



Biology of fruit borer, *Helicoverpa armigera* (Hubner) in/on chilli fruits

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Abstract

Biology of chilli fruit borer, *H. armigera* indicated that the female laid eggs singly or in batches of 2 to 3 on tender leaf and shoots of chilli plant. Eggs were hemispherical with flat base and prominently sculptured with numerous ridges running from one polar end to another. The egg laying capacity of the female varied from 742 to 1235 eggs. The hatching percentage was 53.20. The incubation period ranged from 2 to 5 days. The average length of first, second, third, fourth fifth and sixth instar larvae were 1.60 ± 0.22 , 4.57 ± 0.59 , 9.55 ± 1.32 , 11.98 ± 2.33 , 17.71 ± 1.27 and 25.93 ± 3.70 mm, while that the average breadth were 0.26 ± 0.05 , 0.68 ± 0.13 , 1.16 ± 0.26 , 1.83 ± 0.29 , 2.70 ± 0.31 and 3.72 ± 0.37 mm, respectively. The average larval duration of first, second, third, fourth fifth and sixth instar larvae were recorded as 2.88 ± 0.73 , 3.46 ± 0.51 , 3.91 ± 0.79 , 3.73 ± 0.70 , 4.55 ± 0.51 and 4.71 ± 0.72 days, respectively. The total larval period was completed in 23.14 ± 1.28 days, when reared on chilli. The pre-pupal period recorded as 1.48 ± 0.51 days. The average length and breadth of pupa measured as 12.33 ± 0.80 and 3.69 ± 0.52 mm, respectively. The average pupal period was 12.67 ± 1.28 days. The male moth was of greenish-grey while female was of orange brown. The average length of male and female measured from 16.94 ± 0.83 and 20.31 ± 1.62 , while breadth with expanded wingspan measured as 33.12 ± 0.82 and 34.23 ± 1.83 mm, respectively. The sex ratio (Male: female) was 1:2.08. The average pre-oviposition, oviposition and post-oviposition periods were 2.86 ± 0.85 , 8.14 ± 0.85 and 1.52 ± 0.51 days, respectively. The male and female moth lived for 8.56 ± 1.04 and 10.80 ± 1.32 days, respectively. The average longevity of male recorded as 8.67 ± 1.06 days while that of female was 10.90 ± 1.22 days. The average fecundity of the female recorded as 1048.40 ± 193.58 eggs. The total life cycle of male was completed in 40 to 59 days (48.43 ± 2.44 days), while it was completed in 42 to 62 days (50.67 ± 2.13 days) during the present investigation.

Keywords: chilli fruit borer, morphometry and total life-cycle

1. Introduction

Chilli, (*Capsicum annum* L.) popularly known as 'mirch' in Hindi, belongs to the family Solanaceae originated from Latin American region and currently used throughout the world as a spice and is an important condiment crop grown in Gujarat. It was introduced in India by the Portuguese in 16th century and since then it had rapidly spread throughout the country [2]. From ancient time chillies has been used as food, spice and household medicine for several common problems such as high cholesterol, high blood pressure, pain to joint, skin problem, relief of pain in neuropathy, counter irritant in treatment of rheumatism, lumbago and used as carminative, appetizer, stomachic and beverages. While it's biological function is to repel herbivores animals and fungi. Capsicum is derived from the Greek word "Kapsimo" meaning "to bite". The therapeutic effect of chillies is due to capsaicin, protein, fixed oil, thiamine and ascorbic acid [4]. Chilli occupies a pride place among the vegetables for its delicious taste and pleasant flavor. In India, chilli is mainly grown for its fruits which are used prior to its maturity in various culinary preparations and also in stuffing, pizza and burger. Both green and dry chillies are produced world over from the chilli crop. The cultivation of chilli has become capital intensive due to many production

constraints of which the losses caused by pests in paramount. Nearly 25 insects have been recorded attacking chilli leaves and fruits in India, which includes fruit borer, thrips, aphid, whitefly, cutworm, plant bug and other minor pests. The present investigation was carried out to study the biology of *H. armigera* on chilli which provides information on various life stages through which they pass and behavior which they show. The results drawn from these studies are presented and discussed as below.

