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Biology of *Spodoptera litura* Fabricius on popular hybrids of Cabbage

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Abstract
The experiment was conducted in laboratory conditions at the Department of Entomology, College of Agriculture, Badnapur, during 2023-24 under laboratory conditions at 25 ± 1.5 °C temperature with relative humidity of 65 ± 5 percent. The study was primarily cantered on observations such as incubation period, percent viability of eggs, larval period, pupal period, adult longevity, percent emergence for adults, sex ratio, total life cycle, and larval and pupal weight from each hybrid. The study on the biology of *Spodoptera litura* (Fab.) on cabbage revealed that the *S. litura* development duration was observed as 4.53 ± 0.01 days to 4.80 ± 0.01 for the egg, 17.87 ± 0.29 days to 20.47 ± 0.04 days for the larva, 2.78 ± 0.05 days to 2.94 ± 0.02 days for the pre-pupa, 8.66 ± 0.09 days to 9.55 ± 0.10 days for the pupa, 4.84 ± 0.04 days to 4.91 ± 0.02 days for the adult male, 6.15 ± 0.04 days to 6.37 ± 0.02 days for the female, and the total life cycle varied between 34.16 ± 0.39 days to 37.88 ± 0.12 days.

Keywords: Biology, cabbage, egg, larva, life cycle, *Spodoptera litura*

Introduction
India is a major producer of vegetables, with over 40 types of vegetables grown under varied agro-climatic conditions. Key crops include tomato, onion, brinjal, cabbage, cauliflower, okra, and peas. The country's cabbage production is significant, with 428.05 ha of area and production of 9951.98 tons and a productivity of 23.25 Mt/ha. India's major cabbage growing states include West Bengal, Odisha, Bihar, Assam, Gujrat, Maharashtra, Madhya Pradesh, and Chhattisgarh. West Bengal ranks first in both area and production, with 86.04 ha of area and production of 2405.15 tons and 27.95 mt/ha. (Annual report 2022-23, DES, Ministry of Agri. & FW (DA & FW, Govt. of India)). However, cabbage production faces challenges due to pest complexes from germination to harvesting. In India, 37 insect pests have been reported to feed on cabbage, with some being more destructive than others. Lepidopteron larvae, such as diamondback moth, cabbage butterfly, cabbage semi looper, tobacco caterpillar, cabbage head borer, cabbage leaf Webber, and painted bug, are the most destructive pests, causing extensive damage. Cabbage is a popular vegetable crop, requiring intensive plant protection measures. *Spodoptera litura* (Lepidoptera: Noctuid) is a dangerous polyphagous pest that causes massive destruction to field crops like oilseeds, vegetables, pulses, and fruits in the whole world. It was discovered to result in a 26–100% decrease of groundnut yield (Favetti *et al*. 2015; Ashwini *et al*. 2016; Ramzan *et al*. 2021) [5, 3, 21]. Biological studies are crucial for pest management, as they reveal the most vulnerable insect stages and enable intelligent control factor manipulation. Despite the availability of green labeled insecticides, crop failure is common due to defoliator pests' severity and resistance, particularly DBM and *Spodoptera litura*. This investigation aims to study *Spodoptera litura* biology in popular hybrids of cabbage.

Materials and Methods
The experiment was conducted in laboratory conditions at the Department of Entomology, College of Agriculture, Badnapur. The experiment was laid in complete randomized design (CRD) with three treatments replicated five times. The freshly laid egg of *S. litura* was collected from the three different popular hybrids of cabbage. Around 25 eggs were transferred from each hybrid in the Petri dish (diameter 10 cm) placed with moist blotting paper. Every day fresh

leaves were provided with new Petri dishes to newly hatched larvae. Larvae were transferred to a new Petri dish with a soft camel brush. First instar larvae were reared in masses, and after the first moult, ten larvae from each Petri dish were transferred individually to ten plastic containers. The open end of the plastic container was closed with perforated lids for aeration. Fresh leaves were provided one time till early instar larval stages up to third instar and two times for fourth and fifth instar. Fifth moult onward, larvae fed three times a day till early pupation stage. Leaf petioles were wrapped with a moist swab to maintain their turgidity. Once the larvae reached the pre-pupal stage, a container was provided with soft, loose, and dry soil to ease the pupation itself in the container for the adult. The following observations were recorded during the experiment, *viz*., incubation period, percent viability of eggs, larval period, pupal period, and adult longevity. Percent emergence for adults, sex ratio, total life cycle, larval and pupal weight from each hybrid were recorded.

