



Biology and morphometric of shoot and fruit borer (*Leucinodes orbonalis* Guenee) on brinjal crop under laboratory conditions

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Summary

The study on the biology of shoot and fruit borer was carried out in the Research Laboratory of the Department of Entomology, College of Agriculture, CAU, Imphal, India, Kharif season during 2021-22. White, creamy eggs with an oval to elongated shape were placed singly in bunches. On food made from brinjal, the incubation period for the brinjal shoot and fruit borer ranged from 3-7 days, with a mean time of 4.4 ± 1.26 days. The average larval time varied from 13-20 days with a mean duration of 16.8 ± 2.41 days in the brinjal food portion under laboratory conditions. The larvae were white to dark pinkish throughout the instars to become fully grown. It took an average of 9-15 days for a pinkish to dark brown pupa to develop, and between 6 and 8 days for the pupa to mature into an adult. The adult moths were little with whitish wings, and they lived an average of 5.4 ± 1.50 days for female and 2.95 ± 0.98 for male adults, ranging from 4.0 to 5.5 days during the experiment. As a result, the entire life cycle was completed in a brinjal diet ranging from 31 to 39 days, with a mean time of 34.9 ± 2.19 days. During the trial, the male-to-female ratio ranged from 1 to 2, with an average ratio of 1:2 in a lab setting.

JAE Special Issue 2023, Vol 16

Received: 08 May 2023

Accepted: 25 June 2023

Published: 31 July 2023

<https://doi.org/10.58628/JAE-2316-214>

Associated Editor: Dr. BL Jakhar

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Keywords: Shoot and fruit borer, Incubation period, Larvae, Pupa, and Brinjal

Introduction

A significant solanaceous crop farmed throughout the majority of India year-round is brinjal, often known as aubergine or eggplant (*Solanum melongena* L.). Because of its nutritional, therapeutic, and commercial importance, brinjal, the king of vegetables, is a significant crop. As a diuretic, to treat atherosclerosis, diabetes, arthritis, and communication circuit and precaution syndrome, aubergine is utilised (Alam et al. 2003; Alam & Sana 1962; Akshay et al. 2018). In several nations, including Central, South, and South East Asia, some regions of Africa, and Central America, brinjal is one of the most extensively grown vegetables (Harish et al., 2011). In India, it is cultivated over an area 749 thousand hectares with a production of 12874 metric tonnes in year 2021 (Agricultural Statistics At A Glance, 2021). West Bengal is the highest producer in India and other states like Karnataka, Orissa, Andhra Pradesh, Bihar, Maharashtra and Uttar Pradesh (Horticultural Statistics At A Glance, 2018). In Manipur, total 129 hectares of land has been recorded for brinjal cultivation with a production of 1641 metric tonnes (GoM-2021). In Manipur brinjal is popularly known as "khamen". The higher yield and longer fruiting and harvesting period lure the farmer into eggplant production (Ghimire and

Khatriwada, 2001). However, eggplant production is in threat in recent years due to increased cost of production on management of insect pest complex. A total of 17 insect pests and natural enemies in 6 orders and 12 families i.e. *Aleurodicus dispersus* (Russel), *Aphis gossypii* (Glover), *Toxoptera aurantii* (Boyer de Fonscolombe), *Amrasca biguttula biguttula* (Ishida), *Bemisia tabaci* (Gennadius), *Paracoccus marginatus* (Williams and Granara de Willink), *Thrips palmi* (Karny), *Epilachna vigintioctopunctata* (Fabricius), *Leucinodes orbonalis* (Guenee), *Eublemma olivacea* (Walker), *Altica* sp (Geoffroy), *Cheilomenus sexmaculatus* (Fabricius), *Coccinella transversalis* (Fabricius), *Micraspis discolor* (Fabricius), *Oxyopes* sp (Latreille) *Hippasa* sp (Simon) and *Trathala flavoorbitalis* (Cameron) were recorded in the brinjal ecosystem. Also, *Aphis gossypii* (Glover), *Bemisia tabaci* (Gennadius), *Thrips palmi* (Karny), *Epilachna vigintioctopunctata* (Fabricius) (Haldhar & Maheshwari 2021). *L. orbonalis* (Guenee) were found to be the major pests of brinjal which is in accordance with the findings of (Dominic et al. 2019; Soren et al. 2020).

