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The biology of tobacco caterpillar, *Spodoptera litura* under laboratory condition

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Abstract
The present investigation was carried out during the *Rabi* seasons of 2023-24 and 2024-25 a Laboratory of the Department of Entomology, College of Agriculture, Bikaner. The experimental site is situated approximately 9 km from Bikaner city along the Sri Ganganagar road. *Spodoptera litura*, a highly destructive polyphagous pest, completes its life cycle in approximately 34±3.50 days under controlled conditions. Its larval stages, marked by voracious feeding across five instars, cause extensive damage to castor and other crops. Detailed knowledge of its biology is vital for developing effective, sustainable pest management strategies.

Keywords: Tobacco caterpillar, *Spodoptera litura*, biology, life cycle, larval instars

Introduction
Cauliflower is a highly nutritious vegetable, characterized by its low fat and carbohydrate content, while being rich in dietary fiber, water, and vitamin C. As a member of the cruciferous vegetable family, cauliflower is associated with a reduced risk of various cancers even a daily intake as low as 10 grams can yield significant health benefits. It is particularly valued for its high fiber content, which constitutes approximately 5% of its fresh weight and about 50% of its dry weight. Of this, nearly 40% comprises non-starch polysaccharides. Regarding fiber composition, cauliflower's dry matter contains roughly 16% cellulose and 13% lignin. In comparison, Brussels sprouts have higher cellulose content at about 36% and 14.5% lignin.

The crop is vulnerable to a wide range of insect pests throughout its growth period. Major pests include whitefly, *Bemisia tabaci*, cabbage looper, *Trichoplusia binotalis*, mustard aphid, *Lipaphis erysimi*, diamondback moth (DBM), *Plutella xylostella*, tobacco caterpillar, *Spodoptera litura*, and cabbage butterfly, *Pieris brassicae*. Among these, the most destructive and economically significant pests are diamondback moth, *P. xylostella* and tobacco caterpillar, *S. litura*, both of which severely impact crop health and limit profitable cultivation due to the substantial damage they inflict.

Materials and Methods
The present investigation was carried out during the *Rabi* seasons of 2023-24 and 2024-25 at the Experimental Farm and Laboratory of the Department of Entomology, College of Agriculture, Bikaner. The experimental site is situated approximately 9 km from Bikaner city along the Sri Ganganagar road.

Egg masses and first instar larvae of *Spodoptera litura* were initially collected from the field and transferred to clean glass jars containing fresh, tender cauliflower leaves with long petioles. The leaves were placed over moist filter paper and covered with muslin cloth. To maintain leaf freshness, a water-soaked cotton swab was wrapped around each petiole. Larvae were reared in these jars, which were cleaned daily using 2% formaldehyde solution; excreta and filter paper were replaced regularly, and fresh food was provided to ensure hygienic conditions.

Upon reaching the pre-pupal stage, larvae were transferred to separate jars lined with moist filter paper and filled with a 5-6 cm layer of soil to facilitate pupation. Pupae were collected three days after pupation and shifted to egg-laying chambers for adult emergence and oviposition.

Mating period and fecundity
Immediately after adult emergence, one pair of male and female moths was introduced into individual egg-laying glass jars. The inner surface of each jar was lined with white paper to serve as an oviposition substrate. A 3 cm diameter Petri dish containing a piece of cotton soaked in 10% sucrose solution was placed inside each jar to provide nourishment for the adults. The jars were covered with muslin cloth to ensure ventilation. A total of ten such jars were maintained to observe the oviposition period, fecundity, egg viability, and longevity of both male and female moths.

Developmental stages
To document the developmental stages of *Spodoptera litura* egg, larva, pupa, and adult each stage was regularly observed, and detailed data on changes in body size and colour were recorded.

Egg
The number of eggs laid by each female was counted. The incubation period was recorded, in days, from the day of egg laying to the emergence of first instar larvae on each host.

Larva
Immediately after hatching, first instar larvae were reared in glass jars and fed fresh, tender leaves up to the third instar, accommodating their gregarious behavior. As development progressed, the number of larvae was reduced to 20-40 per jar. Rearing jars were cleaned daily with 2% formaldehyde solution; excreta and filter paper were replaced, and fresh food was provided to maintain hygienic conditions.
During the fourth and fifth instar stages, 15-25 larvae were maintained per jar with adequate food and space. The jars were covered with sterilized muslin cloth secured with rubber bands to ensure ventilation and cleanliness.

