Study of Biological Characteristics of Leucinodes orbonalis Guenée which Destroyed Young Shoot and Fruit of Eggplant (Solanum melongena L.): A case in Trang Bom district, Dong Nai province, Vietnam

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Abstract. Leucinodes orbonalis Guenée adult had white insect into dark brown colour. Wings were marked by three small triangular with a pinkish to bluish colour mixed pinkish orangish or dark brown. L. orbonalis female dimension were about 9.6 – 12.3mm, the dimension of L.orbonalis male were 8.1 – 9.5mm. Eggs were 1.0 – 1.2mm in length and oval or elliptical shape. The incubation time was around 5.0 – 6.0 days. Larvae are developed by six stages of age, larvae development period lasts 10 – 12 days. Pupae were pink to dark pink in colour and shiny with the length, width were 11.47 – 15.33 mm, 4.40 – 6.45mm respectively. Pupae developed about 8 – 9 days. The life cycle of L. orbonalis lasted 25.30 ± 0.92 days. L. orbonalis feeding in laboratory had high hatching rate, just 9.36% were not hatched. The early stage of larvae had high death-rate (27.98%) mainly due to dispersion. The older larvae had lower death-rate (10.12%). Pupae had high developed rate, only 4.10% were not development. There were equal rate between male and female adult of L. orbonalis. Laying eggs period of female adult lasted 3 days, in there the first day was the highest laying rate (113 eggs/female/day). L. orbonalis densities were highest on the young shoot and fruit of eggplant at the stage after planting 95 – 150 days and was reduced in a after growing.

1. Introduction

Eggplant (Solanum melongena L.) is a valuable vegetable plant. Eggplant used as a diuretic, communication circuit and precaution syndrome, atherosclerosis, diabetes, treat arthritis, reduce cholesterol in blood [1,2].

In Vietnam, eggplant is one of the most popular vegetables, the effect brought from the cultivation of eggplant is quite high, 1 ha average productivity of about 50 – 60 tons, harvested from 350 – 420 million VND/ha/crop. In recent years, eggplant is grown within pain processing in Dong Nai province. However, there are many types of dangerous insect damage reduces yield and quality in eggplant, which has deep fruit borers is harmful objects most serious [6,7,9]. This article provides results of research on Leucinodes orbonalis Guenée - an object cause dangerous insect on eggplant in Dong Nai province, Vietnam.
2. Materials and Methods

Biological characteristics of eggplant fruit and shoot borer – *L. orbonalis* Guenée was investigated by Borror, Delong (1981) [3,4]. Collecting field samples in Trang Bom district, Dong Nai province in the winter-spring crop of 2018 - 2019, creating the original source. When cocoons turn into the adult, collect each pair of identical ones on the same day, rearing them alone with honey 10% to make them lay eggs. When the eggs lay eggs, collect eggs laid on the same day to track. When eggs hatch the larvae on the same day are kept separately by eggplant and follow up until the larvae pupate. Pupae formed along this track continue. Number of pairs of larvae, pupae tracking 20 - 30 pairs, number of larvae tracking 50-60, number of eggs tracking 300 eggs.

The monitoring criteria are the development time for each phase, each development stage of *L. orbonalis*, the color and body size of the development phases, the development completion rate of the development phases. These indicators are observed daily.

The investigation of the harmfulness of *L. orbonalis* was conducted in 3 gardens in Thanh Binh, Song Thao and Cay Gao communes (Trang Bom district). These surveyed gardens grow the same type of eggplant, each garden has an area of at least 2000 m². Investigate according to the method of 5 points evenly distributed on a row, translation without repetition, each point investigates 3 trees. Keep track of all the fruit and allshoots on plant. Conducting an investigation 5 days/time.

