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Biology studies of tobacco caterpillar, *Spodoptera litura* Fabricius

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Abstract
Biology, morphometrics and geometrical progression of *Spodoptera litura* was studied by rearing *S. litura* under laboratory conditions during 2017. The study was mainly focused on observing morphology of different stages i.e., egg, larva, pupa and adult along with the duration, *S. litura* had five instars. Measurements of all the stages of insect life cycle were recorded. The width of head capsule was recorded at each moult 0.25, 0.36, 0.50, 0.70 and 1.11 mm respectively. The mean values of head capsule width observed (0.36 to 1.11 mm) and estimated (0.36 to 1.10 mm) and the progression factor in the growth of *S. litura* was observed as 1.45, which indicated that an increase in head width during successive instars was very slightly varying from Dyar's law but followed a geometric progression in growth.

Keywords: *S. litura*, biology, morphometrics, head capsule, growth ratio

1. Introduction
Castor, *Ricinus communis* Linnaeus, is an important industrially valued non edible oil seed crop. Castor is grown on a total area of 1.5 m ha with an average production of 1.5 m tonnes, and productivity of 995 kg/ha during 2007 (FAOSTAT 2009) [1]. Gujarat is largest producer of castor (Fundamental Trading Opportunity Report on Castor Seed; 2011) [1]. The yield losses of castor due to insect pests varied widely depending up on the season. Castor is attacked by many insects from sowing to harvesting and among these, chewing insect pests *viz.*, tobacco caterpillar, castor butterfly and slug caterpillar [1]. Among these tobacco caterpillar considering the major problem [1].

The tobacco caterpillar, *Spodoptera litura* (Fab.) is one of the important polyphagous pest on crops, distributed throughout South and Eastern world, infesting 112 species of plants belonging to 44 families, of which 40 species were reported from India [2]. Though is a serious pest of tobacco, it also attacks cole crops, castor, cotton, chilies, sunflower, groundnut, pulses, amaranthus and tomato [3]. In the outbreak condition on tobacco, it was reported that not less than 15 egg masses and 400 to 500 larvae were observed as against four egg masses and 200 larvae per plant in normal condition [3].

In all arthropods, growth of rigid sclerotized parts like insect head grows in a step wise manner with the help of ecdysis that can be easily analysed by assessing the size of body structure in successive instars [4]. In many of the studies on growth of immature insects, the width of the head capsule was used for determining the stage of the instar especially in lepidoptera [4]. Hence measurement of width of head capsule provides basic information for the development of morphometric studies useful for pest management. Head capsule width of different larval instars was often used to determine the age of various lepidopteran pests. The number of larval instars and other information concerning with insect biology help in the development of pest forecasting models based crop phenology, or in the refinement of existing models [5].

According to Dyar (1890) width of head capsule in caterpillars increases by a constant ratio at each moult, that varies from species to species, but usually is 1.2 to 1.4 which was applied to many of insects larvae [6]. This law was used to determine the number of instars and constant development of Tobacco caterpillar, *S. litura* which is an important serious pest of castor, studies on biology, morphometrics and growth will help in identification and management of this pest.

2. Materials and Methods

2.1 Collection, mass multiplication of tobacco caterpillar, *S. litura*

The present study was conducted during 2017 in the Department of Entomology, College of Agriculture, PJTSAU, Rajendranagar, Hyderabad. To study biology and morphometrics of *S. litura*, the mass multiplication was taken up under laboratory conditions (Fig 1). In order to study biology of *S. litura* on castor, initial culture as egg mass were collected from castor fields of student farm, College of Agriculture, PJTSAU, Rajendranagar, Hyderabad, India and transferred to a clean container by providing healthy castor leaves with long petiole. The leaf was kept in the plastic container containing moist filter paper to keep it fresh. This served as immediate source of food for the first instar larvae. Leaf along with the egg mass was transferred to pre sterilized transparent plastic containers and covered with muslin cloth. The leaf was changed when the larvae entered into the third instar. There after containers were cleaned with 2 percent formaldehyde, shade dried and fresh castor leaves were given every day till the larvae entered into the last instar larval stage. These late larval instars were collected from containers and released in to another plastic container having soil for pupation. Pupae thus obtained were collected and kept in small plastic jars covered with muslin cloth. During the process, male and female pupae were separated based on external genitalia. These pupae were kept in separate small plastic jars for adult emergence, which were covered with muslin cloth. Data was recorded on pre oviposition period, oviposition period, fecundity, incubation period, larval period, pupal period and adult longevity of male and females.

