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Biological studies of *Spodoptera litura* L. on Castor (*Ricinus communis* L.) under Laboratory condition

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Abstract

The studies on biology of *Spodoptera litura* (Fabricius) of castor (*Ricinus communis* L.) were carried out during 2015-16. Egg measured on an average 0.42 ± 0.07 mm with an average incubation period of 3.80 ± 0.79 days. The total larval duration ranged from 14 to 18 days with an average 15.80 ± 1.56 days. The duration of pre-pupa on an average 1.60 ± 0.50 days. The pupal duration on an average 6.12 ± 0.83 days. The pre-oviposition period, oviposition period and post-oviposition period was on an average with 1.56 ± 0.51 , 6.72 ± 1.06 and 2.00 ± 0.71 , respectively. The egg laying capacity of female on an average 2101.67 ± 402.76 . The egg hatching on an average of 90.01 ± 4.09 per cent. The longevity of female on an average of 9.44 ± 1.04 days while longevity of male on an average 8.56 ± 0.96 days. The sex ratio of male to female was 1: 3. Total life cycle of male on an average of 32.28 ± 1.93 days and in case of female with an average of 34.32 ± 2.59 days.

Keywords: Biology, *Spodoptera litura* L., castor

1. Introduction

Castor bean (*Ricinus communis* L.) is non-edible oil seed crop with enormous significance. India is the world's largest producer of castor contributing to around 85 per cent of world's total. India produces around 10 lakh tones of castor seed and around 5.5 lakh tones of castor oil. India meets more than 80 per cent of the demand of castor oil, thereby enjoying a dominant position in the world castor scenario. The production in India has been witnessing an increasing trend in the 2001-2014 decade due to rising usage of castor oil in different industries. Moreover, strong export demand for castor oil was also one of the reasons for rise in production. Gujarat, Rajasthan and Andhra Pradesh contribute 96 per cent of the total castor seed production in India.

The major pest problems in castor include the defoliators (*Spodoptera litura* Fabricius), semilooper (*Achaea janata* Linnaeus) and capsule borer (*Conogethes punctiferalis* Guenee), sucking pests viz., leafhopper (*Empoasca flavescens* Fabricius), thrips (*Retithrips syniacus* Mayet) and whitefly (*Trialeurodes ricini* Misra) (Lakshminarayana and Raoof, 2005) [10].

The host range of *S. litura* covers at least 120 species (Venette *et al.*, 2003) [21]. Hosts include field crops grown for food and fiber, plantation and forestry crops, as well as certain weed species (CABI, 2010) [3]. *S. litura* is widely distributed throughout tropical and temperate Asia, Australasia, and the Pacific Islands (Kranz *et al.*, 1977) [8]. The loss caused by *S. litura* in different castor cultivars has been estimated to the tune of 12.0 to 23.50 per cent under Junagadh condition (Anonymous, 1986) [2]. It is serious pest; larvae cause complete defoliation at blossoming and vegetative stage (Lakshminarayan, 2003; Sarma *et al.*, 2005) [9, 9].

2. Materials and Methods

The biology of *S. litura* was studied at P. G. laboratory, Department of Agricultural Entomology, N. M. College of Agriculture, Navsari, Gujarat during June to September, 2015-16. The average minimum and maximum temperature during this study was 28.6 ± 1.15 °C and 34.6 ± 2.00 °C, respectively. While an average relative humidity 30.95 per cent.

2.1 Rearing techniques and mass multiplication technique used

To raise the initial culture of *Spodoptera litura* in laboratory, large numbers of larvae were collected from the Castor Research Station (ICAR), at Navsari Agricultural University, Navsari, Gujarat. Field collected larvae were reared in the glass jar (23 cm diameter × 10 cm height) containing a fresh castor leaves.

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Every day sufficient amount of fresh castor leaves were provided to larvae as a food after cleaning and removing excreta and partially eaten leaves from the glass jar till the larvae grow up to pre-pupal form. The top of glass jar was covered with fine muslin cloth held in position by rubber band. The pre-pupa of *S. litura* are collected separately from the glass jar and put in the petri dish (10 cm diameter). The pupae formed were collected and transferred to another glass jar for the adult emergence.

