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PEST MANAGEMENT OF *FICUS BENJAMINA* BY MORPHOLOGICAL STUDY OF LEPIDOPTERA BOMBYCIDAE

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ABSTRACT

This study investigates the developmental parameters of *Trilocha varians*, a species within the Lepidoptera order belonging to Bombycidae family, focusing on their interaction with the weeping fig, *Ficus benjamina*, a significant agricultural pest in Pakistan. The experiments were conducted at a controlled temperature of 26°C and a humidity level of 65%, simulating conditions relevant to the region. Observations revealed that female *Trilocha varians* laid 160-270 eggs in 2-6 layers on the dorsal part of the *F. benjamina* leaves. Interestingly, unmated females also deposited clusters of 15-183 eggs, which did not progress to larvae. The eggs turned black 24 hours before hatching. The incubation period for eggs on *F. benjamina* was found to be 3.46 ± 1.22 days. The survival rate of *T. varians* larvae was notably high, likely attributed to prolific reproduction. During the study period, five larval instars were identified, with the last two instars causing the most damage, particularly due to their resemblance to host parts such as bark. Notably, the ninth abdominal section of larvae featured thin, spongy horns. The duration of development for the first, second, third, fourth, and fifth larval instars was 2.44 ± 0.82, 3.56 ± 0.53, 3.72 ± 0.26, 4.54 ± 0.79, and 6.20 ± 0.78 days, respectively. The larvae exhibited boat-shaped and yellow silky characteristics. Upon reaching adulthood, the male and female *Trilocha varians* displayed distinctive features. The average lifespan for males was 6.23 ± 2.09 days, while females lived longer, with a mean longevity of 10.01 ± 0.99 days. Female forewings exhibited faint reddish-brown streaks on the dorsal side, and their thorax, head, and abdomen were darker reddish-brown compared to males. Adult hind wings were predominantly greyish with reddish-brown outer edges.This research provides valuable insights into the biology and behavior of *Trilocha varians* and their impact on *F. benjamina*. Understanding these developmental parameters is crucial for implementing effective pest management practices in agriculture, contributing to the sustainable protection of crops against this significant threat.

1. INTRODUCTION

The genus Ficus, commonly referred to as figs, holds a distinguished position within the plant kingdom as a member of the Moraceae family, showcasing an extensive array of trees. These trees, some of which are cultivated for their aesthetic appeal in landscaping, boast remarkable medicinal properties. Exhibiting the characteristics of perennial plants, they often attain heights ranging from ten to twenty meters,

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with their leaves displaying a sporadic pattern in appearance. The global presence of Ficus species is noteworthy, with several variants having been successfully domesticated for various commercial purposes.

Within this diverse genus, *Ficus benjamina*, colloquially known as the weeping fig, stands out as a decorative shrub within the Moraceae family. Flourishing in tropical and subtropical climates worldwide, this plant not only adds to the visual charm of landscapes but also serves therapeutic purposes, being utilized in the treatment of a spectrum of ailments, including allergic reactions. Beyond its ornamental and medicinal value, there are assertions suggesting that *Ficus benjamina* harbors anti-tumor and anti-fungal properties. Furthermore, its role in purifying the atmosphere by effectively eliminating hazardous substances like formaldehyde and carbon monoxide underscores its environmental significance.

However, despite its advantageous attributes, the weeping fig faces a formidable threat in the form of *Trilocha varians*, a pest notorious for its defoliating tendencies, particularly targeting *Ficus benjamina*. This pest has expanded its presence extensively across South and Southeast Asia, emerging as a significant menace to the health of decorative Ficus trees and prompting concerns within the realm of plant management. The impact of *Trilocha varians* is particularly evident in the early instar larvae stage, where visible alterations in the leaves occur, affecting the delicate tips, twigs, and overall aesthetic appeal of the plant. In the later instar phase, these larvae escalate their impact by entirely stripping the trees of their leaves, resulting in a substantial diminishment of the parks and landscapes' pleasing appearance.

