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Life cycle and biology of *Spodoptera litura* (Noctuidae: Lepidoptera) on castor (*Ricinus communis*)

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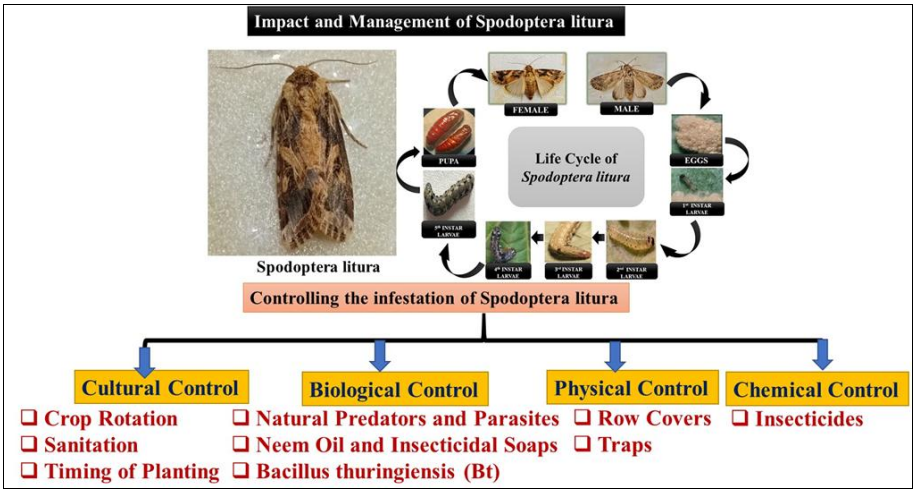
Abstract
This research investigates the biology and culture techniques of *Spodoptera litura*, a destructive pest affecting various agricultural and horticultural crops worldwide, including India. The study was conducted under laboratory conditions in 2023 and further observations were obtain in 2024. The study focused on the developmental duration across different life stages: egg, larva, pupa, and adult. Findings revealed that female moths lay approximately 850-900 eggs, with incubation lasting 4.5±0.71 days. The larval stage comprises five instars, with the average durations for the first to fifth instars recorded as 2.50±0.71, 3.50±0.71, 2.50±0.71, 3.50±0.71 and 5.00±1.41 days, respectively. Adult longevity differed by sex, with males surviving 9.00±1.41 days and females 10.0±1.41 days. The complete life cycle from egg laying to adult emergence spanned an average of 30±2.82 days.
The study concluded that castor serves as a suitable host for *S. litura*, facilitating vigorous larval feeding and subsequent pest proliferation. These insights contribute to understanding the life cycle dynamics and potential management strategies for this significant agricultural pest.

Graphical Abstract



1. This research investigates the biology and culture techniques of *Spodoptera litura*, a destructive pest affecting various agricultural crops
2. The study focused on the developmental duration across different life stages: egg, larva, pupa, and adult.
3. The study concluded that castor serves as a suitable host for *S. litura*, facilitating vigorous larval feeding and subsequent pest proliferation.

Keywords: Biology, castor, culture, developmental stages, *Spodoptera litura*

Introduction
Spodoptera litura (Fabricius) (Lepidoptera: Noctuidae), commonly known as the tobacco cutworm or cotton leafworm, is a highly destructive and widely distributed agricultural pest that poses a significant threat to global crop production. According to Shukla and Patel [1], Ahmad et al. [2], Ramzan et al. [3], Ganguly and Srivastava [4], this polyphagous insect has an

extensive host range, infesting more than 120 plant species, including economically important crops such as cotton (*Gossypium spp.*), soybean (*Glycine max*), groundnut (*Arachis hypogaea*), tomato (*Solanum lycopersicum*), tobacco (*Nicotiana tabacum*), castor (*Ricinus communis*), and various vegetables from the Cucurbitaceae and Brassicaceae families. The adaptability of *S. litura* to diverse host plants, coupled with its rapid developmental cycle and high fecundity, makes it a persistent and severe threat to agricultural production, particularly in tropical and subtropical regions worldwide [5-6].

The larval stage of *S. litura* is particularly damaging, as larvae exhibit voracious feeding behavior, consuming leaves, stems, flowers, and even fruits [7]. This feeding activity leads to severe defoliation, reduced photosynthetic efficiency, and overall plant weakening, resulting in significant yield losses. Under severe infestations, plants may be entirely defoliated, leading to yield reductions of up to 80% in the absence of effective pest management strategies [8-10]. Furthermore, the indirect impact of *S. litura* infestations includes increased susceptibility of crops to secondary infections by pathogens, further compounding economic losses.

