "pupal stage" includes the prepupal period - from cocoon spinning to moulting of the larval skin.

Rates of development of pupae at various temperatures are given in Table 4. Plate I, b shows the regression line drawn from these data. This line crosses the temperature axis at a point close to that for the larva,

namely at 12°C. The threshold of development of both stages thus, apparently, lies between 11 and 12°C.

Table 4. - Development rate of Euzophera pupae at various temperatures

Temperature, in °C	Number of rearings	Total number of individuals	Average development period in days	% of daily development (empiric)	% of daily development (calculated)
13.5	10	27	65.45	1.52	0.91
18	11	58	46.6	2.14	3.34
22	14	98	17.88	5.59	5.50
23	18	63	15.11	6.61	6.04
25.5	41	152	13.92	7.18	7.39
27	22	179	12.56	7.96	8.20
30	5	22	9.80	10.20	9.82

The Adult

The adult (Plate I, c) is 6-8 mm long, with a wing-span of 14-22 mm. The body is yellowish-brown. An undulating brown line runs across the distal third of the forewing; two other lines parallel to this run closer to the side margin. On the disc, close to the first undulating line, is a dark, cocoa-coloured spot. The hind wings are cream-coloured, except for the yellowish veins. There is a brown line at the base of the fringe along the margins of both fore- and hind wings.

Habits

The adults are active at night. The pre-oviposition period was very variable, ranging from 1 to 20 days. Its length naturally, depended upon the temperature, but there were great differences in individuals at the same temperature. At room temperature, at the optimal range of 20-25°C, the majority of the moths (over 75%) began egg-laying 1-3 days after emergence; at 26°C and 30°C the majority of the moths (80%) began laying 2-6 days after emergence (Table 5).

Table 5. - Preoviposition period in days

Temperature in °C	Number of females which began laying after: 1 day	2-3	4-6	7-9	10-12	13-16	17-20	Total numbers females	Average period
30	1	6	5	0	0	0	0	12	3.4
26	6	12	9	0	1	0	0	28	3.2
22	6	8	4	3	5			26	3.27
17-18	1	11	6	2	3	2	1	26	5.79
16	1	2	6	3	0	3	1	16	8.17
10	1	2	6	3	2	2	1	17	7.47

Oviposition

Egg-laying generally lasts from 2 to 4 days. Some females, however, completed oviposition in one day, while others continued to lay for 5 and 6 days. Temperature had little effect upon the length of this period.

The number of eggs laid by one female might be affected, among other factors, by conditions in which the pre-imaginal stages developed. Here, only the effects of different temperatures of the larval period within the optimal range were considered.

The effects of temperature at which larvae were reared, upon egg-laying of the ensuing moths, was investigated by rearing larvae at one temperature, and adults at another. Some temperature combinations were made, as shown in Table 6.

Table 6. - Egg-laying by females which as larvae were reared at one temperature and as adults at another.

Temperature °C at which were reared		Number of females	Number of females laying 0-50 eggs	Average of egg laid
larvae	adults			
22	26	7	3	45
22	26	6	5	
26	26	10	7	107
26	26	4		
22	22	10	5	130
22	22	2	0	
26	22	5	2	
26	22	15	6	133

When larval temperature was 26°C there was no significant difference in egg-laying between adults reared at 22°C or 26°C; but when the larval temperature was 22°C, there was a big difference; moths kept at 22°C laid on the average about 3 times more than moths kept at 26°C.

Fig. 2, A & B shows egg-laying by moths which, as adults, were reared under different temperature conditions; the larvae of the two batches were of the same source, but reared under different conditions, namely, indoors (18°C) and outdoors (14-16°C).

It is evident that the temperature at which the adult lives has a more decisive effect upon egg-laying.

A comparison of egg-laying by moths which were kept at a room temperature above 22°C and those kept at 15°C (Plate 2 C & D), shows the following differences: At the lower temperature (15°C) :

1) there were more non-laying moths; 2) over 50% of the moths laid less than 100 eggs; and 3) none laid more than 200 eggs. At the higher room temperature (22°C): 1) almost all the moths laid; 2) about 50% of the moths laid more than 100 eggs; and 3) 25% laid more than 200, and some, more than 300 eggs. This is also shown by moths of the same generations reared under different temperature conditions (Fig. 2 A & B).

Number of Generations

Under favourable conditions the adult lives about 7-10 days.