2. Materials and methods

Initially, the larvae of *H. armigera* were collected from chickpea field at College Farm, N. M. College of Agriculture, Navsari and reared on same crop under laboratory condition till pupation. Larvae were reared individually to avoid cannibalism. Simultaneously, chilli plants were also raised individually in pot for further studies on various aspects of biology of the pest on chilli. Newly emerged male and female moths were released in pair in the oviposition cage (20 cm diameter x 45 cm height) for mating. A pot of chilli plant was kept in oviposition cage for females to provide resting and oviposition site. Piece of black colour muslin cloth (1 sq. ft.) was hanged in an oviposition cage for egg laying. Oviposition

cage was covered with black coloured muslin cloth to create darkness. Cotton swab dipped in five per cent honey solution was kept in small vial and placed in oviposition cage as food to the male and female moths. The eggs were collected with camel hair brush from the leaf, shoots, pot surface, black coloured muslin cloth and also from the bottom of the cage. Collected eggs were used for further study. Simultaneously, a general culture of the pest is also maintained in the laboratory during the study. Colour and morphology of egg was determined with the help of Stereo Trinocular microscope Olympus-SZ (16) fitted with Brand Catcam-130 camera having software power Scopephoto for measuring the size of egg. Freshly laid 25 eggs were separately kept on chilli leaf placed on wet cotton piece in Petri dish (10 cm diameter). The eggs were observed twice a day (8.00 am and 4.00 pm) until the emergence of larvae and incubation period was recorded. With a view to determine the number and duration of different larval instars and total larval period, the newly emerged larvae were placed individually in plastic culture tubes (2.5 cm diameter x 7.5 cm height) with the help of fine camel hair brush. A small twig with tender leaves was provided as food to the larvae (first and second instar) and the end of twig was wrapped with moist cotton swab to maintain a turgidity. Thereafter, fresh and tender green chilli fruits were provided as food to the larvae to onward instars (third, fourth and fifth). The food was replaced every alternate day. All the larvae were kept under observation daily for their change of instars. A change of instar was confirmed by presence of casted head capsule and sometimes exuviae in the rearing tube. The duration of each instar was worked out and length as well as breadth of each instar were also measured. About 2.5 to 3.0 cm thick layer of moist soil was provided in the glass jar (10 cm diameter x 13 cm height) to full grown larvae for pupation. To record the pre-pupal period, the larvae were observed from the time when it stops feeding and become sluggish to the time when it undergoes soil for pupation. Pupae were collected from earthen cocoon and separated sex wise on the basis of morphometric differentiation. The male and female pupae were kept in plastic jar (12 cm diameter x 15 cm height). Pupal period was recorded from time of larva underwent soil to the emergence of adult. The colour and size of pupae were also recorded. The moths emerged were observed for their colour and size. Male and female were confirmed by presence of tuft of hairs at the end of abdomen in case of female which was absent in male. Ten pairs of male and female moth of the same age group were paired separately in oviposition cage to study their preoviposition, oviposition and post oviposition periods as well as longevity of adults and fecundity. The length and breadth with their expanded wings were also measured with the help of vernier caliper. The sex ratio was worked out on the basis of male and female moths emerged from the general culture maintained in the laboratory. Pre-oviposition period was calculated from the date of emergence of female adult to the date of starting laying eggs. Likewise, a period from starting of laying eggs to the ceasing of laying eggs was considered as oviposition period while ceasing of laying eggs to the death of female was considered as post oviposition period. Total life cycle was considered as the period between date of laid egg to the date of adult died.

3. Results and Discussion

Egg

Site and pattern of egg laying

In laboratory, it was observed that, the female moth of *H. armigera* laid eggs singly or in batches of 2 to 3 eggs. The eggs were glued on tender leaf lower surface and shoots of the chilli plant. Occasionally the eggs were also found on pot, piece of black colour muslin cloth and bottom of the cage. The egg laying was slow and low in number in the initial stage, but it increased gradually and slower down at the later part of the oviposition period. Earlier, similar pattern of egg laying was recorded by previous scientists [5,6].