Several factors contribute to the persistence and widespread distribution of *S. litura*. According to Sharma et al. [8] and Maharjan et al. [11], Its remarkable adaptability to diverse climatic conditions allows it to thrive in agroecological zones ranging from tropical to temperate regions. Additionally, the species exhibits high reproductive potential, with a single female capable of laying up to 890 eggs during her lifetime [12]. This high fecundity and a short developmental cycle facilitate rapid population growth and frequent outbreaks, complicating pest control efforts. Understanding the life cycle of *S. litura* is crucial for developing effective and sustainable pest management strategies. Laboratory rearing of the pest enables detailed investigations into its developmental stages, survival rates, and responses to varying environmental factors such as temperature, humidity, and diet [13-14]. Such studies provide essential insights into its biology and ecology, which are critical for designing integrated pest management (IPM) programs. Effective control measures- including biological control, pheromone trapping, and host plant resistance-rely on a comprehensive understanding of the insect's life history. Therefore, continuous research on the life cycle of *S. litura* is imperative to mitigate its impact on global agriculture and ensure food security.

Materials and Methods

Research Location

This research was conducted during 2023-2024 in the Department of Zoology, School of Science, IFTM University, Moradabad. The study aimed to investigate the biology and rearing techniques of *Spodoptera litura* (Fab.) under controlled laboratory conditions.

Collection of egg mass

To study the biology of *Spodoptera litura* on castor (*Ricinus communis*), egg clusters were collected from cabbage (*Brassica oleracea*) fields in Hasanpur, Amroha district, Uttar Pradesh, India. Female moths typically lay their eggs on the underside of plant leaves, making it necessary to carefully inspect the leaves for egg clusters. Once located, leaves containing egg masses were cut from the host plant and transferred into clean plastic containers. To maintain the eggs in optimal conditions, fresh, healthy, and soft long-stemmed castor leaves were provided as a food source for the developing larvae. This ensured that the larvae had access to suitable nourishment immediately after hatching.

Rearing technique of *S. litura*

The rearing of *Spodoptera litura* was conducted under controlled environmental conditions in the laboratory. The collected egg masses were transferred into transparent plastic containers that had been disinfected with ethanol and lined with blotting paper. The egg masses were placed in these containers along with washed, dried, and fresh castor leaves. The container was tightly sealed using sterilized white muslin cloth and a rubber band to ensure cleanliness and airflow. Fresh castor leaves were provided daily as a food source until the larvae reached the final larval stage. Regular cleaning of the rearing boxes was performed daily to prevent fungal growth, especially in humid weather conditions.

Larvae that showed signs of dehydration, such as shrinkage in the later instar stages, were collected and transferred to separate sterilized containers lined with blotting paper. Once pupation occurred, the pupae were transferred to a pupation jar that had been disinfected with ethanol. The bottom of the jar was filled with soil, and the sides were lined with hanging strips of butter paper to provide a substrate for adult egg laying.

The pupation jars were regularly monitored until adult emergence. After emerging from the pupae, the adults were fed a 10% honey solution using a cotton swab. The cotton swabs, soaked in the honey solution, were replaced daily to prevent contamination in the jar. After 3-4 days, the egg masses laid by the adults were collected using a wet camel-hair brush. The butter paper strips containing egg clusters were then placed in sterilized plastic containers lined with blotting paper and soft castor leaves, ensuring a suitable environment for the neonate larvae for further mass rearing of *S. litura*.

Statistical analysis

The data on developmental stages were statistically analyzed by using SPSS-16.

Results and Discussion

The study on the life cycle of *Spodoptera litura* under controlled laboratory conditions yielded significant insights into the insect's development stages and rearing techniques. Eggs collected from *Brassica oleracea* and butter paper (pupation jar) displayed a typical cluster formation, with each cluster containing approximately 250 to 300 eggs. The incubation period lasted an average of 4.5±0.71 days (Table 1), during which the eggs transitioned from a yellowish-brown to a darker shade, indicating imminent hatching.

