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Biological and Morphometric Characteristics of *Spodoptera litura* (Fabricius) on Soybean under Laboratory Conditions

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Bionomics studies of *Spodoptera litura* (Fabricius) were conducted in the laboratory with soybean as host to study the morphological characters at different stages in its life cycle. Keeping this in view, this study was conducted during 2022-23 at laboratory, Dept. of Entomology, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.). From studies it was found that eggs were spherical in shape and yellowish creamy in colour. First instar larva was pale green in colour and fully grown larva

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changed to dark blackish brown colour with larval period of 15.7 ± 1.34 days. Pupae were dark reddish brown and pupal period lasted for 7.2 ± 0.63 days. The adult moth was brown in colour with a complex pattern of creamish white coloured crisscross markings on the forewings and silvery white hindwings with longevity of 6.5 ± 0.53 days in male, 7.1 ± 0.32 days in female and total life cycle was completed in 32.7 ± 1.32 days. Morphometric studies were also conducted and found that the diameter of egg was 0.43 ± 0.02 mm. Fully grown larva was about 35.85 ± 1.57 mm in length and 4.32 ± 0.15 mm in width. Pupa was having 14.84 ± 0.83 mm length and 4.11 ± 0.23 mm width. The female moth had body length of 16.20 ± 1.03 mm and wing span of 32.97 ± 1.39 mm whereas, male moth had body length of 15.30 ± 1.16 mm and wingspan of 32.11 ± 0.92 mm.

Keywords: Biology; morphometrics; Spodoptera litura; soybean.

1. INTRODUCTION

Soybean, *Glycine max* L. Merrill, is known as the "wonder crop", "Golden Bean" of 20th century, "miracle crop" of 21st century, "gold from soil" and "cow of the field" in light of its different uses. Insect pests are the major drawbacks in realising the yield potential. During early seventies, soybean was considered to be the safest crop with regard to insect pest attack, but with rapid increase in area under soybean, its extension to newer areas added the new insect pests which are causing great concern to its productivity.

Lepidopteran pests are the main hazard to soybean crop, calling for increased management attention. Among them *Spodoptera litura* is a polyphagous pest and has been reported on about 112 cultivated plants. *S. litura* may cause an economic loss ranged from 25.8 - 100% [1]. Pest consumes the leaves of developing plants as well as their pods, stems and roots. The tobacco caterpillar, *Spodoptera litura* (Fab.), is a serious and devasting pest in soybean crop. Its damage is in peak from mid -August to October due to preference of feeding young foliage [2]. The study of biology and morphometrics of insect helps us to know the stages of the insect and also helps in identifying the presence of insect in the field. It further helps in planning the pest control tactics in the early stage which prevents the pest from reaching the economic injury level by identifying the key mortality factors. Keeping this in view, this study was conducted during 2022-23 at laboratory, Dept. of Entomology, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.).

2. MATERIALS AND METHODS

In order to study, biology of *S. litura* on soybean, initial culture of egg masses was collected from soybean fields of Research Cum Instructional Farm at IGKV, Raipur (C.G.). To study biology and morphometrics of *S. litura,* mass multiplication of *S. litura* was taken up. For this purpose, the egg mass was collected and transferred to a clean container by providing healthy soybean leaves with petiole. The leaf was kept in the plastic container containing moist filter paper to keep it fresh. This served as immediate source of food for the first instar larvae. Leaf along with the egg mass was transferred to pre sterilized transparent rearing boxes. The leaf was changed when the larvae entered into the next instar. There after rearing boxes were cleaned with 2 per cent formaldehyde, shade dried and fresh leaves were given every day till the larvae entered into the last instar larval stage.

These late larval instars were collected from containers and released in to another plastic container having soil for pupation. Pupae thus obtained were collected and kept in rearing boxes. During the process, male and female pupae were separated based on external genitalia. These pupae were kept in separate rearing chamber for adult emergence. As a source of food for newly emerged adults honey solution was provided. Totally ten specimens were killed and later transferred in to blotting paper for removing moisture. Later, observed for calculating average length and width from each individual stage of insects using stereo zoom binocular microscope and vernier callipers.

3. RESULTS AND DISCUSSION

3.1 Biology of Tobacco Caterpillar *Spodoptera litura* (Fab.). on Soybean

Studies were carried out on tobacco caterpillar, *S. litura* which was reared on soybean under laboratory conditions for observing biological parameters *viz*., incubation period, larval period from first to fifth instar, total larval period, pupal period, adult male and female longevity, total

developmental period and results were presented in the Table 1.

