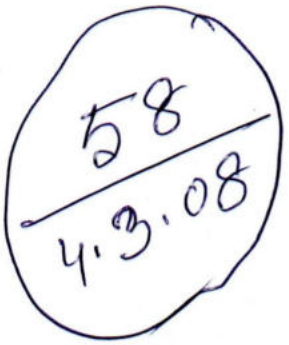
Biology and leaf consumption of mango defoliator *Cricula trifenestrata* Helfer (Lepidoptera: Saturniidae)

A Thesis
By



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Registration No. 0605026
Session : 2006-2007

Master of Science (M.S.)
in
Entomology

Department of Entomology
Hajee Mohammad Danesh Science and Technology University
Dinajpur

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Submitted to the Department of Entomology, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur in partial fulfilment for the requirements of the Degree of

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November 2007


DEDICATED TO
MY
BELOVED PARENTS AND BROTHER

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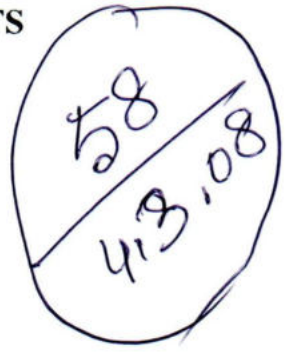
The author

Abstract

A study was undertaken to observe the biology and leaf consumption of mango defoliator, *Cricula trifenestrata* Helfer in the laboratory, Department of Entomology, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur during the period of April to July, 2007 at 25 ± 2°C and 75 ± 5 % RH (at room temperature and humidity). The results of biology reveal that the pre-oviposition, oviposition and incubation period of the mango defoliator were 2.3, 0.5 and 8.7 days, respectively. The average number of eggs laid by a female was 141.70 and the hatching rate was 88.81 %. The mean duration of the first, second, third, fourth and the final instar larvae were 5.30, 5.10, 6.10, 5.80 and 6.20 days, respectively. The mean duration of pre-pupa and pupa were 2.50 and 19.55 days. The average longevity of male and female moths was 2.90 and 4.20 days, respectively. The average total developmental periods from egg to adult were 59.2 days. The morphological data show that the average length and breadth of eggs were 2.27 and 1.86 mm, respectively. The mean length and breadth of 1st, 2nd, 3rd, 4th and 5th instar larvae were 4.08, 13.90, 30.09, 61.37, 81.49 and 2.17, 5.09, 7.23, 11.22, 15.51 mm, respectively. The average length and breadth of male and female cocoons were 41.98, 50.89 and 12.31, 16.22 mm whereas the length and breadth of male and female pupae were 31.64, 35.57 and 10.61, 12.58 mm, respectively. The average length and breadth of male and female moths were 22.35, 32.48 and 32.02, 74.14 mm, respectively. The data of the feeding behaviour reveal that 1st, 2nd, 3rd, 4th and 5th instar larvae consumed 10.5, 20.7, 85.3, 415.6 and 650.3 cm^2 or 0.50, 1.20, 2.80, 8.50 and 16.40 g leaves, respectively. A larva consumed 1164.45 cm^2 or 27.2 g leaf during its developmental period and the result shows that the final instar larvae consumed the highest amount of leaf.

CONTENTS



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Chapter 1
Introduction

CHAPTER I

Introduction

Mango, *Mangifera indica* L. is one of the king of fruits of the world (Butani, 1979). It is the most popular fruit among millions of people in the orient and has a great economic importance in tropical and sub-tropical regions (Mondal et al., 2004). It is considered to be the choicest of all indigenous fruit (Singh, 1960). It is also one of the important fruits in Bangladesh. It tops the list and second in terms of production among the fruits in Bangladesh. It is grown under a tropical and sub-tropical climate in all parts of the country, but production of quality mango is confined to the northwestern part of Bangladesh, particularly in the districts of greater Rajshahi and Dinajpur (Matin et al., 2006). There is perhaps no fruit other than ripe mango that contains 2743 mg of carotene, the precursor of vitamin A. Both unripe and ripe mangoes are a good source of vitamin C (ascorbic acid 16 mg) (Hossain, 1989).

Bangladesh produces 187220 metric tons of mangoes annually from 124715 acres of land (BBS, 2000) which is very poor as compared to the neighboring countries. The most important reasons for this decline of mango production are the infestation of different insect pests. It has been reported that over 175 species of insects infest and damage mango regularly (Fletcher, 1970; Veva, 1969 and Nayar et al., 1976). Mango defoliator, mango hopper, mealybugs, bark-eating caterpillars, stem borers, scale insects, fruit flies, stone weevils, gall midges etc. are the common insect pests of mango. Among them, mango defoliator *Cricula trifenestrata* Helfer is one of the most important destructive insect pests of mango. Its caterpillar is a major pest of mango and destroying 13 to 51 %

leaves (Ahmed and Alam, 1994). It is also infested Daruchini plant *Cinnamomum zeylanicum* (Ahmad and Ahmad, 1991; Sujata-Yadav and Anand-Kumar, 2003), cashew *Anacardium occidentale* (Pal and Medda, 2006) and plantation crops (Das et al., 1999).

Mango defoliator is widely distributed in Asia, mainly tropical countries such as Bangladesh, India, Indonesia, Malaysia, Srilanka, Philippines. It is also distributed in Australia, Africa and South America (Mukherjee, 1953). The common name, defoliator refers to the larval habit of defoliating the leaves of mango plant during feeding. Mango defoliator is also known in Bengali as Amer Pata Khcko Shua Poka or 'Am Patar Bichcha Poka' (Hossain, 1989) and Wild Silk Moth (Pal and Medda, 2006). It occurs occasionally in large number, feeds gregariously on the leaves and may defoliate the trees completely. Most of the varieties of mango are infested by this pest in the country (Burhanuddin and Ahmed, 1989). The larvae are seen feeding voraciously on leaves, resulting complete defoliation with only the mid-ribs being left. If left uncontrolled, the larvae can defoliate the whole plant as it moved from one side of the plant to another (Pal and Medda, 2006).

Recently, mango defoliator has been found to cause serious damage to the mango plants in different parts of Bangladesh. Management of this pest is now of great importance to the mango growers.

Before developing suitable control measures for any pest, detailed information regarding the biology, leaf consumption behaviour of the larvae is most essential. On the other hand the morphological study provides information about amount of insecticide application, types of insecticide and spray method determination as well as susceptibility to insecticide application. But reviews about this pest are limited and environmental conditions of Dinajpur are different from other areas of the country. So, the present study was undertaken with the following objectives:

1. to know the detailed biology of mango defoliator.
2. to determine the actual quantity of leaves consumed by the larvae in terms of area and weight.

Chapter 2
Materials and Methods

CHAPTER 2

Materials and Methods

A study on the biology and leaf consumption of mango defoliator, *Cricula trifenestrata* were conducted in the laboratory of the Department of Entomology and the campus of Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur during the period of April to July, 2007 at 25 ± 2°C and 75 ± 5 % RH (at room temperature and humidity).

2.1. Collection and mass culture of mango defoliator

Male and female moths of *C. trifenestrata* were collected from the mango plant of BRAC centre near Northern side of HSTU, Dinajpur. Five pairs of moths consisting of equal sex ratio were released in a small mango tree of HSTU campus, covered with thin net for mating (Plate 1). The adults female were observed regularly at eight hours interval for their oviposition. After mating the female moths laid eggs in rows at the edge of the mango leaves. The eggs were allowed to hatch.

2.2. Biology of mango defoliator

From the mass culture, newly hatched first instar larvae were carefully collected with the help of a soft camel hair brush and were individually transferred in ten petridishes (one larva in each petridish). Medium aged fresh mango leaves (Var. Fazlee) were supplied every morning to each petridish as food and the leaves were renewed at 12 hours interval. Wet cotton was used to keep them fresh. Data were taken carefully to record the duration of each larval instar, pupa and adult. Reproductive parameters like pre-oviposition period, oviposition period, fecundity etc also studied. In addition, morphometric measurement of eggs, larvae, pupae and adults were also recorded.

For the measurement of length and breadth of the eggs an oculomicroscope (oculomicrometer) was used. The length and breadth of different larval instars and adult moths are measured with the help of millimeter scale.