Monitoring indicators are fruit borers density (individuals/tree) and rate of shoot and fruit damage. These criteria density (MDS) and the rate of damaged shoots, damaged fruit (TLH) are calculated as follows (1) and (2) [5]:

\[
\text{MDS} = \frac{\sum A_s}{\sum A_o}, \quad (1)
\]

Where \(A_s\) - number of insect on surveyed plants; \(A_o\) - number of surveyed plants.

\[
\text{TLH} = \frac{\sum D_d}{\sum D_s} \times 100, \quad (2)
\]

Where \(D_d\) - number of damaged shoot, damaged fruit; \(D_s\) - number of damaged shoots, damaged fruit of survey.

3. Results and discussion

3.1. Fluctuating levels of harmon eggplant

Monitoring the emergence and development of *L. orbonalis* in eggplant, studying changes in their damage in 3 gardens in Trang Bom district, Dong Nai province. The time of the eggplant research is from December 15, 2018 to July 7, 2019.

In Thanh Binh commune, it was noted that *L. orbonalis* first appeared on shoots 20 days after planting with a low density of 0.07 individuals/tree, the rate of damaged shoots was 2.38%. Within 30-95 days after planting, the density of *L. orbonalis* increased slowly and ranged from 0.13 to 1.53 individuals/tree, the rate of damaged fruits ranged from 3.57 to 9.29%, and the rate of damaged shoots was about 2.53 - 2.82% (fig. 1).

The period of 100-150 days after planting is a period of high density and long-term. During this period, high humidity creates favorable conditions for food sources, the environment helps the process of occurrence, damage and deep fluctuations 2.60-5.07 individuals /tree, the rate of damaged fruits was 13.46-29.79%, and the rate of damaged shoots was 4.57 - 7.14%. Especially in the period of 125 days after planting, the density of harmful fruits and the intensity of damaged shoots increased the most (5.07 individuals /tree; 29.79% and 7.14%).

![Graph showing the rate of damaged shoots and fruits over time](image-url)
After 130-150 days after planting, the density of *L. orbonalis* tended to decrease, the density reached 2.60 individuals /tree, the rate of damaged shoots 3.50%, damaged fruit 16.38%.

In the period of 155 days after planting to the end of the crop (180 days after planting), old trees grow slowly, fruits and shoots are small, so the density of *L. orbonalis* decreases by 1.73 individuals /tree, the rate of damaged shoots is 1.33% and damaged fruit 10.77%. To further determine the origin and development of *L. orbonalis*, we conducted a study of changes in their harm in Song Thao commune from January 14, 2019 to July 3, 2019. The results of the survey are shown in fig. 2.

In the study, *L. orbonalis* began to appear 25 days after planting, with an average density of 0.07 individuals /tree, and rate of damaged shoots 1.89%. During the period of 35-60 days after planting, the density of *L. orbonalis* gradually increased from 0.20 to 0.87 individuals /tree, especially rate of damaged shoots (4.19%) and damaged fruits (6.67%) take off. During the eggplant period from 65 to 90 days after planting, the density of *L. orbonalis* increased from 0.80 to 2.13 individuals /tree, the rate of damaged shoots from 3.19 to 3.30%, and rate of damaged fruit 3.45 - 9.09%. At this stage, the tree bears a lot of fruit, so it can create favorable conditions for the rapid growth of *L. orbonalis*.

At the eggplant stage, from 95 to 145 days after planting, the density of *L. orbonalis* increases rapidly and is harmful in the long term. 110 days after planting, the density of *L. orbonalis* reached a maximum of 5.47 individuals /tree, which corresponds to rate of damaged shoots of 7.67% and damaged fruit of 30.46%. 115-145 days after planting density of *L. orbonalis* had a gradual decline from 4.87 individuals /tree to 2.27 individuals /tree, which corresponds to a loss rate of damaged shoots of 6.67%. Down to 2.96% and damaged fruit from 27.81% to 13.79%.

In the period of 150-180 days after planting, the density of *L. orbonalis*, the rate of damaged shoots and damaged fruit began to decrease until the end of harvest, the density of *L. orbonalis* was 1.67 individuals /tree, the rate of damaged shoots of 1.45% and damaged fruit of 11.94%.

