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Biology of *Spodoptera litura* Fabricius on cabbage**Rabari PH, Chaudhari SJ, Chaudhary NJ and Dodia DA****Abstract**

The investigations on biology were carried out in the laboratory of Department of Entomology, C. P. College of Agriculture, S.D. Agricultural University, Sardarkrushinagar during 2013-14. An average length and breadth of eggs measured to be 0.58 ± 0.02 mm and 0.49 ± 0.02 mm, respectively. An average hatching percentage and incubation period were 93.16 ± 4.33 per cent and 3.48 ± 0.77 days, respectively. The larva of *S. litura* passed through six larval instars. The average length of the first, second, third, fourth, fifth and sixth instar larva was 1.48 ± 0.11 , 3.78 ± 0.10 , 10.52 ± 0.33 , 18.75 ± 0.61 , 26.30 ± 0.81 and 35.32 ± 0.87 mm, respectively, while the average breadth of the first, second, third, fourth, fifth and sixth instar larva was 0.32 ± 0.04 , 0.72 ± 0.06 , 1.38 ± 0.10 , 2.19 ± 0.10 , 2.96 ± 0.15 and 4.24 ± 0.17 mm, respectively. The length and breadth of pre-pupa measured to be 27.65 ± 1.35 and 3.91 ± 0.18 mm, respectively. Male pupal length and breadth were 19.20 ± 0.93 and 6.01 ± 0.36 mm, respectively. While, female pupal length and width measured to be 19.39 ± 0.93 and 6.28 ± 0.45 mm, respectively. The average developmental period of first, second, third, fourth, fifth and sixth instars larva was 3.20 ± 0.41 , 2.96 ± 0.73 , 3.36 ± 0.64 , 3.04 ± 0.79 , 3.28 ± 0.46 and 2.76 ± 0.44 days, respectively with a total larval period of 17.88 ± 1.51 days. An average developmental period of pre-pupa was 1.56 ± 0.51 days. An average developmental period of male and female pupa was 8.24 ± 0.93 and 9.52 ± 0.96 days, respectively. An average length and breadth of adult male measured as 19.46 ± 0.98 mm and 38.34 ± 0.76 mm, respectively while, in case of female it measured to be 19.61 ± 1.03 mm and 38.77 ± 0.70 mm, respectively. An average pre-oviposition, oviposition and post-oviposition period were 1.52 ± 0.51 , 7.72 ± 1.37 and 1.48 ± 0.71 days, respectively. An average longevity of male and female were 8.32 ± 1.31 and 10.36 ± 1.25 days, respectively and total life period of male and female were 36.28 ± 2.32 and 38.24 ± 2.52 days, respectively. The fecundity of female recorded as 2267.92 ± 175.97 eggs. Sex ratio of male: female was recorded as 1: 1.25.

Keywords: *S. litura*, length, breadth, male, female**1. Introduction**

India serves as the home to various kind of vegetables as well as fruits and holds a vital position in the field of productions of fruits and vegetables amidst different countries of the world and has been renamed as the vegetable and fruit basket in the world [1]. Vegetables are the fresh and edible portions of herbaceous plants and contain high carbohydrates, vitamins and minerals [2]. India is the second largest producer of vegetables in the world, next to China [3].

The Latin name cruciferous is used for a family because of blossoms of these plants resembles a cross or crucifix [4]. This family includes green cabbage, cauliflower, mustard, turnips, broccoli and Brussels sprouts. The word as early as 600 B.C., wild cabbage was indigenous to the Asia and Mediterranean region and it slowly spreaded into Northern Europe by the Celtic wanderers and later in the Romans [5].

Cabbage is commonly used as salad, boiled vegetable and cooked in curries. It is enriched in protein (1.28 g), carbohydrates (5.8 g) and vitamins A and B₁ (0.061 mg), B₂ (0.040 mg), B₆ (0.124 mg) and C (36.6 mg). Cabbage is excellent source of vitamin C, glutamine and amino acid having anti-inflammatory properties [6]. The typical flavour in cabbage is due to glucoside "Sinigrin" which contains sulphur. Cabbage also possesses medicinal properties having indol-3-carbinol which helps in curing bowel cancer and constipation. The cabbage crop is having infestation of multiple insect pest complex and constitute one of the major limiting factors in crop production by causing appreciable damage.