Newly emerged male and female moths from pupae were carefully removed and released in oviposition jar (23 cm diameter × 10 cm height) which was prepared by top of glass jar was covered with fine muslin cloth held in position by rubber band also put fresh leaves of castor inside oviposition jar. A cotton swab containing cotton swabs dipped in five per cent honey solution was placed in oviposition jar for food to the moths. The leaves were replaced with fresh one daily and the egg masses laid on the leaves removed from jar were collected for further study. The portion of paper and leaves bearing egg masses was carefully removed and transferred to petri dish (10 cm diameter) in which a tender castor leaf was kept in petri dish to maintain the turgidity by putting cotton swab was kept near the petiole. The neonate larvae were reared separately for further study. These studies were conducted in the laboratory.

In mass rearing of *S. litura*, in mass rearing cage cutting of tender shoot of castor taken and shoot was dipped in fresh water filled conical flask to maintain the turgidity of leaves. These shoots were provided to females for resting and oviposition. Ten gravid females obtained from mass culture were released in a glass jar of 23 cm diameter and 10 cm height. These females were kept under observation for the number of eggs laid on leaves from the following days. The adult's females were removed immediately after the egg laying was over. Beginning with these eggs detail biology of *S. litura* was studied.

3. Results and Discussion

Study on biology of insect pests provided the information on various life stages through which they pass, it also helps in planning the plant protection programme. By knowing the activity of the different stages one can decide the strategy of management practices. Having found a scanty report on study of biology of *Spodoptera litura* Fabricius. It was considered necessary to study the biology of the pest. During the studies on various aspects of biology of *S. litura* on castor under laboratory condition, the duration and measurements of different stages were recorded and described below.

3.1 Egg

3.1.1 Site of egg laying: In laboratory as well as in field conditions, the gravid female of *Spodoptera litura* deposited eggs in underneath of leaves in clusters or layers of 1 to 3, the egg masses are usually covered with hair scales from the anal tuft of the female. Occasionally the eggs were laid on the wall of glass jar in which the adults were confined for egg laying in the laboratory. Similar observation was reported by Paris (1968)^[13] reported as eggs were deposited in a layer of 2-3, egg mass covered with a scales. Rattanapan (2007)^[15] reported as eggs were covered with hair scales from anal tuft.

3.1.2 Color, Shape and Size

The freshly laid eggs were round and dirty-white in color,

which changed to deep yellow after one day and became brown dark prior to hatching. The presence appearance and color of eggs was more or less similar with the reported of Gupta *et al.* (2015)^[7] as eggs were ovoid pale yellow in color and CABI and EPPO for the EU.

The diameters of eggs were measured under stereo trinocular microscope. Diameter of eggs varied from 0.20 to 0.50 mm with an average of 0.42 ± 0.07 mm. The results on size of eggs are also in accordance with the reported by CABI and EPPO (2010)^[3] for the EU and Gupta *et al.* (2015)^[7].

3.1.3 Incubation period

Incubation period of eggs was 3 to 5 days with an average 3.80 ± 0.79 days. The incubation period as reported to be Tara (1983)^[19] recorded as 2 days, Shukla and Patel (2011) reported as 4.00 days in the laboratory. The variation might be due to different conditions of nutrition and surrounding environment.

3.1.4 Hatching percent

Hatching of eggs varied from 83.02 to 96.86 per cent with an average of 90.01 ± 4.09 per cent. However, Ghelani (1989)^[6] found that the hatching percentage to be ranged from 89.61 to 96.44 per cent which is more or less in agreement with the present finding.

3.2 Larva

During the study it is observed that the larval passed through six instars. Similar observations have also been reported by Patel *et al.* (1973)^[14], Carasi *et al.* (2014)^[4].

During the present study, larva of *S. litura* moulted five times and thus passed through six larval instars.

3.2.1 First instar

The newly hatched caterpillars are tiny, blackish-green and with a distinct black band on the first abdominal segment. The head capsule was conspicuous; shining black in color and broader as compared to the breadth of the body. The body was covered with hairs, arising from black spots. They were gregarious in habit and fed.