2.2 Morphometrics and growth studies

For recording data on morphometric of different stages of *S. litura* i.e., egg, larvae, pupae and adults were observed using stereozoom binocular microscope and by visually graphical method (Fig 2). Totally, 10 samples were killed in hot water 60 ºC and later transferred in to blotting paper for removing moisture. Later, observed for calculating average length and width from each individual stage of insects.

In order to determine growth in larval instars, the individual larva was observed daily for exuvia as well as head capsule. Moulting was confirmed by the presence of casted head capsule. Width of the head capsule was measured with the help of stereozoom binocular microscope. Application of Dyar's law (1890) was tested for the number of larval instars of *S. litura.*

Growth ratio of head width in successive instars was determined by dividing the mean head capsule width of the respective instar stage with that of the previous instar stage. The exact number of larval instars was confirmed by measuring the width of head capsule of each larval instar by applying Dyar's law and mean was calculated.

2.3 Statistical analysis

Data collected on size of different stages of insect i.e., egg, larva, pupa and adult was analyzed for calculating mean and standard deviation.

3. Results and Discussion

Results pertaining to biology of *S. litura* on castor revealed that total life cycle period lasted for about 28.25 to 36.00 days with an average of 32.13±5.48 days (Table 1 and Fig 3).

3.1 Morphological description of *Spodoptera litura*

3.1.1 Egg

In the laboratory, oviposition occurred during night-time and fecundity of individual female was 890.50±16.26 eggs. Similarly the eggs were laid in mass on *Sesbania aculeata* L. containing 300 - 500 eggs where in 170 eggs per mass, on groundnut observed [7]. There are many results shown 50 - 220 eggs on groundnut, 241.60±41.25 eggs on banana eggs and 262±1.70 eggs [8, 9, 10].

The eggs were covered with yellowish brown hairs and the hairs seen earlier as present on the abdomen of the adult females were not seen confirming that the female had dropped the abdominal hairs after oviposition to cover the laid egg mass. However, the eggs were laid on the leaf, side walls of jar or the muslin cloth cover. On removal of the hairy mass, it was seen that the eggs were laid one over the other in three layers. Eggs were spherical in shape with a diameter of 0.41±0.01 mm and yellowish creamy in colour. Hatching of the eggs was observed in the early morning hours after 3.00±0.00 days and percent hatching was 87.25±7.42 and few hours prior to hatching, colour of the egg mass changed from yellow to dark black. Similar results of incubation period on castor as 3.5, 4 and 5 days [11, 12, 13].

3.2 Larvae

3.2.1 First instar larvae

The neonate larvae were pale green in colour with dark black head having distinctly visible black hairs on the body and tiny black spot on first abdominal segment and which later became yellowish green in colour. First instar larval period lasted for about 2-3 days on castor with an average of 2.50±0.71 days.

3.2.2 Second instar larvae

The second instar larvae appeared pale green in colour and were hairless. The first and second instar larvae were found scraping the chlorophyll of the leaves converting the lamina into a papery form. However, after moulting, the second instar larvae at late stage of development started dispersing to feed individually and the larval period lasted for about 2-3 days with an average of 2.50±0.71 days.