Colour, shape and size

The freshly laid eggs were yellowish white in colour, which changed to deep yellow after a day and become dark brown prior to hatching. Eggs were hemispherical with flat base and prominently sculptured with numerous ridges running from one polar end to another. The present observation is more or less similar with previous studies [1, 5, 6]. The result revealed that, length and breadth of freshly laid eggs measured from 0.42 to 0.56 mm and 0.44 to 0.57 mm with an average 0.49 ± 0.04 mm and 0.51 ± 0.04 mm respectively (Table-1), little bit similar size of eggs was observed by [5,6,3].

Incubation period

It is clear from the data that the incubation period varied from 2 to 5 days with an average of 3.9 ± 0.74 days (Table-1). The incubation period for eggs of *H. armigera* has been reported as 3 to 5 days [1, 4] and 2 to 4 days [3] which are in close concurrence with present finding.

Hatching percentage

Out of 10484 eggs observed under laboratory conditions, 5577 eggs hatched with hatchability of 53.20 per cent when reared on chilli (Table-2). Similarly, 59 per cent hatchability on groundnut [3]. While, it was 83 per cent on rose [5] 77 to 89 per cent on tomato [6].

Larva

In order to study the various larval instar of *H. armigera* in laboratory condition, newly hatched larvae were reared individually in plastic culture tube. The larvae passed through six distinct instars, when reared initially on chilli leaves and thereafter on fresh green fruits, till they pupated. Similar result was found on chickpea and rose [1,5].

First instar

At the time of hatching, larva came out from the egg by making hole on chorion with the help of mouthparts. The body of freshly emerged larva was semi-translucent and dirty white in colour with whitish longitudinal lines on the dorsal surface of the body. Thoracic and anal shield were brown in colour. Whereas, thoracic legs were segmented with first two segments of light brown and tarsi were dark brown to black in colour. Zig-zag spotted line was present on dorsal side and black coloured spiny structure comes out from that spot. Almost similar observations were made on chickpea [1], on rose [5] and on tomato [6]. The newly emerged larva remained

sluggish and became active after 2 to 3 hours on leaves. Similar behaviour when reared on rose ^[5]. The neonate larva initially remained in egg shell and found to feed on chorion of the egg. Thereafter, in search of food, larva was found hanging on petridish with the help of thread like substance secreted from mouth. In the beginning, larva found to feed on tender leaves with its chewing and biting type of mouth parts. The change in instar was confirmed by presence of only head capsule on leaf surface. The exuviae of whole body did not observe in this instar during the study. It can be seen from the data that the length of first instar larva measured from 1.30 to 1.98 mm with an average 1.60 ± 0.22 mm and the breadth varied from 0.18 to 0.35 mm with an average 0.26 ± 0.05 (Table-1). While, average 1.40 mm length and 0.45 mm breadth on chickpea ^[1], 1.80 mm in length and 0.31 mm breadth on groundnut ^[3]. The head capsule was large in size which was dark brown to black in colour. The length and breadth of head capsule measured from 0.19 to 0.38 mm and 0.23 to 0.40 mm with an average 0.28 ± 0.32 mm and 0.07 ± 0.06 mm, respectively (Table-1). The results summarized in indicated that the duration of first instar larva ranged from 2 to 4 days on chilli (2.88 ± 0.73 days) Table-1. Similarly it was also reported as 2 to 3 days on chickpea, rose and on groundnut ^[1, 5, 3].

Second instar

Second instar larva was morphologically resembled to the first instar larva. The larva was yellowish to light brown in colour. Thoracic legs were dark in colour as compared to abdominal legs. The larva was more active than previous instar. It was also observed that, larva of this instar preferred fresh and tender chilli fruit to feed. Similar characteristics was observed in *H. armigera* when reared on rose ^[5]. The larva measured from 3.36 to 5.54 mm with an average 4.57 ± 0.59 mm in length and 0.50 to 0.90 mm with an average 0.68 ± 0.13 mm in breadth (Table-1). While, the body length ranged from 3.50 to 5.00 mm and breadth from 0.70 to 0.80 mm in breadth ^[1]. The head capsule was transparent having brown spot having. The measurement of head capsule is ranged from 0.42 to 0.55 mm (0.49 ± 0.05 mm) in length and 0.44 to 0.59 mm (0.52 ± 0.04 mm) in breadth during the investigation (Table-1). The duration of second instar larva was ranged from 3 to 4 days (3.46 ± 0.51 days) Table-1. The larval period of *H. armigera* ranged from 2 to 3 days of on chickpea and rose ^[1, 5]. Whereas, 2 to 4 days on groundnut ^[3].