Among these, *Spodoptera litura* Fabricius is an important lepidopterous, noctuid, polyphagous and multivoltine pest. It has worldwide distribution and cosmopolitan in food habit, feeding on the plants of economic importance. The larvae of *S. litura* has been reported to feed on 112 cultivated crops all over the world [7].

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The damage is done by larval stage and is often serious. It feed on the foliage gregariously during early stages, while disperse in later stages. These are voracious feeder of the foliage, remaining hidden under soil during the day time. The maximum damage is caused to the young plants, which in severe cases of attack are totally destroyed. Large areas of the leaves of the grown up plants may also be eaten up by the caterpillar^[8]. Considering the above problems, it was need to studied the biology of *S. litura* on cabbage crop under laboratory conditions.

2. Material and Methods

A detail study on biology of *S. litura* was carried out in the laboratory of Department of Entomology, C. P. College of Agriculture, S. D. Agricultural University, Sardarkrushinagar, during *rabi*, 2014. Maximum as well as minimum temperature and relative humidity were recorded daily during the course of study.

2.1 Rearing technique

The initial culture of *S. litura* was established in the laboratory by collecting the larvae from cabbage crop grown at Agronomy Instructional Farm as well as villages around the Sardarkrushinagar. These larvae were reared in round iron cage in the laboratory at room temperature. Fresh leaves of cabbage were provided daily as the food for the larvae. The cut end of the leaf was wrapped with cotton wool and soaked in water to keep the leaf fresh and turgid for longer duration. Grown up larvae were transferred into the rearing glass jar. One third part of the glass jar was filled up with moist soil to provide the appropriate site for pupation to the grown up larvae. After pupation, the pupae were kept as such in the jars containing soil till the adults emerged. A pair of newly emerged male and female was confined in a glass chimney cage prepared by placing a chimney on blotting paper in Petri dish. The top of the chimney was covered with muslin cloth and secured firmly by a rubber band to prevent the escape of the adult. Fresh uninfested leaves of cabbage were provided in the chimney cage for egg laying. Five per cent honey solution was provided as food to the adults by dipping a piece of sponge in the solution. The sponge was changed daily. The leaves, muslin cloth and chimney were observed every morning for egg laying. The eggs were transferred on fresh leaves with the help of a fine camel hair brush. The eggs were kept in separate Petri dishes and used to maintain a pure culture of the pest. Thus, the laboratory culture was raised and maintained for further investigations.

2.2 Egg

Thirty eggs were examined under microscope to study their colour, shape and size. The length and breadth of the eggs was measured with the help of ocular micrometer after calibrating with stage micrometer and average diameter was worked out.

To study the incubation period and hatching percentage of eggs, freshly laid eggs were observed under microscope daily in the morning and evening till they hatched. The eggs were considered as hatched when tiny larva came out from the egg. Average incubation period was then calculated. Hatching percentage was calculated from the number of eggs hatched, out of total number of eggs kept under observation.

2.3 Larva

With a view to determine the number and duration of different larval instars and total larval period, the newly emerged larvae

(first instar) were placed individually in Petri dishes (15 cm diameter x 1.5 cm height) with the help of fine camel hair brush and fresh tender cabbage leaves were kept inside the Petri dish as the food. The leaves in each Petri dish were changed daily in the morning.

For determining the number of larval instars, the size of individual larva were observed daily. The moulting was confirmed by casted off head capsule and increased size of larva of subsequent instars. The larvae in each instar were studied for their colour, shape and size. Observations on number of instars, duration of each instar and total larval period were recorded separately. Measurement of first two instars were recorded under microscope with the help of stage and ocular micrometer. While, the length and breadth of the third to sixth instars were measured with millimeter scale. The total larval period was calculated from the date of hatching of egg to the date of formation of pre-pupa.

2.4 Pre-pupa

When full grown larva (sixth instar) stopped feeding, contracted in size and became sluggish in movement, they were considered to be in the pre-pupal stage. The pre-pupae were observed critically under the microscope for their colour, shape and size. The size of pre-pupa was measured using millimeter scale. The pre-pupal period was recorded individually from inactive stage to complete pupal formation.