Pre-pupal period
The pre-pupal stage was identified by the larva becoming sluggish, reducing in size, and stopping feeding. This was followed by longitudinal body contraction and complete immobility. These characteristic symptoms were used to record observations of the pre-pupal stage. The duration from the onset of these symptoms to pupation was considered the pre-pupal period.

Pupae
The pupal period was recorded from the day of pupation to the day of adult emergence by taking a sample of 10 pupae in each replication.

Adult
i. Percent adult emergence
The number of adults emerged from the pupae was converted to percent to obtain data on percentage adult emergence.

ii. Adult longevity
Adult longevity was determined by placing male and female moths separately in glass jars, each containing 10 pupae. A Petri dish (3 cm diameter) with a piece of cotton soaked in 10% sucrose solution was provided as a food source. The number of days each adult survived, from emergence to death, was recorded as its longevity period.

Results and Discussion
The life cycle of *Spodoptera litura* (Table 1) typically spans 31.50-36.50 days, with an average duration of 34.00±3.50 days, depending on environmental factors such as temperature and humidity. Female moths lay approximately 850-900 eggs during their lifetime, usually in clusters on the underside of host plant leaves. Upon hatching, the larvae pass through five distinct instar stages before pupation. Throughout the larval period, *S. litura* exhibits voracious feeding behavior, resulting in extensive foliage damage to a wide range of crops. This feeding activity can cause substantial yield losses, making *S. litura* one of the most destructive polyphagous pests in agriculture. The life cycle of *S. litura* comprises the following stages:

Incubation period: The eggs of *Spodoptera litura* were incubated for 3-4 days (3.50±0.71) under laboratory conditions. During incubation, the spherical, yellowish-brown eggs gradually darkened as hatching approached. Upon completion of the incubation period, the eggs hatched, releasing first-instar larvae (neonates). These neonates were pale green in color. Shortly after hatching, they began feeding on the leaf surface near the oviposition site and soon became active feeders, initiating rapid growth through successive larval stages.
The present investigation on the biology and life cycle of *Spodoptera litura* under laboratory conditions reaffirmed previously documented findings, offering further clarity on its developmental stages and behavior, which contribute to its status as a serious agricultural pest. The incubation period on castor ranged from 3.0 to 4.0 days. These findings align with the observations of Ramaiah and Maheswari (2015) [12], who reported a 3.0-day incubation period on castor. Similar durations were also recorded by Gupta *et al.* (2015) [3] on mango (5.5 days), Azidah and Azirun (2006) [1] on multiple hosts (3.0 days), Shakya *et al.* (2017) [13] on tomato (4.2 days), Rajasekar and Sridevi (2019) [11] on castor (3.87 days), Konkani *et al.* (2023) on castor (2-3 days), Divya Rawat *et al.* (2023) [17], on different host including cauliflower, Sharma *et al.* (2025) [14] on castor (2-3 days).

Larvae and number of instars: The larvae of *Spodoptera litura* undergo five instar stages during a larval period of approximately 16-20 days (18.00±1.41). The newly hatched larvae (neonates) are cylindrical in shape, with a broad head and an abdomen that tapers toward the tail. Initially, the neonates are slow-moving and light green in color, with a proportionally larger head compared to their body. This stage lasts about 2.50±0.71 days, after which the larvae molt into the second instar. In the second instar, the abdomen becomes wider than the head, and this stage lasts for approximately 3.50±0.71 days, during which the larvae exhibit more active feeding behavior. The third instar larvae are longer and more slender, with distinctive yellow-orange stripes running along the dorsal and lateral sides of the body, and they develop prominent black spots. This stage also lasts for about 3.50±0.71 days. The fourth instar larvae turn dark green and continue to grow rapidly, with this stage lasting an additional 3.50±0.71 days. By the fifth instar, the larvae display a reddish-brown head and black legs. This final stage spans approximately 5.00±1.41 days, during which the larvae prepare for pupation. Throughout all these stages, the larvae are voracious feeders, contributing significantly to crop damage.