Third instar

The third instar larva was similar to second instar in general appearance but differed in size. The colour of the body was yellowish to light brown, but it was darker than previous instar. A dorsal longitudinal line on either side was prominent in third instar. Moreover, a white coloured band was present on lateral side of the body. Prior to moulting, cuticle turn black in colour. The length of third instar larva measured from 7.30 to 11.28 mm (9.55 ± 1.32 mm), while that of the breadth from 0.78 to 1.78 mm (1.16 ± 0.26 mm), Table-1. The present findings are in close agreement with the finding of previous scientist, who reported the average length of third instar larva of *H. armigera* on groundnut to be 8.46 mm with 1.01 mm in breadth^[3]. The head capsule was more compact and

transparent with light brown spots. The data revealed that the length of head capsule of third instar larva measured from 0.61 to 0.75 mm (0.68 ± 0.05 mm), while that of the breadth from 0.62 to 0.83 mm (0.71 ± 0.07 mm), Table-1. The duration required to complete third instar ranged between 3 to 5 days (3.91 ± 0.79 days) Table-1. This period was also reported as 3 to 5 days on groundnut ^[3].

Fourth instar

Variation in colour was observed in fourth instar larva. It was of green, reddish brown, brown and greenish brown. Setae were also observed all over the body of fourth instar larva. Generally the lateral strip on all the larvae were yellowish white, but dorsal strip was of variable in colours. The strips were either continues or broken. The length of fourth instar larva was ranged from 8.55 to 15.90 mm (11.98 ± 2.33 mm), while that of breadth ranged from 1.33 to 2.38 mm (1.83 ± 0.29 mm) Table-1. The present findings are more or less similar to scientist, who reported the length and breadth of fourth instar larvae of *H. armigera* as 12.83 ± 0.45 mm and 2.85 ± 0.04 mm on chickpea, respectively ^[1]. The head capsule of fourth instar larva measured from 1.17 to 1.53 mm and 1.22 to 1.62 mm with an average of 1.36 ± 0.11 and 1.44 ± 0.12 mm, respectively (Table-1). The duration of fifth instar larva ranged from 4 to 5 days (4.55 ± 0.51 days) Table-1. The present findings are more or less in confirmation with past, who reported 3 to 4 days of fifth instar when *H. armigera* reared on chickpea^[1] and 3 to 6 days when reared on rose ^[5].

Fifth instar

The fifth instar larva was showed pinkish brown and pale green colour pattern with broken dorsal strips and continues lateral strips. The black spots were reduced in number. Dorsal strip of pinkish brown larvae was thick and black in colour, while in pale green colour larvae strip was thick and white in colour. The abdomen was turn in yellowish green and thoracic reason was remain dark green coloured, when larvae start moulting. The fifth instar larva was more active and aggressive as compare to previous stage but at the time of moulting larva was less active. The length and breadth of fifth instar larva was ranged from 15.92 to 19.87 mm (17.71 ± 1.27 mm) and 2.12 to 3.16 mm (2.70 ± 0.31 mm), respectively Table-1. Previously, it was also reported average as length and breadth of fifth instar larva of *H. armigera* as 20.97 and 3.25, respectively on chickpea ^[1]. Head capsule was transparent light orange in colour. The length and breadth of head capsule ranged from 1.77 to 2.14 mm with an average of 1.97 ± 0.13 mm and 1.84 to 2.38 mm with an average of 2.11 ± 0.16 mm, respectively (Table-1). The duration of fifth instar larva ranged from 4 to 5 days with an average of 4.55 ± 0.51 mm (Table-1). The present investigation more or less similar confirmation previous, who recorded duration of fifth instar larva of *H. armigera* ranged from 3 to 6 days, when reared on rose ^[5].