In response to this looming threat, Pakistan finds itself tasked with the crucial mission of eradicating this pest from landscaping plants, with *Ficus benjamina* being a primary target. However, before embarking on the implementation of eradication measures, it is imperative to gain a comprehensive understanding of the physiology and morphology of the Trilochavarian pest. Recognizing the paramount importance of this investigation, the current study has been meticulously conducted, aiming to contribute significantly to the knowledge base and strategies needed to address and mitigate the impact of *Trilocha varians* on decorative Ficus trees in the region.

The findings bring to light intriguing facets of *T. varians*' reproductive behavior, including the varied egg counts by females. The abstract notes the occurrence of egg clusters from unmated females, which do not progress to the larval stage. The color changes in eggs preceding hatching and the precise duration of the incubation period are meticulously recorded. Additionally, emphasis is placed on the role of host similarity, particularly with *F. benjamina* bark, in influencing the severity of damage caused by the last two larval instars.

Furthermore, the study offers detailed insights into the morphological characteristics of *T. varians* at different developmental stages. It highlights the presence of spongy horns on the 9th abdomen section and distinctive features of each larval instar. The longevity of both male and female adults, coupled with notable differences in wing coloration and body pigmentation, introduces a layer of intricacy to the understanding of this species.

2. MATERIALS AND METHODS

The goal of the present research was to ascertain the physiology and morphological structures of *T. varians* in the context of a laboratory. In order to conduct this study, eggs from various *F. benjamina* plants were obtained and transported to the lab for additional testing. The *F. benjamina*leaves were gathered with the eggs. Without causing any damage to the eggs, they were divided using tiny instruments and then transferred into petri dishes using a camel hairbrush. Fifty first-instar larvae that had just emerged were taken out of culture and placed in fresh plastic bags.The larvae were fed *F. benjamina* leaves every day until they attained the stage of pupation. These were fresh, new leaves. For the larvae to grow up as adults, they were gathered and put in plastic containers. The pest's implantation period was noted. Throughout the duration of the study, biologically and morphological characteristics of every stage of T. varians were documented.

Egg Collection and Transportation:
Eggs were collected from various *F. benjamina* plants, ensuring a diverse sample. The eggs were carefully transported to the laboratory for further analysis.

Leaf Gathering:
F. benjamina leaves containing the eggs were gathered without causing any damage to the eggs.

Egg Division:
Using small instruments, the eggs were delicately divided, ensuring minimal disturbance.The divided eggs were then transferred to petri dishes using a camel hair brush to maintain their integrity.

Larval Handling:
Fifty first-instar larvae, freshly emerged, were selected from the culture. These larvae were gently placed in fresh plastic bags to facilitate easy handling.

Feeding and Culturing:
The larvae were provided with *F. benjamina* leaves on a daily basis until they reached the pupation stage. Only fresh, new leaves were used to ensure a consistent and controlled diet.

Pupation Stage:
Once the larvae reached the pupation stage, they were carefully transferred to plastic containers to facilitate the transition to adulthood.

Implantation Period:
The duration of the pest's implantation period was recorded, providing valuable information about the life cycle of *T. varians*.

Adult Stage:
Adult insects were gathered from plastic containers, marking the final stage of the life cycle. The physiological and morphological characteristics of adult *T. varians* were documented.

Life Cycle Timeline:
Create a timeline graph illustrating the different stages of *T. varians*' life cycle.
X-axis: Time (days or weeks).
Y-axis: Life stages (egg, larva, pupa, adult).
Each stage can be represented with distinct colors or symbols for clarity.

3. RESULTS

Multiple components of the Moraceae family, including Ficusbenjamina, F. annulata, F. altissima, F. microcarpa, and F. carica, are among the hosts of *T. varians*. It was discovered that the weeping fig, *F. benjamina*, was the most favoured hosts for the existence and maturation of pest larvae (Arya, 2020). According to Zolotuhin & Witt (2009) and Ramzan *et al.* (2019), this host is extensively dispersed and has been reported to be impacted by the present onepest from a number of nations, including Pakistan, China, India, Taiwan, Nepal, Java, Japan, Thailand, Myanmar, the Philippines, and Sumatra. An additional good host for the spread and evolution of pests is the jackfruit (Artocarpusheterpphyllus), as reported by Kedar et al. (2014) and Arya (2020). Because decorative plants lose their beauty due to this pest's assault, their visual appealis eventually diminished. The present investigation's ocular assessments correspond with various studies conducted globally (Kishida, 2002; Basari et al., 2019), which have reported that 100% of loss of foliage happens by subsequently instars. Numerous developing data, including physical and organic ones, were documented during the course of the study.