Upon hatching, the larvae entered the first instar stage as pale green neonates. The duration of the larval stage was approximately 15 to 20 days, encompassing five distinct instars:

- **First Instar:** Lasted about 2 days (Fig 4 and Table 1), characterized by slow movement and light green coloration.
- **Second Instar:** Lasted 3 to 4 days (Fig 4 and Table 1), with increased activity and a broader abdomen.
- **Third Instar:** Lasted 2 to 3 days (Fig 4 and Table 1), marked by elongation and the appearance of yellow-orange stripes and black spots.
- **Fourth Instar:** Lasted 3 to 4 days (Fig 4 and Table 1),

during which larvae became dark green and exhibited rapid growth.
- **Fifth Instar:** Lasted 4 to 6 days (Fig 4 and Table 1), showing a reddish-brown head and black legs, preparing for pupation.

Following the larval stages, the larvae entered a pre-pupal phase characterized by decreased feeding and activity. The pupal stage lasted between 7 to 11 days (Fig 4 and Table 1), during which pupae underwent significant physiological changes. Initially light yellow-green, the pupae darkened to a brown within 20 to 24 hours (Fig 1: F-G).

Life cycle of *Spodoptera litura*

The life cycle of *Spodoptera litura* typically spans 20 to 28 days, depending on environmental conditions such as temperature and humidity. Female moths can lay around 850-900 eggs during their lifespan, often in clusters on the underside of host plant leaves. After hatching, the larvae progress through five distinct instar stages before pupating. During these stages, *S. litura* larvae exhibit voracious feeding behavior, causing extensive damage to a wide range of crops, which makes them a significant agricultural pest. Their feeding can severely impact crop yields, presenting a major challenge to sustainable agricultural practices. The life cycle of this pest includes these following stages:

Egg

Spodoptera litura females lay their eggs on the underside of leaves or on paper in clusters containing approximately 250 to 300 eggs. The eggs are spherical in shape and yellowish-brown in color, and they are often arranged in 2-3 layers, with some eggs stacked on top of others. To protect the eggs, the female covers them with her yellowish-brown abdominal scales, providing an additional layer of defense against environmental hazards and predators. This protective behavior enhances the survival rate of the eggs until they hatch into larvae.

Incubation period and hatching: The eggs of *Spodoptera litura* were incubated for 4-5 (4.5±0.71) days under laboratory conditions. During this incubation period, the spherical, yellowish-brown eggs gradually darkened as they neared hatching. Upon completing incubation, the eggs hatched, releasing first-instar larvae, commonly referred to as neonates. These neonates were pale green in color. Shortly after hatching, the larvae began feeding on the surface of the leaves where the eggs had been laid. They quickly became active feeders, initiating their rapid growth and development through the subsequent larval stages.

Larvae and number of instars

The larvae of *Spodoptera litura* undergo five instar stages during a larval period of approximately 15-20 days. The newly hatched larvae (neonates) are cylindrical in shape, with a broad head and an abdomen that narrows toward the tail. Initially, the neonates are slow-moving and light green in color, with a proportionally wider head compared to their body. After feeding for about two days, the larvae molt into the second instar stage. In the second instar, the abdomen becomes wider than the head. This stage lasts 3-4 days, during which the larvae exhibit more active feeding.

The third instar larvae are longer and more elongated, with distinctive yellow-orange stripes running along the dorsal and lateral sides of their bodies, and they develop prominent black spots. This stage lasts 2-3 days. The fourth instar larvae turn dark green and continue growing rapidly, with this stage lasting an additional 3-4 days. By the fifth instar, the larvae display a reddish-brown head and black legs. These final stages span a period of 4-6 days, during which the larvae prepare for pupation. Throughout these stages, the larvae are voracious feeders, contributing to their potential to cause significant crop damage.

Pupa

During the pre-pupal period, the feeding and movement of *Spodoptera litura* larvae significantly decrease as they prepare for pupation. The larvae typically seek shelter by burrowing under blotting paper or into the soil, where they transform into pupae. The newly formed pupae initially exhibit a light yellow-green color, which gradually darkens to light brown and eventually to dark brown within 20-24 hours after pupation. The prepupal stage lasts for about 2-3 days, followed by the pupal stage, which lasts approximately 7-11 days (Table 1). During this time, the pupae undergo significant physiological changes in preparation for the emergence of adult moths.

Adult

Adult *Spodoptera litura* females are generally larger than males, with shorter abdomen. Males tend to be lighter in color compared to females (Fig 2: B-C). Females typically emerge several days before males, and both sexes are capable of mating for the first time the night following their emergence.