Sixth instar

The sixth instar larva was flattened ventrally but convex dorsally. The body was pinkish brown and pale green in colour with two black longitudinal strips on dorsal side and scattered short hairy setae present all over the body. The

characteristics of larva during moulting were similar to the previous instar. Legs were pinkish to light green in colour. The body length and breadth of sixth instar larva ranged from 20.11 to 30.60 mm (25.93 ± 3.70) and 3.19 to 4.32 mm (3.72 ± 0.37 mm) respectively (Table-1). Similarly, it was also reported as 30.50 to 34.50 mm in length and 3.80 to 4.25 mm in breadth when *H. armigera* was reared on chickpea^[1]. Head capsule of sixth instar larvae was similar in appearance as of fifth instar larvae, but differed in size. After moulting, mostly a head capsule was found in excreta. The length of head capsule varied from 1.86 to 3.44 mm (2.69 ± 0.51 mm), while breadth varied from 2.13 to 3.73 mm (2.96 ± 0.49 mm), Table-1. The data of duration of sixth instar larva ranged from 4 to 6 days (4.71 ± 0.72 days), Table-1. In past, it was ranged from 4 to 8 days when reared on rose^[5].

Total larval instar

The perusal of data revealed that, the total larval development period of *H. armigera* varied from 21 to 25 days (21.4 ± 1.71 days) Table-1. Earlier, this period of *H. armigera* was recorded as 14 to 20 days on chickpea^[1]. While, it was 19 to 28 days when reared on rose^[5]. The variation in the larval period may be because of different hosts.

Pre-pupa

After completion of larval development, final instar larva stopped feeding and change its colour from pinkish brown to light pinkish brown and pale green to light green yellowish with less prominent strips. These was the indication of larva undergoing pre-pupal stage. The full grown larva wondering on the soil for pupation and pupated within the soil by making an earthen cocoon. After preparing an earthen cocoon, the larva contracted its body while the legs remained straight. During this period the larva did not exhibit any movement unless it was disturbed. Finally, larva shedding off cuticle and head capsule was attached with that inside the cocoon and goes into pupal stage. Earlier, the full grown larva of sixth instar becomes sluggish and suspended feeding and movement^[1, 5]. The length and breadth of pre-pupa was varied from 13.02 to 17.29 mm (15.44 ± 1.38 mm) Table-1. The length and breadth of pre-pupa of *H. armigera* was, respectively, 25.43 and 4.56 mm on chickpea^[1], 25.01 and 4.96 mm on rose^[5] and 24.12 to 3.51 mm on groundnut^[3]. The difference found in size of pre-pupa between present study and previous study may be due to different hosts.

Pre-pupal period

The pre-pupal period found ranging from 1 to 2 days (1.48 ± 0.51 days) during present study (Table-1). This stage lasted for 1 to 3 day on both chickpea and rose^[1, 5] and 1 to 4 days on groundnut^[3].

Pupa

The newly formed pupa was transparent green to light green in colour and further, it become hard and changed into reddish brown colour with prominent black eye spot after few hours. The pupa was obtect type. It was smooth, cylindrical, long and tapering towards the posterior end with two parallel spines at the posterior tip. Abdomen was distinctly marked into ten

segments and well defined dark brown spiracles were visible on fourth to ninth abdominal segments. Male and female pupae were differentiated at pupal stage based on morphometric characters. Male pupa carries genital aperture on ninth abdominal segment, whereas, in case of female, it was present on eight abdominal segments. Movement of abdomen was observed when pupa was disturbed. Present observation more or less similar to earlier study, when *H. armigera* reared on chickpea and rose, respectively^[1, 5]. Looking to the data in Table-1, the length of pupa measured from 10.98 to 13.42 mm (11.41 ± 1.03 mm), while that of breadth measured from 2.59 to 3.57 mm (3.21 ± 0.36 mm). Earlier, the length and breadth of pupa measured as 19.00 and 5.72 mm on chickpea^[1] and 20.93 and 6.09 mm on rose^[5]. Thus, it is clear from this study that, host plant playing role in size of various stages of pest. The morphometric measurements of pupa were also taken to identify the sex of pupa. Accordingly, the distance between anal and genital pores of male pupa was recorded as 0.45 to 0.67 mm (0.56 ± 0.45 mm), while in female, it was 1.39 to 1.72 mm (1.55 ± 0.11 mm), Table-1. Thus, it was observed that the distance between anal and genital pore was more in female than male. Previously it was also similar while studying biology of pest on groundnut^[3]. The data given in Table-1 revealed that the pupal period varied from 11 to 15 days with an average of 12.67 ± 1.28 days. In past, recorded average pupal period of 13.15 days of *H. armigera* on chickpea^[1] while, was 10.44 days on rose^[5].

