

# BIOLOGY OF BRINJAL SHOOT AND FRUIT BORER (*LEUCINODES ORBONALIS* G.) IN LOW HILLS OF HIMACHAL PRADESH

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## ABSTRACT

The brinjal shoot and fruit borer (*Leucinodes orbonalis* G.), a major pest in brinjal (*Solanum melongena*) cultivation, poses a significant threat to the yield and quality of eggplant worldwide. This insect pest, native to South Asia, has spread across various regions of Asia and Africa, causing severe economic losses. The pest shows a complex life cycle consisting of egg, larval, pupal, and adult stages. The pest attacks both the shoot and fruit of brinjal plants, leading to direct damage, reduced marketability, and loss of revenue for farmers. Studies shows that the pest can cause up to 60% to 70% reduction in yield and in severe infestation, significantly affects both the quality and quality of brinjal fruits. This study was conducted in the department of Entomology, College of Horticulture and Forestry, Neri (Hamirpur), Himachal Pradesh during the year of 2020-21. Our results show the pest's ability to adapt to various environmental conditions, and its rapid reproduction rate make it challenging to control. This paper provides a complete understanding regarding the biology of brinjal shoot and fruit borer, with a particular focus on its life cycle.

**KEYWORDS:** Eggplant, shoot and fruit borer, biology, life cycle, larval stages

## INTRODUCTION:

The brinjal (*Solanum melongena* L.), often known as eggplant, is among the most widely grown vegetables across the globe. Its importance spans multiple regions, especially in South Asia, Southeast Asia, and Africa, where it forms a crucial part of the agricultural landscape. Eggplant is rich in nutrients such as dietary fiber, vitamins, and minerals, making it an edible food crop for multitudes (Ghosh 2022). Despite its widespread cultivation, the brinjal shoot and fruit borer, (*Leucinodes orbonalis*), is the most damaging and persistent (Abhishek and Dwivedi 2021). The *Leucinodes orbonalis* is an important pest of eggplant, inflicting severe injury to both vegetative and reproductive parts of the plant (AVRDC 2003). Brinjal shoot and fruit borer has a complex life cycle, which includes holometabolous metamorphosis. Female moth places their eggs on the tender shoots, stems, and fruits of brinjal plants, where they hatch into larvae that cause significant damage (Varma and Anandhi 2009, Alpuerto 2003). The larvae tunnel into the shoot tips and fruits where they feed on the plant tissue, leading to wilting, necrosis, and fruit rot. The larvae remain in the plant for about 10-15 days during which they cause irreversible damage. Upon reaching maturity, the larvae pupate in the soil or plant debris, eventually emerging as adult moths to complete the life cycle (Basu and Sinha 2018). As a result, infestation can lead to significant yield losses, sometimes exceeding 60-70% (Singh and Singh 2001).

The pest can spread rapidly in regions where brinjal is grown intensively, and the dense planting of crops creates favourable conditions for its development. The pest's ability to adapt to a wide range of environmental conditions and its capacity for rapid reproduction have made it a challenging pest to control in brinjal cultivation (Dar *et al.* 2017).

## MATERIAL AND METHODS

Experiments were managed in the department of entomology, College of Horticulture and Forestry, Neri (Hamirpur), Himachal Pradesh (31°41' N and 76° 28' E; 650 m amsl), during 2020-21 for the study of "Biology of brinjal shoot and fruit borer, (*Leucinodes orbonalis* G.) in low hills of Himachal Pradesh." The research involved both field and laboratory work, encompassing pest sampling, life cycle observations, damage assessment and statistical analysis. This procedure was selected to ensure a complete understanding of the pest's biology and its effects on brinjal cultivation.