3.2.3 Third instar larvae

The third instar larvae changed their body colour to dark green with two dorsal black spots on the first abdominal segment and dark crescent shaped spots on the sides of the subsequent abdominal segment. The spots on first segment were largest, followed by those on the eighth segment. Three yellowish colour bands were observed on each segment on the dorsal surface of the larvae from mouth to posterior end of the abdomen which were not clear. Third instar larval period lasted for about 3-4 days with an average of 3.50±0.71 days.

3.2.4 Fourth instar larvae

The fourth instar larvae changed their colour from green to dark blue-green dorsally and pale greenish yellow ventrally. The three lines of dorsal bands changed the colour, with the central band becoming bright orange and the two lateral bands becoming yellow. Black intermittent spots appeared dorsally along each lateral yellow band and the larval period lasted for about 2-3 days with an average of 2.50±0.71 days.

3.2.5 Fifth instar larvae

After fourth moult, colour of the larvae changed to dark blackish brown with three lines or bands as mentioned above.

The black intermittent spots clearly appeared dorsally along each lateral yellow band from anterior to posterior part of the body and fifth instar larval period lasted for about 2-3 days with an average of 2.50±0.71 days. The third, fourth and fifth instar larvae were voracious feeders eating the whole leaf blade leaving only the midrib intact and the total larval period lasted for about 13.50±3.54 days. The larval period was completed in 23.9±0.71 days on castor [13]. However, the shortest period of 13.50±3.54 days as observed in the present study might be due to the effect of variation in environment especially temperature during rearing period.

Prior to pupation, the mature larvae curled into C-shape and the prepupal period lasted for about 0.75-1.00 days with an average of 0.88±0.18 days.

3.3 Pupae

Pupae appeared pale yellowish initially, later became dark reddish brown in colour. The male pupae showed genital aperature on 9th abdominal segment on ventral side in the form of x shape. Likewise, the female pupae had genital aperature on 8th abdominal segment in the form of an inverted v shape was observed. The pupal periods lasted for 7-8 days with an average of 7.50±0.71 days. In support of present result, the male and female pupal period ranging from 8-9 and 9-12 days, respectively [12]. Several researchers also reported pupal period as 17.80±2.33 days on castor [13].

3.4 Adult

The adult moth was brown with a complex pattern of creamy coloured crisscrossing markings on the forewings. The hind wings were silvery white in colour. The males had a prominent white band on forewings unlike female and male adults were somewhat bright colored than female. Thorax was covered with bright colored scales.

Thus entire life cycle of *S. litura* was completed in 28.25 to 36.00 days with an average of 32.13±5.48 days under laboratory conditions. Present results coincide with the observations of of life cycle 27.89 to 35.23 days on groundnut, 24 days on cotton, 39.80±1.88 days on banana, 29 to 35 days on pegaga and 35.44 (male) and 36.04 (female) days on cabbage [7, 14, 9, 15, 16].

Documentation of morphometric data of *S. litura* on castor (Table 2) revealed diameter of the egg as 0.41± 0.01 mm, first instar larvae were measured as 1.49 ± 0.09 mm in length and 0.23 ± 0.03 mm in width, second instar with an increased body length of 4.44±0.82 mm and width of 0.51±0.07 mm, third instar was 11.92±1.48 mm in length and 1.49±0.06 mm in width, fourth instar larvae as 23.15±0.55 mm in length and 3.44±0.87 mm in width. Fifth instar has recorded a maximum body length of 37.72±0.45 mm and width of 5.94±1.47 mm. Width of the head capsule from first to fifth instar was measured as 0.25 ±0.02, 0.36± 0.02, 0.50± 0.02, 0.70± 0.01 and 1.11± 0.03mm respectively. Average length of the pupa was about 14.05±2.26 mm and width 4.87± 0.89mm. Body length of male and female adults was about 15.50 ±0.12 and 17.50 ±0.11 mm respectively. Wing span of male and female moths measured as 37.00 ±0.13 and 37.00 ±0.16 mm respectively (Table 2).