Plate 1. A small mango tree of HSTU campus covered with thin net for mating

2.3. Leaf consumption by mango defoliator

The leaf foliage consumed by each larval instar was also measured daily by subtracting leaf before and after consumption using Mettler digital balance (Model- MR 220, No. 971373) in case of weight and Electric automatic area meter (Model L- 13000, LI- COR, Nebrasca USA) in case of area.

From laboratory stock culture, one newly hatched first instar larva was released into each petridish with ten replications. The medium mature leaves were supplied by making small pieces with the help of a sharp scissor. The initial weight of supplied leaf pieces in each petridish was taken separately with the help of electric balance. To find out the weight of consumed leaves (g) in 24 hours (A) , the weight of unused leaves (C) and the weight of moisture loss from the control petridish (D) were subtracted from the initial weight of supplied leaves (B).

Calculation can be as follows:

A = B-(C+D), Where,

A = Weight of consumed leaves (g)

B = Initial weight of supplied leaves (g)

C = Weight of unused leaves (g)

D = Weight of moisture loss from the control petridish (g)

The process was repeated in case of all larval instars. Leaf consumption by each larval instar in different days was recorded.

2.4. Statistical analysis

Data of the leaf consumption of different larval instars were analyzed by Analysis of variance (ANOVA) and the mean values were separated by Duncan's Multiple Range Test (DMRT). All analysis was preformed using SPSS, version 12.01 (SPSS, Chicago, IL, USA).

Chapter 3
Results and Discussion

CHAPTER 3

Results and Discussion

In the present study, the biology and leaf consumption of mango defoliator *Cricula trifenestrata* were investigated. In these connections various data were collected. They were statistically analyzed and the results are harmonically presented in different figures, tables and plates.

3.1. Biology of mango defoliator

3.1.1. Pre-oviposition period

It was found that the females did not lay eggs just after attaining the adult stages. The pause between the date of the emergence of the adult and the first egg deposition was the pre-oviposition period. During that period the female became less active and preferred taking rest on the ventral surfaces of the leaves. The pre-oviposition period varied from 1 to 4 days with an average of 2.3 ± 0.37 days (Figure 1 and Table 2). Huq et al. (1991) stated that the pre-oviposition period was slightly over 2 days. Alam and Hazarika (1953) reported that the pre-oviposition period ranged from 2 to 3.5 days with an average of 2.5 days. However, the results of present study varied from other findings, which might be due to different environmental conditions and quality of food.

3.1.2. Oviposition period

The oviposition period was considered as the duration between the period first and last egg laying by the female. During the oviposition period the fertilized females visited mango plants and laid eggs on the ventral surface of both margin of the leaves. A very short oviposition period was noted and varied from 0.3 to 0.6 days with the mean 0.5 ± 0.03 days (Figure 1

and Table 2). Alam and Hazarika (1953) reported that the oviposition period was 0.3 to 0.5 days, which is supported by the present study.

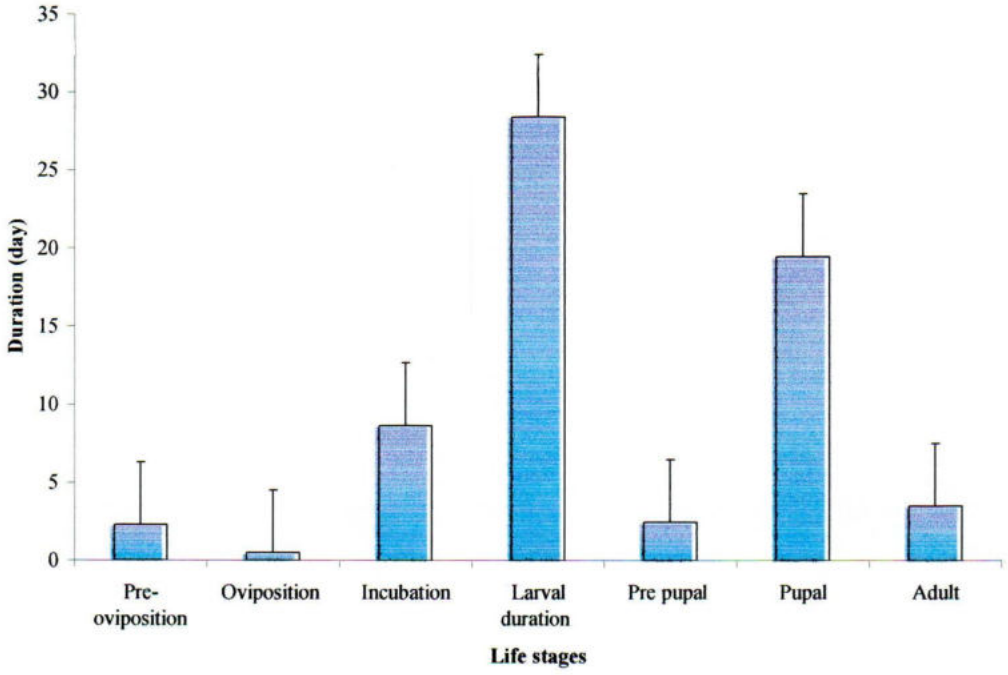

Fig. 1. Graphical representation of numerical data of duration of different life stages (mean ± SE) of *C. trifenestrata.*

3.1.3. Eggs

The female laid eggs in chain longitudinal rows along the dorsal as well as ventral margin of the leaves. There was a single row, or 2-3 rows arranged parallel to one another and preferred young leaves for laying (Plate 2). The eggs were attached vertically to the surface by means of a sticky fluid. The eggs were ovoid and whitish which changed its colour and became creamy to light orange and finally, dark and semi-transparent in colour.

Plate 2. Egg Masses of *C. trifenestrata*

The average length of eggs was 2.27 ± 0.15 mm with minimum size of 1.5 mm and maximum size of 3 mm. On the other hand the average breadth of eggs was 1.86 ± 0.12 mm with a minimum and maximum size of 1.1 mm and 2.3 mm, respectively (Figure 5 and table 3). Ahmed and Alam (1994) observed that the eggs were 1.98 mm length and 1.52 mm breadth.

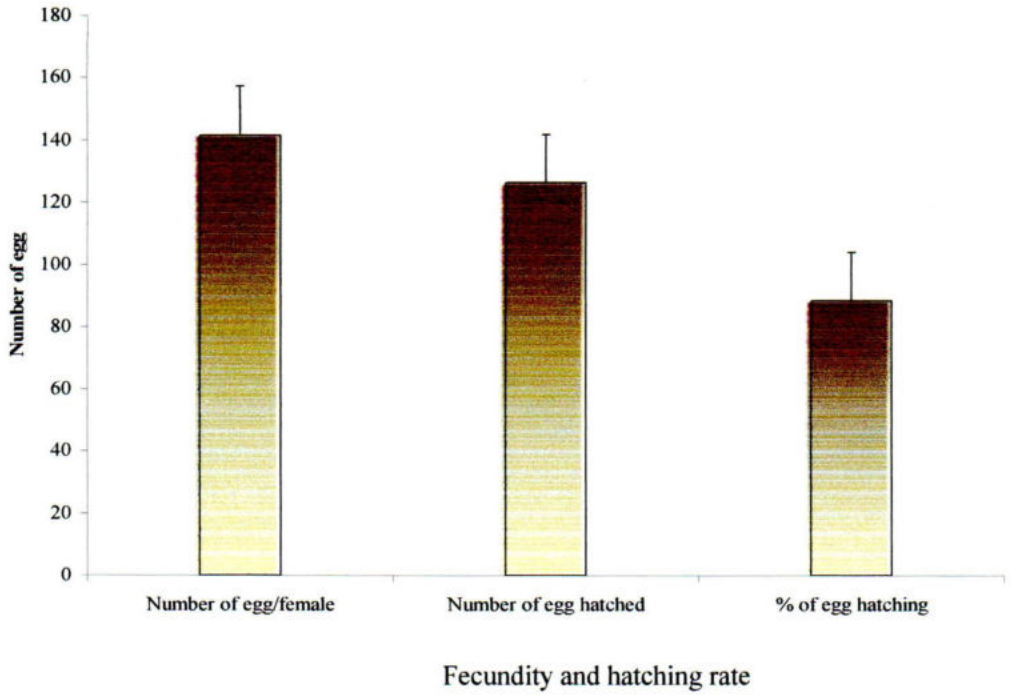

Fig. 2. Graphical representation of numerical data of fecundity and hatching rate (% mean ± SE) of *C. trifenestrata.*

3.1.4. Fecundity and hatching rate

The total number of eggs laid and hatched by a female were varied from 93 to 214 and 85 to 198 eggs with an average of 141.70 ± 11.79 and 126.50 ± 11.63 eggs, respectively (Figure 2 and Table 1). The viability of eggs ranged from 82.67 to 95.67% with a mean of 88.81 % ± 1.37 (Figure 2 and table 1). Sujata-Yadav and Anand-Kumar (2003) observed that *C. trifenestrata* was laid 157-252 eggs. Huq et al. (1991) showed that the moth was laid 177.3 eggs and egg viability varied between 61 – 70 % per female.