To observe the life cycle and feeding behaviour of *Leucinodes orbonalis*, a detailed sampling protocol was followed. The first step involved identifying and marking experimental plots. These plots were regularly monitored throughout the growing season to assess the presence and activity of the pest. Visual inspections were performed to identify signs of infestation, such as wilting shoots, boreholes, and discoloured or rotting fruits. Once the infested area was located, plants were sampled to collect eggs, larvae, and pupae, which were carefully examined in the laboratory. The pest specimens were reared in controlled conditions to observe their

development from egg to adult stages. Rearing cages were used to isolate individuals and prevent cross-contamination, and they were kept in incubators at a temperature of 23-30°C to stimulate field conditions. Each stage (egg, larva, pupa, and adult) of the pest's life cycle was carefully documented, including the length of each stage, survival rates, and developmental times. These observations allowed for a detailed understanding of the pest's biology and the data collected were used to estimate the potential for multiple generations within a growing season. These experiments were designed to determine the optimal conditions for pest growth and reproduction, which would help predict when infestation is likely to occur. In all experiments, pest population dynamics were recorded at key points, and data were collected at regular intervals throughout the growing season. In conclusion, this methodology combines field experiments and laboratory observations to provide a comprehensive understanding of *L. orbonalis* biology.

## RESULTS AND DISCUSSION

The results of the study are presented in a structured manner, based on the main objectives: the observations of the biology and life cycle of brinjal shoot and borer, the assessment of the pest damage, and the analysis of the economic impact of pest control methods.

### Life cycle observations of *Leucinodes orbonalis*

The life cycle of *L. orbonalis* was closely monitored under field and controlled conditions. In this laboratory, the developments of each life stage were pursued to establish the total duration of the life cycle under varying environmental conditions.

**Egg Stage:** The average incubation period for eggs under field conditions was observed to range from 3 to 5 days. Temperature fluctuations influenced the incubation time, with higher temperatures leading to shorter incubation periods. At an optimal temperature of 28 to 30°C, the eggs hatched in approximately 3 days. The eggs' average length and width were 0.70 to 0.90 mm and 0.40 to 0.60 mm, respectively, with an average of  $0.82 \pm 0.02$  mm and  $0.50 \pm 0.02$  mm (Table 1).

Our findings are consistent with the findings of Bindu *et al.* (2015), Singh and Singh (2010), Onekutu *et al.* (2013) who reported that the egg's measurements were 0.80 mm in length and 0.52 mm in width, 0.75 mm in length and 0.53 mm in breadth, 0.94 mm in length and 0.50 mm in width, respectively.



**Plate 1: Eggs of *Leucinodes orbonalis***

**Larval stages:** The larval stages were the most devastating phase in the pest's life cycle. A total of five larval instars were observed that feed on both shoot and fruit tissues, with notable feeding damage recorded in fruits.

**First instar:** The freshly hatched larva had a noticeable dark head and was a dirty white hue (Plate 2). Larvae in their first instar ranged in length from 1.60 to 2.55 mm, with a mean of  $2.14 \pm 0.11$  mm and in width from 0.20 to 0.35 mm, with a mean of  $0.30 \pm 0.02$  mm (Table 1). Average width of the head capsule was  $0.48 \pm 0.03$  mm, with a range of 0.35 to 0.60 mm (Table 2). The average longevity of the first instar larvae was  $2.5 \pm 0.17$  days, with a span of 2 to 3 days (Table 3). The findings of current investigations are consistent with these publications. According to Bindu *et al.* (2015), the larvae's first instar duration varied from 2 to 3 days, with a mean of  $2.6 \pm 0.55$  days. They were 1.60 to 2.45 mm in length with an average of  $2.03 \pm 0.36$  mm and 0.2 to

0.32 mm in width, with a mean of  $0.26 \pm 0.05$  mm. According to Varma and Anandhi (2009) the first larval instar lasted 1.40 days and had an average length of 1.21 mm and an average width of 0.27 mm. Onekutu *et al.* (2013) newly emerged larvae were cylindrical, cream to brownish pink and had an average head capsule size of 0.45 mm. Their average body length and breadth were 4.19 mm and 0.47 mm, respectively.

**Second instar:** The second instar grew larger and underwent a minor colour change. The second instar was pink and pale brown in colour (Plate 2). At an average of  $4.11 \pm 0.13$  mm, the second instar larva's length varied from 3.50 to 4.80 mm and its width ranged from 0.50 to 0.90 mm, with a mean of  $0.71 \pm 0.05$  mm (Table 1). The head capsule width of second larval instar varied from 0.65 to 0.85 mm with an average of  $0.74 \pm 0.03$  mm (Table 2). It lasted the range of  $2.6 \pm 0.31$  days, with an average of 1 to 14 days (Table 3).