In Cay Gao commune, an area of 4,000 m² and was studied from January 17, 2019 to July 7, 2019, to further determine the occurrence and development of fruiting and shoots on eggplants. The results are shown in fig.3.
The study showed that *L. orbonalis* began to appear on the shoots 30 days after planting. In the period of 45 - 80 days after planting, the eggplant has strong branches, flowers and fruits. At this stage, the density of *L. orbonalis* was from 0.27 to 1.53 individuals / tree, the rate of damaged shoots varied from 2.24 to 3.19%, and the damaged fruit was about 2.25 - 7.79%. During the period from 80 to 110 days after planting, starting with the rainy season, humidity increases, eggplants thrive on stems, shoots, create favorable conditions for *L. orbonalis* grows and accumulates. 110 days after planting, the density of *L. orbonalis* increased dramatically and reached a maximum of 5.20 individuals / tree, equivalent to 6.93% of damaged shoots and 29.09% of damaged fruit.

During the period from 115 - 140 days after planting, the density of *L. orbonalis* tended to gradually increase, decreasing from 4.80 individuals / tree to 2.60 individuals / tree, the rate of damaged shoots from 6.10 to 3.26%, and the rate of damaged fruit from 27.27 to 16.42%.

In the period from 145 to 180 days after planting, the density of *L. orbonalis*, the rate of damaged shoots and damaged fruit began to decrease before the end of harvest, the density of *L. orbonalis* was 1.73 individuals / tree, the rate damaged shoots of 1.92%, and the rate of damaged fruit of 11.36%.

### 3.2. Morphological characteristics of *L. orbonalis*

During the survey, some morphological characteristics of *L. orbonalis* were recorded, the results are presented in Table 1.

| Survey period       | Tracking criteria | Average Value (X ± SD) (mm) | Variability | Number of observations |
|---------------------|-------------------|-----------------------------|-------------|-----------------------|
| **Female adult moth** | Body length       | 11.00 ± 0.85               | 9.6 – 12.3  | n = 20                |
|                     | Body width        | 2.41 ± 0.08                | 2.3 – 2.5   |                       |
|                     | Wingspan size     | 22.24 ± 1.71               | 19.9 – 25.2 |                       |
|                     | Beard length      | 8.61 ± 0.58                | 7.6 – 9.7   |                       |
|                     | Body length       | 8.66 ± 0.46                | 8.1 – 9.5   |                       |
|                     | Body width        | 1.94 ± 0.13                | 1.7 – 2.1   | n = 20                |
|                     | Wingspan size     | 17.58 ± 1.24               | 15.2 – 19.4 |                       |
|                     | Beard length      | 7.04 ± 0.42                | 6.2 – 7.7   |                       |
| **Male adult moth**  | Eggs              |                            |             |                       |
|                     | Length            | 1.12 ± 0.06                | 1.0 – 1.2   | n = 30                |
|                     | Width             | 0.56 ± 0.04                | 0.48 – 0.60 |                       |
| **Larvae of age 6**  | Length            | 18.20 ± 2.74               | 14.85 – 22.50 | n = 20 |
|                     | Width             | 4.07 ± 0.37                | 3.44 – 4.55 |                       |
| **Pupae**            | Length            | 12.97 ± 0.90               | 11.45 – 15.33 | n = 30 |
|                     | Width             | 5.58 ± 0.50                | 4.40 – 6.45 |                       |

Note: \(\bar{X}\) - The average value; SD - Standard deviation

*Adult moth*

The adult moth of *L. orbonalis* is a small white butterfly with dark brown and gray-brown veins. The brown belly is covered with a milky layer. Two pairs of milky white wings. The forewing has a triangular shape, along the contour of the Costa there are brown stripes extending to the top of the wing, on the forewing there are 3 triangular dots with a slight pinkish greenish tint, orange-pink or dark brown. The
The head cover is 0.56 ± 0.04 mm, the width is approximately 0.28 mm.

The abdomen has 10 segments, the last of which is sharper than the other. Female genitals have yellow hair, but men do not (fig. 4).