Larval development: The larval instars showed a typical progression, with the first, second, third, and fourth instar lasting approximately 2.0-4.0 days each, and the fifth instar extending for 4-6 days. The total larval period observed was around 13-15 days, corroborating the work of Ramaiah and Maheswari (2015) [12] (13.50 days on castor), Gupta *et al.* (2015) [3] (15.45 days on mango), Shakya *et al.* (2017) [13] (25.00 days on tomato), Rajasekar and Sridevi (2019) [11] (12.67 days on castor), Konkani *et al.* (2023) (13-14 days), Divya Rawat *et al.* (2023) [17], on different host including cauliflower, Sharma *et al.* (2025) [14] (15-20 days on castor). Castor was consistently identified as the most suitable host, whereas cotton and soybean were less favorable, impeding larval growth. These findings are in line with reports by Dwivedi *et al.* (2016) [2], which also highlighted the retarding effect of cotton on larval development. Shorter larval durations on preferred hosts were also supported by studies from Mishra and Srivastava (2013) [8], Mandal *et al.* (2014) [7].

Pupa

During the pre-pupal period, the feeding and movement of *Spodoptera litura* larvae decrease significantly as they prepare for pupation. The larvae typically seek shelter by burrowing under blotting paper or into the soil, where they transform into pupae. Newly formed pupae are initially light yellow-green in color, gradually darkening to light brown and eventually to dark brown within 20-24 hours after pupation. The pre-pupal stage lasts about 1-2 days (1.50±0.71), followed by the pupal stage, which lasts approximately 7-9 days (8.00±1.41). During this period, the pupae undergo extensive physiological changes in preparation for the emergence of adult moths.

Pupal period: The pupal stage lasted for about 7.0-9.0 days, in agreement with Ramaiah and Maheswari (2015) [12] (7.50 days on castor), Shabout *et al.* (2011) (7.54 days on castor), Rajasekar and Sridevi (2019) [11] (7.66 days), Konkani *et al.* (2023) (5-7 days), Divya Rawat *et al.* (2023) [17], on different host including cauliflower, Sharma *et al.* (2025) [14] (7-11 days on castor). Cotton and soybean were associated with slightly longer pupal durations.

Adult

Adult *Spodoptera litura* females are generally larger in size than males and possess a relatively shorter abdomen. Males, on the other hand, are usually lighter in color compared to females. Females typically emerge a few days earlier than males, and both sexes attain sexual maturity and are capable of mating on the first night following emergence. The general body coloration of the adults varies from white to light yellow.

Adult emergence: The adult emergence rate ranged between 73% and 85%. These observations are comparable to those of Soni *et al.* (2001), who reported adult emergence rates of 90.63% and 92.50% on cauliflower.

Adult longevity: The longevity of male and female moths ranged from 5.0-7.0 days and 6.0-8.0 days, respectively. These results are consistent with Ramaiah and Maheswari (2015) [12], who recorded longevity of 6.50 days (male) and 8.00 days (female), and Rajasekar and Sridevi (2019) [11], who reported 3.16 days (male) and 5.50 days (female). Additional support comes from Shabout *et al.* (2011) (female longevity: 6.33 days), Konkani *et al.* (2023) (male: 7.0-10.0 days, female: 8.0-11.0 days), and Sharma *et al.* (2025) [14] (male: 8.0-10.0 days, female: 9.0-11.0 days).

Table 1: Biology of tobacco caterpillar, *S. litura* under laboratory condition

Sr. No.	Stages of the insect	Minimum (Days)	Maximum (Days)	Mean ± SD
1.	Incubation Period (days)	3.0	4.0	3.50±0.71
2.	First instar larvae	2.0	3.0	2.50±0.71
3.	Second instar larvae	3.0	4.0	3.50±0.71
4.	Third instar larvae	3.0	4.0	3.50±0.71
5.	Fourth instar larvae	3.0	4.0	3.50±0.71
6.	Fifth instar larvae	4.0	6.0	5.00±1.41
7.	Pre-Pupal period	1.0	2.0	1.5±0.71
8.	Pupal period	7.0	9.0	8.00±0.1.41
9.	Percent adult emergence (%)	73.0	85.0	79.00±8.49
10.	Male adult longevity	5.0	7.0	6.00±1.41
11.	Female adult longevity	6.0	8.0	7.00±1.41
12.	Total life cycle	31.50	36.50	34.00±3.50

Conclusion

The present study clearly elucidates the complete life cycle and developmental biology of *Spodoptera litura* under laboratory conditions, confirming its rapid development, high fecundity, and destructive feeding behavior. The pest completed its life cycle within a short duration, with five larval instars responsible for maximum crop damage. Castor proved to be the most suitable host, supporting faster development, while cotton and soybean retarded growth. The findings corroborate earlier reports and highlight the adaptive potential of *S. litura* across hosts. Understanding its biology is crucial for devising timely and effective integrated pest management strategies.

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