Table 1. **Numerical data of** fecundity and hatching rate of mango defoliator.

No of Observation	Eggs laid No./female	Eggs hatched No./female	Hatching Rate (%)	Incubation period (days)
1	127	105	82.67	7
2	93	85	91.39	9
3	113	95	84.07	11
4	120	105	87.50	8
5	103	90	87.37	10
6	148	125	84.45	7
7	178	156	87.64	9
8	214	198	92.52	8
9	185	177	95.67	10
10	136	129	94.85	8
Mean ± SE	141.70 ± 11.79	126.50 ± 11.63	88.81 ± 1.37	8.7 ± 0.42

3.1.5. Incubation Period

Incubation period is the duration between the dates of laying egg to its hatching. In the study, the incubation period varied from 7 to 11 days with an average of 8.7 ± 0.42 days (Figure 1 and Table 1). Ali and Karim (1991) observed that the incubation period of mango defoliator was 9 to 10 days. Sujata-Yadav and Anand-Kumar (2003) showed that incubation period of *C. trifenestrata* was 10.40 ± 0.55 days.

Table 2. **Numerical data of** duration (days) of different life stages of mango defoliator.

Different life stages	Periods (days)		Mean ± SE
	Minimum	Maximum	
Incubation period	7	11	8.70 ± 0.42
Larval instars			
1st Instar	4	7	5.30 ± 0.30
2nd Instar	4	7	5.10 ± 0.31
3rd Instar	5	8	6.10 ± 0.35
4th Instar	4	7	5.80 ± 0.33
5th Instar	5	8	6.20 ± 0.33
Total larval period	25	32	28.50 ± 0.78
Pre-pupal period	2	3	2.50 ± 0.17
Pupal period			
Male	16	21	18.10 ± 0.50
Female	18	24	21.00 ± 0.68
Pre-oviposition period	1	4	2.30 ± 0.37
Oviposition period	0.30	0.60	0.50 ± 0.03
Adult longevity			
Male	1	5	2.90 ± 0.38
Female	3	7	4.20 ± 0.42

3.1.6. Larva

It was observed that the larvae of *C. trifenestrata* passed through five instars with four moults. The duration of different instars was different. Just before moulting the larvae shrank and exhibited very slow movement and attached themselves to the surface of the petridish or leaves with posterior end.

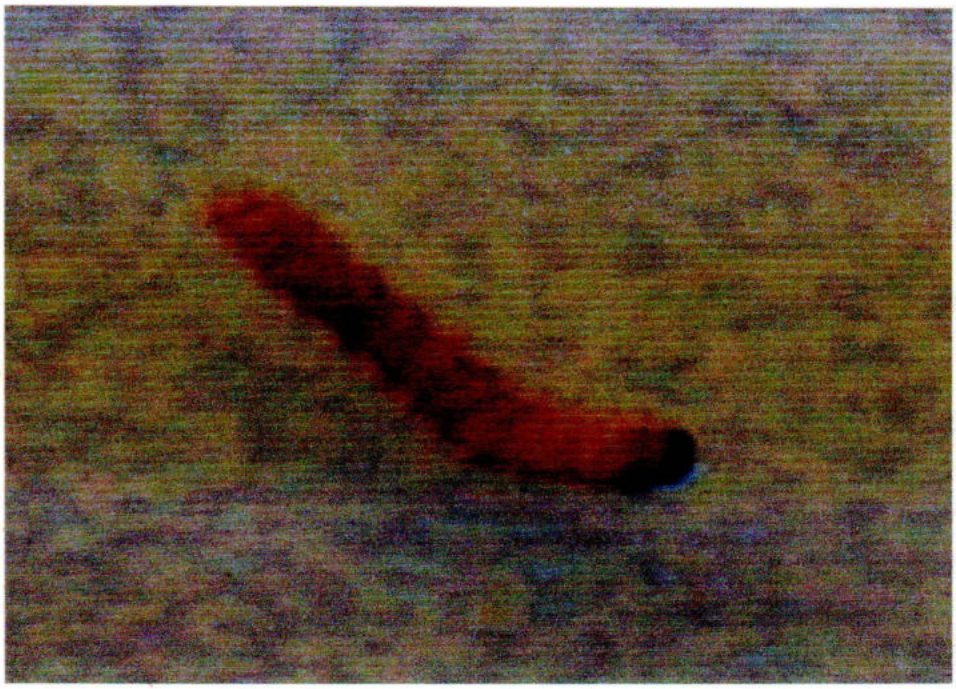

Plate 3. First instar larva of *C. trifenestrata*

Plate 4. Second instar larva of *C. trifenestrata*

3.1.6.1. First instar

After hatching, the soft bodied larva was light yellow to yellowish brown, which later turned to yellowish red with prominent dark brown head. The thoracic segments were distinct and each segment with a pair of legs. So that the tiny larva appeared densely clothed with hairs. The abdomen possessed five pairs of prolegs which were present on the third to the sixth and in the tenth abdominal segments (Plate 3).

The duration of this instar varied from 4 to 7 days with an average of 5.30 ± 0.30 days (Figure 3 and Table 2). The duration of the 1st instar larvae of *C. trifenestrata* averaged 5.4 and 5.2 days for generation I and II, respectively (Ahmed and Alam, 1994). Huq et al. (1991) observed that the duration of 1st instar larvae was 5.9, 5.6, 5.3 and 5.1 days for generation I, II, III, and IV, respectively.

Morphological measurements were made for the body length and breadth, and are presented in the Figure 4 and table 3. The results highlighted that the length of the 1st instar larvae measured from 3.5 to 5 with an average of 4.08 ± 0.15 mm and the breadth varied from 1.5 to 3.1 with a mean of 2.17 ± 0.18 mm, respectively (Figure 4 and Table 3). Ahmed and Alam (1994) mentioned that the standard size of the 1st instar larvae was 3.72 mm.

3.1.6..2. Second instar

The 2nd instar larva came out by leaving the exuviae of the 1st instar larvae. The body of the larva was clothed with tuft of long whitish and short blackish hairs arising from the tubercles. The general body colour of the larvae was combination of bands of red, yellow and black (Plate 4).

The results revealed that the duration of the 2nd instar larva was 4 to 7 with an average of 5.10 ± 0.31days (Figure 3 and Table 2). Ahmed and Alam (1994) reported that the duration of the 2nd instar larvae was 5.7 and 5.3, days for generation I and II, respectively.

The length of the 2nd instar larva was 13.2 to 14.5 with an average of 13.90 ± 0.13 mm and the breadth was 4 to 6.2 with a mean of 5.09 ± 0.24 mm, respectively (Figure 4 and Table 3). Ahmed and Alam (1994) pointed out that the average size of the 2nd instar larva was 14.10 mm.

3.1.6.3. Third instar

At this instar the larva was more active, feed more and increased in size gradually than the two previous instars. The body color of the larva was reddish yellow with a blackish red head. There was a dense growth of softer whitish hairs, arising irregularly from the mid-dorsnl area and the sides of each segment. Legs and prolegs were brick red in colour. Ventral side of each segment was red (Plate 5).

The results indicated that the duration of the 3rd instar larvae lasted from 5 to 8 days with an average of 6.10 ± 0.35 days (Figure 3 and Table 2). Ahmed and Alam (1994) pointed out that the duration of the 3rd instar larva was 6.1 days. Huq et al. (1991) showed that the duration of the 3rd instar larva was 6.4 days.

The length of the 3rd instar larva was 29.2 to 31.2 with an average of 30.09 ± 0.21 mm; the breadth measured from 6.1 to 8.1 with a mean of 7.23 ± 0.20 mm, respectively (Figure 4 and Table 3). Huq et al. (1991) mentioned that the average size of the 3rd larval instar was 29.2 mm.