* Eggs

Female adult moths lay eggs on young parts of eggplants. Eggs are oval, ellipse. Eggs are laid scattered in separate fruits or in groups of 4-15 eggs, arranged in the form of tiled roofs on young leaves (usually the leaves of the second or fourth from top to bottom), shoots and flower shoots. When laying eggs, the eggs are slightly yellowish, milky white, after 2 days the eggs become dark yellow reddish, after hatching the eggs there is a white crust. The average egg size is 1.12 ± 0.06 mm, ranging from 1.0 to 1.2 mm in length and width by about 0.56 ± 0.04 mm with a deviation of 0.48 - 0.60 mm.

* Larvae

The survey reported that the caterpillar survived 6 years of age with changes in size and color (table 2).

**Table 2. Size of larval shells of L. orbonalis**

| Age of larvae | Head shell length (mm) | Width shell length (mm) | Number of observations |
|---------------|------------------------|-------------------------|------------------------|
|               | (X ± SD)               | Variability             | (X ± SD)               | Variability |
| Age 1         | 0.31 ± 0.02            | 0.28 – 0.32             | 0.33 ± 0.03            | 0.28 – 0.36 | 15 |
| Age 2         | 0.67 ± 0.04            | 0.56 – 0.72             | 0.68 ± 0.04            | 0.60 – 0.72 | 15 |
| Age 3         | 0.99 ± 0.07            | 0.88 – 1.16             | 1.07 ± 0.09            | 0.96 – 1.20 | 15 |
| Age 4         | 1.36 ± 0.05            | 1.24 – 1.44             | 1.38 ± 0.09            | 1.28 – 1.52 | 15 |
| Age 5         | 1.77 ± 0.08            | 1.56 – 1.88             | 1.85 ± 0.06            | 1.72 – 1.92 | 15 |
| Age 6         | 3.64 ± 0.18            | 3.36 – 3.92             | 3.95 ± 0.34            | 3.44 – 4.36 | 15 |

**Note:** X - The average value; SD - Standard deviation

Newly hatched larvae emerge from the shell and crawl out. Newly hatched larvae are very flexible and move quickly in search of food. The larvae undergo 6 molts. In preparation for molting, the larvae often release silk directly on a muddy road, they shrink, the color of the body changes and begins to shed. The molting process begins at the beginning, gradually molting down to the belly. After molting, they leave a dark brown shell.

**Age 1:** the body is pale transparent, the head is larger than the body, the head is dark brown, the body is hairy, and there are 2 small spines at the end of the abdomen. The caterpillar is agile, releasing the silk when sliced into fruit. The size of the head cap is 0.28–0.32 mm, the average length is 0.31 ± 0.02 mm, the width is approximately 0.28-0.36 mm, the average length is 0.33 ± 0.03 mm.

**Age 2:** the body is pale yellow, the head is yellowish-brown, with dark brown streaks on the front of the chest and 3 developed pectoral legs. The size of the head cover is 0.56 - 0.72 mm, the average length is 0.67 ± 0.04 mm, the width is approximately 0.60 - 0.72 mm, the average is 0.68 ± 0.04 mm.

**Age 3:** the body is dark brown, the head is dark brown, there is a horizontal dark brown stripe on the front of the chest, there are 3 small dark brown spots on the abdomen at the end of the abdomen, and the body is clearly lit. The size of the head cover is about 0.88-1.16 mm, the average length is 0.99 ± 0.07 mm, the width is 0.96 - 1.20 mm, the average is 1.07 ± 0.09 mm.
Age 4: the body becomes dark brown, the middle of the back has a pale pink stripe, the head is brown, the upper part of the head clearly looks like a "v", the front of the chest is noticeably transverse and there are many brown spots on each burn. The last abdominal segment has 2 spines. The size of the head cover is 1.24-1.44 mm, the average length is 1.36 ± 0.05 mm, the width is about 1.28 - 1.52 mm, the average is 1.38 ± 0.09 mm.