The body length of first instar measured from 1.45 to 1.65 mm with an average of 1.55 ± 0.07 mm, breadth from 0.20 to 0.25 mm with an average 0.23 ± 0.01 mm and breadth of head capsule 0.24 to 0.32 mm with an average 0.28 ± 0.02 mm. The size of first instar larvae was more or less agreement with the reports of Pansaree *et al.* (2006)^[12] studied as larval length 1.25-1.31 mm on Panch mukhi genotype and larval length 1.29-1.34 mm on KCA⁻¹ genotype of colocasia, respectively. Gupta *et al.* (2015)^[7] who reported that length varies between 1.82-2.35 mm with an average of 2.05 ± 0.26 mm, head capsule measured 0.24-0.27 mm with an average of 0.25 ± 0.00 mm.

The duration of first instar larvae varies from 2 to 3 days with an average 2.24 ± 0.44 days. The duration of first instar larvae was more or less accordance with the reports of Patel *et al.* (1973)^[14] who reported as an average 2 days, Divakara and Doddamane (2015)^[5] studied as 2.27 ± 0.23 days on castor and Gupta *et al.* (2015)^[7] reported as 2-3 days.

3.2.2 Second instar

The second instar larva was pale green in colour. The distinctive feature was the presence of a prominent black spot on each side of first and eighth abdominal segments. Three

longitudinal whitish lines were present, one on the dorsal surface and one each on dorso-lateral surface. The head turned from black to pale brown and possessed a prominent triangular mark.

The length of second instar larvae ranged from 3.50 to 4.50 mm with an average 4.0 ± 0.34 mm, breadth 0.60 to 0.90 mm with an average 0.75 ± 0.09 mm and breadth of head capsule 0.35 to 0.45 mm with an average 0.42 ± 0.02 mm. The present findings on size is in accordance to the Pansaree *et al.* (2006) [12] reported as length 4.00-4.30 mm, Gupta *et al.* (2015) [7] as length 3.52-5.38 mm with an average of 4.30 ± 0.96 mm, width varies between 0.87-1.15 mm and head capsule measured 0.36-0.40 mm with an average of 0.40 ± 0.00 mm. The variation might be due to different conditions of nutrition and surrounding environment. The duration of second instar ranged from 2 to 3 days with an average 2.24 ± 0.44 days.

The present finding is more or less similar to the Patel *et al.* (1973) [14] studied the 1.63 days, Pansaree *et al.* (2006) [12] reported it to be 3-4 days, Divakara and Doddamane (2015) [5] studied as 2.33 ± 0.00 days and Gupta *et al.* (2015) [7] who reported as 3.75 ± 1.08 days on Panch Mukhi genotype and 2-3 days on KCA⁻¹ genotype, respectively.

3.2.3 Third instar

The third instar larvae were black in color with three thin yellow lines down the back, one in the middle and one on each side. A row of black dots run along its side and conspicuous row of dark triangle decorated its sides. The body length of third instar larvae range from 9.31 to 11.51 mm with an average 10.59 ± 0.65 mm, breadth 1.21 to 1.60 mm with an average 1.48 ± 0.10 mm and breadth of head capsule 0.63 to 1.02 mm with an average 0.73 ± 0.10 mm. The present finding is similar to the result of Pansaree *et al.* (2006) [12] as the larval length 11.30-13.00 mm and 13.20-15.00 on Panch mukhi and KCA⁻¹ genotype of colocasia, respectively, Vashisth and Chandel (2013) [20] studied as length 10.85 mm, width 1.52 mm with the head capsule 0.96 mm on tomato and Gupta *et al.* (2015) [7] who reported as length of 7.00-13.10 mm. The duration of third instar 2 to 3 days with an average 2.52 ± 0.51 days.

The results is similar with Patel *et al.* (1973) [14] as an average 1.43 days on castor, Pansaree *et al.* (2006) [12] reported that the duration 2-3 days, Divakara and Doddamane (2015) [5] studied as 2.15 ± 0.01 days on castor and Gupta *et al.* (2015) [7] reported that 2-4 days with an average of 3.00 ± 0.90 days on mango. The variation might be due to different conditions of nutrition and environment.