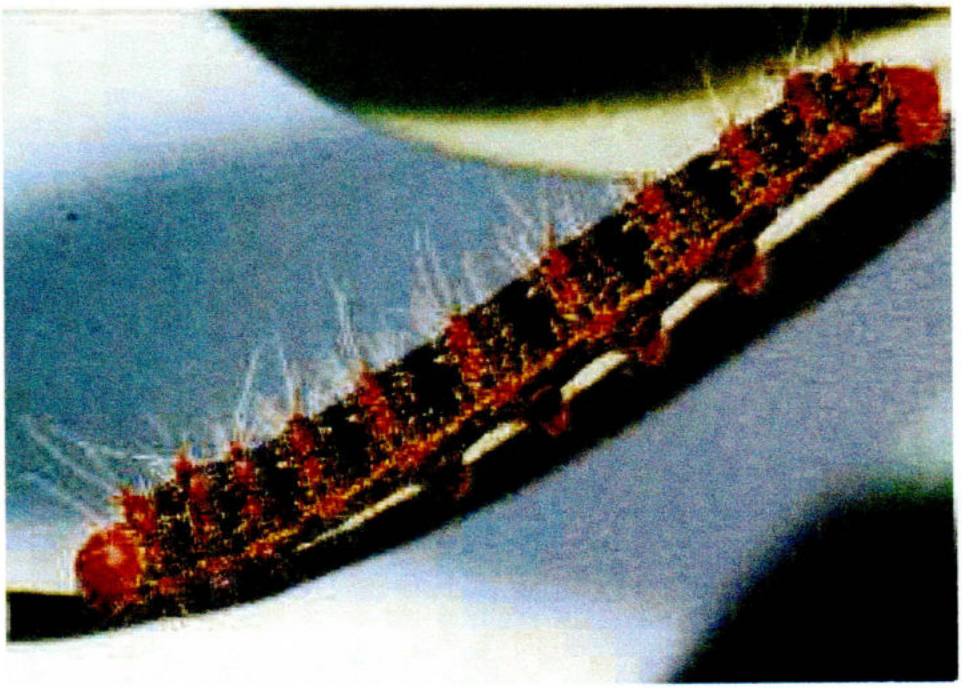

Plate 5. Third instar larva of *C. trifenestrata*

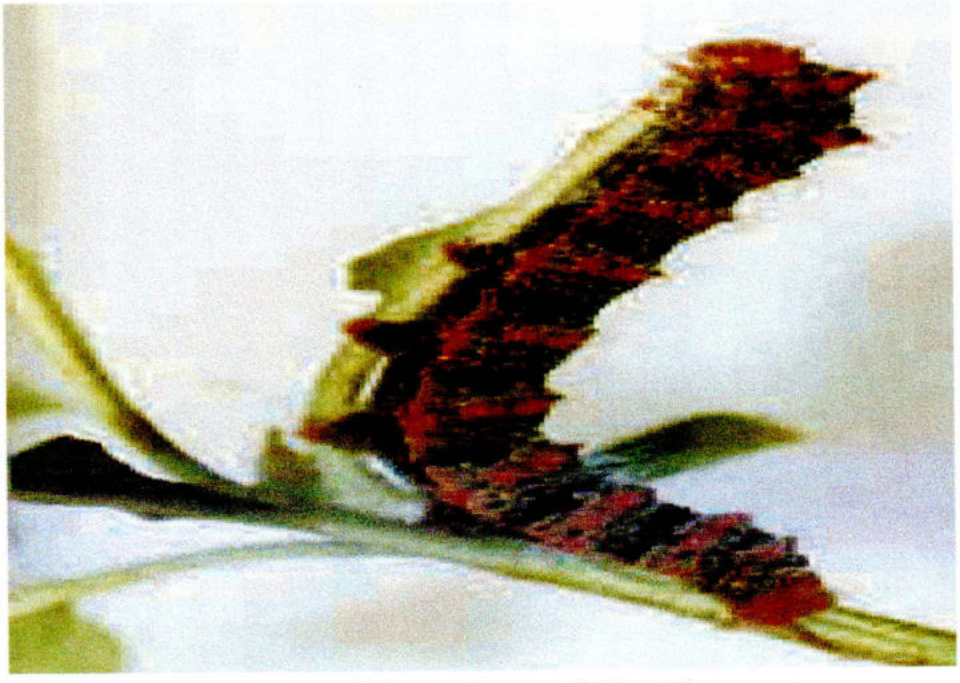

Plate 6. Fourth instar larva of *C. trifenestrata*

3.1.6.4. Fourth instar

After third moulting, the 4th instar larvae came out of the exuviae of the 3rd instar larvae. The 4th instar larvae were similar to 3rd instar in colour but they differ in size and shape as well. In this instar the larvae seemed to be full grown Lepidopteran larvae as their size became remarkably large and fed more voraciously (Plate 6).

Observation made on the larval duration of the 4th instar larvae varied from 4 to 7 days with an average of 5.80 ± 0.33 days (Figure 4 and Table 2). Ahmed and Alam (1994) pointed out that the duration of the 4th instar larvae was 6.0 and 5.1, days for generation I and II. Huq et al. (1991) observed that the 4th instar larvae lasted from 6.1 days.

The body length of the 4th instar larva was 60.2 to 63.5 mm with an average of 61.37 ± 0.33 mm; the breadth was 10.1 to 12.3 mm with an average of 11.22 ± 0.22 mm (Figure 4 and Table 3). Huq et al. (1991) cited that the average size of the 4th instar larvae was 50.5 mm.

3.1.6.5. Fifth instar

The full grown fifth instar larva was elongate, cylindrical and robust. The thorax and abdomen were brilliantly coloured by symmetrically arranged transverse alternating bands of black, yellow and red on the dorsal side of each segment (Plate 7).

The average duration of final instar larvae lasted for 5 to 8 days with an average of 6.20 ± 0.33 days (Figure 3 and Table 2). Ahmed and Alam (1994) cited that the duration of the 5th instar larvae of *C. trifenestrata* averaged 6.1 and 5.0 days for generation I and II, respectively. Huq et al. (1991) observed that the duration of 5th instar larvae was 6.1 days.

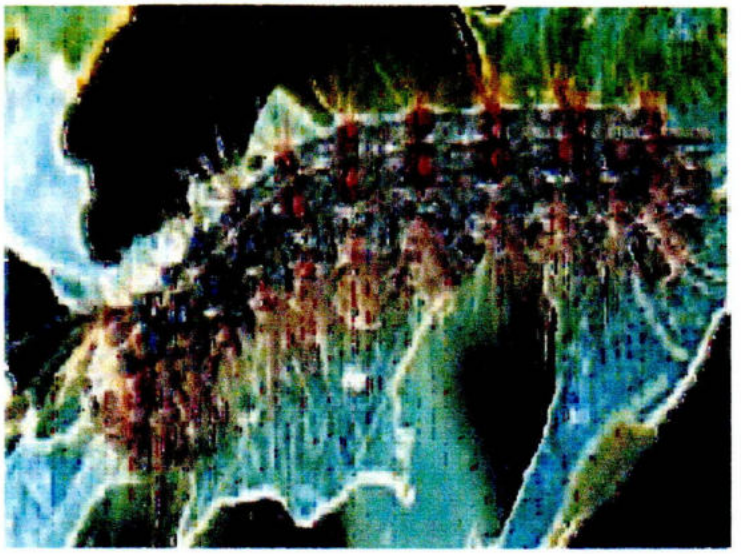

Plate 7. Fifth instar larva of *C. trifenestrata*

The results pointed out that the body length of the 5th instar larva was 80.5 to 82.8 mm with an average of 81.49 ± 0.23 mm ; breadth was measured 14.5 to 16.4 mm with an average of 15.51 ± 0.21 mm, respectively (Figure 4 and Table 3). Huq et al. (1991) mentioned that the average size of the 5th instar larva was 78.2 mm, respectively.

3.1.6.6. Total larval period

The mean of the total larval period was 28.50 ± 0.78 days with the minimum of 25 days and the maximum of 32 days (Figure 3 and Table 2). Huq et al. (1991) showed that the total larval period ranged from 26 to 31 days with an average of 27.4 days. Ahmed and Alam (1994) observed that larval period of mango defoliator was 29.3 and 25.9 days for generation I and II, respectively.

