Biology of Fruit borer, *Helicoverpa armigera* (Hubner) on tomato under laboratory conditions

ABSTRACT

The experiment on biology of fruit borer *Helicoverpa armigera* (Hubner) was carried out in the Bio-controlLaboratory, Department of Entomology, S.V.P.U.A.&T., Meerut. Results showed that the mean pre-oviposition, oviposition and post-oviposition period of fruit borer on tomato lasted for 2.46 ± 0.29, 6.33 ± 0.14 and 1.67 ± 0.14 days, respectively. A female laid on an average 329.40 ± 68.17 eggs. The incubation period was observed to be 3.08 ± 0.32 days on tomato. The first instar larva was very active with body length of 1.54 ± 0.81 mm and body breadth of 0.46 ± 0.05 mm. The larval development completed within 22.45 ± 0.44 days. The duration of each instar on tomato was found to be 2.58 ± 0.26, 3.50 ± 0.14, 3.42 ± 0.26, 3.71 ± 0.28, 4.38 ± 0.16 and 4.83 ± 0.14 days, respectively. The mean pre-pupal period lasted for 2.00 ± 0.24 days on tomato. The mean pupal period lasted for 12.33 ± 0.62 days. Longevity of adult ranged from 8 to 11 days with an average of 9.30 ± 1.25 days in males, while the longevity of female moths ranged from 10 to 14 days with an average of 11.30 ± 1.34 days. The male moth measured 17.79 ± 0.41 mm in length, 35.55 ± 0.92 mm in breadth and the female moth measured 19.76 ± 0.58 mm in length, 40.08 ± 0.99 mm in breadth on tomato. The sex ratio for male and female was 1: 0.76 on tomato. The generation from egg to death of male and female *i.e.,* total life cycle was found to be completed within 39 to 60 days with an average of 50.3 ± 7.51 days and 41 to 63 days with an average of 53.5 ± 7.93 days, respectively.

Key words: *Biology; Fruit borer; Helicoverpa armigera; Tomato; Laboratory.*

1. INTRODUCTION

Tomato,*Solanum lycopersicum* (L.) is an important vegetable crop grown worldwide after potato. Tomato has its origin in the South American Andes. Tomatoes contribute to a healthy, well-balanced diet. Tomato is a rich source of vitamin A and C [9]and known as “poor man’ orange. It is also stated that it possesses anti cancerous properties. It serves as an antioxidant as the β carotene functions to help prevent and neutralize free radical chain reaction and ascorbic acid is an effective scavenger of super oxide, hydrogen peroxide and other free radicals. Per 100g ripe tomato fruits contains Vitamin C (31.0 mg), Vitamin A (320 IU) and Riboflavin (0.001 mg), Nicotinic acid (0.4 mg) and minerals *viz.,* Potassium (114.0 mg), Sulphur (24.0 mg), Chlorine (38.0), Sodium (45.8 mg), Calcium (20.0 mg), phosphorus (36.0 mg), Iron (1.8 mg), Magnesium (15.0 mg), Copper (0.19 mg) (Aykroyd, 1963). In India, tomato occupies an area of 0.84 million hectare with production of 20.69million metric

tonnes(Horticulture Statistics Division, Department of Agriculture, Co-operation & Farmer's Welfare, 2021-22). Major tomato growing states in India are Madhya Pradesh, Odisha, Karnataka and Gujarat. In Uttar Pradesh, it occupies an area of 22.79thousand hectare with production of 9.09lakh metric tonnes(Horticulture Statistics Division, Department of Agriculture, Co-operation & Farmer's Welfare, 2021-22).

Tomato fruit borer, thrips, whitefly, leaf miner, leafhopper, aphid and jassid infest and hamper the growth and development of the plants and fruits from seedling to harvesting. The sucking pests, white fly, thrips and aphid not only feed on foliage, stem and fruit in deteriorating the quality, but also act as a vector for disseminating tomato virus [16].