According to Bindu *et al.* (2015), second stage caterpillar was pink and pale brown, measuring 4.00 mm in length and 0.70 mm in width. Its mean duration was  $2.8 \pm 0.71$  days, with an average of 1 to 4 days. According to Onekutu *et al.* (2013) the average width of the head capsule of second instar larvae was  $0.74 \pm 0.06$  mm, with a range of 0.60 to 0.85 mm. Body length, body breadth, and developmental period ranged from  $0.90 \pm 0.16$  mm,  $6.98 \pm 2.16$  mm and 1.16 to 0.40 days, respectively. According to Singla *et al.* (2018), second instar larvae had a mean length of 4.55 mm, a mean width of 0.80 mm, and head capsule widths of 0.43 mm. According to Varma and Anandhi (2009) the lifespan of second instar were two days.

**Third instar:** The third instar differed in size and colour from those in their second instar, although they were similar in shape. The third larval instar was pink in colour (Plate 2). The third instar larvae's length and width varied from 6.50 to 9.50 mm with a mean of  $7.92 \pm 0.37$  mm and 1.20 to 1.80 mm with a mean of  $1.53 \pm 0.07$  mm, respectively (Table 1). The width of the head capsule varied from 0.95 to 1.20 mm with a mean of  $1.09 \pm 0.03$  mm (Table 2). Larvae in the third instar lasted an average of  $3.1 \pm 0.18$  days, with an average of 2 to 4 days (Table 3).

Based on the findings of Bindu *et al.* (2015), third instar larvae ranged in length from 6.55 to 9.25 mm with a mean of  $8.03 \pm 0.64$  mm and in breadth from 1.20 to 1.70 mm with a mean of  $1.48 \pm 0.20$  mm. Larvae in their third instar lasted between two to four days, with an average of  $3.2 \pm 0.84$  days. According to Onekutu *et al.* (2013) the third larval form had an average head capsule width of  $1.06 \pm 0.11$  mm, ranging from 0.90 to 1.20 mm. Body width, length and developmental period ranged from  $1.38 \pm 0.16$  mm,  $11.10 \pm 2.32$  mm, and 1.48  $\pm$  0.41 days, respectively. Based on the findings of Singla *et al.* (2018) the third instar's mean length, mean breadth and head capsule width ranged from 8.48 mm, 1.69 mm and 0.77 mm, respectively. Larvae in their third instar lasted an average of 3.11 to 5.83 days.