Results and Discussion

Egg Stage

The masses of eggs were placed at the top of foliage. They had a felt made of light brown scale that had come out of the female moth's abdomen. Egg masses had a golden brown to creamy appearance. The tip of the egg, which represented the developing larval head, turned blackish just before hatching. Finally, just before hatching, the entire egg mass changed from brown to black.

Incubation Period

Average incubation period ranged from 4.53 ± 0.01 days to 4.80 ± 0.01 days (Table 1). Videshi (4.53 ± 0.01 days) had the shortest incubation duration, followed by Dollar (4.75 ± 0.02 days) and BC-79 (4.80 ± 0.01 days), all of which were comparable to one another and distinct from other hosts. The outcomes supported the findings of Soni *et al*. (2001) [16], who found that cabbage required a mean incubation period of 5.60 days. The results corroborate the finding of Shukla and Patel (2011) [15], who reported the incubation period for the banana cultivar Grand Naine was 4.21 ± 0.99 days. Tuan *et al*. (2015) [10] reported that the incubation period of *Spodoptera litura* (Fab.) was 3.9 days, while Ashwini *et al*. (2016) [3] reported 2.0–2.7 days on cabbage. period of *Spodoptera litura* (Fabricius) on cabbage was 3.9 days (Tuan *et al*., 2015) [10]; 2.0-2.7 days (Ashwini *et al*., 2016) [3] where the incubation period of *Spodoptera litura* (Fabricius) on cabbage was 3.9 days (Tuan *et al*., 2015) [10]; 2.0-2.7 days (Ashwini *et al*., 2016) [3].

Hatchability

Depending on the cultivar, the hatchability of eggs ranged from 80.20 ± 0.86 to 86.00 ± 0.70 percent (Table 1). On BC-79, the maximum hatchability of 86.00 ± 0.70 percent was recorded. Videshi had the lowest hatchability at 80.20 ± 0.86 percent, followed by Dollar at 82.40 ± 0.92 percent, respectively. Kumar and Bhattacharya (2019) [6] reported that the percent viability of eggs of *Spodoptera litura* in cauliflower was 88%, while 92% in cabbage.

Table 1: Incubation period and hatchability of eggs of *S. litura* on different cultivars of cabbage

Cultivar	Incubation period (days)* Mean ± SE	Hatchability of eggs (%) * Mean ± SE
Videshi	4.53±0.01	80.20±0.86
Dollar	4.75±0.02	82.40±0.92
Bc-79	4.80±0.01	86.00±0.70
CD (p = 0.05)	0.05	2.58

*Mean based on 5 replications

Larval Stage

The larvae went through five instars and four moults. The number of moults indicated by exuviae generated during moulting defined the larval instars. After an hour, the newly hatched larva changed from being white to yellowish green. From the head to the tail, a pattern of red, yellow, and green lines was observed. As it grew older, the larva developed three thin yellow lines along its back, one on each side and one in the middle. Its color turned brownish. On either side of the back were prominent rows of dark triangles. On either side of the second and third body segments from the head, there was a white dot. The mature larva measured up to 5 cm in length. The head's third and fourth portions were bigger than the body's remaining segments.

First Instar

The larvae had light green coloration. The first instar larvae's mean duration differed significantly amongst cultivars, ranging from 3.16 ± 0.06 to 3.84 ± 0.01 days. The average larval duration on Videshi was minimum at 3.16 ± 0.06 days. Statistically, the average larval duration on Dollar (3.79 ± 0.06 days) was comparable with BC-79 (3.84 ± 0.01 days), respectively. Muhammad reported the period of first larval instar on cotton was 3.55±0.10.