The fruit borer, *Helicoverpa armigera* (Hubner) is the most destructive pest of tomato in India, which is commonly known as American bollworm, gram pod borer, and fruit borer (Meena and Raju, 2014) causing serious damage and responsible for significant yield loss up to 55 per cent [17]. Tomato fruit borer (*Helicoverpa armigera*) is the major constraints in the higher production of tomato fruits. Indiscriminate use of pesticides resulted in failure of control of the tomato fruit borer [8].

Tomato is one of the important vegetable crops and severely infested by fruit borer, *H. armigera*. Since few years, considerable research work on biology of fruit borer, *H. armigera* infesting tomato has been done in abroad and India as well, but comparatively less work has been carried out under Western region of Uttar Pradesh. Hence, the present investigation was planned and conducted at the Bio-control laboratory, Department of Entomology, College of Agriculture, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (U.P.).

2. MATERIALS AND METHODS

The experiment was conducted in the Bio-control Laboratory, Department of Entomology, College of Agriculture, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (U.P.), from April, 2023 to June, 2023. All techniques used in experiment are discussed below:

The insect culture was procured from Crop Research Center, College of Agriculture, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (U.P.), in April month. The single larvae were kept in plastic plates to prevent cannibalism. Fresh leaves and shoots were given daily as a food for first and second instar larvae. Further, tender and green fruits of tomato were givenevery day as a food for third to sixth instar larvae up to pupation. Newly developed pupae were stored separately in a small glass jar filled with dry soil, the top of which was covered with muslin cloth, and the jar was tightly fastened with a rubber band. Using the cast head capsule as a baseline, the number of moultings was calculated. The time between each moulting was recorded as the period for the corresponding instar. The linear

measurements of body length and breadth were taken on a "micrometre scale." Therefore, the data obtained was calculated and presented.

2.1 Pre-pupal period

The time period needed from the stage at which the larva is stopped feeding until the formation of pupa was determined for six larvae, and the average pre-pupal period was calculated. The study was replicated four times.

2.2 Pupal period

To observe pupal period, six newly hatched pupae were observed in glass jars until the adult stage emerged. The mean pupal period was calculated. The study was replicated four times. The average pupa length and breadth were also measured using a "micrometre scale."

2.3 Adult longevity

Adults were placed in separate cages according to their sexes, and a cotton with ten percent honey solution was used as food for adult moths. The longevity of ten males and females was observed byanalysing the time duration between emergence and the death of adults. Thus,the average longevity of male and female moth has been calculated.

2.4 Adult morphometrics

Total ten adults were taken to measure the body length and breadth by using “micrometer scale.” The data was calculated and presented.

2.5 Sex ratio

To assessthe sex ratio, pupaetaken from the egg mass of a female and kept under observation separately. The adults that emerged from them were divided into their respective sexes, and according to their sex, the number of males and females were calculated from the total number of pupae used.

2.6 Life cycle

The overall time required to complete the life cycle was calculated based on the duration of the egg, larval, pre-pupal, pupal and adult stages.

3. RESULTS AND DISCUSSION

The results are presented and discussed below:

3.1 Pre-oviposition, oviposition and post-oviposition period

The pre-oviposition, oviposition and post-oviposition period were recorded and the results are presented in Table 1.

It was found that the pre-oviposition period wasin range of 2 to 3 days with a mean of 2.46 ± 0.29 days. The oviposition period was found to be in between 5 to 8 days with a mean of 6.33 ± 0.14 days. The post-oviposition period was observed only for 1 to 2 days with a mean of 1.67 ± 0.14 days. These findingsupporting findings of Pandey and Kumar [11], according to their finding,the pre-oviposition, oviposition and post-oviposition period were 3.12 ± 0.66 days, 9.8 ± 0.54 days and 1.22 ± 0.36 days, respectively. Gadhiya et al. [6] also reported that pre-oviposition, oviposition and post-oviposition period were in range of 2-4 days, 6-8 days and 0-2 days, respectively.

Table1: Pre-oviposition, oviposition, post-oviposition period and fecundity of *H. armigera* on tomato.