The brinjal shoot and fruit borer has been reported to be a serious pest that reduces crop yield by up to 70% and causes massive production losses (Singh & Nath 2010). This pest's host range is extremely broad. Aside from brinjal, it also affects other solanaceous plants such as *S. tuberosum* L. (Potato), *S. aculeatissimum* Jacq. (Indian nightshade), *S. indicum* L. (Black nightshade), *S. myriacanthum* Dunal (Kota bengena), *S. torvum* Swartz (Turkey berry), *Lycopersicon esculentum* Mill (Tomato) and some weeds also. This pest is active during the rainy and summer seasons and has a distinct

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feeding pattern. The larva bores into the shoots during the early stages of crop growth, causing drooping, withering, and drying of the affected shoots due to disruption of the vascular system and translocation of food materials. The larvae bore through the calyx and later into the flower buds and fruits at later stages of plant growth, and the bored holes are invariably plugged with excreta (Butani & Jotwani 1984; Haldhar & Deshwal 2017). Because of the loss of quality, the infested fruits become unfit for human consumption and lose market value. A biology study was undertaken in the laboratory conditions to record the various data in the life cycle of the Brinjal shoot and fruit borer.

Materials and Methods

The Brinjal Shoot and Fruit Borer biology study was conducted in the Research Laboratory of the Department of Entomology, College of Agriculture, CAU., Imphal, Manipur, India. From the experimental field a large number of infested brinjal were collected from these brinjal larvae of BSFB were collected (Fig 1) and these larvae were kept separately in 3"1" clean glass tubes. Fresh brinjal fruits were cut into small pieces and placed in glass tubes daily to feed developing larvae (Fig 2). Brinjal fruit pieces were changed daily and the glass tubes were cleaned with ethanol to avoid fungal and microbial pathogenic growth. test tubes were closed with

the help of muslin cloth and tied with a rubber band. As larvae reached the fifth instar, that can be seen by the change in colour of larvae (Fig 3) and its size a folded and grooved paper was placed in each glass tubes to ensure a trouble-free pupation (Fig 4). A glass jar measuring 360 mm by 150 mm and covered with muslin cloth was used to catch the newly developed pupae (Fig 5) and transport them there for adult emergence (Fig 6). The male and female moths were removed from the jar individually, placed in pairs in another glass jar, and covered with muslin cloth. To feed the adults, a cotton piece soaked in a 5 percent honey solution was hung through a muslin cloth with thread. A delicate brinjal twig was placed inside a glass jar with a 50 ml beaker of water for egg laying. As many of the eggs were found to adhere to the glass jar walls, they were counted and stored in glass jars as such after being collected from these female moths. With the aid of a soft camel hair brush and very thin pieces of brinjal, the newly hatching larvae were placed in petrified plates. The brinjal slice was fed to the larvae starting in the second instar and replaced daily (Haldhar et al. 2013; Haldhar & Maheshwari 2018). Every day up until adult emergence, *L. orbonalis* growth and development were observed. A fine camel hair brush was used to carefully remove the eggs that had been left on the glass chimneys.