Klein (1941) obtained five generations of this moth in the coastal plain in Israel. This was confirmed by the author, who reared successive generations outdoors, always from the first individuals of each generation.

The autumn generation, which started in October, matured in the first days of January, their emergence continuing until April. This generation, arbitrarily called the first, lasted about 120 days. Its offspring, the second generation, matured in May (about 100 days), the third generation matured in July (60 days) , the fourth in mid-August, and the fifth in October (each about 45 days). There may, therefore, be an overlapping of generations, the last adults of the first generation may still be active when the first adults of the second generation emerge.

Abstract

The economic status of Euzophera osseatella Tr. is discussed. Data were obtained from rearings under various conditions, both outdoors and at constant temperatures and humidities. From these, development thresholds were calculated, and found to lie between 9 and 10°C for the egg, at 11.3°C for the larva, and a t 12°C for the pupa.

The length of development at various temperatures is given. At 25°C the egg developed in 7.20 days, the larva in 32.6, and the pupa in 13.5 days.

Egg-laying under various temperature conditions is discussed in detail, and the number of generations obtained in outdoor rearings in Israel, determined.

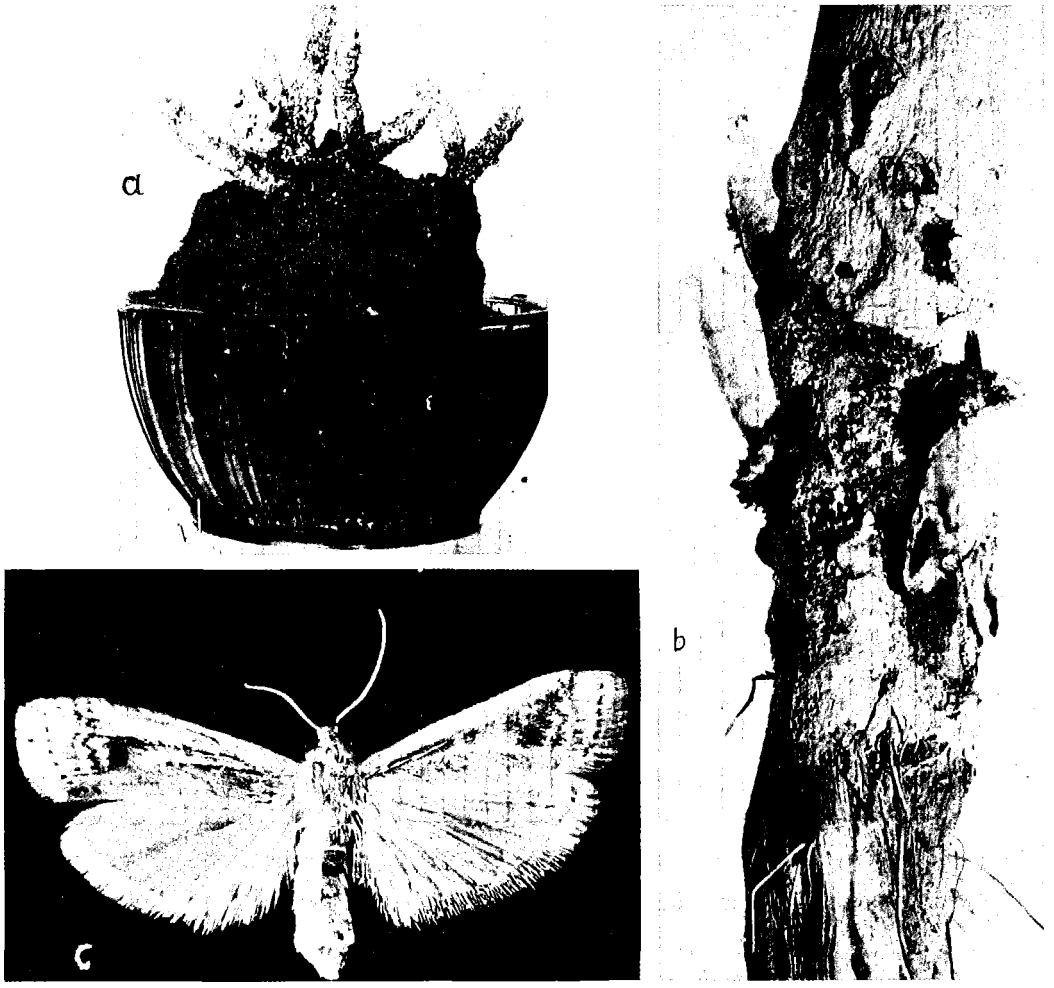
References

1. Bodenheimer, F.S., (1930). Schaedlingsfauna Palestinas. Paul Parey, 439 pp.

2. Klein, H.Z., (1941). The eggplant borer Euzophera osseatella Tr. Hassadeh 21: 143-144 (in Hebrew).

3. Willcocks, F.C. (1922). A survey of the more important Economic Insects and Mites of Egypt. Sult. Agr. Soc. Cairo Bull. 1