S. no.	Stage	Developmental period (Days)		Mean ± S.D.
		Minimum	**Maximum**	
1	Pre-oviposition	2	3	2.46 ± 0.29
2	Oviposition	5	8	6.33 ± 0.14
3	Post-oviposition	1	2	1.67 ± 0.14
	Egg laying	**No. of eggs**	**No. of eggs**	**Mean ± S.D.**
4	Fecundity	237	421	329.40 ± 68.17

3.2 Fecundity

The observed data showed that the total number of eggs a female laid throughout the course of her lifetime ranged from 237 to 421 with an average of 329.40 ± 68.17 (Table 1). These findings are in line with those made by Sharma et al. [13], who claimed that the female of *H. armigera* laid between 256.60 to 490.66 eggs. The results are also consistent with the findings of Herald and Tayde [7], who claimed that female moths can lay between 405 to 420 eggs, with a fecundity of 412.00 ± 5.24.

3.3 Eggs

The freshly laid eggs were spherical in shape and yellowish or creamy white in colour.The average length of eggs found to be in range of 0.43 mm to 0.64 mm with an average of 0.53 ± 0.062 mm. The average breadth of eggs found to be in range of 0.36 mm to 0.54 mmwith an average of 0.46 ± 0.063 mm (Table 2). According to Ali et al. [2], the size of eggs varied from 0.42 mm to 0.60 mm in length and 0.40 mm to 0.55 mm in breadth.

Table 2: Morphometrics of eggs of *H. armigera* on tomato.

S. no.	Length (mm)	Breadth (mm)
1	0.52	0.36
2	0.51	0.39
3	0.64	0.54
4	0.56	0.44
5	0.43	0.45
6	0.48	0.41
7	0.49	0.53
8	0.52	0.50
9	0.61	0.53

10	0.50	0.44
Range	**(0.43-0.64)**	**(0.36-0.54)**
Mean ± S.D.	**0.53 ± 0.062**	**0.46 ± 0.063**

3.4 Incubation period

The data of incubation period is showed in Table 3. The incubation period was found to be in range of 2 to 4 days with mean of 3.08 ± 0.32 days.The findings are supporting the findings of Gadhiya et al. [6]who reported that the incubation period varied in between 2 to 4 days. Damanpreet et al. [5] also reported that the incubation period was of 3.37 ± 0.08 days in tomato during spring season.

Table 3: Life cycle of *H. armigera* on tomato.

S. no.	Stage	Duration (days)		Mean ± S.D.
		Minimum	Maximum	
1	Egg Period	2	4	3.08 ± 0.32
2	Larval period			
	1st instar	2	3	2.58 ± 0.26
	2nd instar	3	4	3.50 ± 0.14
	3rd instar	3	4	3.42 ± 0.26
	4th instar	3	5	3.71 ± 0.28
	5th instar	4	5	4.38 ± 0.16
	6th instar	4	6	4.83 ± 0.14
	Total larval period	19	25	22.45 ± 0.44
3	Pre-pupal period	1	3	2.00 ± 0.24
4	Pupal period	9	15	12.33 ± 0.62
5	Adult longevity			
	Male	8	11	9.30 ± 1.25
	Female	10	14	11.30 ± 1.34
6	Total life cycle			
	Male	39	60	50.30 ± 7.51
	Female	41	63	53.50 ± 7.93

3.5 Larval development

In present experiment it was found that *H. armigera*had six larval instars. The findings related to larval period and larval instar are given in Table 3. The development period of larvae was found to be in range of 19 to 27 days with a mean of 22.45 ± 0.44 days. During development,it was found that the larvae moulted for five times. Theexplanation of each larval instar is given below.

The current observations are consistent with those made by Nasreen and Mustafa [10], who stated that the larval development took 17.33 ± 0.33 days to complete. Finding of Ali et al. [2]thatstated the larval period took 6.96 days on chickpea.

3.6 First larval instar

During studies, it was revealed that the time duration of first larval instar was found to be in the range of 2 to 3 days with a mean of 2.58 ± 0.26 days (Table 3). The morphometrics of first

instar larvae of *H. armigera* are presented in Table 4. It was observed that the length of first instar larvae varied in between 1.22 mm to 1.84 mm with a meanof 1.54 ± 0.81 mmand the breadth of first instar larvae was found to be in range of 0.38 mm to 0.52 mm with a mean of 0.46 ± 0.05 mm (Table 4).