Adult

Immediately after emerging from the pupa, adult took a rest for some time to stretch and harden its wings and other body parts. Once the body acquired normal structure and hardened the wings, adult looking for the food. The compound eyes were dark brown in color and were located laterally on the head. It possessed a pair of antennae of setaceous type on the dorsal side of the head between the compound eyes. Siphoning type of mouthpart was coiled and rested beneath the head. The adults were of medium size with broad thorax possessing yellowish brown forewings and legs were long with dirty white scaly appearance. There was a distinguished colour pattern between male and female moths. Males were of greenish-grey in colour, whereas, females with orange brown and were also identified by the presence of tuft of hairs on the tip of abdomen. There was series of the dots on margin and black kidney shaped marked on underside of each forewing. The transparent membranous part of the forewings was covered with creamy coloured scale. Hind wings were lighter in colour and each possessed a dark coloured patch at the apical end. These observations are more or less in agreement with those reported when *H. armigera* was reared on chickpea and rose respectively^[1, 5]. The length of adult male varied from 15.94 to 18.21 mm (16.94 ± 0.83 mm) and the breadth varied from 32.18 to 34.79 mm (33.12 ± 0.82 mm), Table-1. Whereas, in case of female, the length varied from 17.90 to 22.83 mm (20.31 ± 1.62 mm) and the breadth varied from 30.16 to 36.68 mm (34.23 ± 1.83 mm), Table-1. These observations on length and breadth were almost similar to the observations recorded, when *H. armigera* was reared different

host viz., chickpea, rose and groundnut, respectively^[1, 5, 3].

Pre-oviposition, oviposition and post-oviposition period

Table-1 shows that pre-oviposition period varied from 2 to 4 days (2.86 ± 0.85 days) which are close concurrence to those of previous^[1, 3]. The oviposition period ranged from 7 to 9 days (8.14 ± 0.85 days). Earlier, this period reported as 4 to 7 days^[5] and 6 to days^[3]. The post-oviposition period during the studies ranged from 1 to 2 days with an average of 1.52 ± 0.51 days. In past it was 0 to 2 days of post-oviposition period in *H. armiger*^[5, 3].

Fecundity

In laboratory, the egg laying capacity recorded during the study was varied from 742 to 1235 eggs (1048.40 ± 193.58 eggs) per female on chilli (Table-2). Almost similar fecundity of 290 to 910 eggs per female on rose^[5], while it was 405 to 420 on chickpea^[1] and 163 to 318 on groundnut^[3].

Longevity of adult

The longevity of male ranged from 7 to 10 days (8.67 ± 1.06 days) while mated female lived for 9 to 13 days (10.90 ± 1.22 days), Table-2. As per previous record both male and female

of *H. armigera* lived for about 7 to 11 and 10 to 14 days respectively^[1]. Similarly, longevity of male and female adults as 4 to 8 and 5 to 11 days, respectively^[5]. While, the duration of male and female adults as 7 to 8 days and 8 to 10 days respectively^[3].

Sex ratio

Based on morphological characters mentioned earlier, the adult were differentiated into their sexes. Out of 100 adults emerged from laboratory mass culture during period of study, 34 were males and 66 were females, which indicated the preponderance of female. The sex ratio of male to female was 1: 2.08 (Table-1). The sex ratio of *H. armigera* was 1: 1.12 when reared on groundnut^[3].