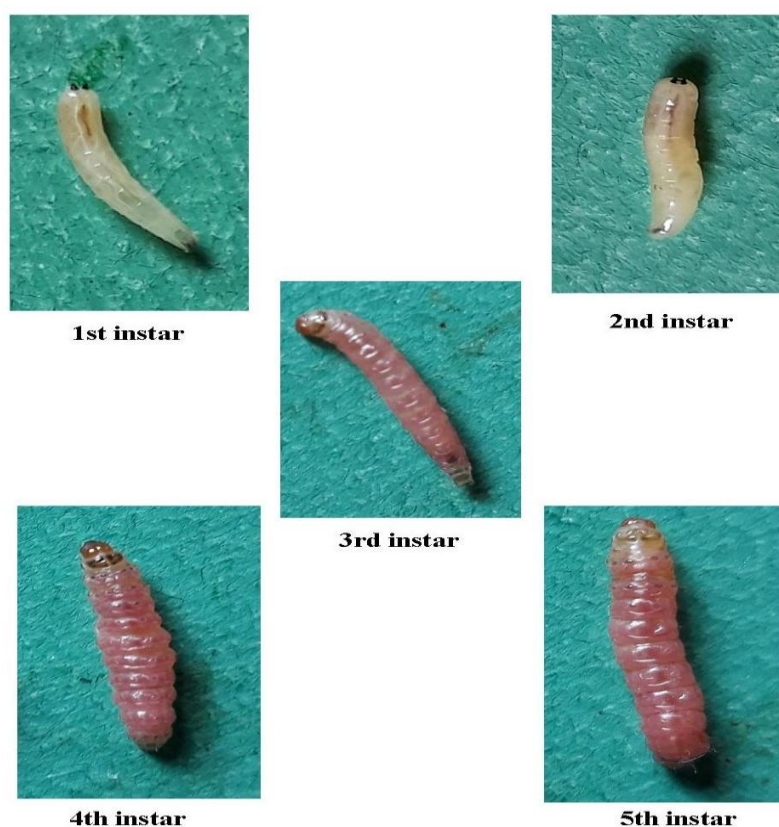


Plate 2: Different larval instars of *Leucinodes orbonalis*

**Fourth instar:** The fourth stage larva was rosaceous in colour and larger in size compared to the third instar (Plate 2). The body length of the fourth instar varies from 10 to 14 mm, with a mean of  $11.99 \pm 0.47$  mm, and the width ranged from 1.70 to 2.0 mm, with a mean of  $1.85 \pm 0.04$  mm (Table 1). An average width of the head capsule is  $1.45 \pm 0.03$  mm, which ranges from 1.30 to 1.60 mm (Table 2). The fourth instar lasted an average of  $3.4 \pm 0.16$  days, with a range of 3 to 4 days (Table 3).

According to Bindu *et al.* (2015), fourth instar larvae ranged in length from 10.55 to 13.25 mm with an average of  $11.74 \pm 0.46$  mm and width ranged from 1.76 to 1.95 mm with a mean of  $2.13 \pm 0.39$  mm. They also lasted between 3 and 4 days, with an average of  $3.4 \pm 0.89$  days. Onekutu *et al.* (2013) finds that mean of head capsule width of fourth instar was  $1.44 \pm 0.08$  mm with a range of 1.25 to 1.55 mm. Body length, width and developmental period vary from  $1.71 \pm 0.15$  mm,  $16.58 \pm 1.75$  mm and  $2.63 \pm 0.45$  days, respectively. On the basis of Singla *et al.* (2018) the fourth instar's mean length, mean breadth, and head capsule width ranged from 10.05 mm, 2.10 mm and 1.34 mm, respectively. According to findings of Saxena (1965) the average larval length and width of the fourth instar ranged from 9.30 mm to 1.80 mm.

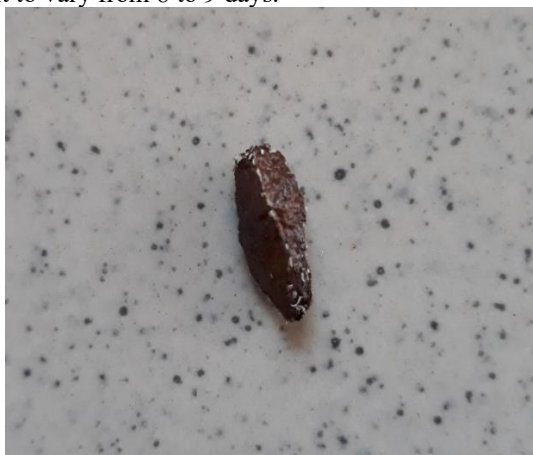
**Fifth instar:** The fully developed larva had a pinkish hue (Plate 2). The length of the fifth instar varied from 15.5 to 20.0 mm, with a mean of  $17.57 \pm 0.57$  mm, and breadth ranged from 3.5 to 4.5 mm, with an average of  $4.10 \pm 0.11$  mm (Table 1). The head capsule width ranged from 1.65 to 2.20 mm with a mean of  $1.98 \pm 0.06$  mm (Table 2). The lifespan of fifth instar larvae varied from 2 to 3 days and an average of  $2.4 \pm 0.84$  days (Table 3).

According to Bindu *et al.* (2015), the fully developed larvae measured between 15.25 to 19.55 mm in length with an average of  $17.30 \pm 1.15$  mm and width measured between 3.3 to 4.25 mm with an average of  $3.92 \pm 0.35$  mm and the duration lasted between 2 to 3 days with an average of  $2.8 \pm 0.55$  days. Onekutu *et al.* (2013) mentioned that head capsule width of fifth larval instar measured from 1.60 to 2.20 mm with a mean of  $1.73 \pm 0.15$  mm. The mean of length, width and developmental period ranged from  $18.44 \pm 0.28$  mm,  $2.15 \pm 0.29$  mm and  $4.46 \pm 0.71$  days, respectively. Singla *et al.* (2018) mentioned that the fifth instar larval stage lasted between 1.56 to 3.80 days. The average length, average width and head capsule width of varied from 13.08 mm, 2.28 mm and 1.36 mm, respectively.