Table 4: Morphometrics of first larval instar of *H. armigera* on tomato.

S. no.	First larval instar	
	Body Length (mm)	**Body Breadth (mm)**
1	1.22	0.47
2	1.53	0.38
3	1.84	0.52
4	1.50	0.50
5	1.67	0.45
6	1.63	0.49
7	1.69	0.42
8	1.43	0.39
9	1.34	0.52
10	1.58	0.44
Range	**(1.22-1.84)**	**(0.38-0.52)**
Mean ± S.D.	**1.54 ± 0.81**	**0.46 ± 0.05**

3.7 Second larval instar

Study revealed that the time duration of second instar larvaewas found to be in range of3 to 4 days with a mean of 3.50 ± 0.14 days (Table3). The second instar larvae werehyperactive. It was observed that the length of the second instar larvae variedin between 3.42 mm to 5.12 mm with a meanof 4.14 ± 0.57 mm and the breadth of second instar larvae was varied between 0.62 mm to 0.76 mm with a mean of 0.66 ± 0.07 mm(Table5).

Table 5: Morphometrics of second larval instar of *H. armigera* on tomato.

S. no.	Second larval instar	
	Body Length (mm)	**Body Breadth (mm)**
1	3.54	0.54
2	3.42	0.76
3	3.73	0.70
4	3.85	0.65
5	4.54	0.62
6	5.12	0.68
7	4.90	0.72
8	3.80	0.70
9	4.30	0.65
10	4.15	0.55
Range	**(3.42-5.12)**	**(0.62-0.76**
Mean ± S.D.	**4.14 ± 0.57**	**0.66 ± 0.07**

3.8 Third larval instar

Study revealed that the time duration of third instar larvae was found to be in range of 3 to 4 days with a mean of 3.42 ± 0.26 days (Table 3). It was observed that the length of the third instar larvae varied in between 7.20 mm to 9.25 mm with a mean of 8.16 ± 0.75 mm and the

breadth of third instar larvae was varied in between 0.82 mm to 0.89 mm with a mean of 0.85 ± 0.03 mm(Table 6).

Table 6: Morphometrics of third larval instar of *H. armigera* on tomato.

S. no.	Thirdlarval instar	
	Body Length (mm)	**Body Breadth (mm)**
1	7.55	0.81
2	7.85	0.82
3	7.20	0.85
4	8.55	0.87
5	8.96	0.84
6	8.37	0.85
7	8.93	0.89
8	7.52	0.88
9	7.38	0.82
10	9.25	0.85
Range	**(7.20-9.25)**	**(0.82-0.89)**
Mean ± S.D.	**8.16 ± 0.75**	**0.85 ± 0.03**

3.9 Fourth larval instar

Study revealed that the time duration of fourth instar larvae was found to be in range of 3 to 5 days with a mean of 3.71 ± 0.28 days (Table 3). It was observed that the length of the fourth instar larvae varied in between 10.50 mm to 17.84 mm with a Mean of 14.55 ± 2.10 mm) and the breadth of third instar larvae was varied in between 0.98 mm to 1.23 mm with an average of 1.12 ± 0.10 mm (Table 7).

Table 7: Morphometrics of fourth larval instar of *H. armigera* on tomato.

S. no.	Fourthlarval instar	
	Body Length (mm)	**Body Breadth (mm)**
1	14.56	1.21
2	10.50	1.23
3	16.85	1.14
4	15.43	1.15
5	12.70	0.99
6	13.54	1.14
7	13.78	1.18
8	14.57	1.19
9	17.84	0.98
10	15.75	0.98
Range	**(10.50-17.84)**	**(0.98-1.23)**
Mean ± S.D.	**14.55 ± 2.10**	**1.12 ± 0.10**

3.10 Fifthlarval instar

Observed data revealed that the time duration of fifth instar larvae was found to be in range of 4 to 5 days with a mean of 4.38 ± 0.16 days (Table 3). It was observed that the length of the fifth instar larvae varied in between 18.23 mm to 25.65 mm with a mean of 21.37 ± 3.01 mm

and the breadth of fifth instar larvae was varied in between 1.84 mm to 2.63 mm with an average of 2.24 ± 0.29 mm(Table8).