Growth ratio for *Spodoptera* species were calculated and the results showed that *S. litura* has the growth ratio between 1st and 2nd instar has 1.44, 2nd and 3rd has 1.38, 3rd and 4th has 1.40, 4th and 5th has 1.59 (Table 3 and Fig 4). The average ratio of increase in head capsule width in each instar was calculated as 1.45 (Table 4) and confirmed that consecutive larval instars followed a more or less regular geometrical progression of 1.45 following Dyar's law.

Fig 1: A, B, C and D. Collection and mass multiplication of *S. litura*

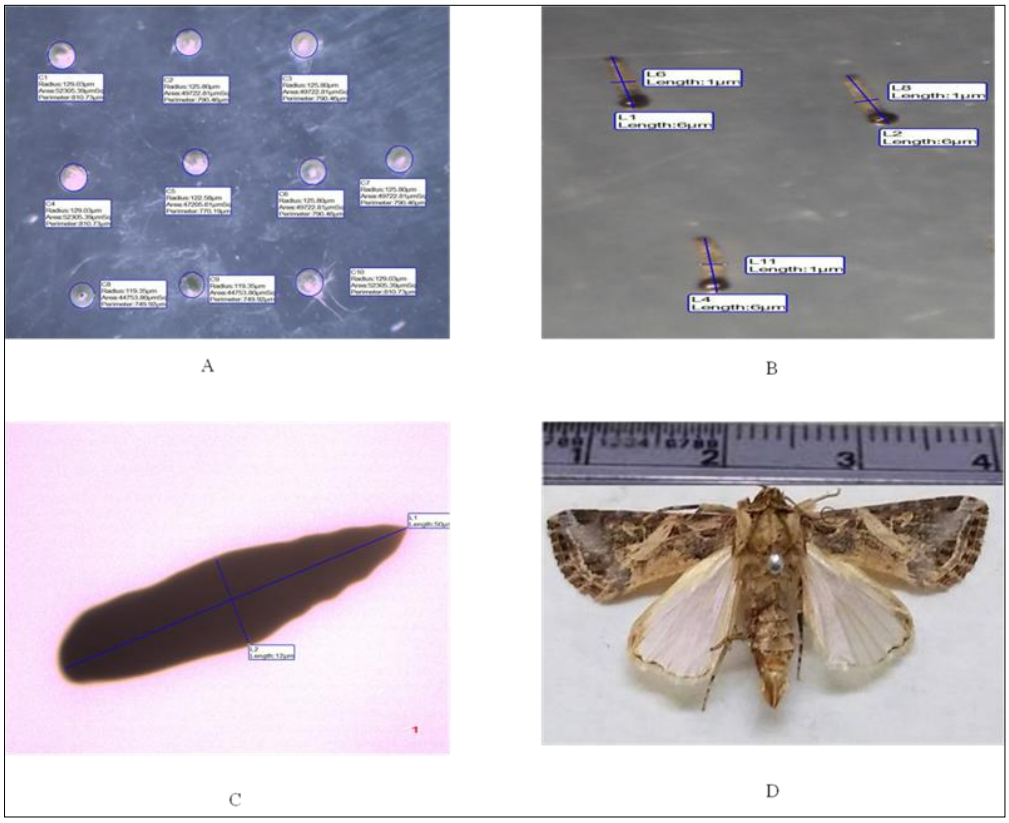

Fig 2: Morphometrics of *S. litura* A. Eggs; B. Larval stages; C. Pupa; D. Adult

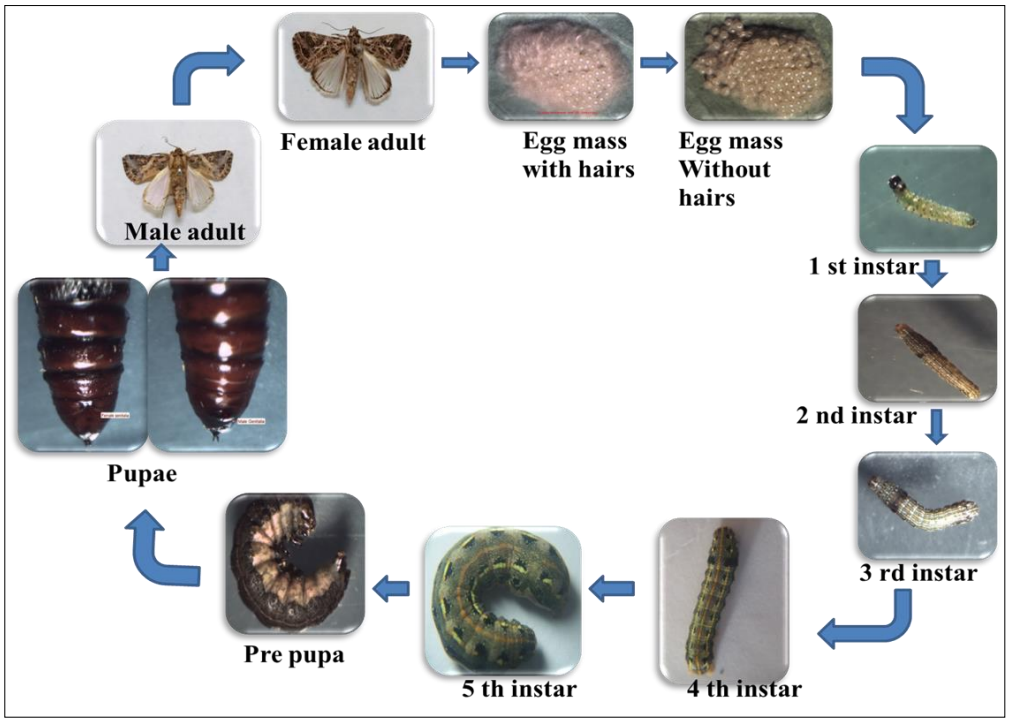

Fig 3: Life cycle of *S. litura*

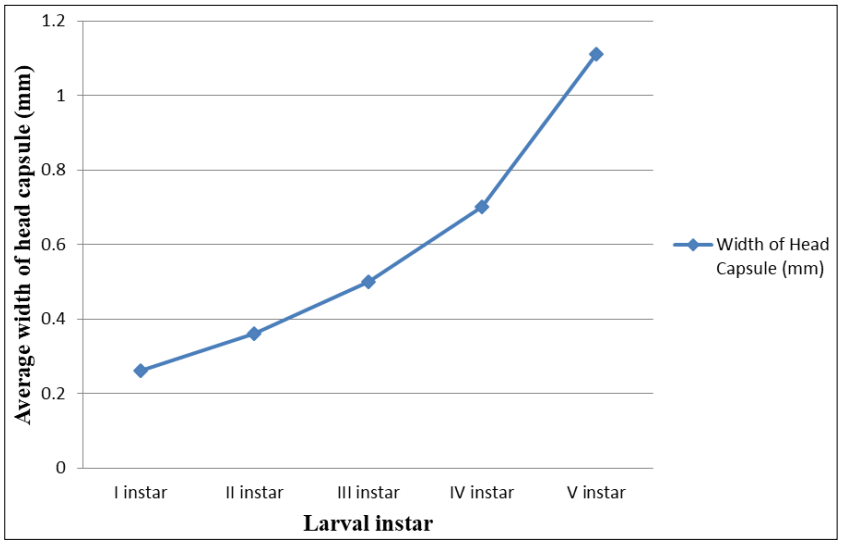

Fig 4: Relation between larval growth and head width of *S. litura*

Table 1: Biology of Tobbacco caterpillar, *Spodoptera litura* (Fab.)