3.2 Morphological Description of *Spodoptera litura*

Egg: In the laboratory, oviposition occurred during night. The eggs were covered with yellowish brown hairs (Fig. 1) and the hairs seen earlier as present on the abdomen of the adult females were not seen after oviposition confirming that the female had dropped the abdominal hairs after oviposition to cover the laid egg mass. On removal of the hairy mass, it was seen that the eggs were laid one over the other in three layers. Eggs were spherical in shape and yellowish creamy in colour.

Hatching of the eggs was observed in the early morning hours after 3.00 ± 0.00 days and few hours prior to hatching, colour of the egg mass changed from yellow to dark black because of the growing embryo inside the egg. Similar results were obtained by Balasubramanian et al. [3] recording incubation period as 3.5 days, 4 days by Kandagal and Khetagoudar [4] and 5 days by Cardona et al. on castor [5] which were similar with present finding that was 3 days.

Larvae (Fig. 2):

First instar larvae: The neonate larvae were pale green in colour with dark black head having distinctly visible black hairs on the body and tiny black spot on first abdominal segment and larvae were found to be feeding gregariously because the eggs are laid in masses and when a large number of larvae gather, it becomes difficult for their predators to detect or reach them easily. This is important for their survival and safety. First instar larval period lasted for about 2-3 days on soybean with an average of 2.3 ± 0.48 days.

Fig. 1. Egg masses of *Spodoptera litura*

Table 1. Biology data of tobacco caterpillar, *Spodoptera litura* (Fab.) on soybean

S. No	Stage of insect	Minimum value in days	Maximum value in days	Mean in days	±Standard deviation
1	Egg Incubation period	3	3	3	0.00
2	Larva				
a	1st instar	2	3	2.3	0.48
b	2nd instar	2	3	2.6	0.52
c	3rd instar	3	4	3.5	0.53
d	4th instar	3	4	3.7	0.48
e	5th instar	3	4	3.6	0.52
f	Total larval period	13	18	15.7	1.34
3	Pupal period	6	8	7.2	0.63
4	Adult				
a	Male	6	7	6.5	0.53
b	Female	7	8	7.1	0.32
c	Average	6.5	7.5	6.8	0.35
	Total life cycle	29.5	34.5	32.7	1.32

Fig. 2. Different larval instars of *Spodoptera litura*

Fig. 3. Just moulted Pupa

Second instar larvae: The second instar larvae appeared pale green in colour and were hairless. The first and second instar larvae were found scraping the chlorophyll of the leaves converting the lamina into a papery form. After moulting, the second instar larvae began to develop by dispersing to feed individually. This change in behaviour may be related to the growth and development stages during the life cycle. The mean duration of the second instar larvae was 2.6 ± 0.52 days. This range is definitively defined and therefore limited during this period of the life cycle.

Third instar larvae: The body colour of the larvae in the third instar changes to the current green colour with broad black spots and spots in the form of a crescent. This body colour may have a protective and camouflage function. Three stripes are present on the surface of the larvae from the mouth to the posterior end of the abdomen. This hypothetical feature may be part of the behaviour or interaction with the environment. The larvae in the third instar rest for 3-4 days with an average of 3.5 ± 0.53 days. This framework is based on adaptation to the following stages, and then to the fixed pattern during the life cycle

Fourth instar larvae: Larval body colour changes from green to black to take with the habitat. This colour may aid in camouflage and benefit predation at this stage. The colour of the posterior band changes, with the central multicoloured band becoming bright and the lateral band yellow. This change may be part of behaviour and interactions. Large areas appear along each lateral yellow band. These hypothetical features may have a function in medial protection. Laboratory duration of fourth instar larvae is 3–4 days with amean of 3.7 ± 0.48 days. This framework builds on evidence from previous stages and confirms the following pattern throughout the entire period.

Fifth instar larvae: After fourth moult, colour of the larvae changed to dark blackish brown with three lines or bands as mentioned above. The black intermittent spots clearly appeared dorsally

along each lateral yellow band from anterior to posterior part of the body and the appearance of the black instar along the fire bands may have a warning or deterrent function to alert predators. The fifth instar larval period lasted for about 3-4 days with an average of 3.6 ± 0.522 days. The third, fourth and fifth instar larvae were voracious feeders eating the whole leaf blade leaving only the midrib intact and the total larval period lasted for about 13 to 18 days with average of 15.7 ± 1.34 days on soyabean indicating the complex need for this crucial stage of the life cycle before the larva transforms into a pupa.