Age 5: the body becomes reddish-brown, middle of back has a pale pink stripe, head dark brown, upper part of the head is clearly visible "v" shape, and the front part of the chest noticeable horizontal black, head size is about 1.56 - 1.88 mm in length, average length is 1.77 ± 0.08 mm, a width of about 1.72 - of 1.92 mm, and an average of 1.85 ± 0.06 mm.

Age 6: the body is reddish-brown, full strength 14.85 - 22.50 mm, average 18.20 ± 2.74 mm, width 3.44 - 4.55 mm, average 4.07 ± 0.37 mm the body burns clearly. At the age of 6, the worms move to the left, the body squeezes its silk to prepare the pupae. The size of the head cap is 3.36 - 3.92 mm, average length 3.64 ± 0.18 mm, width 3.44 - 3.36 mm, average 3.95 ± 0.34 mm.

Descriptions of the color and size of the larvae of the above larvae correspond to the description of Dr. Daniela Lupi, 2008; Alam et al., 2003 [8,10].

*Pupae*

By the end of six years of age, the larvae vigorously release silk pupae on tree tops, on old leaves, on stems, or under vegetation. Nymphs are located in 2 layers of thick cocoons, first the cocoon has a pinkish-brown color, on the 2nd and 3rd days gradually turns into a dark pink-brown iridescent, when it is going to become dark brown in color. The length of the cocoon varies from 11.47 to 15.33 mm, the average length is 12.97 ± 0.90 mm, the width is about 4.40 - 6.45 mm, the average is 5.58 ± 0.50 mm.

3.3. Biological characteristics of L. orbonalis

Study the biological characteristics of L. orbonalis in the laboratory to find out their potential danger. A short stage of development facilitates the development of L. orbonalis in many litters throughout the year, and a high rate of development at various stages contributes to a rapid increase in density. The development time of the larva was controlled in the laboratory at room temperature of 26.4 - 30.0°C and humidity of 71.8 - 84.3%. The larvae has 6 years, the development time at each age varies from 1-2 days. Time of development of larvae at the age of 1 year, an average of 1.70 ± 0.47 day, at the age of 2 years average of 1.83 ± 0.38 day, the age of 3 years by an average of 1.90 ± 0.31 day the age of 4 years average of 1.77 ± 0.43 day, the average age of 5 years average of 1.73 ± 0.45 day and age of 6 the average of 1.77 ± 0.43 day. The entire larvae phase varied from 10 to 12 days, with an average of 10.70 ± 0.75 days (table 3).

| Phase phonetic | Phonetic time (days) |  | Number of observations |
|----------------|----------------------|------------------|------------------------|
|                | Average value (X ± SD) | Variability |              |
| Phase eggs     | 5.07 ± 0.25          | 5.0 – 6.0     | 30                     |
| Phase larvae   | 10.70 ± 0.75         | 10.0 – 12.0    | 30                     |
| Phase pupae    | 8.37 ± 0.49          | 8.0 – 9.0     | 30                     |
| Extra nutrition time | 1.17 ± 0.38 | 1.0 – 2.0 | 30                     |
| Life cycle     | 25.30 ± 0.92         | 24.0 – 28.0    | 30                     |
| Average temperature (°C) | 28.16 ± 1.36 | 26.4 – 30.0 |              |
| Average humidity (%) | 78.19 ± 5.54 | 71.8 – 84.3 |              |
In laboratory conditions, the temperature of 26.4 - 30.0 and humidity of 71.8-84.3% recorded the life cycle of *L. orbonalis*, which passes through four stages: eggs, larvae, pupae and adult moth.

The life cycle of *L. orbonalis* (fig. 5) ranges from 24 to 28 days, with an average of 25.30 ± 0.92 days, of which the eggs period lasts 5-6 days, with an average of 5.07 ± 0.25 days. The development time of the larvae ranges from 10 to 12 days, with an average of 10.70 ± 0.75 days. The pupae period lasts 8.0 - 9.0 days, with an average of 8.37 ± 0.49 days. Additional feeding time (time to spawning) of the adult moth varied from 1.0 to 2.0 days, averaging 1.17 ± 0.38 days.