**Total Larval Period:** under optimal conditions, the total larval period varied from 15 to 18 days, with a mean duration of  $16.6 \pm 0.37$  days (Table 3). Bindu *et al.* (2015) supported the similar trend which found that larval period was 14 to 18 days with a mean of  $16.2 \pm 1.48$  days. Kumar *et al.* (2011) found that total larval period were 15.72 days. Singh and Singh (2001) reported that it was 18.16 days. Baang and Corey (1991), Singh and Singh (2003) also reported that the larval period was 15 days and 18.6 days, respectively.

**Pupal stage:** After completing the larval stage, the larvae pupated either in soil or within the plant debris. The pupa was light brown and had a delicate body (Plate 3). The pupa's length ranged from 10.5 to 14.5 with a mean of  $11.81 \pm 0.36$  mm, and width of pupa varied from 4.0 to 5.2 mm with a mean of  $4.73 \pm 0.11$  mm (Table 1). The pupal stage lasted between 8 to 10 days with a mean of  $9.1 \pm 0.23$  days (Table 3).

This is consistent with the results of Bindu *et al.* (2015), who found that length and width of pupa ranged from 10.45 to 14.65 mm and 3.9 to 5.1 mm, respectively, with a mean of  $12.34 \pm 1.67$  mm and  $4.40 \pm 0.47$  mm, respectively. The pupal stage lasted between 8 to 10 days with a mean of  $8.6 \pm 0.89$  days. Kumar *et al.* (2011) finds its duration was 9.66 days. Butani and Verma (1976) stated that pupal period was 7-10 days. On the other hand, Saxena (1965) found it to vary from 8 to 9 days.



**Plate 3: Pupa of *Leucinodes orbonalis***

**Adult stage:** The mature moth was white in colour with brown and greyish scales covering its head and thorax. There were creamy white and large bands of light brown colour present in the forewings. A tiny black wavy line is visible at the hind wing's apical margin (Plate 4). The wings have some fringe on the edges. The length of adult male moths ranged from 10.5 to 15.5 mm with a mean of  $12.5 \pm 0.58$ , while the width of male adult moths varied from 2.3 to 3.5 mm with a mean of  $2.97 \pm 0.14$  mm. The length and width of female moths ranged from 12 to 16 mm with a mean of  $13.8 \pm 0.40$  and 2.6 to 3.6 mm with an average of  $3.10 \pm 0.13$ , respectively. The expansion of the wings of adult males and females ranged from 18 to 23 mm with a mean of  $20.69 \pm 0.60$  and 21 to 25 mm with a mean of  $22.90 \pm 0.60$ , respectively (Table 1). The life span of an adult male moth varied from 1 to 3 days, with an average of  $2.2 \pm 0.25$  days and the life span of an adult female moth ranged from 3 to 5 days, with an average of  $4.1 \pm 0.23$  days (Table 3).



**Plate 4: Adults of brinjal shoot and fruit borer**

This is consistent with the results of Bindu *et al.* (2015), who mentioned that the lifespan of adult male moth varied from 3 to 5 days with an average of  $4.2 \pm 0.84$  days, while the lifespan of female moth varied from 4 to 7 days with a mean of  $5.8 \pm 0.71$  days. Adult male measured 13.54 mm in length, 2.98 mm in breadth and 20.55 mm in wing span, whereas length of the female moth was reported as 14.53 mm, width was reported as 4.41 mm and 23.41 mm in wing span. According to Onekutu *et al.* (2013), when the wings are widely stretched, adult's measure 20 to 22 cm. The adult male moth's wingspan measured 21.59 mm. An average body length had 13.26 mm, whereas an average body width was 4.20 mm. However, the adult female moths' average body length was 14.17 mm, average body width was 4.59 mm and wingspan were 24.33 mm. According to Singh and Singh (2001) male moth lifespan was 3.53 days.

**Pre- oviposition period:** The average pre-oviposition period for female moths was  $1.50 \pm 0.17$  days, with a range of 1 to 2 days (Table 3). According to Bindu *et al.* (2015), the female moth's pre-oviposition period lasted an average of  $1.81 \pm 0.21$  days, ranging from 1 to 2 days. According to Kumar *et al.* (2011), Onekutu *et al.* (2013) and Kavitha *et al.* (2008) the pre-oviposition period ranged from 1.20 days, 1.19 days and 1.35 days, respectively.