3.2.4 Fourth instar

The fourth instar larvae brown in colour with three thin yellow lines down the back one in the middle and one on each side. A row of black dots run along its side and conspicuous row of dark triangle decorate its sides.

The length of fourth instar larvae 17.50 to 21.00 mm with an average 19.67 ± 1.18 mm, breadth 2.09 to 2.54 mm with an average 2.31 ± 0.17 mm and breadth of head capsule 1.12 to 1.70 mm with an average 1.22 ± 0.11 mm. The results is similar with Pansaree *et al.* (2006) [12] reported as the larval length 18.00 - 19.70 mm and 21.50-22.40 mm on Panch mukhi and KCA⁻¹ genotype of colocasia, respectively, Vashisth and Chandel (2013) [20] studied as 22.65 mm length with 1.75 mm width of head capsule and Gupta *et al.* (2015) [7] who studied as length ranged between 22.60-25.93 mm,

width varies between 3.20-4.20 mm and 1.10-1.20 mm head capsule.

The duration of fourth instar larvae ranged from 2 to 3 days with an average 2.72 ± 0.46 days. The present findings of duration is more or less conformity with the finding of Patel *et al.* (1973) [14] studied as average 1.99 days, Pansaree *et al.* (2006) [12] who reported duration as 2-3 days, Divakara and Doddamane (2015) [5] studied as 2.17 ± 0.13 days on castor and Gupta *et al.* (2015) [7] who reported as 3-5 days with an average of 3.95 ± 0.75 days.

3.2.5 Fifth instar

The fifth instar larvae brown in colour with three thin yellow lines down the back, one in the middle and one on each side. A row of black dots run along its side and conspicuous row of dark triangle decorated its sides.

The body length of fifth instar larvae ranged from 26.5 to 29.5 mm with an average 28.03 ± 1.07 mm, breadth of 2.65 to 3.15 mm with an average 2.89 ± 0.13 mm and breadth of head capsule 1.51 to 1.9 mm with an average 1.76 ± 0.13 mm. The present finding are more or less similar with the results of Pansaree *et al.* (2006) [12] who reported that the larval length 22.1-23.6 mm and 24.02 ± 1.52 mm on Panch mukhi and KCA⁻¹ genotype of colocasia, respectively. Vashisth and Chandel (2013) [20] who studied as width of head capsule 2.86 mm. Gupta *et al.* (2015) [7] reported that length 26.0-33.00 mm with an average of 29.33 ± 3.01 mm, width varies between 5.20-6.43 mm with an average of 5.81 ± 0.86 mm.

The duration of fifth instar larvae ranged from 3 to 4 days with an average 3.08 ± 0.28 days. The present finding of duration is more or less in conformity with the findings of Pansaree *et al.* (2006) [12] who reported that the 2-3 days, Divakar and Doddamane (2015) [5] studied as 3.35 ± 0.15 days on castor. Gupta *et al.* (2015) [7] reported that fifth instar takes 4-5 days.

3.2.6 Sixth instar

The body of the larva was distinctly divided into head, thorax and abdomen. They are black with three thin yellow lines, one in the middle and one each side. A row of black run along each side and a conspicuous row of dark triangles decorate each lateral side. They became light or grey or brown in colour, all lines become dull. Lateral lines start to disappear. The head capsule was black in colour with a typical inverted "V" mark on it.

The body length of sixth instar ranged from 38 to 40 mm with an average 39.16 ± 0.75 mm, breadth 3.80 to 5.00 mm with an average 4.25 ± 0.41 mm and breadth of head capsule 2.2 to 2.75 mm with an average 2.53 ± 0.17 mm. The present finding is more or less similar with the Pansaree *et al.* (2006) [12] reported that the larval length 33.8-35.8 mm and 27.2-29.8 mm on KCA⁻¹ genotype and Panchmukhi genotype of colocasia, respectively.