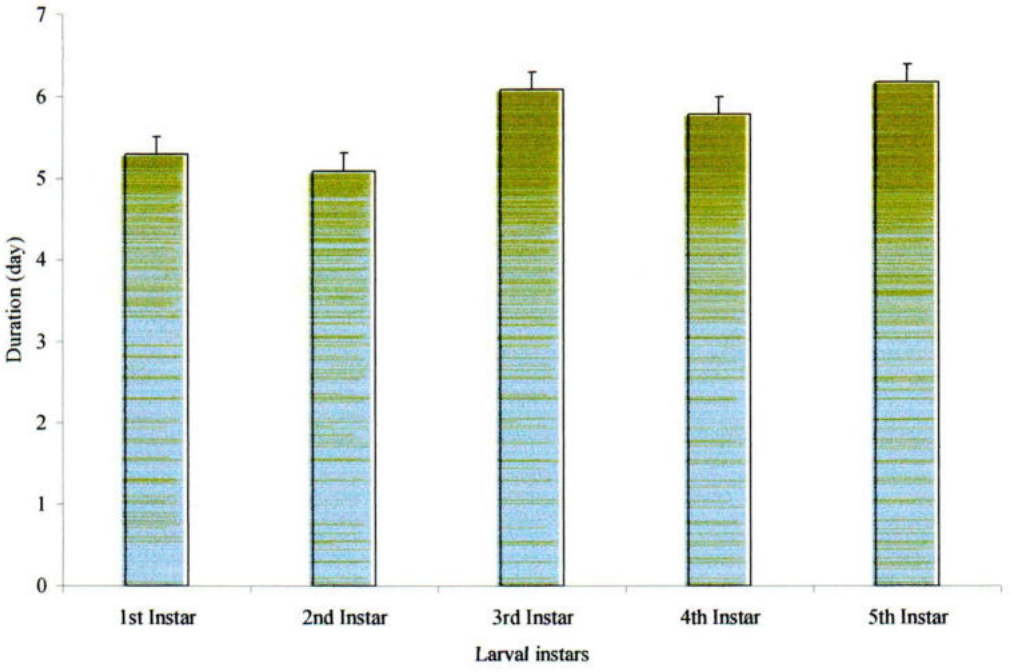

Fig. 3. Graphical representation of numerical data of duration of different larval instars (mean ± SE) of *C. trifenestrata.*

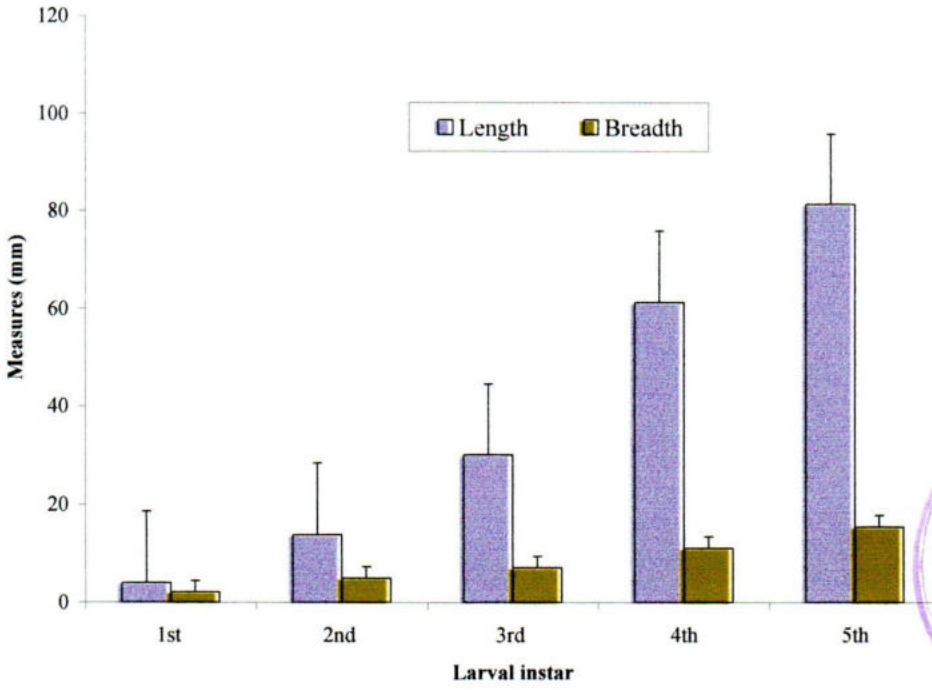

Fig. 4. Graphical representation of numerical data of morphological measurements of different larval instars (mean ± SE) of *C. trifenestrata.*

3.1.7. Pre-pupa

At the beginning of the pre-pupal period, the larva stopped feeding, became less active and did not move fast, and selected a hiding place such as surface of the leaves or stems or petridishes for pupation. The caterpillar made a golden silken cocoon with the help of secretion in which the larval transformation took place.

The duration of the pre-pupa was 2 to 3 days with an average of 2.50 ± 0.17 days, respectively (Figure 1 and Table 2). Ali and Karim (1991) found the pre-pupal period was 1 to 4 days with a mean of 2.8 days.

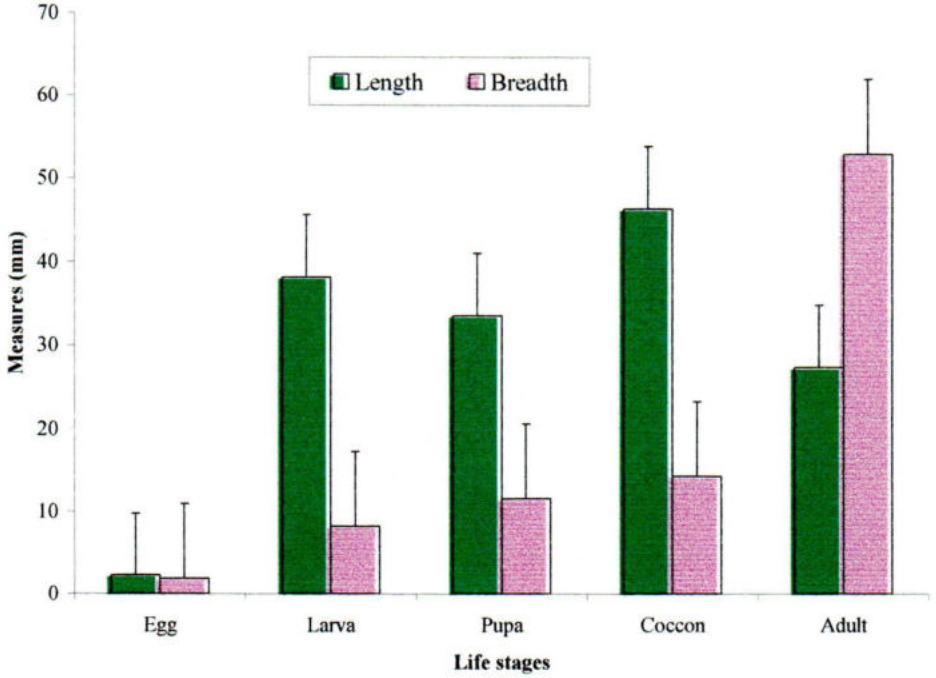

Fig. 5. Graphical representation of numerical data of morphological measurements of different stages (mean ± SE) of *C. trifenestrata.*

3.1.8. Pupa

The pupa was the ultimate transformation of pre-pupa and a non feeding stage. It was obtect form with a robust body and a gradually tapering abdomen. The body colour was chestnut brown. The female pupa was longer and wider than male (Plate 8).

The results clarified that the duration of male pupal period lasted from 16 to 21 days with an average of 18.10 ± 0.50 days while the duration of female pupal period ranged from 18 to 24 with an average of 21.00 ± 0.68 days, respectively .The average total pupal period was 19.55 ± 0.59 days (Figure and Table 2). Ahmed and Alam (1994) observed that the duration of male and female pupae were 23.1 and 22.7 days for I and II generation, respectively.

Plate 8. Pupae of *C. trifenestrata*

The length of male pupa was 30.3 to 34 mm with an average of 31.64 ± 0.37 mm and the breadth was 9.1 to 12.5 mm with an average of 10.61 ± 0.31 mm, while the length of female pupa was varied from 34.2 to 38.1 with an average of 35.57 ± 0.40 mm and the breadth was 11.1 to 14.2 with an average of 12.58 ± 0.31 mm, respectively (Figure 5 and Table 3). Huq et al. (1991) experienced that the length and breadth of male and female pupae were 29.5, 34.2 mm and 11.8, 14.1 mm, respectively.

