

**BIOLOGY AND MASS REARING OF THE ARMYWORM,  
*Spodoptera pecten* Guenée, 1852 (Lepidoptera: Noctuidae)  
IN THE PHILIPPINES UNDER LABORATORY CONDITIONS**

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**ABSTRACT**

The armyworm, *Spodoptera pecten* Guenée, is a polyphagous pest of crops across a wide distribution range in the tropics, including regions such as Japan, Hawaii, and the Philippines. This species is considered an emerging pest of corn and other crops in Southeast Asia, and its increasing occurrence in the Philippines poses potential risks to crop productivity and pest management programs. Understanding its biology is therefore important for accurate identification, monitoring, and development of effective control strategies. Hence, the biology of the pest was investigated using corn leaves (IPB var. 6) as a substrate. The observed developmental periods revealed that eggs hatched within 3–5 days ( $\bar{x} = 3.15 \pm 0.53$ ), first instar, 3-5 days ( $\bar{x} = 3.05 \pm 0.31$ ), second instar, 3-4 days ( $\bar{x} = 3.02 \pm 0.16$ ), third instar, 2-5 days ( $\bar{x} = 3.27 \pm 0.71$ ), fourth instar, 1-4 days ( $\bar{x} = 2.10 \pm 0.74$ ), fifth instar, 1-4 days ( $\bar{x} = 2.76 \pm 0.66$ ), sixth instar, 3-6 days ( $\bar{x} = 4.39 \pm 1.09$ ), pre-pupa, 1-2 days ( $\bar{x} = 1.22 \pm 0.47$ ), and pupa, 8-11 days ( $\bar{x} = 9.48 \pm 0.77$ ). Post-development periods for female adults included pre-oviposition, 0-7 days ( $\bar{x} = 3 \pm 2$ ), oviposition, 0-4 days ( $\bar{x} = 2.27 \pm 1.71$ ), and post-oviposition, 0-2 days ( $\bar{x} = 0.83 \pm 0.72$ ). Female fecundity ranged from 91 to 1,278 eggs ( $\bar{x} = 477 \pm 381.58$  eggs per female). Adult male longevity was  $7.47 \pm 1.35$  days, and female longevity was  $6.93 \pm 2.10$  days, and the sex ratio (male: female) was 1.2:1. Mass rearing of *S. pecten* under laboratory conditions was also discussed. These results may be useful for predicting population dynamics of *S. pecten* and improving its management.

**Key words:** corn, defoliator, IPM, polyphagous pest

**INTRODUCTION**

The genus *Spodoptera* (Lepidoptera: Noctuidae) comprises 31 species, half of which are significant crop pests and have become major invaders, colonizing areas outside their native range, as seen with the fall armyworm, *Spodoptera frugiperda* (J.E. Smith) (Brown et al. 2009; Kergoat et al. 2021). These species are widely distributed throughout tropical and temperate Asia, Australia, and the Pacific Islands (CABI 2022). Known by various names such as fall armyworm, corn leafworm, grass worm, and southern grassworm, their larvae feed on a broad range of host plants- a total of 353 *S. frugiperda* larval host plant records belonging to 76 plant families (Montezano et al. 2018).

*Spodoptera pecten* Guenée is a highly adaptable species with a wide distribution range in the tropics, including regions such as Japan, Hawaii, and the Philippines. Guerrero et al. (2024) reviewed the distribution of *S. pecten*, which included India, Cambodia, Pakistan, Nepal, Bhutan, Bangladesh,

Sri Lanka, Myanmar, Vietnam, Malaysia, China, Brunei, Taiwan, South Korea, Japan, and Papua New Guinea. Known for its polyphagous nature, the larvae of *S. pecten* are notorious for feeding on the foliage of various crops, including rice, corn, and different grass species.

The Philippines experienced outbreaks of several *Spodoptera* species, including *S. exigua* (Hubner), or onion or beet armyworm, which caused an outbreak in 2016 (Navasero 2017; Navasero et al. 2019), and remains a significant pest problem in onion cultivation in Central Luzon. The fall armyworm (FAW), *S. frugiperda*, caused damage in 2019 and remains an invasive pest of corn (Navasero et al. 2019).

The life cycle of *Spodoptera* species follows the typical pattern of lepidopteran insects, passing through egg, larval, pupal, and adult stages. Larvae, commonly known as armyworms due to their tendency to move in large groups resembling an advancing army, are the most destructive stage of the insect. Feeding voraciously on plant foliage, particularly during early crop stages, can cause significant defoliation and yield losses.