Total life cycle

The total life span from eggs to the death of adult occupied by male was 40 to 59 days (48.43 ± 2.44 days) while, female occupied 47 to 57 days (51.72 ± 2.72 days) Table-1. Thus, a total life period of male was shorter than female recorded during present investigation. The present findings are more or less in agreement with those, who studied pest on groundnut^[3].

Table 1: Morphometry and duration of different stages of *H. armigera*

Stage	Particulars	Measurement (mm)			Periods (days)		
		Minimum	Maximum	Mean \pm S.D.	Minimum	Maximum	Mean \pm S.D.
Egg	Length	0.42	0.56	0.49 ± 0.04	2	5	3.56 ± 0.77
	Breadth	0.44	0.57	0.51 ± 0.04			
Larva							
I instar	Length	1.30	1.98	1.60 ± 0.22	2	4	2.88 ± 0.73
	Breadth	0.18	0.35	0.26 ± 0.05			
Head capsule	Length	0.19	0.38	0.28 ± 0.32			
	Breadth	0.23	0.40	0.07 ± 0.06			
II instar	Length	3.36	5.34	4.57 ± 0.59	3	4	3.46 ± 0.51
	Breadth	0.50	0.90	0.68 ± 0.13			
Head capsule	Length	0.42	0.55	0.49 ± 0.05			
	Breadth	0.44	0.59	0.52 ± 0.04			
III instar	Length	7.30	11.28	9.55 ± 1.32	3	5	3.91 ± 0.79
	Breadth	0.78	1.78	1.16 ± 0.26			
Head capsule	Length	0.61	0.75	0.68 ± 0.05			
	Breadth	0.62	0.83	0.71 ± 0.07			
IV instar	Length	8.55	15.90	11.98 ± 2.33	3	5	3.73 ± 0.70
	Breadth	1.33	2.38	1.83 ± 0.29			
Head capsule	Length	1.17	1.53	1.36 ± 0.11			
	Breadth	1.22	1.62	1.44 ± 0.12			
V instar	Length	15.92	19.87	17.71 ± 1.27	4	5	4.55 ± 0.51
	Breadth	2.12	3.16	2.70 ± 0.31			
Head capsule	Length	1.77	2.14	1.97 ± 0.13			
	Breadth	1.84	2.38	2.11 ± 0.16			
VI instar	Length	20.11	30.60	25.93 ± 3.70	4	6	4.71 ± 0.72
	Breadth	3.19	4.32	3.72 ± 0.37			
Head capsule	Length	1.86	3.44	2.69 ± 0.51			
	Breadth	2.13	3.73	2.96 ± 0.49			
Total larval period					21.00	25.00	23.14 ± 1.28
Pre-pupa	Length	13.02	17.29	15.44 ± 1.38	1.00	2.00	1.48 ± 0.51
	Breadth	2.64	3.84	3.20 ± 0.32			
Pupa	Length	10.98	13.42	12.33 ± 0.80	11.00	15.00	12.67 ± 1.28
	Breadth	2.59	4.57	3.69 ± 0.52			
Distance between genital and anal pore	Male	0.45	0.67	0.56 ± 0.45			
	Female	1.39	1.72	1.55 ± 0.11			

Total life span: Egg to adult death							
Male	Length	15.94	18.21	16.94 ± 0.83	40	59	48.43 ± 2.44
	Breadth (wing expanded)	32.18	34.79	33.12 ± 0.82			
Female	Length	17.90	22.83	20.31 ± 1.62	42	62	50.67 ± 2.13
	Breadth (wing expanded)	30.16	36.68	34.23 ± 1.83			

Table 2: Fecundity, hatching percent, longevity, pre-oviposition, oviposition, post oviposition and sex ratio of *H. armigera*

Particulars	Minimum	Maximum	Mean ± S.D.
Fecundity (Eggs/female)	742	1235	1048.40 ± 193.58
Hatching (%)	367	862	52.57 ± 11.22
Longevity			
Male	7	10	8.67 ± 1.06
Female	9	13	10.90 ± 1.22
Pre-oviposition	2	4	2.86 ± 0.85
Oviposition	7	9	8.14 ± 0.85
Post-oviposition	1	2	1.52 ± 0.51
Sex ratio (Male: Female)	1: 1.49	1: 4.00	1: 2.08