The overall body color ranges from white to light yellow. The forewings are characterized by a light brown base adorned with dark brown stripes, while the hindwings are white with a purple sheen (Fig. 2E), featuring dark brown edges and brown veins (Fig 2: B-C). The thorax and abdomen are orange to light brown, and the abdomen has tufts of hair on the dorsal side (Fig 2: D-E). The head is covered with clusters of light and dark brown scales, adding to the insect's distinct appearance.

Adult moths displayed sexual dimorphism, with females being larger than males. The initial coloration of adults varied from white to light yellow, with distinct wing patterns including dark brown stripes on the forewings and a purple sheen on the hindwings. The average time from pupation to adult emergence was recorded, noting that females typically emerged several days before males. This sexual dimorphism and coloration play important roles in mating and camouflage within their environment.

The biology and life cycle of *Spodoptera litura* observed in this study align closely with previously reported findings, providing further insights into the pest's behavior and development under controlled laboratory conditions. The findings reaffirm the adaptability and feeding voracity of *S. litura*, which contribute significantly to its status as a major agricultural pest.

The arrangement of eggs is found in groups having 2 to 3 layers [2] also reported 3-4 consecutive layers of eggs in a single batch. Every egg cluster has 250-300 eggs aligns with studies by Gupta et al. [15], Ramaiah and Maheshwari [16]. The incubation period observed for 4-5 days is consistent with earlier studies, such as those in 4-5 days, Sharma et al. [5], 2-4 days Ramzan et al. [3], 3.5, 4 and 5 days Ramaiah and Maheshwari [16], 6-8 days Gupta et al. [15], 2.5-5.5 days Shukla and Patel [1], which reported a similar duration under

laboratory conditions. The abundant female hair silk (modified scales), were found covering egg masses, forming a 'net' appearance on egg surfaces. The previous studies by Latha et al. [17], Ramaiah and Maheshwari [16] also reported such coverings. In the present study, similar larvae of *Spodoptera litura* undergo five instar stages similar to Gupta et al. [15], Ramaiah and Maheshwari [16], whereas Latha et al. [17] reported that the larvae of *S. litura* (Fabricius, 1775) undergo five molts and six larval instars. As far as feeding is concerned, the early instar larvae feed on soft leaf tissue, and older ones with stronger biting mouthparts even feed on veins and leaf ribs. The mature larvae usually feed at night and remain in the soil during the daytime at the base of host plants. Similar findings were reported by Gupta et al. [15] on mango trees. In the present study, the total duration of the life cycle on castor was 28-32 days and, according to Gupta et al. [15], Ramaiah and Maheshwari [16] the total life period of *S. litura* was 36-50 days, and 28.25-36 days respectively, which are aligned with the present study.