The economic impact of armyworm infestations can be severe, resulting in reduced yields, increased production costs, and economic losses to farmers, especially in regions where agricultural crop cultivation is a primary source of livelihood (Sampiano 2026; Navasero et al. 2019; Navasero 2017; Nueva Ecija Provincial Agriculture 2016). Among these species, *S. pecten* is considered an emerging pest of corn and other crops in Southeast Asia, and its increasing occurrence in the Philippines poses potential risks to crop productivity and pest management programs. Moreover, the reliance on chemical insecticides for pest control raises concerns about environmental pollution, human health risks, and the development of insecticide resistance in armyworm populations. Understanding the biology of *S. pecten* is therefore important for accurate identification, monitoring, and the development of effective control strategies.

Efforts to manage armyworm infestations often involve integrated pest management (IPM) strategies incorporating cultural, biological, and chemical control methods (Machado et al. 2020). Cultural practices such as crop rotation, intercropping, and the use of resistant crop varieties can help reduce the vulnerability of crops to infestation. Biological control agents, including natural enemies such as parasitoids and predators, offer environmentally friendly alternatives to chemical pesticides.

Despite these control efforts, the adaptability, high mobility, polyphagous nature, and rapid reproductive potential of armyworms present challenges for effective pest management (Sampiano 2026). For example, the rapid spread of the fall armyworm (*S. frugiperda*) across the Philippines and its invasion into the Davao Region, feeding aggressively on young leaves, whorls, tassels, and ears causing visible damage such as window paning, ragged cuts, and heavy defoliation that can lead to great losses; coupled with vulnerability of Davao Region's agricultural system across diverse cropping systems, and risks on over reliant to chemical -based control, led to urgent need for region-specific management strategies (Sampiano 2026). Continued research into the biology, ecology, genetics, and behavior of this species is essential for the development of sustainable and resilient agricultural systems capable of mitigating the threats posed by armyworms to global food security and livelihoods.

Recently, egg masses of *S. pecten* from leaves of yellow duranta and mulberry plants in the Philippines were collected for the first time, but these were initially mistaken for the eggs of *Spodoptera litura*, a highly polyphagous and destructive pest in the Philippines (Gabriel 2000) due to the profuse covering of the egg masses. Reports show this species is similar to *Spodoptera mauritia* but slightly smaller (Holloway 1976) and has been reported as a pest of corn in Malaysia and rice in several Asian countries (CABI 2022). Adult males of *S. pecten* are characterized by bipectinate antennae, a feature that distinguishes them from several related *Spodoptera* species with filiform antennae. The adults also exhibit brown forewings with relatively less variegated patterning compared with *S. mauritia*, and

hindwings lacking the strong dark delineation of veins present in that species. In addition, genitalic characters provide reliable identification, with the species exhibiting distinctive structures in both male and female genitalia that are commonly used in taxonomic diagnosis of *Spodoptera* species (Holloway 1976). It was later identified as *Spodoptera pecten* Guenée by molecular analysis (Guerrero et al. 2024).

This study sought to investigate some basic aspects of the biology and rearing of *S. pecten* under laboratory conditions in the Philippines. As a major pest of corn and other crops, understanding its developmental stages and morphological characteristics is important for improving pest management strategies. Specifically, this study aimed to: (1) determine the different life stages, fecundity, longevity and sex ratio of *S. pecten* on a native variety of corn; (2) describe the changes in color, size, and habits during development; (3) determine morphometric measurements at specific growth stages.

## MATERIALS AND METHODS

**Test insects.** Eggs masses of *S. pecten* were collected on leaves of *Duranta erecta* L. (Verbenaceae) and reared in the laboratory from August to December 2024 at the National Crop Protection Center, College of Agriculture and Food Science, University of the Philippines Los Baños.

Fresh corn leaves (IPB var 6) were washed thoroughly and air-dried to ensure cleanliness before offering as food for the neonate larvae (Navasero and Navasero 2020). Once the larvae reached the third instar stage, they were reared individually in Petri plates to avoid any potential cannibalism, competition or interference during feeding and development. Fresh corn leaves, which were both fresh and surface-sterilized, and offered to the larvae daily until pupation.

Pupae were carefully managed and placed in Petri plates for holding before transferring to Mylar cages to facilitate adult eclosion. Adults mated, and females laid eggs on leaves of corn, establishing a colony inside these cages.