3.1.9. Cocoon

The length of male cocoon was measured 40.5 to 45.3 with an average of 41.98 ± 0.55 mm and breadth was 10.7 to 14.3 mm with an average of 12.31 ± 0.29 mm, while the length of female cocoon was 48.5 to 53.3 mm with an average of 50.89 ± 0.43 mm and the breadth was 14.3 to 18.2 mm with an average of 16.22 ± 0.31 mm, respectively (Figure 5 and Table 3).

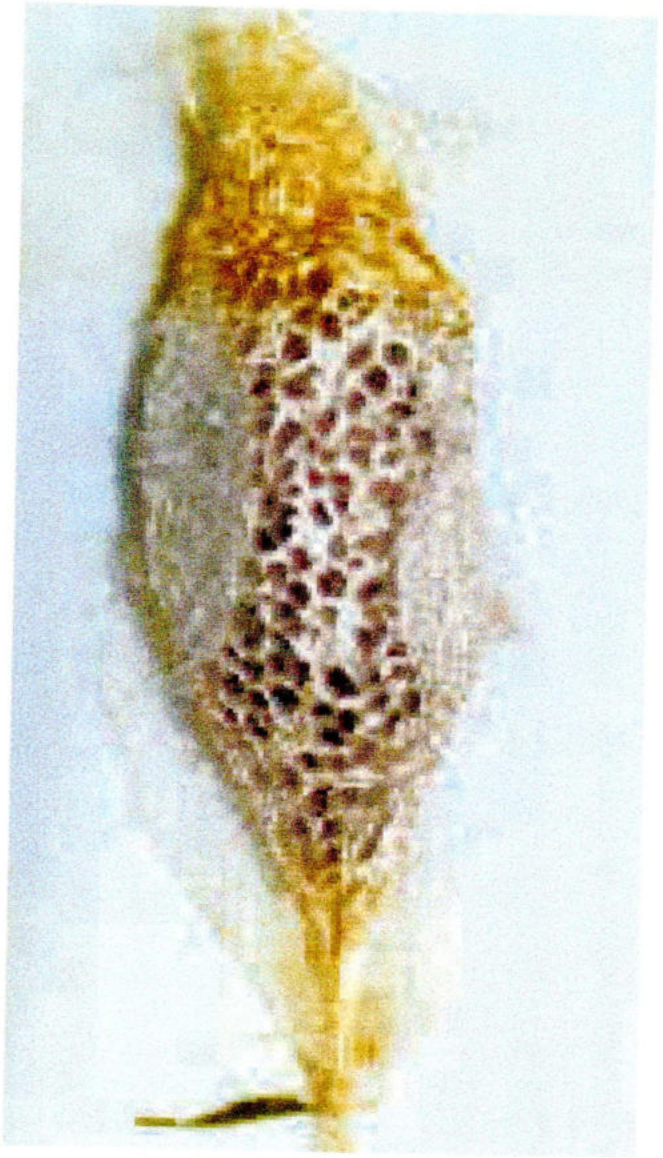

Plate 9. Cocoon of *C. trifenestrata*

3.1.10. Moth

The moths are nocturnal and they are yellowish or reddish in colour. The male possesses two dark spots on the forewing; the smaller one is anterior to the oblique line, and the larger one to just below the anterior margin (Plate 10). The females had 3 large irregularly transparent spots on the forewings and a single one on the hind wing (Plate 11). Near the base of forewings a dark wavy line appeared. Head, thorax, abdomen and appendages of the moth was covered with scales, which were yellowish brown. The bi-pectinate antennae were long with indefinite number of segments. The antenna of male was broader than that of female. The female moth was larger than male in size, and the last abdominal segments of female were broader than that of the male.

The results clarified that the longevity of male moth was 1 to 5 days with an average of 2.90 ± 0.38 days while the longevity of female moth was 3 to 7 days with an average of 4.20 ± 0.42 days, respectively .The average total longevity of moth was 3.55 ± 0.40 days (Figure 6 and Table 2).). Sujata-Yadav and Anand-Kumar (2003) observed the longevity of male and female moths was 4.08 ± 0.64 and 5.60 ± 0.87 days, respectively.

The length of male moth was 21 to 24.2 with an average of 22.35 ± 0.31 mm and breadth was 31 to 33.4 mm with an average of 32.02 ± 0.28 mm, while the length of female moth was 31.10 to 34.20 mm with an average of 32.48 ± 0.34 mm and the breadth was 72.10 to 76.20 mm with an average of 74.14 ± 0.36 mm, respectively (Figure 5 Table 3). Huq et al. (1991) experienced that the length and breadth of male moths were 32.10 and 17.70 mm whereas female moth were 40.00 and 80.70 mm, respectively.

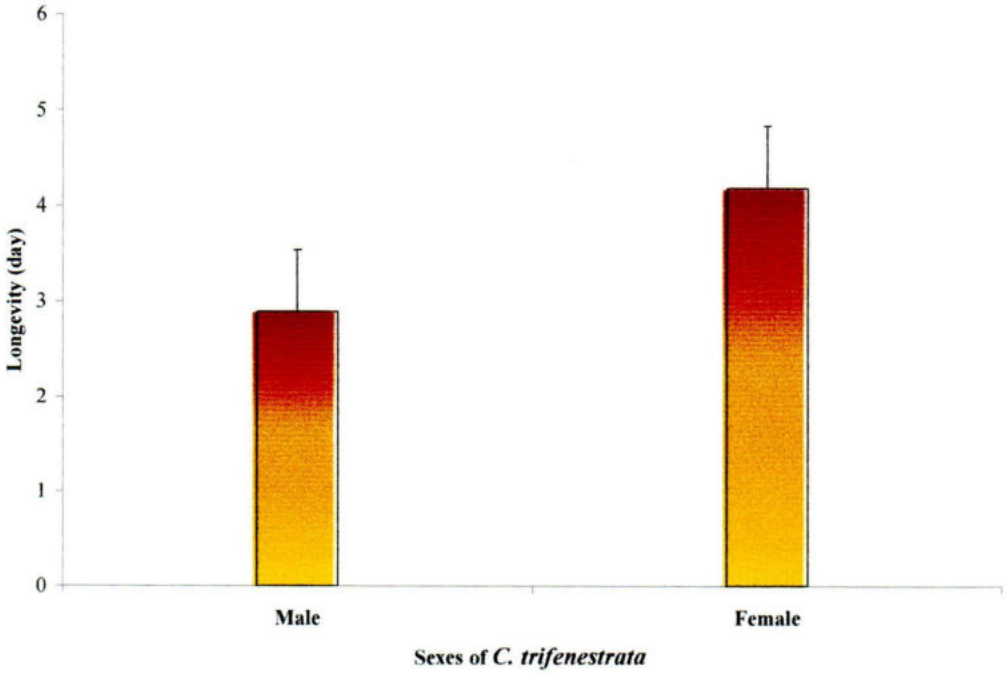

Fig. 6. Graphical representation of numerical data of longevity (mean ± SE) of *C. trifenestrata.*

Table 3. Numerical data of morphological measurement of different life stages of mango defoliator.

Life stages	No. measured	Length (Mean ± SE) mm	Breadth (Mean ± SE) mm
Egg	10	2.27 ± 0.15	1.86 ± 0.12
Larval instars			
1st	10	4.08 ± 0.15	2.17 ± 0.18
2nd	10	13.90 ± 0.13	5.09 ± 0.24
3rd	10	30.09 ± 0.21	7.23 ± 0.20
4th	10	61.37 ± 0.33	11.22 ± 0.22
5th	10	81.49 ± 0.23	15.51 ± 0.21
Pupa			
Male	10	31.64 ± 0.37	10.61 ± 0.31
Female	10	35.57 ± 0.40	12.58 ± 0.31
Cocoon			
Male	10	41.98 ± 0.55	12.31 ± 0.29
Female	10	50.89 ± 0.43	16.22 ± 0.31
Moth			
Male	10	22.35 ± 0.31	32.02 ± 0.28
Female	10	32.48 ± 0.34	74.14 ± 0.36