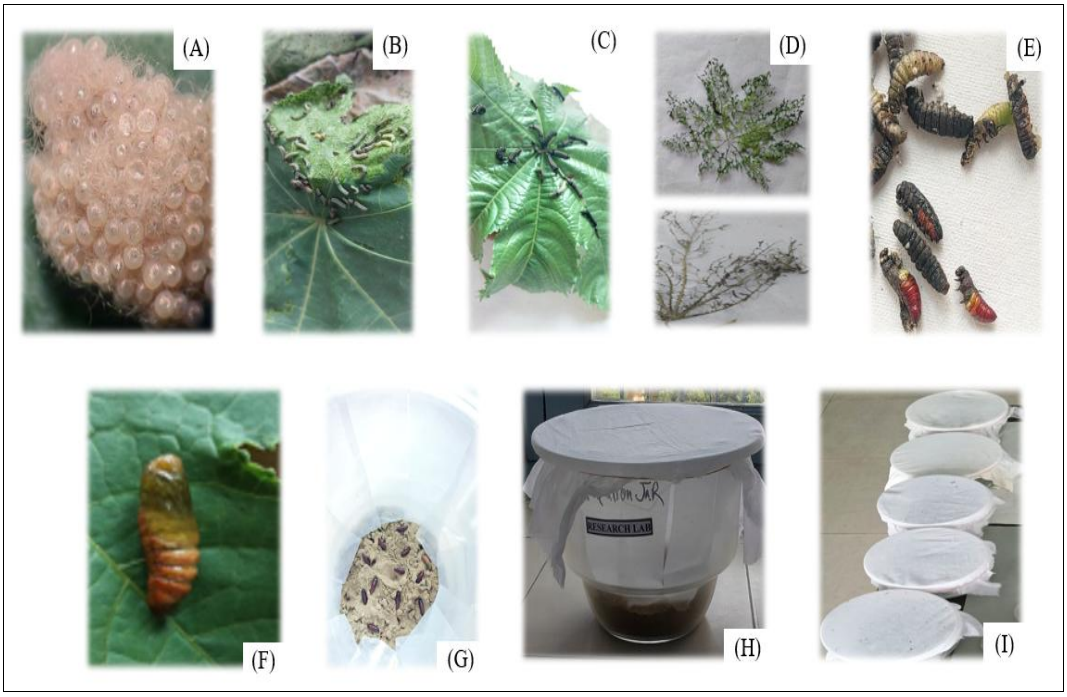


Fig 1: Rearing of *Spodoptera litura*, A: Collected egg mass; B & C: Infestation of larvae on castor; D: Skeletonized leaf; E: Pre-pupation stage; F: Early pupa; G: Late pupa in the soil; H: Pupation & adult emerging jar; I: Rearing boxes.

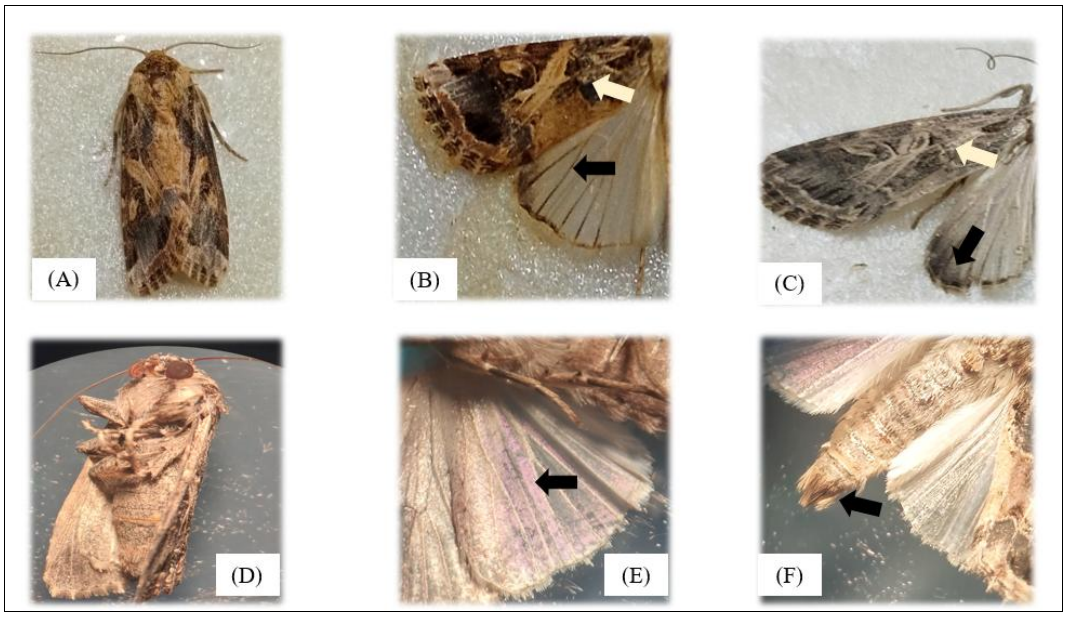


Fig 2: Structural Features of the Adult Moth (*Spodoptera litura*), A: Adult- dorsal view; B: Female- Forewings and Hindwings; C: Male- Forewings and Hindwings; D: Adult- ventral view; E: Hindwings- purple sheen; F: Abdomen has tufts of hair.