**Oviposition Period:** The average oviposition period of female moths was  $2.20 \pm 0.25$  days, with a range of 1 to 3 days (Table 3). This is consistent with the findings of Bindu *et al.* (2015), who mentioned that an average oviposition period for female moths was  $2.55 \pm 0.43$  days, with variations ranging from 2 to 3 days. According to Kumar *et al.* (2011), Onekutu *et al.* (2013), Kavitha *et al.* (2008) and Jat *et al.* (2003) the oviposition period ranges from 1.90 days, 2.71 days, 2.01 days and 2.43 days, respectively.

**Post-oviposition period:** An average post- oviposition duration for female moth was  $3.70 \pm 0.40$  days, which ranges from 2 to 6 days (Table 3). As per the findings of Onekutu *et al.* (2013), Varma and Anandhi (2009) and Jat *et al.* (2003), post-oviposition period varied from 3.75 days, 2.43 days, and 1.26 days, respectively.

**Total life cycle:** *Leucinodes orbonalis* completes its entire life cycle on around 32 to 39 days with an average duration of  $35.3 \pm 0.76$  days. These findings were supported by Lall and Ahmad (1965), Singh and Singh (2001), Kavitha *et al.* (2008), Kumar *et al.* (2011) and Onekutu *et al.* (2013), who mentioned that the total life cycle lasted with 28.17 days, 35.27 days, 36.27 days, 30 days and 36.82 days, respectively.

**Yield loss:** Due to the brinjal shoot and fruit borer, the yield loss was estimated on the number of fruits produced per plant and the weight of harvested fruit. In infested plots, total yield was decreased 40-50% compared to the un-infested plots. Moreover, the quality was drastically reduced after harvest, with 20-30% of

the harvested fruits being considered unfit for marketing due to apparent pest damage. In critically damaged plots, loss of yield reached up to 60-70%, resulting the serious financial losses for farmers.

#### Life cycle observations of *Leucinodes orbonalis*

The life cycle stages of brinjal shoot and fruit borer were observed under both field and controlled laboratory conditions. The development of each stage was affected by environmental conditions such as temperatures and humidity with variations in developmental time.

**Table 1: Morphological parameters of brinjal shoot and fruit borer**

| Sr. No. | Parameter (Insect stage)      | Range     | Measurement in (mm) |
|---------|-------------------------------|-----------|---------------------|
|         |                               |           | (Mean $\pm$ SE)     |
| 1.      | Egg                           |           |                     |
|         | Length                        | 0.70-0.90 | 0.82 $\pm$ 0.02     |
|         | Width                         | 0.40-0.60 | 0.50 $\pm$ 0.02     |
| 2       | First instar larvae           |           |                     |
|         | Length                        | 1.60-2.55 | 2.14 $\pm$ 0.11     |
|         | Width                         | 0.20-0.35 | 0.30 $\pm$ 0.02     |
| 3.      | 2 <sup>nd</sup> instar larvae |           |                     |
|         | Length                        | 3.5-4.8   | 4.11 $\pm$ 0.13     |
|         | Width                         | 0.50-0.90 | 0.71 $\pm$ 0.05     |
| 4.      | 3 <sup>rd</sup> instar larvae |           |                     |
|         | Length                        | 6.5-9.5   | 7.92 $\pm$ 0.37     |
|         | Width                         | 1.2-1.8   | 1.53 $\pm$ 0.07     |
| 5.      | 4 <sup>th</sup> instar larvae |           |                     |
|         | Length                        | 10-14     | 11.99 $\pm$ 0.47    |
|         | Width                         | 1.7-2.0   | 1.85 $\pm$ 0.04     |
| 6.      | 5 <sup>th</sup> instar larvae |           |                     |
|         | Length                        | 15.5-20.0 | 17.57 $\pm$ 0.57    |
|         | Width                         | 3.5-4.5   | 4.10 $\pm$ 0.11     |
| 7.      | Pupa                          |           |                     |
|         | Length                        | 10.5-14.5 | 11.81 $\pm$ 0.36    |
|         | Width                         | 4.0-5.2   | 4.73 $\pm$ 0.11     |
| 8.      | Adult Moth (Male)             |           |                     |
|         | Length                        | 10.5-15.5 | 12.5 $\pm$ 0.58     |
|         | Width                         | 2.3-3.5   | 2.97 $\pm$ 0.14     |
|         | Wingspan                      | 18-23     | 20.69 $\pm$ 0.60    |
| 9.      | Adult Moth (Female)           |           |                     |
|         | Length                        | 12-16     | 13.8 $\pm$ 0.40     |
|         | Width                         | 2.6-3.6   | 3.10 $\pm$ 0.13     |
|         | Wingspan                      | 21-25     | 22.90 $\pm$ 0.42    |