Throughout the rearing process, the setups were kept within a temperature range of 27-29°C, with a relative humidity (RH) maintained at 60-70%, as in FAW (Navasero and Navasero 2020). Additionally, a photoperiod of 12 hours of light followed by 12 hours of darkness (12D:12L) was maintained to mimic natural light cycles and support normal developmental processes.

### Biological Characterization

**Life history.** A pair of adults was caged, with 10 pairs prepared in this manner following the method of Navasero and Navasero (2020) for *S. frugiperda*. These cages, with a diameter of 9 cm, were lined with wax paper above, below, and along the sides to serve as a substrate for oviposition.

The cluster of eggs was individually placed in a Petri dish lined with filter paper moistened with distilled water, where it remained until hatching. From these eggs, 60 neonates were individually transferred onto Petri plates, and fresh corn leaves were offered as food until pupation. The molting, growth, and development of the larva, the need to replace food, were observed and recorded daily. Pupation and eclosion to the adult stage were also recorded. Details in the appearance, color, and hair cover of the egg/egg mass, including the incubation period, characteristics of each larval instar, and the pupal period, were observed and described.

Furthermore, the pre-oviposition, oviposition, and post-oviposition for female adults and the longevity of both male and female adult individuals were recorded by monitoring their lifespan from emergence to death. During the oviposition periods of female adults, fecundity was monitored daily until females stopped laying eggs. Egg hatchability was another parameter monitored and recorded.

**Laboratory mass rearing technique.** The rearing setup consisted of improvised rearing pans (45 cm long, 10 cm high, and 30 cm wide), with aeration windows (22 cm x 14 cm) covered with fine-mesh muslin (used for rearing *S. frugiperda* in Navasero and Navasero 2020). The container was provided with a paper towel, although plain paper could also be used as a lining, which served to collect larvae's excreta and absorb excess moisture, making disposal easier. Before reuse, the containers were properly cleaned and disinfected. A paper towel was placed over the top of the pan before securing the cover to prevent small larvae from escaping.

### Rearing procedure

**Adult pairing.** Newly emerged adults (a female and a male moth) were placed in mating/oviposition cages with cotton balls soaked in a 20% sugar solution for nourishment, following the method of Navasero and Navasero for *S. frugiperda*. Once the females started to lay eggs, each pair was gently moved to a different cage equipped with the same setup, and the egg masses were then collected in a Petri plate for holding. For mass rearing, eggs laid up to the 3rd or 4th day were used.

**Larval feeding and pupation.** Ten to fifteen young corn seedlings, cut at the base and aged 10-15 days after sowing (DAS), were provided per pan to feed approximately 500-1,000 neonate larvae. After 24 hours, five pieces of newly harvested corn stalks were added to replace the spent ones. This routine was repeated every 24 hours, with fresh corn stalks replacing the old ones, which were then carefully removed. At the 3rd instar stage, the larvae in culture were divided into two groups. Another division occurred after an additional 3-4 days, and further splitting was performed as needed. When pre-pupae were observed, these were separated into rearing containers for holding until pupation. Pupae were then transferred to a separate cage for eclosion to adults, initiating another rearing cycle.

**Statistical analysis.** Mean values and standard deviations for the data on life history, body measurements of *S. pecten* were calculated using Microsoft Excel.