2.5 Pupa

The pupa were studied for their colour, shape, size and pupal duration. The length and breadth of pupa was measured by using millimeter scale. The pupal period was considered from the date of formation of pupa to the date of adult emergence. Sex of the adult was identified from the pupa as differentiated from the distance between the markings of genital and anal openings on the pupa.

2.6 Adult

The newly emerged male and female adults were used to study the oviposition period and the rest were killed using insect killing jar. They were pinned, dried and preserved with wing expansion. Such preserved adults were observed under the microscope to study the difference between male and female as well as colour, shape, size and appearance of adult moths. The size of the adults with wing expansion was measured using millimeter scale.

2.7 Pre-oviposition, oviposition and post-oviposition period

To study the pre-oviposition, oviposition and post-oviposition periods, the freshly emerged male and female adults from pupae were paired and confined in chimney cage separately for egg laying. They were provided with five per cent honey solution as food. Fresh leaves of cabbage were provided for egg laying. The sponge for honey solution and the leaves were changed daily. The eggs laid by each female on leaves, chimney wall, Petri dish and muslin cloth were removed daily with the help of fine camel hair brush and total number of eggs laid by each female were recorded separately.

A period between the time of emergence of the female from the pupa and commencement of egg laying was considered as pre-oviposition period. Period between starting of egg laying and ceasation of egg laying was noted as oviposition period while, the period between ceasation of egg laying to the death of female was considered as post-oviposition period.

2.8 Fecundity

Number of eggs laid by each female was recorded daily till the death of the female. From the recorded observations, average fecundity of each female was worked out separately.

2.9 Longevity

Longevity of male and female was calculated separately from the date of emergence to the date of death of the adult.

2.10 Sex ratio

To study sex ratio, laboratory reared adults were observed for their differences in morphological characters to separate them into male and female and the sex ratio was worked out.

2.11 Total life period

The period between egg laying and death of adults was considered as total life period.

3. Results and Discussion

During the study period the average temperature and relative humidity were 24.96 ± 3.03 °C and 58.04 ± 7.71 per cent, respectively.

Table 1: Measurements of different stages of *S. litura*

Sr. No.	Life stage	Particulars	Measurement (mm)		
			Min.	Max.	Mean \pm SD
1.	Egg	Length	0.56	0.60	0.58 ± 0.02
		Breadth	0.47	0.52	0.49 ± 0.02
2.	Larva				
	I instar	Length	1.30	1.69	1.48 ± 0.11
		Breadth	0.25	0.40	0.32 ± 0.04
	II instar	Length	3.65	4.00	3.78 ± 0.10
		Breadth	0.58	0.82	0.72 ± 0.06
	III instar	Length	9.80	10.98	10.52 ± 0.33
		Breadth	1.14	1.57	1.38 ± 0.10
	IV instar	Length	18.15	20.10	18.75 ± 0.61
		Breadth	2.06	2.42	2.19 ± 0.10
	V instar	Length	25.04	27.42	26.30 ± 0.81
		Breadth	2.74	3.16	2.96 ± 0.15
	VI instar	Length	33.20	36.22	35.32 ± 0.87
		Breadth	3.92	4.52	4.24 ± 0.17
3.	Pre-pupa	Length	25.15	30.20	27.65 ± 1.35
		Breadth	3.56	4.18	3.91 ± 0.18
4.	Pupa				
	Male	Length	17.60	20.60	19.20 ± 0.93
		Breadth	5.22	6.48	6.01 ± 0.36
	Female	Length	17.62	20.85	19.39 ± 0.93
		Breadth	5.25	6.75	6.28 ± 0.45
5.	Adult				
	Male	Length	17.65	20.88	19.46 ± 0.98
		Breadth	37.14	39.68	38.34 ± 0.76
	Female	Length	17.72	20.96	19.61 ± 1.03
		Breadth	37.95	40.22	38.77 ± 0.70