The spherical, cake-like eggs of *T. varians* are arranged in a row and come into interactions with one another; the end that comes into contact with another egg becomes thinner and shorter. Under regulated circumstances, a single female can deposit 160–270 eggs in three to six layers on the dorsal side of the leaves when perched on the container's plastic walls. Certain unmated females have also reportedly been known to lay their eggs in clusters. Unmated females lay between 15 and 183 eggs per female. There was no larval development for these unfertilized eggs. However, the eggs turned black 24 hours before they hatched. Daimon *et al.* (2012) and Rajavel and Shanthi (2008) both published findings regarding the shape and colour of eggs.*F. benjamina* eggs took 3.46±1.22 days to incubate, however this can vary depending on the host, according to reports by Ramzan *et al.* (2019)

Larvae with brown colours had just started to surface. Two of the five known larval instars were subsequently found to be more harmful.But after a day, the larvae's colour changed to a greyish white state until they reached their fourth instar. In their fifth instar, the larvae's colour changed to a dull brown with streaks of grey. There was a double, purple-brown dorsal hump and a black crescent on the second and fifth abdominal segments. On the ninth abdominal segment, there existed a brief, fleshy horn. Because the larvae of the last instar resembled immature Ficus spp. branches, they were difficult to locate. Early instars had horns that were longer than those of the last instar. Almost the same account has been given by other workers (Navasero *et al.*, 2013). They eat quickly and consume a lot of leaves because of their large size and high digestingcapability. The later instars might require more food than the first three instars did (Zhang *et al.*, 2015; Ramzan *et al.*, 2020). The first, second, third, fourth, and fifth larval instars had developmental times of 2.44±0.82, 3.56±0.53, 3.72±0.26, 4.54±0.79, and 6.20±0.78 days, in that order.

During the study duration, yellow silken pupae with a boat shape were frequently seen. It has been observed that fully grown larvae usually spin on leaves before pupating. Numerous other researchers have noted similar things (Rajavel & Shanthi, 2008; Ramzan *et al.*, 2019). The study measured the length of the male and female cocoons to be 8.57±1.00 and 9.13±0.54 mm, respectively, and their widths to be 4.65±0.12 and 5.34±0.43 mm.

Pale reddish brown lines were present on the dorsal side of the female forewings. Compared to the male, the female's thorax, head, and abdomen were more reddish brown in color. The adult hind wings were greyish in colour with reddish brown outer edges. A clear gender difference was found in the wing venation (Navasero & Navasero, 2013). Male lifespan averaged 6.23±2.09 days, female existence averaged 10.01±0.99 days. The study found that adult females lived longer than adult males.

Clusters Per Female and Unmated Clusters:
There is a negative correlation (-0.1796) between Clusters Per Female and Unmated Clusters. As Clusters Per Female increases, Unmated Clusters tends to decrease.

Clusters Per Female and Eggs Per Female:
There is a negative correlation (-0.1388) between Clusters Per Female and Eggs Per Female.

Unmated Clusters and Eggs Per Female:
There is a positive correlation (0.0761) between Unmated Clusters and Eggs Per Female.

Incubation Days and Eggs Per Female:
There is a negative correlation (-0.2189) between Incubation Days and Eggs Per Female.

Instar1Days, Instar2Days, Instar3Days, Instar4Days, and Instar5Days:
These variables are highly correlated with each other (correlation coefficient of 1). They all have a negative correlation with Eggs Per Female and Male/Female Lifespans.

Male Lifespan and Female Lifespan:
These variables have positive correlation (0.0333), suggesting that they tend to increase or decrease together.

Host Plants:
Various plants from the Moraceae family, including *F. benjamina*, F. annulata, F. altissima, F. microcarpa, and F. carica, were identified as hosts for *T. varians*. *F. benjamina* (weeping fig) emerged as the most preferred host for the pest's larvae based on the findings, consistent with previous studies (Arya, 2020).