Figure 1. Infested Brinjal with larvae of BSFB



Figure 2. Glass tubes with larvae and fresh-cut brinjals



Figure 3. 5th Instar Larva

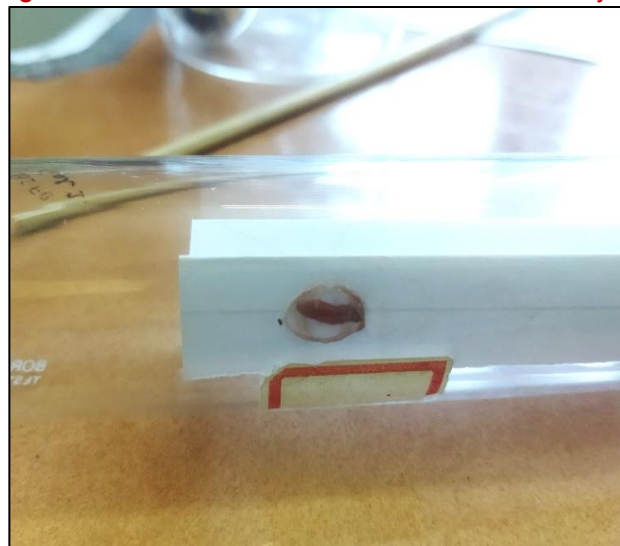


Figure 4. Pupating larva



Figure 5. Pupa of BSFB larvae

Incubation period

For the Incubation period the number of eggs was counted properly and kept on separate Petri dishes with several replications, the number of days it took from egg being laid to hatching were recorded as the incubation period, along with this hatchability percentage was also recorded.

Larval Period

For the study of the larval period, each larvae were placed in each test tube with the feeding of soft pieces of brinjal, larvae of first instar were kept along with soft leaves and tender buds of brinjal. For the second and third instar larvae of *L. orbonalis* soft fruits of brinjal were provided. the feeding was changed daily to avoid microbial infestation and a water-soaked piece of cotton was also placed to avoid larval desiccation and also to maintain the humidity. These test tubes were maintained till the larvae achieved the fifth instar and were about to pupate. Each larval instar's duration was recorded. From hatching to initiation of pupation was taken as the larval period.

Pupal Period

When the larvae pupated inside the glass tube, it was undisturbed for its cycle completion. And when the adult emerged from it then, the adult was separated out for further investigation. The period required from the pupal formation till the eclosion of the adult stage was counted as the pupal period.

Adult Longevity

To study the longevity of adults, the newly emerged moths were kept in glass chimneys and a ten per cent sugar solution was provided as food. From the eclosion of the adult to the death period required was counted as longevity of the adult.

Sex Ratio

Emerged adults were observed with a total sex ratio of 2.1:1 female and male, respectively.

Based on the visual characters like variation in abdomen with projections in the female and the bigger size of the female than that of male, the insect was separated sex wise for sex ratio. The minute egg and 1st Instar images were captured using microscope.

Morphometrics studies of various stages of *L. orbonalis*

External morphology was observed and described based on the body's colour, shape, and marks. The morphometric determination was taken from 10 individuals for each stage. The measurements include i) width and length of egg, ii) body length and width of the



Figure 6. Emerged adult from the pupa

larvae, iii) width and length of the pupae, iv) width and length of both adult moths, v) wingspan length of both adult male and female moths. As the egg's shape is about oval and not round, the breadth of the egg was measured at the broadest part, which is perpendicular to the longest part (length).

The determination of breadth for pupae were measured at the widest part of the body while body length was measured from the tip of the cephalic capsule until the edge of the posterior end. The adult's wingspan was measured between the two forewing tips in a straight-line on the wingspread position. In addition, for adult's body length measurement, the distance from the edge of the head until the edge of the abdomen.

Results and Discussion

The current study on the biology of brinjal shoot and fruit borer was done in laboratory conditions using the variety "Pusa Purple Long". The laid eggs on the leaves were collected and examined under a microscope, eggs were seen as creamy white in colour with a blunt oval shape. As the eggs mature, they become orange with a black spot at the tip. The incubation period varied from 3-7 days with a mean duration of 4.4 ± 1.26 days. These results are in accordance with the observations of Ghosh & Senapati (2001), who reported a mean incubation period of 5.23 days on brinjal. The present findings are also in accordance with the findings of Mehto et al. (1983), Jat et al. (2003), and Singh & Singh (2003), who reported incubation periods of 5.4, 4.30 and 5.65 days. Slight variations in the duration may be due to variation in the host on which the previous generation of the moth was reared, which might have contributed to this in the next generation. The total hatching percentage of eggs collected is found to be in the range of 65.22-94.74, with a total mean percentage of 82.46 ± 8.56 . The results are in accordance with Hung et al. (2020), who reported that the hatching percentage of 85.92 ± 12.17 . The newly hatched larva was creamy white, while the full-grown larva was cylindrical and pinkish. The head of the larva was dark brown and had strong mandibles for mastication. The thorax of the larva showed three distinct segments with a pair of well-developed thoracic legs on each segment. The abdomen had ten segments and five pairs of prolegs. The total duration of the larval period varied from 13-20 days, with a mean duration of 16.8 ± 2.41 days. These results also showed similarity to the findings of Radhakishore et al. (2010), who reported that the total larval period varied from 15-18 days. The