## RESULTS AND DISCUSSION

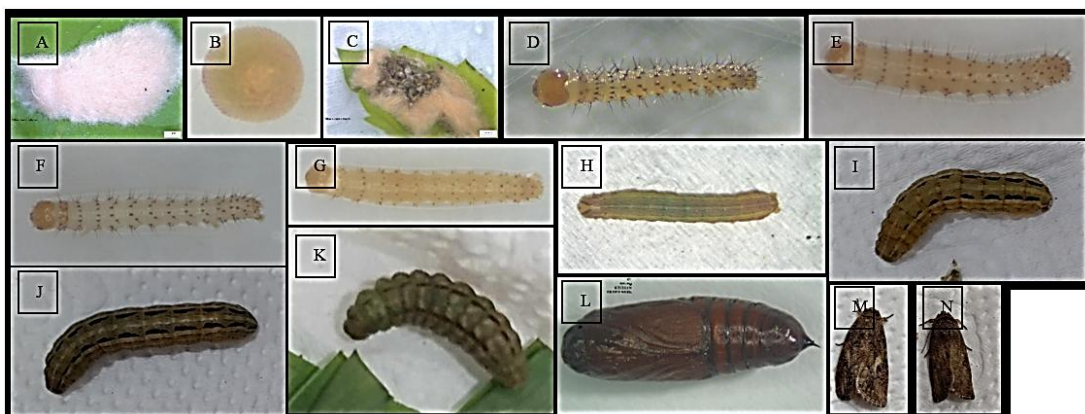
### Life history of *S. pecten*

**Eggs.** Eggs of *S. pecten* exhibited distinctive characteristics, being spherical or slightly flattened, with a smooth surface and initially displayed a pale coloration. As these matured, their color gradually darkened (Fig. 1 A-C). These eggs were typically laid in clusters, covered with thick hairs. These were commonly found on the undersides of leaves of various host plants, such as corn, mulberry, yellow duranta, or other suitable substrates like muslin cloth, wax paper, or Mylar plastic, within the oviposition cage. On average, the eggs measured  $0.44 \pm 0.01$  mm (Table 1). In the laboratory setting, the incubation period for the eggs typically ranged from three to five days ( $X=3.15 \pm 0.53$ ) (Table 2).

**Table 1.** Measurements (mm) of the egg, larval instars, pupae, and adults of *Spodoptera pecten* reared on corn under laboratory conditions.

Developmental Stage	Parameter	Mean±SD
Egg	Width	0.44±0.01
Larva		
1 <sup>st</sup> instar		
Head capsule	Width	0.25±0.01
Body	Length	2.17±0.20

<b>Developmental Stage</b>	<b>Parameter</b>	<b>Mean±SD</b>
	Width	0.34±0.04
2 <sup>nd</sup> instar		
Head capsule	Width	0.43±0.07
Body	Length	3.28±0.20
	Width	0.55±0.05
3 <sup>rd</sup> instar		
Head capsule	Width	0.72±0.09
Body	Length	6.31±0.57
	Width	1.08±0.17
4 <sup>th</sup> instar		
Head capsule	Width	0.96±0.09
Body	Length	9.09±0.75
	Width	1.51±0.13
5 <sup>th</sup> instar		
Head capsule	Width	1.52±0.35
Body	Length	15.34±1.83
	Width	2.42±0.32
6 <sup>th</sup> instar		
Head capsule	Width	2.50±0.13
Body	Length	25.59±3.81
	Width	4.31±0.27
Pupa		
Male	Length	13.17±0.70
	Width	4.50±0.20
Female	Length	13.52±0.85
	Width	4.69±0.33
Adult		
Male		
Wing expanse	Wing expanse	31.45±1.25
Female		
Wing expanse	Wing expanse	30.68±3.88



**Figure 1.** *Spodoptera pecten*: A. egg-mass, B. Egg, C. eggs hatching, D. and E. 1<sup>st</sup> instar, F. 2<sup>nd</sup> instar, G. 3<sup>rd</sup> instar, H. 4<sup>th</sup> instar, I. 5<sup>th</sup> instar, J. 6<sup>th</sup> instar, K. pre-pupa, L. pupa, M. male adult, N. female adult

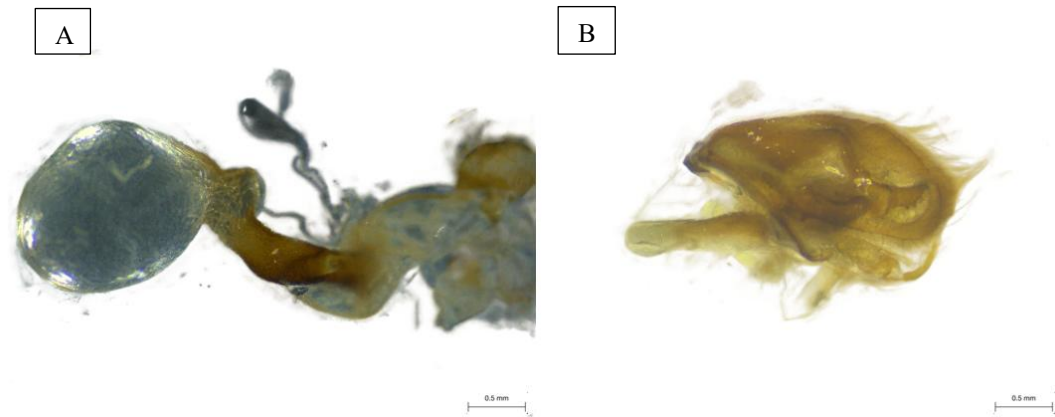
**Larval stage.** During the larval stage, newly hatched larvae were tiny, hairy, and pale in color with olive brown heads and whitish V-shaped sutures (Fig. 1D-E). These often exhibited gregarious behavior, congregating in large groups, and displayed a characteristic looping motion when agitated. As the larvae progressed through development, they underwent distinct instar stages, with each instar marked by specific morphological, size, and behavioral changes. For instance, the second instar (Fig. 1F) appeared less hairy and lacked the looping habit when crawling, until the third instar (Fig. 1G). Upon reaching the fourth instar until the sixth (Fig. 1H-J), larval skin became smooth. The coloration of larvae varied, encompassing shades of green, brown, or black, often with intricate patterns and markings.