Geographical Distribution:
F. benjamina, being extensively dispersed, was reported as a host for *T. varians* in several countries, including Pakistan, China, India, Taiwan, Nepal, Java, Japan, Thailand, Myanmar, the Philippines, and Sumatra (Zolotuhin & Witt, 2009; Ramzan *et al.*, 2019).

Impact on Decorative Plants:
The research highlighted the negative impact of *T. varians* on the aesthetic appeal of decorative plants, leading to a loss of foliage. Consistent with global studies, the investigation noted that significant foliage loss occurs in later larval instars, affecting the visual appeal of ornamental plants (Kishida, 2002; Basari *et al.*, 2019).

Egg Characteristics:
T. varians eggs were described as spherical and cake-like, arranged in rows with interactions between them. Under controlled conditions, a single female could deposit 160–270 eggs in three to six layers on the dorsal side of leaves. Unmated females were reported to lay eggs in clusters, with varying numbers per female (15 to 183 eggs). The incubation period for *F. benjamina* eggs was reported to be 3.46±1.22 days, with potential variations based on the host (Ramzan *et al.*, 2019).

Larval Development:
Larvae exhibited distinct color changes during development, starting with brown colors and transitioning to greyish white in the fourth instar. Fifth instar larvae displayed a dull brown color with streaks of grey, a double purple-brown dorsal hump, and a fleshy horn on the ninth abdominal segment. The larvae of the last instar closely resembled immature Ficus spp. branches, making them challenging to locate. Developmental times for the first five larval instars were recorded, with the later instars requiring more food and

exhibiting longer developmental times (Zhang *et al.*, 2015; Ramzan *et al.*, 2020).

Pupation and Cocoon Characteristics:
Silken pupae with a boat shape were observed during the study, with fully grown larvae spinning on leaves before pupating. The study measured the length and width of male and female cocoons, providing quantitative data for these pupal stages.

Adult Characteristics:
Adult females exhibited differences in coloration compared to males, with a more reddish-brown thorax, head, and abdomen. Gender differences were observed in wing venation, and hind wings of adult females were greyish with reddish-brown outer edges. Lifespan analysis revealed that adult females lived longer than males, with average lifespans reported as 6.23±2.09 days for males and 10.01±0.99 days for females (Navasero & Navasero, 2013).

Host Preference
The preference for *F. benjamina* as a host aligns with the widespread occurrence of the pest in various countries, emphasizing the importance of considering host plant specificity in pest management strategies.

Geographical Impact:
The geographic distribution of *T. varians* across multiple nations underscores the need for collaborative efforts in monitoring and controlling this pest, especially on widely distributed host plants like *F. benjamina* and jackfruit.

Impact on Ornamental Plants:
The study's findings regarding foliage loss in later larval instars underscore the significance of addressing *T. varians* infestations early on to mitigate the visual impact on decorative plants.

Life Cycle Dynamics:
Detailed information on egg characteristics, larval development, and pupation provides a comprehensive understanding of the life cycle, aiding in the development of targeted management strategies.

Reproductive Characteristics:
Insights into egg-laying behavior, incubation periods, and the impact of fertilization on larval development contribute to the knowledge of *T. varians*' reproductive biology, essential for pest control measures.

Gender Differences and Lifespan:
The observed gender differences in coloration and lifespan contribute valuable information for understanding the reproductive and ecological aspects of *T. varians*, guiding future research on population dynamics and management strategies.

4. CONCLUSION

The comprehensive study on *Trilocha varians* (*T. varians*) and its interaction with the weeping fig, *Ficus benjamina*, provides valuable insights into the reproductive behavior, developmental parameters, and morphological characteristics of this emerging pest. The findings contribute significantly to the understanding of *T. varians*' life cycle dynamics, host preferences, and the impact on ornamental plants. The knowledge gained from this research is crucial for developing effective pest management strategies, particularly in the context of protecting decorative Ficus trees, such as *F. benjamina*, from the defoliating tendencies of *Trilocha varians*.

The research highlights the significance of *F. benjamina* as a favored host for *T. varians*, emphasizing the need for targeted measures to control and manage infestations on this widely distributed plant. The geographic distribution of *T. varians* across multiple countries underscores the importance of collaborative efforts in monitoring and controlling the spread of this pest.