The duration of sixth instar for 3 days which was more or less similar with result of Patel *et al.* (1973) [14] who studied that the instar take an average 2.15 days on castor, Pansaree *et al.* (2006) [12] reported that the 1-2 days on Panch mukhi genotype of colocasia. Divakara and Doddamane (2015) [5] who studied as 2.45 ± 0.27 days on castor. It might be differ due to different host crops used as food.

3.2.7 Total larval period

The total larval duration ranged from 14 to 18 days with an

average 15.80 ± 1.56 days. Patel *et al.* (1973) ^[14] who recorded that the total larval period was 12.98 days on castor, Seth and Sharma (2001) ^[1] studied that the total larval period was 16.2 ± 0.7 days on castor. Pansaree *et al.* (2006) ^[12] reported that the 16.08 days and 12.7 days on Punch mukhi and KCA⁻¹ genotype of colocasia, respectively. Xue *et al.* (2010) ^[22] studied that the total larval period on tobacco was 23.2 d, 17.5 d on sweet potato, 15.8 d on cowpea and 13.3 d on Chinese cabbage. Carasi *et al.* (2014) ^[4] who noted as total larval period was 19.36 days on mulberry. Divakara and Doddamane (2015) ^[5] who studied as 17.50 ± 1.06 days on castor. This might be differ due to different host crops used as food.

3.3 Pre-pupal period

When the larva completed its development, it stopped feeding and searched for a suitable site for pupation. The larva stopped feeding about two days before pupation. The larva spun sticky threads and formed earthen cocoon. After contracted length and appendages and became quiescent. They are dark to black color, lethargic, contracted in size and acquired somewhat 'comma-shaped' body structure.

The length of pre-pupal 18.9 to 21.5 mm with an average 20.49 ± 0.73 mm, breadth 3.5 to 4.5 mm with an average 4.16 ± 0.35 mm. The duration of pre pupa ranged from 1 to 2 days with an average 1.60 ± 0.50 days. Pansaree *et al.* (2006) ^[12] who noticed that the pre-pupal 1.09 days on colocasia KCA⁻¹ genotype and 1.74 days on Panch mukhi genotype of colocasia. Divakara and Doddamane (2015) ^[5] who studied as pre-pupal period 2.24 ± 0.12 days on castor.

3.4 Pupal period

Pupation takes place in the soil in an earthen cell, with red brown in color and abdomen is movable and eyes and antennal case is prominent. The freshly moulted pupae were pale green in color that gradually changed to dark brown as a result of tanning of the cuticle in a span of about 4 h after moulting. Female pupae were slightly larger than the male pupae. The pupae were sexed according to position of the gonopore which was located on the 8th abdominal sternum in case of female pupae and on the 9th abdominal sternum in male pupae.

The pupal duration ranged from 5 to 7 days with an average 6.12 ± 0.83 days The present finding is similar with the result with Patel *et al.* (1973) ^[14] who studied that the male pupae take 7.3 days and female 6.08 days on tobacco, Tara (1983) ^[19] recorded that the 8-11 days with an average of 9.37 ± 1.37 days, Seth and Sharma (2001) ^[1] who studied that the pupal period was 7.9 days on castor.

3.5 Adult

The adults (male and female) of *S. litura* were ash brown colored moths. The conspicuous head of the moth possessed a black compound eyes and filiform antennae. The thorax and abdomen were covered with brownish scales. The fore wings are somewhat narrower than hind wings.

3.5.1 Male adult: The male moth is distinguished from female moth by having shiny bluish forewings, slender abdomen and a prominent large continuous yellow oblique patch in the centre of the forewing.

The length of male ranged from 13 to 15 mm with an average 13.74 ± 0.69 mm, breadth 35 to 38.5 mm with an average

37.10 ± 1.08 mm. The present finding of the length and breadth of adult's moth are more or less in agreement with those reported by Rattanapan (2007) ^[15].

3.5.2 Female adult

The female is generally bigger than the male. The abdomen of female is blunt while the abdomen of male is narrower and pointed.