Second Instar

Following the moult, the second instar larvae immediately began feeding by scraping the leaves, and as they grew older, they made consistent holes in the leaves that separated from the veins. A few minutes prior to melting, the larvae ceased feeding. On Videshi, the lowest mean duration of larvae in their second instar was 4.47 ± 0.10 days. Statistically, it was comparable to Dollar (4.69 ± 0.03 days) and BC-79 (4.96 ± 0.02 days), respectively. The outcomes were similar with findings of Muhammad who reported the 3.59±0.09 period of the second larval instar.

Third Instar

On Videshi, the third instar larvae's duration was the shortest at 3.47 ± 0.10 days. It was followed by comparable times for Dollar (4.07 ± 0.01 days) and BC-79 (4.11 ± 0.01 days), respectively. Compared to present results, Muhammad also reported the 3.99±0.10 period of third larval instar.

Fourth Instar

There was a minimal duration of 3.43 ± 0.09 days for fourth instar larvae on Videshi which was statistically comparable with Dollar (3.73 ± 0.06 days). The maximum duration of fourth instar larvae was observed on BC-79 (4.10 ± 0.01 days). Rabari *et al*. (2018) [7] reported the duration of larval instar of 3.43 ± 0.09 days.

Fifth Instar

There was a minimal duration of 3.35 ± 0.02 days for fifth instar larvae on Videshi and statistically, it was comparable to Dollar (3.38 ± 0.02 days) and BC-79 (3.46 ± 0.01), respectively. Rabari *et al*. (2018) [7] reported the fifth larval period of 3.28 ±0.46 days.

Table 2: Duration of larval instars of *S. litura* on different cultivars of cabbage

Cultivar	Duration (days)* Mean ± SE					
	I instar	II instar	III instar	IV instar	V instar	Total
Videshi	3.16±0.06	4.47±0.10	3.47±0.10	3.43±0.09	3.35±0.02	17.87±0.29
Dollar	3.79±0.06	4.69±0.03	4.07±0.01	3.73±0.06	3.38±0.02	19.66±0.09
Bc_79	3.84±0.01	4.96±0.02	4.11±0.01	4.10±0.01	3.46±0.01	20.47±0.04
CD (p = 0.05)	0.16	0.20	0.18	0.19	0.06	0.5

* Mean based on 5 replications

Total Larval Duration

The BC-79 had considerably longer total larval durations (20.47 ± 0.04), while Videshi had the shortest total larval duration (17.87 ± 0.29 days), followed by Dollar (19.66 ± 0.09 days). The larval duration on cabbage was reported to be 13.33 days by Xue *et al*. (2010) [11] and 15.55 days by Shahout *et al*. (2011) [9]. The total larval period was observed as 21.10±1.08 days by Ashwini (2014) [2]. Sreenivasa *et al*. (1997) [17], which is more or less tally with the present findings.

Pre-Pupal Period

The larva stopped feeding and changed to a darker color prior to pupal development. It also shrank in size and took on a reversible C shape. Videshi had a minimum pre-pupal time of 2.78 ± 0.05 days, which was statistically equivalent to Dollar (2.90 ± 0.03 days) and BC-79 (2.94 ± 0.02 days), respectively (Table 3). Ashwini (2014) [2] reported the mean duration of pre pupal period as 2.22±0.38 days. However, observations made by earlier workers for the total pupal period of *Spodoptera litura* (Fabricius) reported 7.54 days (Shahout *et al*., 2011) [9] and 6.95-11.92 days (Ashwini *et al*., 2016) [3]. Yadav *et al*. (2014) [13] reported that the pupal period on cauliflower was 10.25 days and that on cabbage it was 9.91 days. Shakya *et al*. (2015) [14] noticed that the total pupal period lasted for 7-9 days on a tomato host.