4. Conclusion

Biology of chilli fruit borer, *H. armigera* indicated that the female laid eggs singly or in batches of 2 to 3 on tender leaf and shoots of chilli plant. Occasionally the eggs were found on pot, piece of black colour muslin cloth and platform. The freshly laid eggs were yellowish white in colour which changed to deep yellow after one day and become dark brown prior to hatching. Eggs were hemispherical with flat base and prominently sculptured with numerous ridges running from one polar end to another. The length and breadth of freshly laid eggs were ranging from 0.42 to 0.56 mm and 0.44 to 0.57 mm respectively. The egg laying capacity of the female varied from 742 to 1235 eggs with an average 1048.40 ± 193.58. The hatching percentage was 53.20. The incubation period ranged from 2 to 5 days.

The larvae passed through six distinct instars when fed on chilli leaves and fresh green chilli fruits. The body colour of freshly emerged larva was semi-translucent, dirty white in colour with whitish longitudinal lines on the dorsal surface of the body. The second instar larva was yellowish to light brown in colour having transparent brown spotted head capsule. The third instar larva was similar in general appearance but differed in size. At the time of moulting, cuticle turn to black in colour. Head capsule was more compact and transparent with light brown spots. In fourth instar, larvae appeared in various colours of green, reddish brown, brown, greenish brown and covered with setae all over the body. The fifth instar larvae were showed pinkish brown and pale green colour pattern with broken dorsal strips and continues lateral strips. Head capsule was transparent and light orange in colour. The sixth instar larva was flattened ventrally but convex dorsally. The body was pinkish brown and pale green in colour with two black longitudinal strips on dorsal side and scattered short hairy setae were present on all over the body. Mostly, a head capsule was found in excreta after moulting. The average length of first, second, third, fourth fifth and sixth instar larvae were 1.60 ± 0.22, 4.57 ± 0.59, 9.55 ± 1.32, 11.98 ± 2.33, 17.71 ± 1.27 and 25.93 ± 3.70 mm, while that the average breadth were 0.26 ± 0.05, 0.68 ± 0.13, 1.16 ± 0.26, 1.83 ± 0.29, 2.70 ± 0.31 and 3.72 ± 0.37 mm, respectively. The average larval duration of first, second, third, fourth fifth

and sixth instar larvae were recorded as 2.88 ± 0.73, 3.46 ± 0.51, 3.91 ± 0.79, 3.73 ± 0.70, 4.55 ± 0.51 and 4.71 ± 0.72 days, respectively. The total larval period was completed in 23.14 ± 1.28 days, when reared on chilli. The larva undergoes pupation in soil by preparing an earthen cocoon and the pre-pupal period recorded as 1.48 ± 0.51 days. The newly formed pupa was transparent green to light green in colour and further it became hard and changed into reddish brown colour with prominent black eye spot. The pupa was of oblect type. The average length and breadth of pupa measured as 12.33 ± 0.80 and 3.69 ± 0.52 mm, respectively. The average pupal period was 12.67 ± 1.28 days. The male moth was of greenish-grey while female was of orange brown. Presence of tuft of hairs on the tip of abdomen of female is the identification character. The average length of male and female measured from 16.94 ± 0.83 and 20.31 ± 1.62, while breadth with expanded wingspan measured as 33.12 ± 0.82 and 34.23 ± 1.83 mm, respectively. The sex ratio (Male: female) was 1:2.08. The average pre-oviposition, oviposition and post-oviposition periods were 2.86 ± 0.85, 8.14 ± 0.85 and 1.52 ± 0.51 days, respectively. The male and female moth lived for 8.56 ± 1.04 and 10.80 ± 1.32 days, respectively. The average longevity of male recorded as 8.67 ± 1.06 days while that of female was 10.90 ± 1.22 days. The average fecundity of the female recorded as 1048.40 ± 193.58 eggs. The total life cycle of male was completed in 40 to 59 days (48.43 ± 2.44 days), while it was completed in 42 to 62 days (50.67 ± 2.13 days) during the present investigation.

5. Reference

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