present findings are also in accordance with the findings of Ghosh & Senapati (2001), who reported that the range of larval period varied from 14 to 18 days.

The full-grown larva emerged from the infested shoots and pupated in the dried shoots and leaves in tough silken cocoons. The mean pupal period in 'Pusa Purple Long', the pupal period varied from 9-15 days with a mean duration of 12.3 ± 1.76 days. The dark brown pupa has a wider cephalic and narrow anal and eight hook-shaped fine spines at the posterior end of the abdomen. The result agrees with Wankhede et al. (2009), who reported a pupal period of 7-14 days with a mean of 10.2 ± 0.36 . Pupation took place on the glass jars, soil, muslin cloth, and sometimes inside the fruits and on the leaves of the plants.

The total development period includes the number of days it took to hatching of eggs to larvae, the larval period and a number of days it was in the state of pupation. In this experiment, it has been noted that the total development period for BSFB is 34.9 ± 2.19 days which ranges from 31-39 days. The results follow Bindu et al. (2015), who reported a total development period of 32-37 days with a mean of 35.2 ± 1.72 . The adult moth was of white colour with a head and thorax covered with greyish and brown scales. The forewings were creamish white with large patches of light brown colour over them. In the case of the hind wing, a faint black wavy line was observed close to the apical margin. The wings were slightly fringed at the margins. The female moth was generally larger than the male and had a tuft of hair at the tip of the abdomen. The Sex ratio of the number of emerged adults is found to be in the ratio of 2.1:1. The results are in accordance with Sharma et al. (2017), who reported a sex ratio of 2:1.

The pre-oviposition period is the period before the oviposition of the first egg. The pre-oviposition period was found to vary from 1-2 days with an average duration of 1.55 ± 0.43 days in 'Pusa Purple Long'. These results are in accordance with those of Sharma et al. (2017), who reported a pre-oviposition period of 1.20 days and are also in agreement with the findings of Rohokale et al. (2018), who reported the pre-oviposition averaged 1.50 days. The period of egg laying after the pre-oviposition period till the termination of egg laying was considered the oviposition period. The oviposition period was found to vary from 2-4 days with an average duration of 2.7 ± 0.75 days in 'Pusa Purple Long'. These results are more or less in agreement with those of Sharma et al. (2017), who reported that the mean oviposition period averaged 2.00 days.

Fecundity is described as the number of eggs that the female insects are laying in the total life span, the fecundity that is found in this experiment ranges from 80-123 with a mean of 99.3 ± 15.10 eggs per female. The results are in accordance with Rohokale et al. (2018), who reported that fecundity 86-109 with a mean of 93.40 ± 6.50 .

Females lived longer than males. The mean longevity of the ovipositing female was 5.4 ± 1.50 days, ranging from 4-8 days in 'Pusa Purple Long'. The mean longevity of the male was 2.95 ± 0.98 days which varied from 2-5 days in 'Pusa Purple Long'. These results are in accordance with those of Rohokale et al. (2018), who reported the longevity of male and female as 4.1 days and 6.4 days, respectively, but contrary to the findings of Ghosh & Senapati (2001), who observed that male longevity was 2.87 days while the female longevity was 5.17 days.