One notable feature was the presence of distinct longitudinal stripes that run along the body, providing camouflage and aiding in their concealment among foliage. Additionally, rows of tubercles, small protuberances on the larvae's body, were observed, each bearing setae or tiny hairs.

**Pupal stage:** Non-feeding stage, typically oblong, reddish-brown or dark brown in color, and had a smooth, cylindrical shape, with distinct segmentation and appendages (Fig. 1H). Inside the pupal case, the adult structures developed, including wings, legs, antennae, and reproductive organs. The duration of the pupal stage varied. Initially, the pupa was greenish yellow, turning reddish-brown and finally blackish, before eclosion into the adult stage.

**Adult stage:** Upon emergence from the pupal case, adult moths had wings covered in scales, which varied in coloration and pattern but often included shades of brown, gray, or tan, with distinctive markings (Fig. 1 I-J), darker in males. The wingspan of adult moths ranged from approximately 30-40 mm for males and females. The antennae of the male moth are combed-like. Adult moths are equipped with mouthparts adapted for feeding on nectar from flowers, although they did not feed extensively. Moths are nocturnal. The adults exhibited brown forewings with relatively less variegated patterning compared with *S. mauritia*, and hindwings that lack the strong dark delineation of veins present in that species (Holloway 1976).

The genitalia of the male and female adults are shown in Figure 2, similar to those illustrated by Holloway (1976) for *S. pecten*.



**Figure 2.** Genitalia of *Spodoptera pecten*: A) female and B) male. (Photo credits: Maricon dP. Javier).

Table 2 shows the durations of the different life stages of *S. pecten*. The eggs and the first three larval instars had the same durations. The combined duration of the fourth and fifth instar was as long as the 6<sup>th</sup> instar. The pre-pupal period was about  $1.22 \pm 0.47$  d while the pupal period was  $9.48 \pm 0.77$  d. Total larval period was 17.71d and total development period was  $30.32 \pm 0.54$ d.

The pre-oviposition ( $3 \pm 2$  days) and post-oviposition ( $0.83 \pm 0.72$  d) periods were observed on *S. pecten*. The oviposition period was  $2.27 \pm 1.71$  d.

Fecundity of females exhibited a wide variability in the number of eggs laid throughout their lifetime, ranging from 91 to 1278 eggs, with a mean of  $477 \pm 381.58$  eggs). Adult male longevity was  $7.47 \pm 1.35$  days, and female longevity was  $6.93 \pm 2.10$  days; the sex ratio (male:female) was 1.2:1.

**Table 2.** Duration (in days) of the egg, larval instars, pupa, and post developmental stages of *Spodoptera pecten*.

Developmental Stage	Range (days)	Mean $\pm$ SD
Egg	3-5	$3.15 \pm 0.53$
Larva		
First instar	3-5	$3.05 \pm 0.31$
Second instar	3-4	$3.02 \pm 0.16$
Third instar	2-5	$3.27 \pm 0.71$
Fourth instar	1-4	$2.10 \pm 0.74$
Fifth instar	1-4	$2.76 \pm 0.66$
Sixth instar	3-6	$4.39 \pm 1.09$
Pre-Pupa	1-2	$1.22 \pm 0.47$
Total larval period	14-18	$17.71 \pm 1.01$
Pupa	8-11	$9.48 \pm 0.77$

Developmental Stage	Range (days)	Mean $\pm$ SD
Pre-oviposition period	0-7	3 $\pm$ 2
Oviposition period	0-4	2.27 $\pm$ 1.71
Post oviposition	0-2	0.83 $\pm$ 0.72
Total developmental period (Egg-Adult)	30-32	30.34 $\pm$ 0.54

**Mass rearing of *S. pecten*.** Survivability of larvae was 90 percent, pupation of survivors was 100 percent, and eclosion into adults was 100 percent (Fig. 3).