The length of female 15.5 to 19.5 mm with an average 16.54 ± 1.18 mm, breadth 35 to 40 mm with an average 38.30 ± 1.17 mm. The present finding of the length and breadth of adult's moth are more or less in agreement with those reported by CABI and EPPO for EU.

3.5.2.1 Pre-oviposition period

The pre-oviposition period was found to be varying from 1 to 2 days with an average of 1.56 ± 0.51 days.

3.5.2.2 Oviposition period

The oviposition period varied from 5 to 8 days with an average of 6.72 ± 1.06 days.

3.5.2.3 Post-oviposition period

The post-oviposition period was found to be varying from 1 to 3 days with an average 2.00 ± 0.71 days. Thus, the present finding of was more or less in conformity with Patel *et al.* (1973) ^[14] who reported that the average period of pre-oviposition, oviposition and post-oviposition was 1.6, 5.1 and 1.2 days, respectively. The variation might be due to different condition of nutrition and surrounding environment.

3.5.2.4 Fecundity

The results on fecundity revealed that the egg laying capacity of female varied from 1600 to 2650 eggs with an average of 2101.67 ± 402.76 eggs. The present finding is in agreement with the finding of Miyahara *et al.* (1971) ^[11], Patel *et al.* (1973) ^[14] and Ahmad *et al.* (2013) ^[1].

3.6 Longevity

The longevity of female varied from 8 to 11 days with an average of 9.44 ± 1.04 days. While longevity of male varied from 7 to 10 days with an average 8.56 ± 0.96 days. Thus the male lived shorter than the female. Gupta *et al.* (2015) ^[7] reported an average longevity of adults as 8.32 ± 0.20 days, which was more or less in agreement with the present findings.

3.7 Sex ratio

Adult emerged from laboratory reared pupae were observed separately to their sexes. The sex ratio of male: female recoded in laboratory was 1: 3 which is more or less in agreement with the finding of Pansaree *et al.* (2006) ^[12].

3.8 Total life cycle

Total life cycle period of *S. litura* (egg to death of adult) recorded on castor in laboratory are presented in Table 1. Total life cycle of male ranged from 29 to 35 days with an average of 32.28 ± 1.93 days and in case of female it was 31 to 42 days with an average of 34.32 ± 2.59 days. Thus, the duration of life cycle of female was longer than male.

In past, the life span of male and female ranging from 28 to 34 and 28 to 35 days, respectively, which is in closed agreement with the present findings.



Plate 1: Moths confined in glass jar for egg laying



Plate 2: Mass rearing cage for *S. litura*



Plate 3: Oviposition cage contain shoot of castor in flask for egg laying for female



Plate 4: Egg laying by female on castor leaves



Plate 5: Field collected larvae were reared in the glass jar (20 cm height × 15 cm diameter) containing a fresh castor leaves