Plate 10. Male moth of *C. trifenestrata*

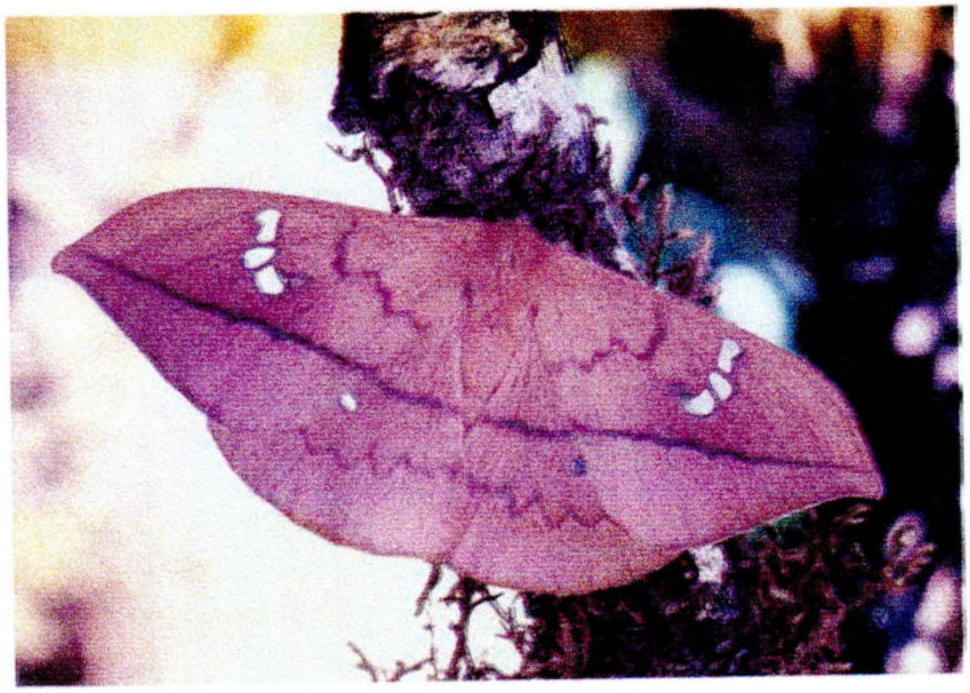

Plate 11. Female moth of *C. trifenestrata*

3.2. Leaf consumption by mango defoliator

3.2.1. Area basis

The 1st, 2nd, 3rd, 4th and 5th instar larvae consumed average 10.50, 20.70, 85.30, 415.60 and 650.30 cm^2 of leaves, respectively. The total leaf consumption by a larva throughout the larval developmental period was 1164.45cm^2 (Figure 7 table 4). Ahmed and Alam (1993) reported that the mean leaf consumption of this insect was 1298.34 cm^2 which is slightly differ but nearly close proximity to the present findings.

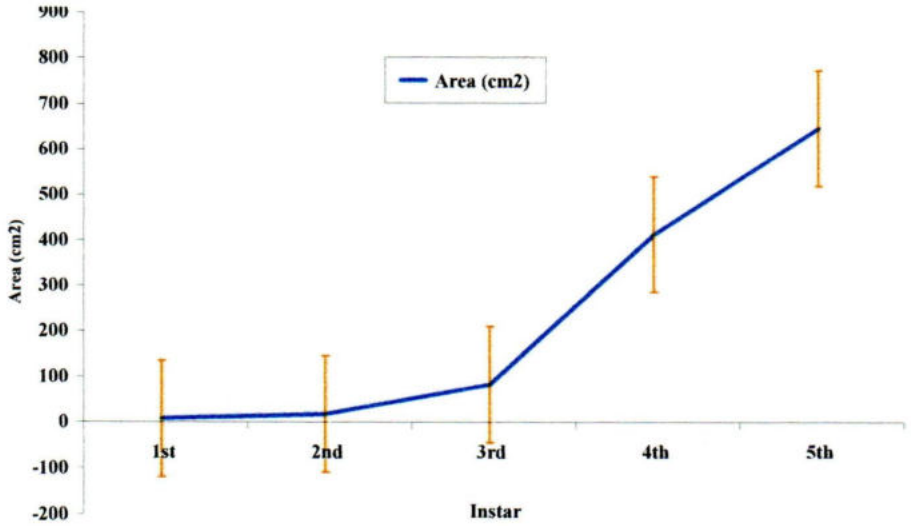

Fig. 7. Graphical representation of numerical data of mango leaf consumption pattern (area basis) at different larval instars (mean ± SE) of *C. trifenestrata.*

Table 4. Numerical data of leaf consumption (area and weight) by different larval instars of mango defoliator.

Instars	Area (cm^2)	Weight (gm)
1st	10.5	0.5
2nd	20.7	1.2
3rd	85.3	2.8
4th	415.6	8.5
5th	650.3	16.4
Total	1164.45	27.2

3.2.2. Weight basis

The larvae consumed 0.50, 1.20, 2.80, 8.50 and 16.40 g of leaves at 1st, 2nd, 3rd, 4th and 5th instars. The total leaf consumption by a larva was 27.2 g during the entire larval period of 28.50 days, respectively (Figure 8 table 4). It was observed that the final instar larva consumed the highest quantity of leaf among the instars. Ahmed and Alam (1993) cited that the mean leaf consumption of this insect was 35.75g. They also observed that the leaf consumptions by this insect from 1st to 5th instars larvae were 0.40, 0.59, 2.79, 13.27 and 18.67g of leaves, respectively which is slightly different to the present finding. However, these variations might be due to temperature and food materials used during the two experiments.

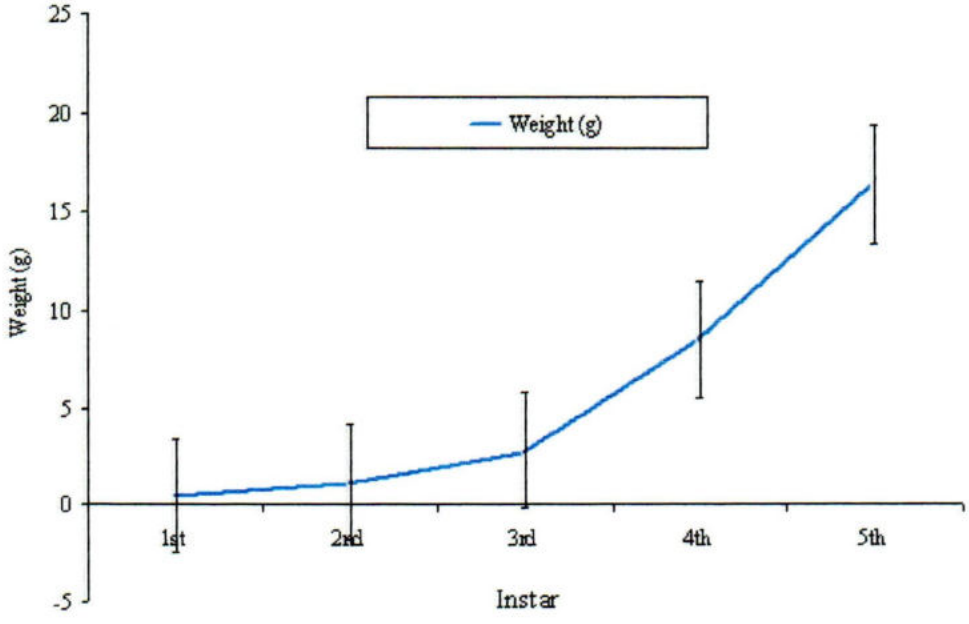

Fig. 8. Graphical representation of numerical data of mango leaf consumption pattern (weight basis) at different larval instars (mean ± SE) of *C. trifenestrata.*

Chapter 4
Summary and Conclusion

CHAPTER 4

Summary and Conclusion

The biology of *Cricula trifenestrata* stated that the average pre-oviposition and oviposition periods were 2.3 ± 0.37 and 0.5 ± 0.03 days, respectively. The female laid eggs in a scattered manner or in small batches of two or more longitudinal rows along the dorsal margin of the leaves. The number of eggs laid per female was 141.70 ± 11.79 and hatched with an average of 126.05 ± 11.63 while the hatching rate was 88.81 ± 1.37 %, and the incubation period was observed 8.7 ± 0.42 days. After hatching the larvae passed 5 instars. The average duration of the 1st, 2nd, 3rd, 4th and 5th instar larvae were 5.30 ± 0.30, 5.10 ± 0.31, 6.10 ± 0.35, 5.80 ± 0.33 and 6.20 ± 0.33 days, respectively. The average duration of pre-pupa was 2.50 ± 0.17 days. The pupal period ranged from 16 to 24 days with an average of 19.55 ± 0.59 days, respectively. The average longevity of male and female moth was 2.9 ± 0.38 and 4.20 ± 0.42 days, respectively. The average total developmental periods from egg to adult were 59.2 days.