Only approximately 54.7% of the eggs laid by females of *S. pecten* in this study are fertile, indicating that a significant portion of the eggs may not successfully hatch or develop into viable offspring. This observation underscores the importance of factors such as mating success, environmental conditions, and physiological state in determining the fertility and reproductive output of female *S. pecten*. Likewise, the lifespan of male and female *S. pecten* individuals reveals interesting patterns. While both sexes exhibit relatively short lifespans, with males typically living between 4 to 12 days and females between 4 to 10 days, males tend to live slightly longer on average than females. This disparity in lifespan between the sexes may reflect differences in energy allocation, reproductive strategies, or susceptibility to environmental stressors (Cui et al. 2018).



**Figure 3.** Set-up for mass rearing *Spodoptera pecten*: a) fresh young corn leaves, b) young corn leaves in a rearing pan, c) larvae with newly replenished food, d) covered rearing pan, e) sorting of larvae based on instar, f) pupation in rearing pans, g) pooled pupae from rearing pans, h) oviposition cage with adult males and females on young leaves of corn as oviposition substrates.

The immature feeding stages (larvae) of *S. pecten* underwent six instars on corn. However, in other species of *Spodoptera*, some authors have reported five to eight larval instars, on corn for *S. exigua*, attributed to the quality of the host plant, differences in geographic population, presence of hairs on leaves, variability or reduction of nutritional quality of host plant species (Azida and Sofian-Azirun 2006).

The duration of the immature stages of *S. pecten* resembled those described of the same genus for other species of *Spodoptera*, and whose larvae fed with various host plants such as *S. frugiperda*, and *S. albula* (Montezano et al. 2013), *S. frugiperda* on corn and *S. exigua* on cabbage leaves (Azidah and Sofian-Azirun 2006) *S. litura* on castor leaves (Sharma et al. 2025), asparagus (Ye et al. 2022), and other host plants (Sultan et al. 2020). Despite the similarities, several authors have shown a great variation in the duration of the life cycle of the *Spodoptera* species, as influenced by the larval diet (Ye et al. 2022; Mehta et al. 2021; Silva et al. 2019).

The pre-oviposition and post-oviposition periods, as described, are integral components of the reproductive cycle of *S. pecten*, shedding light on the timing and dynamics of egg-laying behavior. With a mean duration of  $3 \pm 2$  days, the pre-oviposition period denotes the timeframe leading up to egg-laying, during which females prepare for reproduction. Similarly, the post-oviposition period, averaging  $0.83 \pm 0.72$  days, occurs immediately after egg-laying and likely involves recovery or recuperation. Notably, both these periods are slightly shorter than the oviposition period itself, which spans approximately  $2.27 \pm 1.71$  days. This discrepancy suggests that the act of egg-laying is the most time-intensive phase within the reproductive cycle of *S. pecten*.

Moreover, the observation that the pre-oviposition period in *S. pecten* is longer than the post-oviposition period implies a significant aspect regarding the sexual maturation of females. A longer pre-oviposition period indicates a more extended period required for females to reach sexual maturity and readiness for reproduction (Milonas et al. 2011). This suggests that females undergo a process of physiological development and preparation before they become capable of laying eggs. This finding underscores the importance of understanding the reproductive biology and life history traits of *S. pecten*, as it provides insights into the factors influencing population dynamics, reproductive success, and potentially, strategies for pest management or conservation efforts.

## CONCLUSION

Some basic aspects of the biology and rearing of *S. pecten* under laboratory conditions in the Philippines were investigated. The species completed its development from egg to adult in about 33 days under laboratory conditions, with eggs hatching in about 3 days, six larval instars lasting about 2–4 days each, and a pupal period of about 9 days. High larval survival, pupation, and adult emergence demonstrated its adaptability to corn, despite moderate egg viability. The rearing protocol provides a foundation for future studies on host range, natural enemies, and integrated pest management strategies, and the biological data generated here are essential for predicting population outbreaks and designing effective control measures for this emerging pest in the Philippines.

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Conceptualization: MMN, MSG, MdPJ; Study design: MMN, MSG, MdPJ; Sample collection: MMN, MSG, MdPJ; Conduct of experiment: MMN, MSG, MdPJ; Data curation: MdPJ; Visualization: MMN, MSG, MdPJ; Formal analysis: MdPJ; Supervision: MMN, MSG; Writing – Original draft preparation: MMN, MSG, MdPJ; Writing – Review and editing: MMN, MSG