3.1 Egg

The female moths laid the eggs in cluster or masses on lower surface of the leaves. Freshly laid eggs were pale white and changed to dark or grey black, a day before hatching. The freshly laid eggs were nearly round in shape and pale green in colour and after few hours eggs turned to whitish green in colour. The whole egg mass was covered with brown hair like scales. Before hatching, tip of egg became black in colour. The length of eggs ranged between 0.56 to 0.60 mm with an average of 0.58 ± 0.02 mm, while the breadth varied from 0.47 to 0.52 mm with an average of 0.49 ± 0.02 mm (Table 1). The incubation period of the egg of *S. litura* varied from 3

to 5 days with an average of 3.48 ± 0.77 days (Table 2). The nearest incubation period of 3.40 days was also obtained on castor^[9].

3.2 Hatching percentage

It can be seen from Table 2 that hatching percentage of eggs varied from 87.33 to 97.33 per cent (Av. 93.16 ± 4.33), when average temperature was 24.96 ± 3.03 °C and relative humidity was 58.04 ± 7.71 . More or less similar results were also obtained^[14]. The average hatching per cent of *S. litura* on cabbage was 93.33 to 96.00 per cent^[10].

3.3 Larva

From the present study, it was found that the larvae of *S. litura* passed through six larval instars.

3.4 First instar

On hatching the young larva made a hole in the egg shell. The freshly hatched larva was pale or dirty white in colour with a prominent shiny black head capsule. Short hairs were observed on body, arising from black spots. The newly hatched larva was whitish and turned yellowish green in colour. The length of first instar larva varied from 1.30 to 1.69 mm with an average of 1.48 ± 0.11 mm and breadth of first instar larva varied from 0.25 to 0.40 mm with an average of 0.32 ± 0.04 mm (Table 1). Length and breadth of first instar larva reared on castor was an average of 1.86 ± 0.02 mm and 0.39 ± 0.02 mm, respectively^[15]. The duration of first instar larva varied from 3 to 4 days with an average of 3.20 ± 0.41 days (Table 2).

Table 2: Duration of different stages of *S. litura*

Sr. No.	Life stage	Period (days)		
		Min.	Max.	Mean \pm SD
1.	Egg	3	5	3.48 ± 0.77
	Hatching (%)	87.33	97.33	93.16 ± 4.33
2.	Larva			
	I instar	3	4	3.20 ± 0.41
		2	4	2.96 ± 0.73
	II instar	3	5	3.36 ± 0.64
		2	4	3.04 ± 0.79
	III instar	3	4	3.28 ± 0.46
		2	3	2.76 ± 0.44
	IV instar	3	4	3.28 ± 0.46
		2	3	2.76 ± 0.44
	V instar	3	4	3.28 ± 0.46
		2	3	2.76 ± 0.44
	VI instar	3	4	3.28 ± 0.46
		2	3	2.76 ± 0.44
3.	Pre-pupa	1	2	1.56 ± 0.51
		15	21	17.88 ± 1.51
4.	Pupa			
	Male	7	10	8.24 ± 0.93
		8	11	9.52 ± 0.96
	Female	7	10	8.24 ± 0.93
		8	11	9.52 ± 0.96
5.	Adult			
	Pre-oviposition	1	2	1.52 ± 0.51
		6	10	7.72 ± 1.37
		1	3	1.48 ± 0.71
	Oviposition	1	3	1.48 ± 0.71
		6	10	7.72 ± 1.37
		1	3	1.48 ± 0.71
	Post-oviposition	1	3	1.48 ± 0.71
		6	10	7.72 ± 1.37
		1	3	1.48 ± 0.71
Longevity				
	Male	6	10	8.32 ± 1.31
		9	12	10.36 ± 1.25
	Female	6	10	8.32 ± 1.31
		9	12	10.36 ± 1.25
	Fecundity	1987	2578	2267.92 ± 175.97
		Sex ratio (Male: Female)		
	Laboratory	1: 1	1: 1.50	1: 1.25
		Total life span: Egg to adult death		
	Male	33	40	36.28 ± 2.32
		35	43	38.24 ± 2.52
	Female	33	40	36.28 ± 2.32
		35	43	38.24 ± 2.52
7.	Temperature (°C)	21	33	24.96 ± 3.03
8.	Relative Humidity (%)	44	69	58.04 ± 7.71