The average length and breadth of the eggs were 2.27 ± 0.15 and 1.86 ± 0.12 mm, respectively. The average length and breadth of the 1st instar larva were 4.08 ± 0.15 and 2.17 ± 0.18 mm, respectively. Whereas, the 2nd instar larva was 13.90 ± 0.13 mm in length, while 5.09 ± 0.24 mm in breadth. The body size of the 3rd instar larva measured 30.09 ± 0.21 mm in length and 7.23 ± 0.20 mm in breadth. The 4th instar larva was 61.37 ± 0.33 mm in length and 11.22 ± 0.22 mm in breadth. The final instar larva attained a greater size and shape and its length and breadth were 81.49 ± 0.23 and 15.51 ± 0.21 mm, respectively.

The male pupae were smaller than the female one. The average length of the male was 31.64 ± 0.37 mm and breadth was 10.61 ± 0.31 mm, while the female pupa was 35.57 ± 0.40 and 12.58 ± 0.31 mm, respectively. The male and female moths were yellowish and reddish in colour. Male moth was smaller than the female moth. The average length of male moth was 22.35 ± 0.31 mm and the breadth was 32.02 ± 0.28 mm while the female moth was 32.48 ± 0.34 and 74.14 ± 0.36 mm, respectively.

The 1st, 2nd, 3rd, 4th and 5th instar larvae consumed on an average 10.50, 20.70, 85.30, 415.60 and 650.30 cm^2 area of leaves, respectively. The mean leaf consumption by a larva throughout the larval developmental period was 1164.45 cm^2 or 27.2 g. The larvae of 1st, 2nd, 3rd, 4th and 5th instars consumed 0.50, 1.20, 2.80, 8.50 and 16.40 g of leaves, respectively. Among the larval instars, the final instar larva consumed the highest quantity of leaf.

The findings of the present study indicated an increased knowledge on the biology of *C. trifenestrata* that will be helpful for its management.

Chapter 5
References

CHAPTER 5

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CHAPTER 6

Appendices

Appendix 1. Pre-oviposition and oviposition periods (days) of mango defoliator

No of Observation	Pre-oviposition Period (days)	Oviposition Period (days)
1	2	0.4
2	1	0.6
3	3	0.5
4	2	0.3
5	4	0.5
6	1	0.4
7	1	0.5
8	2	0.6
9	3	0.6
10	4	0.5
Mean ± SE	2.3 ± 0.37	0.5 ± 0.03

Appendix 2. Morphological measurement (mm) of eggs mango defoliator.

No. of observation	Eggs	
	Length (mm)	Breadth (mm)
1	2.5	2
2	2	1.6
3	2.2	1.9
4	1.5	1.1
5	2	1.7
6	2.3	2
7	1.8	1.5
8	3	2.3
9	2.6	2.2
10	2.8	2.3
Mean ± SE	2.27 ± 0.15	1.86 ± 0.12

Appendix 3. Morphological measurement (mm) of larvae of mango defoliator.

No. of observation	1st Instar		2nd Instar		3rd Instar		4th Instar		5th Instar	
	Length (mm)	Breadth (mm)	Length (mm)	Breadth (mm)	Length (mm)	Breadth (mm)	Length (mm)	Breadth (mm)	Length (mm)	Breadth (mm)
1	4	2.5	14	5.6	30.1	7.7	60.2	11.5	81.1	15.3
2	3.5	3	13.2	6	29.2	8	60.5	12.2	80.7	16.4
3	3.7	3.1	13.5	6.2	29.5	8.1	60.7	12.3	80.9	16.2
4	4.1	2.5	14	5	30	7.1	61.5	11.5	81.6	15.7
5	3.5	1.5	13.5	4.1	29.5	6.9	60.2	10.7	80.5	15
6	4.5	1.8	14	4.3	30.3	6.5	61.3	10.5	81.7	14.6
7	3.8	1.5	13.8	4	29.7	6.1	61.5	10.1	81.6	15.5
8	4.2	2	14.2	5.3	30.3	7.4	61.8	11.1	81.7	16.2
9	5	2.1	14.5	5.4	31.1	7.3	62.5	11	82.3	14.5
10	4.5	1.7	14.3	5	31.2	7.2	63.5	11.3	82.8	15.7
Mean ± SE	4.08 ± 0.15	2.17 ± 0.18	13.90 ± 0.13	5.09 ± 0.24	30.09 ± 0.21	7.23 ± 0.20	61.37 ± 0.33	11.22 ± 0.22	81.49 ± 0.23	15.51 ± 0.21

Appendix 4. Measurement of larval period (days) in different instars of mango defoliator.

No. of observation	Larval periods of different instars (days)					
	1st	2nd	3rd	4th	5th	Total
1	6	5	7	6	7	31
2	5	7	5	7	6	30
3	7	4	6	5	7	29
4	4	6	5	7	5	27
5	6	5	8	6	7	32
6	5	4	6	4	6	25
7	5	6	7	5	8	31
8	6	4	5	5	5	25
9	4	5	7	7	6	29
10	5	5	5	6	5	26
Mean ± SE	5.30 ± 0.30	5.10 ± 0.31	6.10 ± 0.35	5.80 ± 0.33	6.20 ± 0.33	28.50 ± 0.78

Appendix 5. Morphological measurement (mm) of pupa of mango defoliator.

No. of observation	Male		Female	
	Length (mm)	Breadth (mm)	Length (mm)	Breadth (mm)
1	32.5	11.2	36.7	13.3
2	31.3	12.5	35.5	14.2
3	30.5	11.3	34.3	13.5
4	32.3	10.7	36.5	12.1
5	34	10.5	38.1	12
6	30.3	11	34.2	13.5
7	32.2	10.3	36	12.3
8	31.5	10	35.1	12.1
9	30.3	9.5	34.2	11.7
10	31.5	9.1	35.1	11.1
Mean ± SE	31.64 ± 0.37	10.61 ± 0.31	35.57 ± 0.40	12.58 ± 0.31

Appendix 6. Morphological measurement (mm) of cocoon of mango defoliator.

No. of observation	Male		Female	
	Length (mm)	Breadth (mm)	Length (mm)	Breadth (mm)
1	45.3	14.3	50.7	18.2
2	41.1	12.5	52.3	16.3
3	43.2	11.3	51.2	15.2
4	40.5	10.7	53.3	14.3
5	42.2	12.5	50.7	16.5
6	41.1	12.2	50.7	16.3
7	40.5	12.5	51.5	16.2
8	44.3	12.3	50.7	16.5
9	40.5	12.3	49.3	16.3
10	41.1	12.5	48.5	16.4
Mean ± SE	41.98 ± 0.55	12.31 ± 0.29	50.89 ± 0.43	16.22 ± 0.31

Appendix 7. Measurement of pre-pupal and pupal periods (days) of mango defoliator.

No. of observation	Pre-pupal Period (days)	Pupal Period (days)	
		Male	Female
1	2	20	24
2	3	18	19
3	2	17	20
4	3	19	21
5	3	16	18
6	2	18	20
7	3	16	19
8	2	18	22
9	3	18	23
10	2	21	24
Mean ± SE	2.50 ± 0.17	18.10 ± 0.50	21.00 ± 0.68

Appendix 8. Morphological measurement (mm) of moth of mango defoliator.

No. of observation	Male		Female	
	Length (mm)	Breadth (mm)	Length (mm)	Breadth (mm)
1	22.3	32.5	32.7	74.1
2	23.1	33.4	34	76.2
3	22.5	32.3	33.1	74.2
4	24.2	31	31.5	73.3
5	21.3	33.2	34.2	75
6	22.3	32.3	32.5	72.1
7	21	31.2	32.3	74
8	22.1	31.1	31.1	73.2
9	23.2	31.2	32.2	75.1
10	21.5	32	31.2	74.2
Mean ± SE	22.35 ± 0.31	32.02 ± 0.28	32.48 ± 0.34	74.14 ± 0.36

Appendix 9. Adult longevity (days) of mango defoliator.

No. of observation	Male	Female
1	4	5
2	1	3
3	3	4
4	2	3
5	3	5
6	5	7
7	2	3
8	4	4
9	2	3
10	3	5
Mean ± SE	2.90 ± 0.38	4.20 ± 0.28