SE- Standard Error

Number of observations:10

**Table 2: Head capsule width of various larval instars of *L. orbonalis***

| Larval Instar   | Range(mm) | Head capsule Measurement in (mm) (Mean $\pm$ SE) |
|-----------------|-----------|--------------------------------------------------|
| 1 <sup>st</sup> | 0.35-0.60 | 0.48 $\pm$ 0.03                                  |
| 2 <sup>nd</sup> | 0.65-0.85 | 0.74 $\pm$ 0.03                                  |
| 3 <sup>rd</sup> | 0.95-1.20 | 1.09 $\pm$ 0.03                                  |
| 4 <sup>th</sup> | 1.30-1.60 | 1.45 $\pm$ 0.03                                  |
| 5 <sup>th</sup> | 1.65-2.20 | 1.98 $\pm$ 0.06                                  |

**Table 3: Duration of different stages of *L. orbonalis***

| Sr. No. | Parameters (insect stages) | Mean duration (days) |                  |
|---------|----------------------------|----------------------|------------------|
|         |                            | Range                | Mean $\pm$ SE    |
| 1.      | Incubation period          | 3-5                  | 3.9 $\pm$ 0.23   |
| 2.      | Total larval period        | 15-18                | 16.6 $\pm$ 0.37  |
| 3.      | Pupal Period               | 8-10                 | 9.1 $\pm$ 0.28   |
| 4.      | Total developmental period | 32-39                | 35.3 $\pm$ 0.76  |
| 5.      | Pre-oviposition period     | 1-2                  | 1.5 $\pm$ 0.17   |
| 6.      | Oviposition period         | 1-3                  | 2.2 $\pm$ 0.25   |
| 7.      | Post-oviposition period    | 2-6                  | 3.7 $\pm$ 0.40   |
| 8.      | Adult longevity            |                      |                  |
|         | Male                       | 1-3                  | 2.2 $\pm$ 0.25   |
|         | Female                     | 3-5                  | 4.1 $\pm$ 0.23   |
| 9.      | Fecundity (eggs/female)    | 160-240              | 202.6 $\pm$ 8.31 |

SE-Standard Error

Number of observations:10

### Implications for future research

The findings from this study highlight the significance of espousing a combined approach to managing brinjal shoot and fruit borer. Further studies should focus on evolving more effective, sustainable pest management planning that integrates resistant varieties, biological control agents and cultural practices. There is also a necessity to examine the genetic basic of resistance in brinjal and to identify novel cultural practices of brinjal shoot and fruit borer that can be included into biological control programs.

Furthermore, future research is required to examine the environmental and ecological consequences of numerous pest management strategies, especially, in terms of their effects on non-target organisms and soil health. The role of climate change in varying pest dynamics also permits future investigations, as changes in temperature and humidity may affect the pest's growth and development. Understanding these relationships is crucial for anticipating future pest outbreaks and developing adaptive pest management strategies. The investigations also emphasize the requirement of policy intervention that promotes the sustainable agricultural practices. Inspiring farmers to adopt IPM practices and minimizing their dependency on chemical pesticides could lead to more sustainable pest management and enhance the long-term feasibility of brinjal farming.

## CONCLUSION

In conclusion, one of the most crucial outcomes from this study was speedy life span of *Leuc orbonalis* and remains one of the most serious and tenacious pests, affecting eggplant cultivation widely. The ability of pest to complete multiple generations within a single cropping season is an essential aspect that make it such a major threat to eggplant. This study has contributed a profound understanding into the pest's biology and its influence on brinjal crops by examining the life cycle of brinjal shoot and fruit borer and analysing the range of damage to eggplant.

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