Table 1. Developmental period of different life stages of *Leucinodes orbonalis* Guenee

S. No.	Biological Parameter	Duration (Days)	
		Brinjal	
		Range	Mean $\pm$ SD
1	Incubation period	3-7	4.4 ± 1.26
2	Hatching percentage	65.22-94.74	82.46 ± 8.56
3	Larval period		
	1 st instar	2-5	3.95 ± 0.92
	2 nd instar	1-4	2.3 ± 0.94
	3 rd instar	2-4	3.2 ± 0.67
	4 th instar	2-5	3.55 ± 0.98
	5 th instar	2-5	3.8 ± 1.03
	Total larval period	13-20	16.8 ± 2.41
4	Pre-pupal period	1-2	1.4 ± 0.45
5	Pupal period	9-15	12.3 ± 1.76
6	Total development period	31-39	34.9 ± 2.19
7	Adult longevity	Female	5.4 ± 1.50
		Male	2.95 ± 0.98
8	Pre-oviposition period	1-2	1.55 ± 0.43
9	Oviposition period	2-4	2.7 ± 0.75
10	Post-oviposition period	1-2	1.45 ± 0.43
11	Fecundity	80-123	99.3 ± 15.10
12	Sex ratio (F/M)	2.1:1	

The instars were differentiated based on the larvae's body shape, size and body colour. Eggs were elliptical in size, with a length of 0.93 mm and 0.56 mm in width. The

mean body length of 1st instar measured was 3.62 mm, and the body width was 0.50 mm, the second instar's body length measured was 6.22 mm and the body width

were 0.90 mm. The third instar was bigger in size than the second instar, with a body length of 10.66 mm and a body width of 1.29 mm. The fourth instar's body length was 14.02 mm and its width was 1.72 mm. The fifth instar's body length was 16.45 mm and 2.07 mm in width. The pupae have a total length of 12.28 mm and width of 5.73 mm. (This data suggests that the larvae shrink during the pupation). An adult female was found

to be bigger in length than the adult male, with a size of 11.51 mm and a width of 3.90 mm, while an adult male had a length of 9.40 mm and a width of 3.24 mm. Wingspan length of female was 21.80 mm and male has wingspan length of 18.25 mm. All the results are in accordance with Onekutu et al. (2013) and Hung et al. (2020).

Table 2. Body measurements (mm) of the life stages of *Leucinodes orbonalis* Guenee

S. No.	Morphological Parameters	Measurements (mm)	
		Body length	Body width
		Mean±SD	Mean±SD
1	Egg	0.93±0.06	0.56±0.06
2	I st Instar	3.62±0.60	0.50±0.08
3	II nd Instar	6.22±1.04	0.90±0.13
4	III rd Instar	10.66±1.31	1.29±0.27
5	IV th Instar	14.02±1.42	1.72±0.25
6	V th Instar	16.45±1.04	2.07±0.49
7	Pupa	12.28±1.32	5.73±0.54
8	Adult (female)	11.51±0.80	3.90±0.60
9	Adult (male)	9.24±0.81	3.24±0.92
10	Adult wingspan (female)	21.80±1.73	
11	Adult wingspan (male)	18.25±1.11	

Conclusion

The biological research on shoot and fruit borer in brinjal during kharif season revealed that the total life cycle of shoot and fruit borer was completed in 37.85 and 40.3 days in male and female respectively and the mean fecundity of this pest was recorded as 99.3 eggs per female. Eggs are oval or ellipsoidal in shape and are initially white and later turn into yellowish in colour as it matures. The adult moth of *L. orbonalis* is white with dark brown streaks. The front wing is triangular with 3 points of pink or dark brown. The rear wing is shorter and narrower than the front one. The larval period completed in four instars of stage. The pupae are iridescent dark brown nymphs, when they are about to turn into adults, they are dark brown in color. Consequently, conditions were found during this season favorable for the growth and development of *L. orbonalis*.

Declaration of interests

The authors have no conflict of interest to declare.

Data sharing

All relevant data are within the manuscript.

Acknowledgments

All sort of assistance rendered by Dean, College of Agriculture, CAU, Imphal, Manipur, India for the above study is gratefully acknowledged.

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