Pupal Period

The pupae had an oval form and were dark reddish brown in color. The antennal casing and eyes were darker and more noticeable. There were two little spines at the abdomen's tip (Fig. 1). BC-79 was found to have the longest pupal time (9.55 ± 0.10 days), which was significantly longer than that of other cultivars (Table. 3). Videshi had the shortest pupal period, measuring 8.66 ± 0.09 days, which was comparable to Dollar 8.81 ± 0.05 days. The findings of Tuan *et al*. (2015) [10], who reported the pupal period lasts for 9.0±0.1 days. Gopika recorded the Pupal period lasted for 7.45±1.14 days.

Table 3: Pre-pupal and pupal periods of *S. litura* on different cultivars of cabbage

Cultivar	Duration (days)* Mean ± SE	
	Pre-pupal	Pupal
Videshi	2.78±0.05	8.66±0.09
Dollar	2.90±0.03	8.81±0.05
Bc_79	2.94±0.02	9.55±0.10
CD (p = 0.05)	0.12	0.27

* Mean based on 5 replications

Pupal Weight

The present study observed that the female pupae weighed more than the male pupae (Table 4). The female pupa on Videshi had the heaviest weight (0.388 ± 0.004 g), which was significantly higher than that on Dollar (0.376 ± 0.003 g) and BC-79 (0.361 ± 0.005 g), respectively. Among the three cultivars, BC-79 had the lightest pupae (0.361 ± 0.005 g). The male pupae weighed the heaviest on Videshi (0.380 ± 0.004 g), and the weight was comparable with that on Dollar (0.356 ± 0.002 g) and BC-79 (0.353 ± 0.006 g). The outcomes supported the observations made by Xue *et al*. (2010) [11], who found that the weight of the male pupa on Chinese cabbage was 0.354 ± 0.002 g, and the weight of the female pupa was 0.362 ± 0.003 g.

Table 4: Weight of male and female pupa of *S. litura* on different cultivars of cabbage

Cultivar	Pupal weight (g)* Mean ± SE	
	Male	Female
Videshi	0.380±0.0047	0.388±0.0043
Dollar	0.356±0.0026	0.376±0.0030
Bc_79	0.353±0.0069	0.361±0.0054
CD (p = 0.05)	0.015±0.005	0.013±0.004

*Mean based on 5 replications

Adult Stage

The adult moth's hairy body was a shade of greyish brown. The hind wings were greyish white with grey margins, while the forewings had a heavily varied pattern with lines along the veins. The forewings were greyish to reddish brown. In general, the female was bigger than the male. The female had a spherical abdomen with a tubular aperture, while the male had a pointed abdomen. The male had a darker body color than the female, who had a pale brown body. Pre-oviposition, oviposition, and post-oviposition periods the pre-oviposition and post-oviposition durations of the five cultivars did not differ significantly (Table 5). From 1.99 ± 0.06 days to 2.12 ± 0.01 days, there was a variation in the pre-oviposition time. The differences were 2.12 ± 0.01 days for Dollar, 2.02 ± 0.02 days for BC-79, and 1.99 ± 0.06 days for Videshi. The maximum oviposition period of 2.60 ± 0.04 days was recorded on Dollar; this was followed by BC-79 (2.57 ± 0.02 days) and Videshi (2.50 ± 0.03 days), in that order. the maximum post-oviposition period recorded on BC-79 (1.78±0.04) was followed by Dollar (1.75±0.01) and Videshi (1.73±0.02) The outcomes were supported by Rabari *et al*. (2018) [17], who reported that the pre-oviposition, oviposition, and post-oviposition periods ranged from 1.52±0.51, 2.72±1.37, and 1.48±0.71 days, respectively.

Table 5: Pre-oviposition, oviposition and post-oviposition period of *S. litura* on different cultivars of cabbage

Cultivar	Pre-oviposition period (days)* Mean ± SE	Oviposition period (days)* Mean ± SE	Post-oviposition period (days)* Mean ± SE
Videshi	1.99±0.06	2.50±0.03	1.73±0.02
Dollar	2.12±0.01	2.60±0.04	1.75±0.01
Bc-79	2.02±0.02	2.57±0.02	1.78±0.04
CD (p = 0.05)	NS	NS	NS

* Mean based on 5 replications.