3.5 Second instar

The second instar larva was quite different from first instar. The black head capsule was casted off and new head capsule

was pale brown having a triangular marks. The general body colour was pale green. The distinctive feature was the presence of prominent black spots on either sides of dorsum of first and eighth abdominal segment. The third thoracic segment was broader than the first and second thoracic segments. First abdominal segment was also broader than the remaining one. There were three longitudinal pale white lines on the dorsolateral surface of the body. The larva during second instar slightly increased in size with light green to dark green in colour, three pairs of black thoracic legs and prolegs were present on the abdomen.

Length of second instar larva ranged from 3.65 to 4.00 mm with an average of 3.78 ± 0.10 mm, while the breadth ranged from 0.58 to 0.82 mm with an average of 0.72 ± 0.06 mm (Table 1). The duration of second instar larva varied from 2 to 4 days with an average of 2.96 ± 0.73 days (Table 2). The duration of second instar larva as 2 to 4 days with an average of 2.84 ± 0.74 days on cabbage^[10]. Duration of second instar was 3 to 5 days with an average of 4.15 ± 0.58 days on castor^[12].

3.6 Third instar

The body of third instar larva was green in colour. Third instar larva was similar to second instar but possessed the prominent black spots on each side of first and eighth abdominal segments. The yellow and green lines observed from head to caudal region on body of the larvae. Dark patches also observed on meso-thorax. The larva became dark green in colour. Length of third instar larva ranged from 9.80 to 10.98 mm with an average of 10.52 ± 0.33 mm, while the breadth ranged from 1.14 to 1.57 mm with an average of 1.38 ± 0.10 mm (Table 1). Length and breadth of third instar larva reared on cabbage was an average of 10.54 ± 0.61 mm and 1.41 ± 0.10 mm, respectively^[10]. The duration of third instar larva varied from 3 to 5 days with an average of 3.36 ± 0.64 days (Table 2).

3.7 Fourth instar

Fourth instar larva was dark grey to olive green in colour. The yellowish strips became more prominent. These findings are similar to the records of Cardona *et al.* (2007)^[12]. Length of fourth instar larva ranged from 18.15 to 20.10 mm with an average of 18.75 ± 0.61 mm, while the breadth ranged from 2.06 to 2.42 mm with an average of 2.19 ± 0.10 mm (Table 1). Shukla (2000)^[10] stated that length and breadth of fourth instar larva reared on cabbage was an average of 18.46 ± 0.97 mm and 2.20 ± 0.07 , respectively. The duration of fourth instar larva varied from 2 to 4 days with an average of 3.04 ± 0.79 days (Table 2). Duration of fourth instar larva as 2 to 4 days with an average of 3.06 ± 0.68 days, when larva reared on cabbage^[10].

3.8 Fifth instar

The fifth instar larva was yellowish brown in colour and row of black dots run along with its site. The length of fifth instar larva ranged from 25.04 to 27.42 mm with an average of 26.30 ± 0.81 mm, while the breadth ranged from 2.74 to 3.16 mm with an average of 2.96 ± 0.15 mm (Table 1). Length and breadth of fifth instar larva was 26.04 ± 1.12 mm and 2.85 ± 0.13 mm, respectively on cabbage^[10]. The duration of fifth instar larva varied from 3 to 4 days with an average of 3.28 ± 0.46 days (Table 2).

3.9 Sixth instar

The full grown larva during sixth instar became plumpy,

stout, smooth and cylindrical and also stop feeding. The colour of the larva was velvety black or blackish green. The head was broader with six ocelli on each side. The prolegs were equal in size and crochets on them were uniordinal and arranged in semi-circular pattern. These findings are similar to the earlier records^[13]. The length of full-grown sixth instar larva ranged from 33.20 to 36.22 mm with an average of 35.32 ± 0.87 mm, while the breadth ranged from 3.92 to 4.52 mm with an average of 4.24 ± 0.17 mm (Table 1). Length and breadth of sixth instar larva reared on cabbage was an average of 34.26 ± 1.45 mm and 4.09 ± 0.17 mm, respectively^[10]. The duration of sixth instar larva varied from 2 to 3 days with an average of 2.76 ± 0.44 days (Table 2).