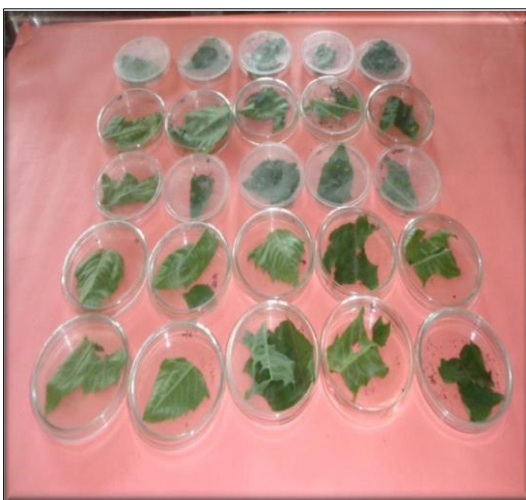


Plate 6: Castor leaves used as a food for larval rearing of *S. litura*

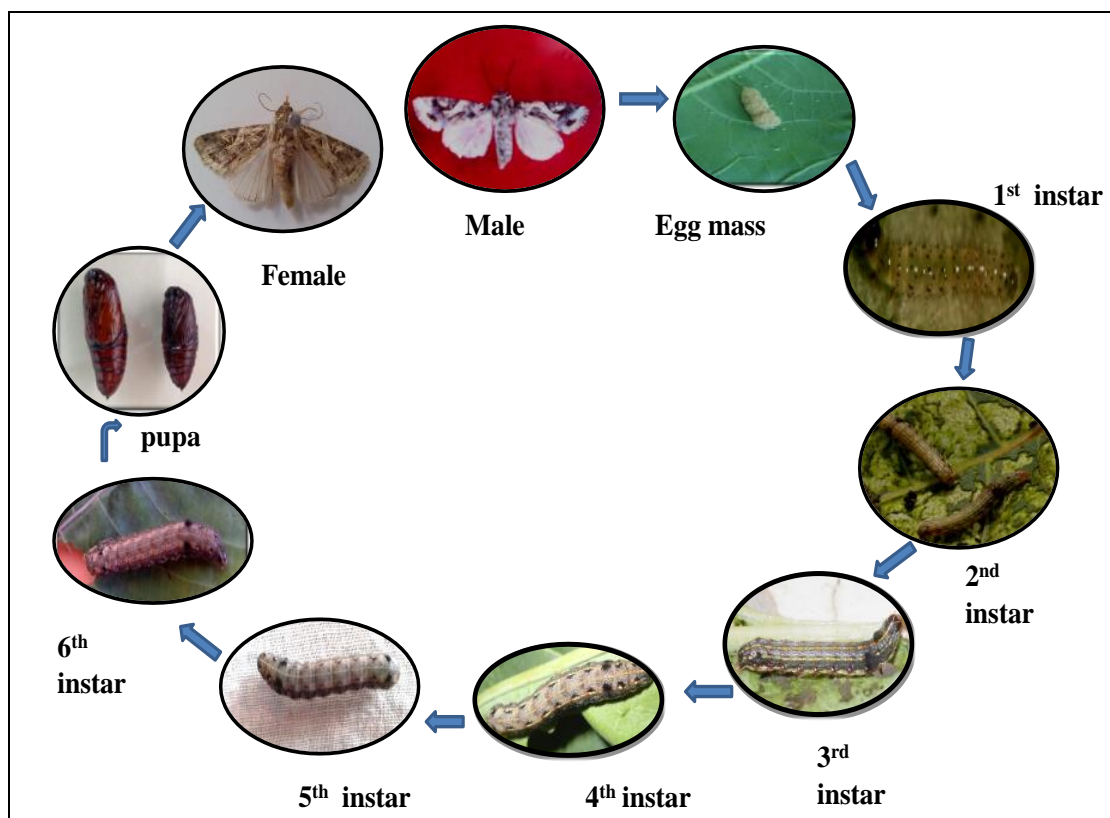


Fig 1: Life cycle of *Spodoptera litura* on castor

Table 1: Biology of *Spodoptera litura* L. on castor

Sr. No.	Particulars	Period (days)		
		Minimum	Maximum	Mean ± SD
1	Egg period	2	3	2.40 ± 0.50
2	Hatching percentage	83.02	96.86	90.01 ± 4.09
3	Larval period			
	First instar	2	3	2.24 ± 0.44
	Second instar	2	3	2.24 ± 0.44
	Third instar	2	3	2.52 ± 0.51
	Fourth instar	2	3	2.72 ± 0.46
	Fifth instar	3	4	3.08 ± 0.28
	Sixth instar	3	3	3.00 ± 0.00
	Total	14	18	15.80 ± 1.56
4	Prepupal period	1	2	1.60 ± 0.50
5	Pupal period	5	7	6.12 ± 0.83
6	Adults period			
	Pre-oviposition	1	2	1.56 ± 0.51
	Oviposition	5	8	6.72 ± 1.06
	Post-oviposition	1	3	2.00 ± 0.71
	Longevity:			
	Male	7	10	8.56 ± 0.96
	Female	8	11	9.44 ± 1.04
7	Total life cycle			
	Male	29	35	32.28 ± 1.93
	Female	31	42	34.32 ± 2.59
8	Egg laying capacity (number)	1600	2650	2016.00 ± 361.02
9	Sex ratio	Male: Female		1: 3

SD = Standard Deviation

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