PLATE I.



a. Dish with potato on which Euzophera larvae were reared; note the protruding silk tubes spun by the larvae. Tuber kept at 26°C and high relative humidity.

b. Infested root of eggplant; note cocoons on root surface.

c. Female moth of Euzophera osseatella Tr. 3 x enlarged.

PLATE II.

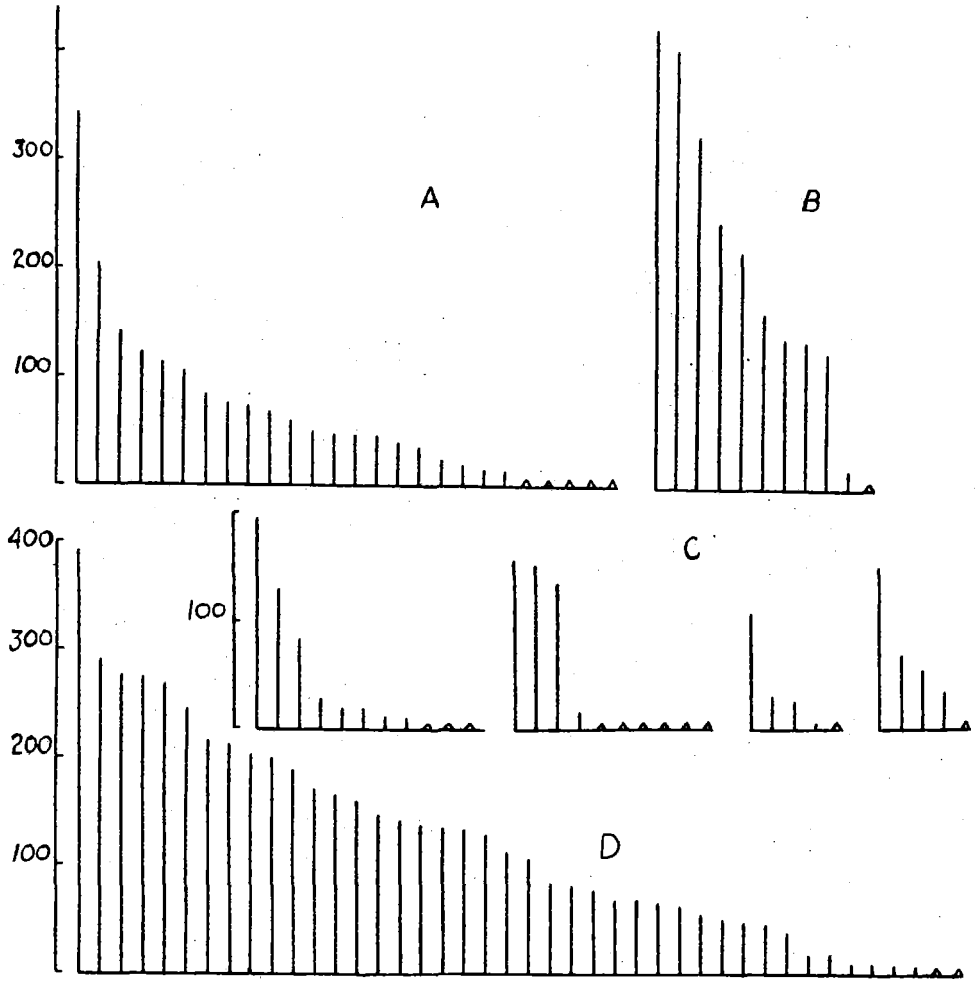


Fig. 6. - Individual records of oviposition by Euzophera females.

Figures at left indicate number of eggs.

A. Larvae reared indoors - average temperature 18°C, adults reared outdoors in February - average temperature 12-16°C.

B. Larvae of the same generation reared outdoors -average temperature 14-16°C, adults reared outdoors in April - average temperature 18-23°C.