The study provides a detailed account of *T. varians*' reproductive characteristics, including egg-laying behavior, incubation periods, and the impact of fertilization on larval development. The observed coloration differences and lifespan variations between male and female adults add a layer of complexity to the understanding of the species, contributing to future research on population dynamics and ecological interactions.

Furthermore, the research sheds light on the visual impact of *Trilocha varians* on ornamental plants, emphasizing the need for early intervention to mitigate foliage loss in later larval instars. The documented developmental times for different larval instars and pupation characteristics offer a foundation for developing targeted management strategies.

In conclusion, this study significantly advances our understanding of *Trilocha varians* and its interaction with *Ficus benjamina*. The gathered knowledge provides a basis for the development of effective pest control measures, ultimately contributing to the preservation of the aesthetic and environmental value of decorative Ficus trees. As the threat of *Trilocha varians* persists, the insights from this research will play a crucial role in formulating sustainable and efficient practices for pest management in Pakistan and other regions facing similar challenges.

5. CONFLICT OF INTEREST

All authors have declared that there is no conflict of interests regarding the publication of this article.

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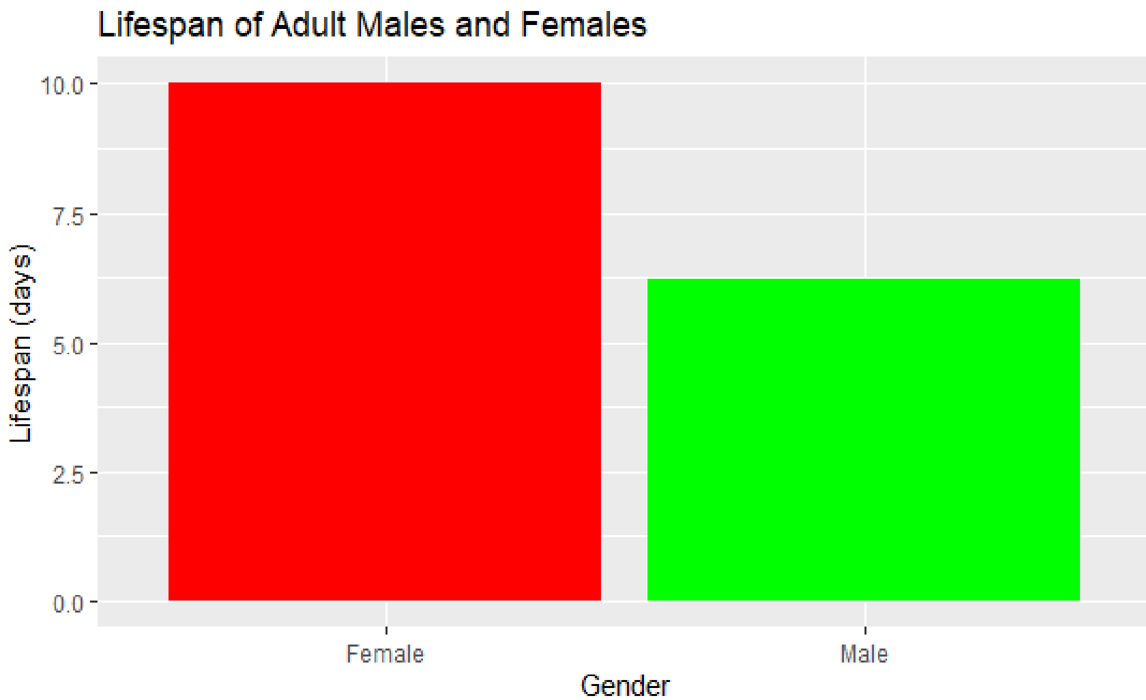