Similar observations were made by Cardona et al*.* [5] where *S.litura* has completed its larval period in 23.9 ± 0.71 days on castor. However, the shortest period as observed in the present study might be due to the effect of variation in environment especially temperature during rearing period and the host plant used. Similarly, Bae [6] examined the larval, pupal and adult longevity of *S. litura* on 11 host plants, including soybean, they found that soybean had the shortest larval duration (11.5 days).

Prior to pupation, the mature larvae curled into C-shape and the prepupal period lasted for about half day to one day. Larvae after shedding its last larval skin becomes prepupa and first it was green in colour (Fig. 3) and in later stages it changes into yellow colour and then into pale brown and brown colour.

Pupae: The pupal stage begins with a noticeable colour change, as the pupal colour changes from pale yellow to the classic red. This colour has already become biological and structural and speaks of the transformation of the body within the insect during this necessary stage of the life cycle. The male pupa showed genital aperture on 9th abdominal segment. Likewise, the female pupa had genital aperture on 8th abdominal segment was observed (Fig. 4). The pupal period lasted for 6-8 days with an average of 7.2 ± 0.63days. The length of the pupal period may have an impact on the growth and final maturity of the insect, and may play a role in the adaptation and survival of this species in different environments.

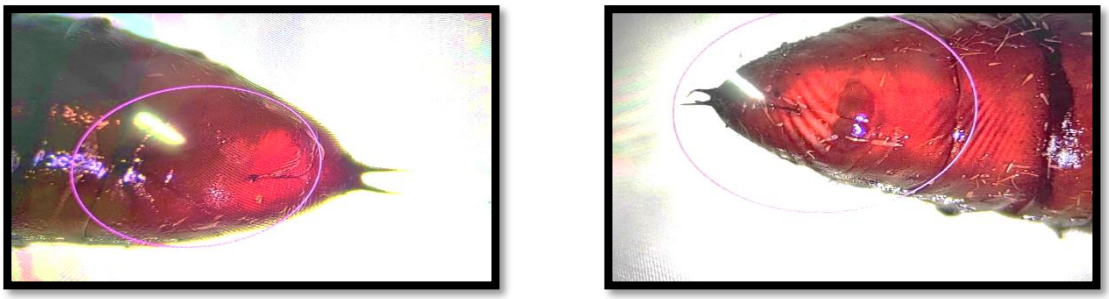

Fig. 4. Genital opening of female and male pupa of *Spodoptera litura*

Fig. 5. Male and female adult moths of *Spodoptera litura*

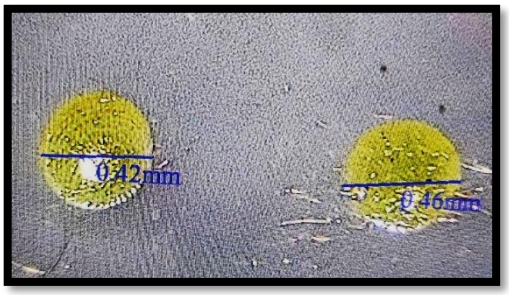

Fig. 6. Egg diameter of of *Spodoptera litura*

Fig. 7. Adult wingspan of *Spodoptera litura*

Table 2. Morphometric data of the life stages of tobacco caterpillar, *Spodoptera litura* (Fab.) on soybean

S. No	Stage of insect	Minimum value in mm	Maximum value in mm	Mean in mm	±Standard deviation
1	Egg diameter (Fig. 6)	0.4	0.46	0.43	0.02
2	Larva				
a	1st instar				
	Length	1.39	1.52	1.46	0.04
	Width	0.21	0.24	0.23	0.01
b	2nd instar				
	Length	3.75	5.14	4.60	0.49
	Width	0.39	0.58	0.47	0.06
c	3rd instar				
	Length	10.31	12.63	11.54	0.67
	Width	1.42	1.57	1.47	0.06
d	4th instar				
	Length	19.10	23.12	21.55	1.33
	Width	2.80	3.40	3.10	0.16
e	5th instar				
	Length	33.90	37.80	35.85	1.57
	Width	4.10	4.60	4.32	0.15
3	Pupa				
	Length	13.50	16.30	14.84	0.83
	Width	3.70	4.50	4.11	0.23
	Weight in gm	0.17	0.26	0.20	0.03
4	Adult				
a	Body length				
	Male	14.00	17.00	15.30	1.16
	Female	15.00	18.00	16.20	1.03
b	Wing span (Fig. 7)				
	Male	30.20	33.10	32.11	0.92
	Female	30.50	34.70	32.97	1.39

In support of present result, Kandagal and Khetagoudar [4] also reported male and female pupal period ranging from 8-9 and 9-12 days, respectively. On contrary some researchers also reported pupal period as 17.80 **±** 2.33 days on castor [5].