The survey showed that the eggs of *L. orbonalis* has a high hatching rate, ranging from 52.09 - 96.64%, with an average of 85.92 ± 12.17%. The percentage of the larvae that survived to the pupae stage in three studies varied from 95.14 to 96.03%, with an average of 95.51 ± 0.47%. The pupae dance rate is about 96.95 - 98.35%, with an average of 97.70 ± 0.70%. The percentage of the adult moth lays eggs in the range from 85.45 to 90.80%, with an average of 88.71 ± 2.84% (table 4).

The spawning period of adults of *L. orbonalis* ranged from 1.0 to 2.0 days, with an average of 1.17 ± 0.38 day. The spawning time lasts from 2 to 4 days, with an average of 3.2 ± 0.63 days. The time after spawning of females varied from 1-2 days, on average 1.2 ± 0.42 days. The average life expectancy of females is small 3-5 days, with an average of 4.4 ± 0.70 days. Life expectancy for male is shorter than for female and varies between 2-3 days, with an average of 2.4 ± 0.52 days and usually after the death of male. The ability of *L. orbonalis* lay eggs high, the number of eggs laid by a single female varies from 87 to 342 eggs, with an average of 249.5 ± 72.77 eggs. The number of unborn eggs varied from 0 to 116 eggs, with an average of 19.2 ± 36.23 eggs. This proves that the ability of *L. orbonalis* to lay eggs is not limited by artificial cultural environment (table 5).
Table 5. Period growth and fertility of adult *L. orbonalis*

| Period                              | Phonetic time (days) | Average value (X ± SD) | Variability | Number of observations |
|-------------------------------------|----------------------|------------------------|-------------|------------------------|
| Extra nutrition time                |                      | 1.17 ± 0.38            | 1.0 – 2.0   | 30                     |
| Time to lay eggs                    |                      | 3.2 ± 0.63             | 2 – 4       | 10                     |
| Time after spawning                 |                      | 1.2 ± 0.42             | 1 – 2       | 10                     |
| Longevity of female adult moth      |                      | 4.4 ± 0.70             | 3 – 5       | 10                     |
| Longevity of male adult moth        |                      | 2.4 ± 0.52             | 2 – 3       | 10                     |
| Ability to lay eggs / females (eggs)|                      | 249.5 ± 72.77          | 87 – 342    | 10                     |
| Number of unborn eggs (eggs)        |                      | 19.2 ± 36.23           | 0 – 116     | 10                     |
| Average temperature (°C)            |                      | 28.16 ± 1.36           | 26.4 – 30.0 |                        |
| Average humidity (%)                |                      | 78.19 ± 5.54           | 71.8 – 84.3 |                        |

Observing the activity of *L. orbonalis* adults, they mate, lay eggs from evening to night (at 19-24 pm) and spawn at 21-22 pm.

4. Conclusion
The damage of *L. orbonalis* is mainly in the period of 95 - 150 days after planting and decreases until the end of harvest.

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 females size varies from 9.6 to 12.3 mm, the male ranges from 8.1 to 9.5 mm.

Eggs oval or ellipse. Egg sizes vary from 1.0 to 1.2mm long and 0.48 to 0.60mm wide. The larvae are 6 years old, strenuous to release silk pupae on the tree or under the vegetation and reproductive time is about 10 - 12 days. The pupae are iridescent dark brown nymphs, when they are about to turn into arms, they are dark brown in color, the length varies from 11.47 to 15.33 mm, the width is about 4.40 - 6.45 mm and the pupae lasts 8 - 9 days. The life cycle of *L. orbonalis* is about 25.30 ± 0.92 days. Average fertility of the female 249.5 ± 72.77 eggs, time to lay eggs at night.

Identify harmful levels, morphological and biological characteristics of *L. orbonalis* on eggplant in Trang Bom, Dong Nai.

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