S. No	Stage of the insect	Minimum * (Days)	Maximum * (Days)	Mean (days)	± SD
1	Incubation period	3.00	3.00	3.00	0.00
2.	Larval period				
a.	I instar	2.00	3.00	2.50	0.71
b.	II instar	2.00	3.00	2.50	0.71
c.	III instar	3.00	4.00	3.50	0.71
d.	IV instar	2.00	3.00	2.50	0.71
e.	V instar	2.00	3.00	2.50	0.71
	Total larval period	11.00	16.00	13.50	3.54
3.	Pre pupal period	0.75	1.00	0.88	0.18
4.	Pupal period	7.00	8.00	7.50	0.71
5.	Adult longevity				
	a. Male	6.00	7.00	6.50	0.71
	b. Female	7.00	9.00	8.00	1.41
	Average	6.50	8.00	7.25	1.06
6.	Total life cycle	28.25	36.00	32.13	5.48
7.	Pre oviposition period	2.5	3.75	3.13	0.88
8.	Oviposition period	3.5	4.5	4.00	0.71
9.	Fecundity (no.)	879.00	902.00	890.50	16.26
10.	Percent of hatching	82.00	92.50	87.25	7.42

*Mean of 10 individuals SD: Standard deviation

Table 2: Morphometrics of the life stages of Tobacco caterpillar, *Spodoptera litura* (Fab.)

S. No	Stage of the insect	Minimum * (mm)	Maximum * (mm)	Mean (mm)	± SD
1	**Egg**				
	a. Diameter	0.40	0.42	0.41	0.01
2	**I instar larva**				
	a. Length	1.42	1.56	1.49	0.09
	b. Width	0.20	0.25	0.23	0.03
	c. Width of the Head capsule	0.23	0.26	0.25	0.02
3	**II instar larva**				
	a. Length	3.86	5.02	4.44	0.82
	b. Width	0.45	0.56	0.51	0.07
	c. Width of the Head capsule	0.34	0.37	0.36	0.02
4	**III instar larva**				
	a. Length	10.87	12.97	11.92	1.48
	b. Width	1.44	1.53	1.49	0.06
	c. Width of the Head capsule	0.48	0.52	0.50	0.02
5	**IV instar larva**				
	a. Length	22.76	23.54	23.15	0.55
	b. Width	2.82	4.06	3.44	0.87
	c. Width of the Head capsule	0.69	0.71	0.70	0.01
6	**V instar larva**				
	a. Length	37.40	38.04	37.72	0.45
	b. Width	4.89	6.98	5.94	1.47

	c. Width of the Head capsule	1.08	1.13	1.11	0.03
7	**Pupa**				
	a. Length	12.45	15.65	14.05	2.26
	b. Width	4.23	5.50	4.87	0.89
8	**Adult(Male)**				
	a. Body length	14.00	17.00	15.50	0.12
	b. Wing span	35.00	39.00	37.00	0.13
	Adult(Female)				
	a. Body length	16.00	19.00	17.50	0.11
	b. Wing span	35.00	39.00	37.00	0.16

*Mean of 10 individuals SD: Standard deviation

Table 3: Head capsule width of different larval instars of *S. litura* (Fab.)

S. No	Larval instars	Range (mm) *	Mean (mm)	± SD
1	I instar	0.24-0.26	0.25	0.02
2	II instar	0.34-0.37	0.36	0.02
3	III instar	0.48-0.52	0.50	0.02
4	IV instar	0.69-0.71	0.70	0.01
5	V instar	1.08-1.13	1.11	0.03

*Mean of 10 individuals SD: Standard deviation

Table 4: Average width of head capsule of *S. mauritia* and growth rate during larval development

S. No	Larval instars	Estimated Width of Head Capsule (mm)	Observed Width of Head Capsule (mm)	± SD	Growth ratio
1	I instar	0.25	0.25	0.02	-
2	II instar	0.36 x 1.45 = 0.36	0.36	0.02	1.44
3	III instar	0.50 x 1.45 = 0.52	0.50	0.02	1.38
4	IV instar	0.70 x 1.45 = 0.76	0.70	0.01	1.40
5	V instar	1.11 x 1.45 = 1.10	1.11	0.03	1.59
Mean growth rate					1.45

SD: Standard deviation

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