Adult: The adult moth was brown with a complex pattern of whitish creamy coloured crisscrossing markings on the forewings. The hind wings were silvery white in colour. The males had a prominent white band on forewings unlike female and male adults were somewhat bright coloured than female (Fig. 5). Adult male longevity was 6 to 7 days with an average of 6.5 ± 0.53 days and female ranged from 7 to 8 days with an average of 7.1 ± 0.32 days. This suggests that some individuals lived similarly compared to males. The entire life cycle of *S. litura* was completed in 29.5 to 34.0 days with an average of 32.7 ± 1.32 days under laboratory conditions. This is same with previous observations on other crops such as peanuts, cotton, bananas and cabbage, where the cycle of insect reached between 24 and 39.8 days.

This information on characteristics and life cycle is useful for understanding the dynamics of this insect pest. Present results are similar with the observations of Thippeswamy [7] where life cycle of *S. litura* ranged from 27.89 to 35.23 days on groundnut, 24 days on cotton by Patel et al. (1986), 39.80 ± 1.88 days on banana by Abhishek and Patel [8], and 35.44 (male) and 36.04 (female) days on cabbage by Ashwini et al. [9]. Total male and female life span were 31.40 + 2.03 and 33.4 + 2.15 days as reported by Bhumika et al. [10]. Similarly, Ramaiah and Uma [11] also reported incubation period was 3.00 ± 0.00 days, larval period was 13.50 ±3.54 days and pupal period lasted for about 7.00 ± 0.00 days for male and 8.00 ± 0.00 for female. Male and female adults survived for 6.50 ± 0.71days and 8.00 ± 1.41 days, respectively and total developmental period lasted for 32.13 ± 5.48 days. Divya et al., [12] reported that the total lifecycle ranged from 34.66±.11.83 days which are on par with the present results.

Morphometric data of *Spodoptera litura* on soybean: Morphometric data of *S. litura* was recorded using binocular microscope and vernier calliper were presented in Table 2.

Similar studies on morphometrics of *S. litura* were conducted on different hosts including grapevine [13]. Nagal and Agarwal [14] who have recorded diameter of the egg as 0.87 mm and 0.47 mm, respectively which was found as 0.43 mm in the present study where the size of the egg was found smaller than the above-mentioned results which might be due to change of host.

Similarly, the length of the larval body from first to fifth instar was recorded as ranging from 1.39 to 37.80 mm and width from 0.21 to 4.60 mm which coincided with the observations made by Vashist and Chandel [15] as 1.54 to 38.90 mm and 0.24 to 5.55 mm and Jadhav et al. [13] as 1.53 to 38.48 mm and 0.23 to 5.98 mm and Ashok and Pavithran [16] as 0.61-24.99mm and 0.12-4.42mm. As sixth instar was not observed in the present study, observations could not be recorded though it was observed by Vashist and Chandel [15] and Nagal and Agarwal [14].

With regard to pupa, the average length was 14.84 mm where similar observation as 15.37 mm and 14.27 mm made observed by Jadhav et al. [13] and Nagal and Agarwal [14]. Similarly, wing span of adults was recorded as 32.00 mm where it was 29 to 39 mm by Jadhav et al. [13] and 34.90 to 39.02 mm by Nagal and Agarwal [14] and 35.10 to 38.73 mm by Rishabh et al. [17] confirming the present results.

4. CONCLUSION

From the biology studies it was found that eggs were spherical in shape and yellowish creamy in colour. First instar larva was pale green in colour and fully grown larvae changed to dark blackish brown colour. Pupa were dark reddish brown. The adult moth was brown in colour with a complex pattern of creamish white coloured crisscross markings on the forewings and silvery white hindwings. The entire life cycle of *S. litura* was completed in 32.7 ± 1.32 days under laboratory conditions on soybean. This clear information on the external appearance and dimensions at different life stages provides a comprehensive picture of the dynamics of this pest in the laboratory.

Morphometric studies revealed that the diameter of egg was 0.43 ± 0.02 mm. Fully grown larva was about 35.85 ± 1.57 mm in length and 4.32 ± 0.15 mm in width. Pupa was having 14.84 ± 0.83 mm length and 4.11 ± 0.23 mm width. The female moth had body length of 16.20 ± 1.03 mm and wing span of 32.97 ± 1.39 mm whereas male moth had body length of 15.30 ± 1.16 mm and wingspan of 32.11 ± 0.92 mm. Overall, these detailed data on the morphological features at different stages of the life cycle provide a comprehensive picture of the entire structure of this pest biology.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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