3.10 Total larval period

The total larval period varied from 15 to 21 days with an average of 17.88 ± 1.51 days (Table 2). The average larval period of *S. litura* on cabbage was 18 to 28 days^[16].

3.11 Pre-pupa

Pre-pupal stage was characterized by shortening of full grown larva in length, became sluggish and wrinkled and suspended feeding movement. The pre-pupa was dark brown or lighter reddish in colour and developed slightly greenish in colour at sternum before pupation. The length of the pre-pupa ranged from 25.15 to 30.20 mm with an average of 27.65 ± 1.35 mm, while the breadth ranged from 3.56 to 4.18 mm with an average of 3.91 ± 0.18 mm (Table 1). The duration of pre-pupal stage varied from 1 to 2 days with an average of 1.56 ± 0.51 days (Table 2). Aaverage pre-pupal period of 2.12 days on cabbage^[9].

3.12 Pupa

It was observed that, after a short pre-pupal period, the pre-pupa entered into the soil and pupation took place in earthen cocoon. The casted off skin remained within the cocoon at the caudal end of pupa. The colour of freshly formed pupa was light yellowish green and changed to light brown within 20 to 24 hrs which later on turned dark brown. The pupae were obtect and broadly rounded anteriorly and tapered posteriorly. Abdomen was distinctly marked into 10 segments. The genital aperture of male and female was situated on 9th and 8th abdominal segment, respectively. The anal aperture in both the sexes was found on 10th abdominal segment. Two pointed hooks were present on the tip of the abdomen. The pupa showed convulsive movement with its abdomen, when it was slightly disturbed.

The length of male pupa ranged from 17.60 to 20.60 mm with an average of 19.20 ± 0.93 mm. The length of female pupa varied from 17.62 to 20.85 mm with an average of 19.39 ± 0.93 mm, which was slightly more than male pupa. The breadth of male pupa ranged from 5.22 to 6.48 mm with an average of 6.01 ± 0.36 mm. Similarly, it was 5.25 to 6.75 mm with an average of 6.28 ± 0.45 mm in case of female pupa which was slightly more than male pupa (Table 1). The duration of male pupa varied from 7 to 10 days with an average of 8.24 ± 0.93 days, while duration of female pupa varied from 8 to 11 days with an average of 9.52 ± 0.96 days (Table 2). The pupal duration of 8 to 10 days with an average of 9.14 days^[10] and 9 to 11 days on cabbage^[11] was recorded earlier.

3.13 Adult

The moth emerged by making a small slit along the mid-dorsal line of pupa. Soon after emergence, the wings were

found folded which did not cover the entire abdomen. After some time, the moth made movement and the wings got completely expanded to its normal size. The adult moths (male and female) of *S. litura* were yellowish brown in colour with conspicuous head having black compound eyes. The sexual dimorphism was well pronounced in antennal character, where the female possessed setaceous and male with pectinate antennae. The thorax and abdomen were covered with dense brownish scales. The female was slightly bigger and stout than the male. The forewings in both the sexes were narrower than the hind wings. The forewings of the male had brown coloured strips beginning from the coastal margin and running backward to fuse with the similar coloured strips on the anal margin. In female, the strips were divided into narrow streaks by brownish dark scales. The hind wings of both the sexes were white with brown border. The tip of abdomen in male was long and tapering as compared to that of female. The length of male moth ranged from 17.65 to 20.88 mm with an average of 19.46 ± 0.98 mm. The length of female moth varied from 17.72 to 20.96 mm with an average of 19.61 ± 1.03 mm, which was slightly more than male moth. The breadth of male moth ranged from 37.14 to 39.68 mm with an average of 38.84 ± 0.76 mm. Similarly, it was 37.95 to 40.22 mm with an average of 38.77 ± 0.70 mm in case of female moth, which was slightly more than male moth (Table 1). The pre-oviposition period of female moth varied from 1 to 2 days with an average of 1.52 ± 0.51 days (Table 2). The oviposition period of *S. litura* female moth ranged from 6 to 10 days with an average of 7.72 ± 1.37 days (Table 2). The female moths lived for 1 to 3 days after completion of egg laying and occupied on an average post-oviposition period of 1.48 ± 0.71 days (Table 2).