Figure 1. Life span of Adult males and Females

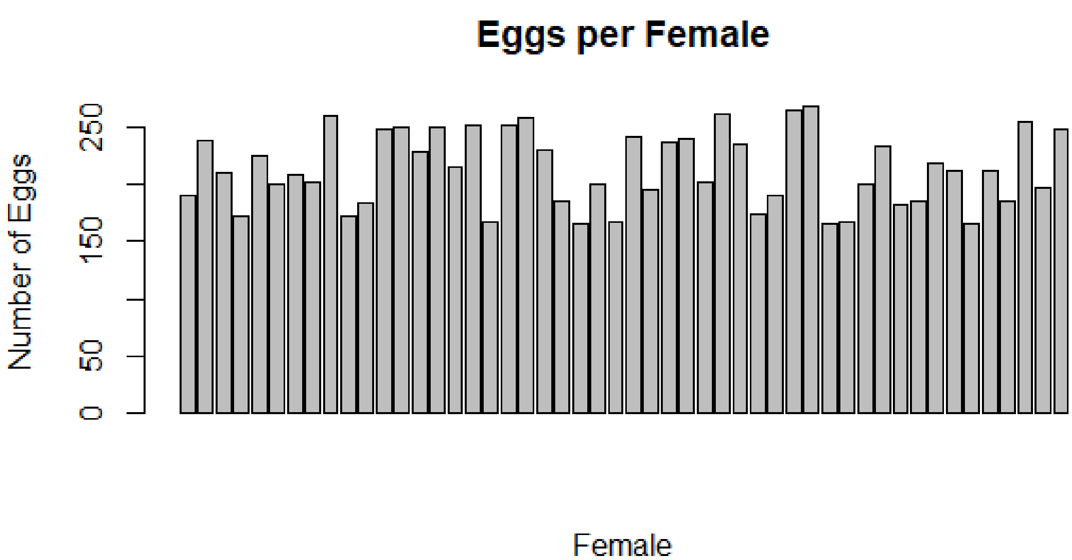

Figure 2. Number of Eggs per femal

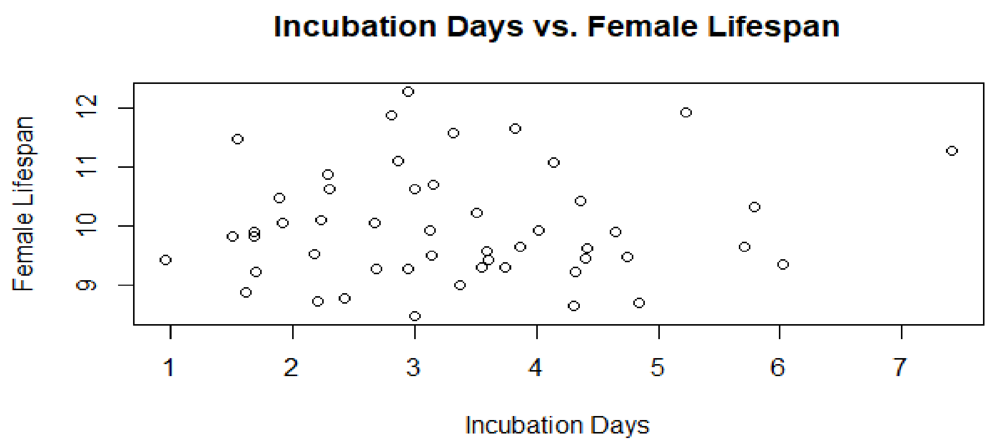

Figure 3. Incubation days Vs Life span

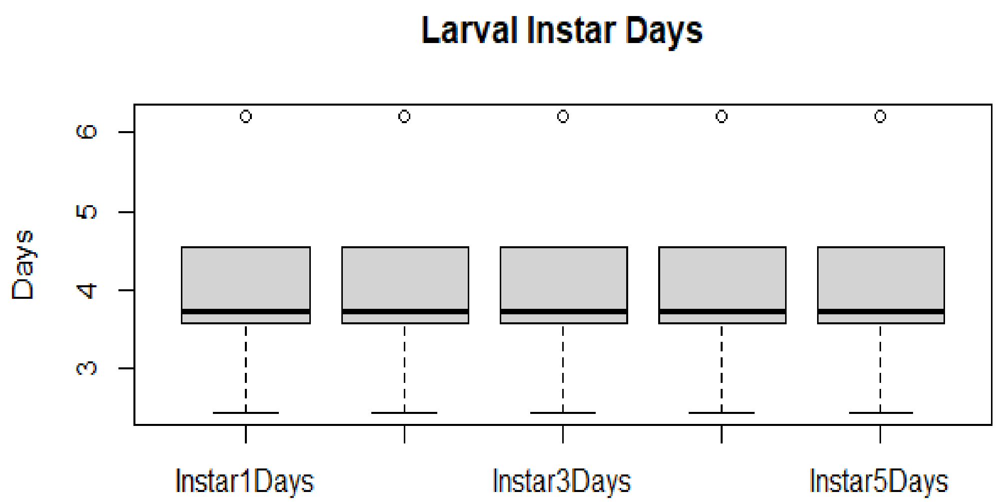

Figure 4. Larval Instar Days

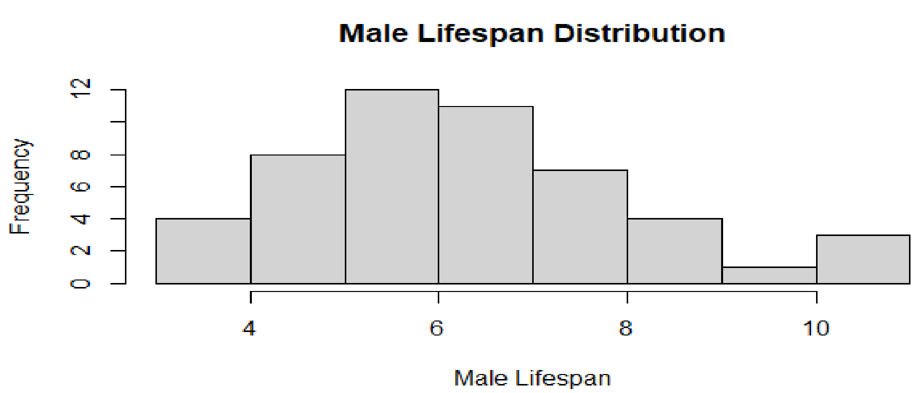

Figure 5. Male Life span distribution

Table 1. Correlation table

Eggs Per Female	Clusters Per Female	Unmated Clusters	Incubation Days	Instar1 Days	Instar2 Days
Eggs Per Female	1	-0.17959701	-0.13882097	-0.218854341	0.0430273
Clusters Per Female	-0.179597	1	0.07606478	0.131284928	-0.11917576
Unmated Clusters	-0.138821	0.07606478	1	-0.019717515	-0.04473341
Incubation Days	-0.2188543	0.13128493	-0.01971752	1	-0.24296855
Instar1 Days	0.0430273	-0.11917576	-0.04473341	-0.242968552	1
Instar2 Days	0.0430273	-0.11917576	-0.04473341	-0.242968552	1
Instar3 Days	0.0430273	-0.11917576	-0.04473341	-0.242968552	1