Longevity of Adults

The adult moth's life spans on various cabbage cultivars did not show any significant differences. Nonetheless, females survived longer than males in general. Male longevity varied between

4.84 ± 0.04 days on Videshi and 4.91 ± 0.02 days on BC-79. In contrast, it was 4.87 ± 0.02 days on Dollar populations. The lifespan of female adults that emerged from raising on BC-79 was 6.37 ± 0.02 days, which was comparatively longer than that of Dollar (6.29 ± 0.03 days) and Videshi (6.15 ± 0.04 days) (Table 6). Similar results were reported by Rabari *et al*. (2018) [7], who recorded the adult longevity of male and female was 8.32 ± 1.31 and 10.36 ± 1.25 days.

Table 6: Longevity of adults of *S. litura* on different cultivars of cabbage

Cultivar	Longevity (days)* Mean ± SE	
	Male	Female
Videshi	4.84±0.04	6.15±0.04
Dollar	4.87±0.02	6.29±0.03
Bc_79	4.91±0.02	6.37±0.02
CD (p = 0.05)	NS	NS

*Mean based on 5 replications

Sex Ratio

Regardless of the host plant, there were more females than males (Table 7). The female to male ratio was observed maximum on BC-79 (1.52:1), followed by Dollar (1.33:1), and Videshi (1.21: 1). The current results are quite similar to those of Muhammad *et al*. (2022) reported that the sex ratio of female to male was recorded as 1:0.7, 1:0.6 and 1:0.5.

Table 7: Sex-ratio of adults of *S. litura* on different cultivars of cabbage

Cultivar	Sex ratio (female: male)
Videshi	1.21: 1
Dollar	1.33: 1
Bc-79	1.52: 1

*Observations based on 40 moths per cultivar

Fecundity

On top of the leaves, the eggs were placed in batches. The female moth's abdomen had been separated, leaving a field of light brown scale covering both. Greenish-creamy masses of eggs were seen. As the egg approached hatching, the developing larvae head turned a dark brown color, and the entire egg eventually turned a deep brown color. Table 8 indicates that there were no significant variations in *S. litura* fecundity between hosts. The cultivars with the highest fecundity were Videshi (143.77 ± 2.98 eggs per female), followed by Dollar (141.08 ± 2.58 eggs per female) and BC-79 (137.17 ± 0.96 eggs per female), respectively. Similar results were recorded by Ashwini (2014) [2], who reported the fecundity observed as 304.40±183.93 eggs per female.

Table 8: Fecundity of *S. litura* on different cultivars of cabbage

Cultivar	Fecundity (eggs/female) * Mean ± SE
Videshi	143.77±2.98
Dollar	141.08±2.58
Bc_79	137.17±0.96
CD (p = 0.05)	(NS)

*Mean based on 5 replications

Total Life Cycle

The study revealed that Videshi had the lowest total life cycle (34.16 ± 0.39 days), while BC-79 had the highest (37.88 ± 0.12 days), followed by Dollar (36.24 ± 0.07 days) (Table 9). The findings are similar to Shukla and Patel (2011) [15], who noted that on Banana cv. Grand Naine, the entire life cycle is 39 ± 1.88 days. Yadav (2020) [12] recorded the total life cycle of the tobacco caterpillar on cabbage as 32.94 days.

Table 9: Total life cycle of *S. litura* on different cultivars of cabbage

Cultivar	Total life cycle (days)* Mean ± SE
Videshi	34.16±0.39
Dollar	36.24±0.07
Bc_79	37.88±0.12
CD (p = 0.05)	0.75

*Mean based on 5 replications

Conclusion

The information of present study provides valuable insights into the biology of the *Spodoptera litura*, which can be used for comparative studies with other crops. Effective IPM strategies can rely on the synchronized timing of *S. litura* life stages, enabling more precise interventions at vulnerable points in the pest's life cycle. Therefore, this study provides valuable insights into the biology of *S. litura*, offering a foundation for optimizing pest management approaches in cabbage cultivation.

Plate 1: Pupae of *Spodoptera litura*

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