3.14 Fecundity

The female was found laying eggs underside of leaf, on the wall of glass chimney and rarely on muslin cloth, when reared in laboratory. The egg laying capacity of female varied from 1987 to 2578 eggs with an average of 2267.92 ± 175.97 eggs (Table 2). The fecundity of female *S. litura* was 2122 to 2883 eggs per female on cabbage ^[10].

3.15 Longevity

The longevity of mated female moths ranged from 9 to 12 days with an average of 10.36 ± 1.25 days, while the longevity of male moths ranged from 6 to 10 days with an average of 8.32 ± 1.31 days (Table 2). The longevity of mated female moth was 10 to 12 days, while the longevity of male moth was 6 to 7 days on cabbage and tobacco ^[11].

3.16 Sex ratio

The observations made on emergence of adult revealed that the male: female ratio was 1: 1.25 (Table 2).

3.17 Total life span

The total life cycle of *S. litura* occupied on an average of 36.28 ± 2.32 days ranging from 33 to 40 days in case of male, while 38.24 ± 2.52 days ranging from 35 to 43 days in case of female (Table 2). The total life cycle of *S. litura* as 31 to 41 days for male and 33 to 42 days for female ^[10]. The total life cycle of *S. litura* on cabbage was 41 to 45 days for male and 46 to 49 days for female ^[11].

4. Conclusions

The average length and breadth was 0.58 ± 0.02 mm and 0.49 ± 0.02 mm, respectively. The average incubation period was

3.48 ± 0.77 days, whereas average hatching percentage of eggs was 93.16 ± 4.33 per cent. The larva of *S. litura* passed through six larval instars. The average length of the first, second, third, fourth, fifth and sixth instar larva was 1.48 ± 0.11 , 3.78 ± 0.10 , 10.52 ± 0.33 , 18.75 ± 0.61 , 26.30 ± 0.81 and 35.32 ± 0.87 mm, respectively, while the breadth was 0.32 ± 0.04 , 0.72 ± 0.06 , 1.38 ± 0.10 , 2.19 ± 0.10 , 2.96 ± 0.15 and 4.24 ± 0.17 mm, respectively. The average developmental period of first, second, third, fourth, fifth and sixth instars larva was 3.20 ± 0.41 , 2.96 ± 0.73 , 3.36 ± 0.64 , 3.04 ± 0.79 , 3.28 ± 0.46 and 2.76 ± 0.44 days, respectively with a total larval period of 17.88 ± 1.51 days. The average length and breadth of pre-pupa were 27.65 ± 1.35 and 3.91 ± 0.18 mm, respectively. The average pre-pupal period was 1.56 ± 0.51 days. The average length and breadth of male pupa was 19.20 ± 0.93 and 6.01 ± 0.36 mm, respectively, while in case of female it was 19.39 ± 0.93 and 6.28 ± 0.45 mm, respectively. The average pupal period of male and female was 8.24 ± 0.93 and 9.52 ± 0.96 days, respectively. The adult male measured 19.46 ± 0.98 mm in length, while 38.34 ± 0.76 mm in breadth (with wing expansion). The length and breadth of female moth was 19.61 ± 1.03 mm and 38.77 ± 0.70 mm, respectively. The average pre-oviposition, oviposition and post-oviposition period were 1.52 ± 0.51 , 7.72 ± 1.37 and 1.48 ± 0.71 days, respectively. The eggs were laid in clusters and were covered with short brown hairs. The egg laying capacity of a female was 2267.92 ± 175.97 eggs. The average longevity of male and female was 8.32 ± 1.31 and 10.36 ± 1.25 days, respectively. Thus, the female of *S. litura* had comparatively longer life span than the male. The sex ratio of male: female was 1: 1.25 under laboratory conditions. The total life cycle of male moth was 36.28 ± 2.32 days, while in case of female it was 38.24 ± 2.52 days.

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