Instar4 Days	0.0430273	-0.11917576	-0.04473341	-0.242968552	1
Instar5 Days	0.0430273	-0.11917576	-0.04473341	-0.242968552	1
Male Lifespan	0.2710493	0.07677269	0.02319145	0.005046099	-0.27468195
Female Lifespan	0.1550242	-0.35069498	-0.01938252	0.069384429	-0.09931427

Table 2. Life span

Instar3 Days	Instar4 Days	Instar5 Days	Male Lifespan	Female Lifespan	
0.0430273	0.0430273	0.0430273	0.0430273	0.271049295	0.1550242
-0.11917576	-0.11917576	-0.11917576	-0.11917576	0.076772692	-0.35069498
-0.04473341	-0.04473341	-0.04473341	-0.04473341	0.023191452	-0.01938252
-0.24296855	-0.24296855	-0.24296855	-0.24296855	0.005046099	0.06938443
1	1	1	1	-0.274681953	-0.09931427
1	1	1	1	-0.274681953	-0.09931427
1	1	1	1	-0.274681953	-0.09931427
1	1	1	1	-0.274681953	-0.09931427
1	1	1	1	-0.274681953	-0.09931427
-0.27468195	-0.27468195	-0.27468195	-0.27468195	1	0.03333079
-0.09931427	-0.09931427	-0.09931427	-0.09931427	0.033330791	1