Table 8: Morphometrics of fifth larval instar of *H. armigera* on tomato.

S. no.	Fifth larval instar	
	Body Length (mm)	**Body Breadth (mm)**
1	18.85	1.84
2	25.65	1.98
3	24.65	2.25
4	25.20	2.34
5	18.23	2.18
6	19.35	2.53
7	23.54	2.58
8	19.96	1.86
9	18.45	2.63
10	19.83	2.24
Range	**(18.23-25.65)**	**(1.84-2.63)**
Mean ± S.D.	**21.37 ± 3.01**	**2.24 ± 0.29**

3.11 Sixth larval instar

Observed data revealed that the time duration of sixth instar larvae was found to be in range of 4 to 6 days with a mean of 4.83 ± 0.14 days (Table 3). It was observed that the length of the sixth instar larvae varied in between 28.35 mm to 33.87 mm with an average of 31.19 ± 1.96 mm and the breadth of sixth instar larvae was varied in between 2.82 mm to 3.24 mm with a mean of 3.06 ± 0.16 mm (Table9).

Table 9: Morphometrics of sixth larval instar of *H. armigera* on tomato.

S. no.	Sixth larval instar	
	Body Length (mm)	**Body Breadth (mm)**
1	32.56	3.00
2	33.87	3.24
3	28.65	2.85
4	31.55	2.98
5	32.81	2.82
6	30.35	3.15
7	32.60	3.19
8	32.15	3.22
9	29.00	2.95
10	28.35	3.22
Range	**(28.35-33.87)**	**(2.82-3.24)**
Mean ± S.D.	**31.19 ± 1.96**	**3.06 ± 0.16**

The present findings are supporting the findings of Singh and Yadav [15] who reported that the average larval period of *H. armigera* was 18.06 ± 0.77 days on red gram. The morphometrics of larval instars is supporting the findings of Ali et al. [2], who reported the morphometrics of first, second, third, fourth, fifth and sixth larval instar were 1.40 ± 0.06 mm, 3.88 ± 0.11 mm, 7.90 ± 0.19 mm, 12.83 ± 0.45 mm, 20.97 ± 0.61 mm & 32.50 ± 0.35 mm, respectively.

3.12 Pupation

The observations on pre-pupal period and pupal period are given in Table 3.

3.13 Pre-pupal period

After completion of all larval stages, the Sixth instar larvae stopped feeding and moving and started slenderizing their bodies. Findings showed thatthe pre-pupal period was in range of 1 to 3 days with an average of 2.00 ± 0.24 days.

3.14 Pupal period

Pupae were yellowish green when first developed, then darkened to mahogany brown within a few hours and further darkened before adult moth emergence. When touched, only their five posteriormost abdominal segments rotated in a 360° circle. Data in Table 3 showed that the pupal period lasted from 9 to 15 days with a mean of 12.33 ± 0.62 days. The length of pupae was found to be in range of 19.35 mm to 19.96 mmwith a mean of 19.56 ± 0.22 mm and the breadth was in range of 4.80 mm to 5.20 mm with a mean of 4.99 ± 0.16mm(Table 10).

Table 10: Morphometrics of pupae of *H. armigera* on tomato.

S. no.	Length (mm)	Breadth (mm)
1	19.40	5.10
2	19.49	4.80
3	19.54	5.20
4	19.85	5.00
5	19.96	5.20
6	19.78	5.00
7	19.35	5.10
8	19.39	4.80
9	19.43	4.90
10	19.41	4.80
Range	**(19.35-19.96)**	**(4.80-5.20)**
Mean ± S.D.	**19.56 ± 0.22**	**4.99 ± 0.16**

The present finding is supporting the findings of Chaitanya et al. [4] who stated that the average pre-pupal and pupal period of *H. armigera* were 2.17 ± 0.52 days and 9.50 ± 0.45 days, respectively on pigeon pea. Findings on morphometrics are supporting the findings of Ali et al. [2], who showed the breadth and length of pupae were on an average 5.72 ± 0.08 mm &19.00 ± 0.30 mm, respectively.