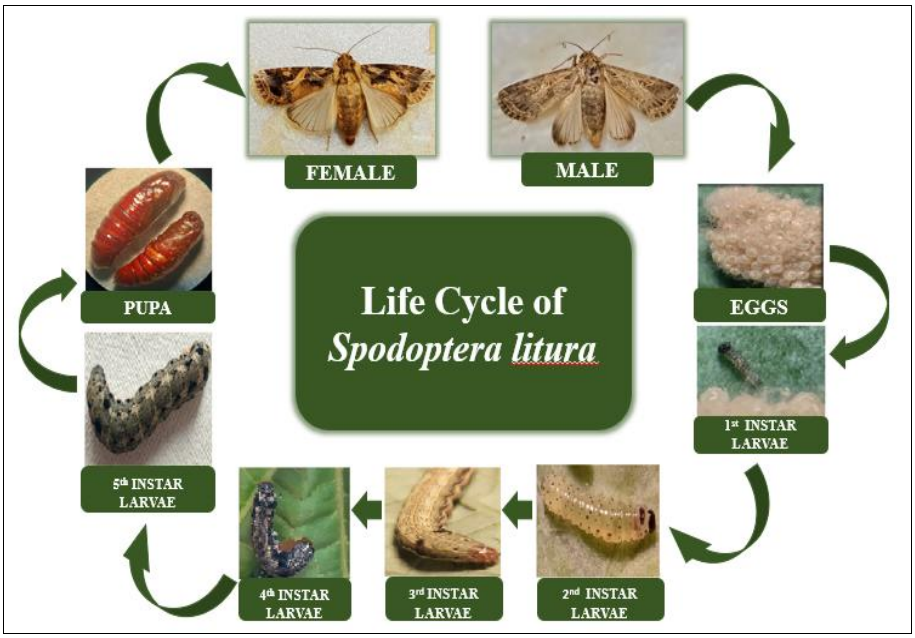


Fig 3: Life cycle of *Spodoptera litura*

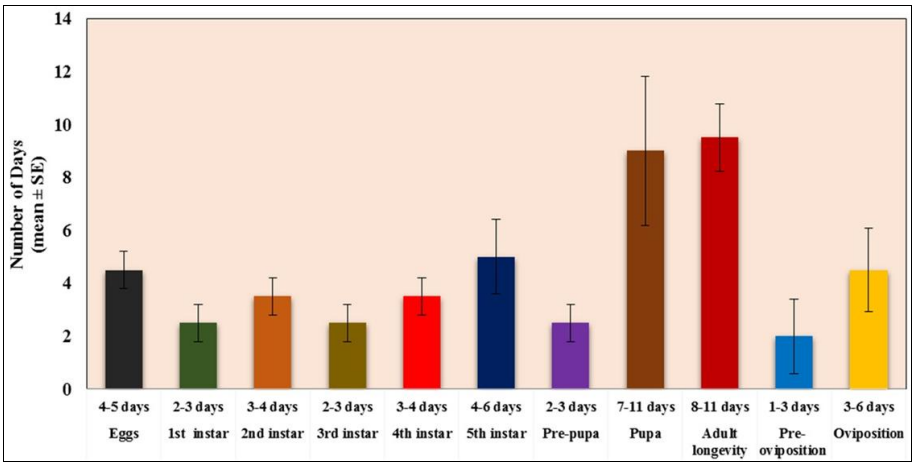


Fig 4: Graph depicting duration of *Spodoptera litura* development throughout all stages

Table 1: The Developmental Stages of *S. litura*, A Timeline of Transformation

Stages	Mean ± SD	Duration (days)
Eggs	4.50±0.71	4-5 days
Larva		
1st	2.50±0.71	2-3 days
2nd	3.50±0.71	3-4 days
3rd	2.50±0.71	2-3 days
4th	3.50±0.71	3-4 days
5th	5.00±1.41	4-6 days
Total larval period	17.5±3.54	15-20 days
Pupa		
Pre-pupa	2.50±0.71	2-3 days
Pupa	9.00±2.83	7-11 days
Adult longevity		
Male longevity	9.00±1.41	8-10 days
Female longevity	10.0±1.41	9-11 days
Ovipositional period		
Pre- oviposition	2.0±1.41	1-3 days
Oviposition	4.5±2.12	3-6 days
Total life cycle	30±2.82	28-32 days

Conclusion

This study provides valuable insights into the life cycle and developmental stages of *Spodoptera litura* under controlled laboratory conditions, substantiate its adaptability and voracious feeding behavior. The detailed observations on egg clusters, larval instars, pupation, and adult emergence align closely with previous research, further validating the pest's biological patterns. Notably, the study highlights the critical role of environmental conditions in shaping the insect's growth cycle, with findings emphasizing the rapid development and resilience of *S. litura*. Given its ability to thrive across various host plants and its destructive feeding habits, these insights contribute significantly to pest management strategies, aiding in the formulation of effective control measures to alleviate its impact on agriculture.

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