C. Larvae reared outdoors at 18-22°C, adults in incubator at 15-16°C.

D. Larvae collected in the field during autumn - average temperature 20-23°C, adults reared indoors - average temperature 23°C.

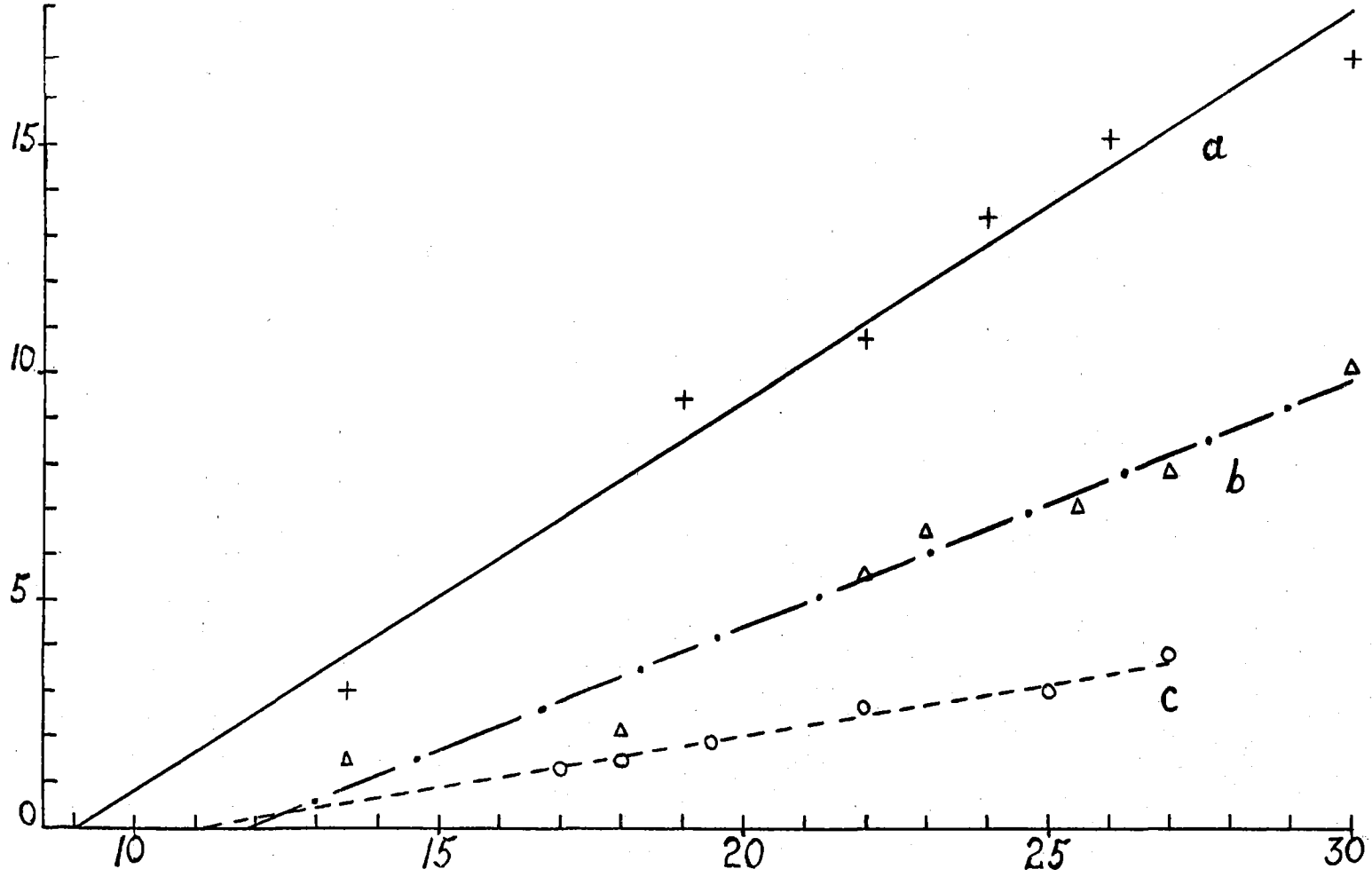


PLATE III.

Regression lines of egg (a), larva (c) and pupa (b) of Euzophera osseatella.