3.15 Adult longevity

The adult longevity was studied for both the sexes and the observations are presented in Table 3. Male moths were observed to have short lifespans. They lived for 8 to 11 days with an average of 9.30 ± 1.25 days, while females lived for 10 to 14 days with an average of 11.30 ± 01.34 days.

Sharma et al. [13] recorded the longevity of male and female was 2.44 to 5.89 and 8.79 to 11.33 days, respectively. Bhatt and Patel [3] obtained the mean adult longevity of 9.15 and

11.40 days for males and females, respectively. Ali et al. [2] recorded the mean adult longevity of 9.17 ± 0.42 and 11.74 ± 0.51 days for males and females, respectively.

3.16 Adults

Adult moths had large thorax and stout body. Male adult moths had greenish brown forewings, whereas female moths had orange-brown forewings. There were several dots on the edges of forewings. On the other hand, the hind wings were lighter in colour with a thick dark brown border at the tip.

Data in Table 11 showed that the length of females was found to be in range of 18.70 mm to 20.60 mm with an average of 19.76 ± 0.58 mm and breadth was in range of 38.70 mm to 41.10 mm with a mean of 40.08 ± 0.99 mm. the length of males was found to be in range of 17.20 mm to 18.40 mm with an average of 17.79 ± 0.41 mm and breadth was in range of 34.20 mm to 37.00 mm (average 35.55 ± 0.92 mm). the findings of morphometrics are supporting the findings of Sharma et al.[13]who recorded that the averagebreadth & length of female were 42.15 ± 0.65 mm & 19.82 ± 0.75 mm, respectively. The average breadth & length of male were 38.30 ± 0.35 mm & 18.42 ± 0.58 mm, respectively.

Table 11: Morphometrics of adults of *H. armigera* on tomato.

S. no.	Male		Female	
	Body Length (mm)	**Body Breadth (mm)**	**Body Length (mm)**	**Body Breadth (mm)**
1	18.00	36.40	20.10	39.20
2	18.10	36.10	19.50	39.40
3	18.20	37.00	19.80	40.30
4	17.50	36.00	18.70	41.50
5	17.20	34.20	20.00	41.10
6	18.10	34.80	20.60	39.80
7	17.50	34.50	20.40	40.80
8	18.40	36.20	19.00	38.70
9	17.40	35.40	19.80	39.00
10	17.50	34.90	19.70	41.00
Range	**(17.20-18.40)**	**(34.20-37.00)**	**(18.70-20.60)**	**(38.70-41.10)**
Mean ± S.D.	**17.79 ± 0.41**	**35.55 ± 0.92**	**19.76 ± 0.58**	**40.08 ± 0.99**

3.17 Sex ratio

The sex ratio was calculated by observing 60 adults. Out of all the adults, 34 moths were recordedas males and 26 were females. After calculation, the male and female ratio was found to be 1:0.76 (Table 12).

Table 12: Sex ratio in *H. armigera* on tomato.

S. no.	No. of adults examined	Male moth	Female moth
1	6	2	4
2	6	3	3
3	6	1	5
4	6	4	2
5	6	5	1

6	6	4	2
7	6	4	2
8	6	3	3
9	6	4	2
10	6	4	2

The findings on sex ratio are closely matching with the findings of Pandey and Kumar [11], who observed the sex ratio of male and female was of 1:0.76. Sharma et al.[13]also showed that the sex ratio of male&female was varied from 1:0.67 to 1:1.22 in generation to generation.

3.18 Life cycle

The life cycle of male and female was completed within 39 to 60 days (Mean 50.3 ± 7.51 days) and 41 to 63 days (Mean 53.5 ± 7.93 days), respectively (Table 3).

The observations are supporting the findings of Shivanna et al.[14]who described the life cycle offemale and male was 50.13 ± 1.23 days and 47.40 ± 0.80 days, respectively.

4. Conclusion

The results of these experiments may be helpful in determining the *H. armigera* field population. Comprehensive data on growth, survival, and reproduction/fecundity are provided by the current study of *H. armigera* biological properties, which is a crucial first step in putting any control measures into place.

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