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BIOLOGY OF THE RED- STRIPED SOFT SCALE INSECT, *Pulvinaria tenuivalvata* (Newstead) (HEMIPTERA: COCCIDAE), AN EMERGING PEST OF SUGARCANE IN THE PHILIPPINES

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ABSTRACT

The red-striped soft scale insect, *Pulvinaria tenuivalvata* (Newstead), has recently become a major threat to sugarcane production in the Philippines, causing concern among growers in Luzon and Negros Island regions. The present study was undertaken from August 2025 to January 2026 to document the biology of the pest on sugarcane under laboratory conditions. The results revealed that the incubation period of the egg was 2 to 3 days. The nymphs passed through three nymphal instars, with durations of 5 to 6 days each for the first and second nymphal instars, and 4 to 5 days for the third nymphal instar. The total nymphal period lasted about 16 to 19 days. All adults produced were females; the young adult female lasted 8 to 15 days, mature adult 17 days and senescing adult lasted 14 days. Total adult period was 44 to 46 days. Total developmental periods (egg to death) were 63 days. The number of eggs produced by female adults was about 197 eggs. All progenies observed were females, confirming parthenogenetic reproduction, thelytochus type. Extensive morphological and behavioral observations, supported by photographic documentation, revealed gradual changes in color, body shape, and dorsal features from hatching to adult maturity, providing critical baseline data for identifying life stages and monitoring population development. The information generated on durations of developmental stages, reproductive capacity, and adult longevity is essential for understanding population dynamics and predicting infestation patterns. These findings are particularly important for timing control measures, targeting vulnerable stages, and evaluating the potential role of biological control agents under Philippine conditions. The results also provide a scientific basis for developing monitoring protocols, improving identification of developmental stages in the field, informed decision-making, and the development of sustainable approaches to managing *P. tenuivalvata* populations and minimizing potential impacts on sugarcane productivity and farmers' income.

Key words: developmental period, invasive pest, parthenogenesis, *Saccharum officinarum*

INTRODUCTION

Pulvinaria tenuivalvata (Newstead) (Hemiptera: Coccomorpha: Coccidae), commonly referred to as the red-striped soft scale insect (RSSI; also referred to as red-striped soft scale, RSSS, in earlier literature; Watson and Foldi 2002), is becoming one of the most important invasive, polyphagous insect pests attacking sugarcane in the Philippines. It poses a threat to sugarcane cultivation, alarming growers in Luzon Island (Navasero et al. 2023; Guerrero et al., 2024) and Negros Island region (SRA 2025). Originally recognized as a major pest in Egypt since the mid-1990s, the species damages sugarcane directly by sap extraction and indirectly by honeydew excretion, which promotes sooty mold growth, interferes with photosynthesis, causes leaf withering, and reduces yield and sucrose content (Watson and Foldi 2002; Ghabbour and Hodgson 2000; Ali et al. 2000).

Pulvinaria tenuivalvata was described by Newstead in 1911 as *Lecanium tenuivalvatum* on citronella grass and elephant grass in Uganda and was later redescribed and illustrated by De Lotto in 1965 and Williams in 1982 (Ghabbour and Hodgson 2000). A key was provided by Williams (1982) as cited by Ghabbour and Hudson (2000) for the five species of *Pulvinaria* infesting Poaceae, namely, *P. iceryi* (Signoret), *P. sorghicola* De Lotto, *P. elongata* Newstead, and *P. tenuivalvata* (Newstead). Moreover, Ghabbour and Hodgson (2000) described and illustrated mounted specimens of the three nymphal instars of *P. tenuivalvata* with an accompanying key while Abdel-Razak et al. (2017) provided a detailed redescription and illustration of the adult female. A related name, *Pulvinaria saccharia* De Lotto, 1964, described from sugarcane in South Africa, was later synonymized with *P. tenuivalvata* (Abdel-Razak et al. 2017). Several misidentifications have also been recorded in the literature, including *Pulvinaria elongata* (Karem and El-Kahier 1992) and *Saccharolecanium krugeri* (Ali et al. 1997), underscoring the taxonomic complexity of the species.

Pulvinaria tenuivalvata is widely distributed across Africa and parts of Asia, with records from Egypt (El-Serwy et al. 2008; Ghabbour and Hodgson 2002; Watson and Foldi 2002), Ethiopia (De Lotto 1959), Kenya (De Lotto 1966), Mali (Ben-Dov 1993; Gavrilov-Zimin and Stekolshikov 2018), Senegal (Étienne and Matile-Ferrero 1993), Sierra Leone (Ben-Dov 1993), South Africa (De Lotto 1964), Tanzania (Ben-Dov 1993), Uganda (De Lotto 1965; Newstead 1911; Sasscer 1912), Zimbabwe (Hodgson 1967a; Hodgson 1969a), and the Philippines, where it has been documented in Luzon (Navasero et al. 2023) and Negros (Mago 2025). The species exhibits a broad host range across at least three plant families, with a strong association with Poaceae. Major hosts include sugarcane (*Saccharum officinarum*) (De Lotto 1964; De Lotto 1966; El-Serwy et al. 2008; El-Shazly et al. 2005; Hodgson 1967a), rice (*Oryza sativa*) (Étienne and Matile-Ferrero 1993; Williams 1982), maize (*Zea mays*) (El-Shazly et al. 2005), sorghum (*Sorghum bicolor*) (Étienne and Matile-Ferrero 1993), and several grasses such as *Cymbopogon citratus* (De Lotto 1965; Newstead 1911), *Imperata cylindrica* (El-Shazly et al. 2005), and *Pennisetum purpureum* (Gowdey 1917). Additional hosts from other families include *Convolvulus arvensis* (Convolvulaceae) (Abd-Rabou and Evans 2021) and *Sida acuta* (Malvaceae) (Navasero et al. 2023), indicating its polyphagous nature and capacity to persist in diverse agroecosystems. The morphology and systematics of *P. tenuivalvata* have been well studied (Watson and Foldi 2002). Diagnostic characters distinguishing this species from closely related taxa, such as *Saccharolecanium krugeri*, include differences in spiracular setae, dorsal setae morphology, leg proportions, claw dentition, and anal opening structure (Watson and Foldi 2002; Ali et al. 1997). The adult female is elongate-oval, measuring approximately 3.4–6.5 mm in length, with a membranous derm, shallow anal cleft, and poorly developed stigmatic clefts.

Soft scale insects (Hemiptera: Coccidae) constitute a diverse and economically important group of sap-feeding insects, many of which are serious agricultural pests (Kakoti et al. 2023). Continuous taxonomic studies have revealed considerable diversity within this group, with new species and genera still being described from different regions of the world (Kondo et al. 2026).

Sugarcane, *Saccharum officinarum* L. (Poaceae) and several other grasses, such as *Imperata cylindrica* (L.) Beauv. have been documented as host plants of *P. tenuivalvata*. However, studies have demonstrated a strong preference for sugarcane, emphasizing its economic importance (Abdel-Rahman et al. 2016). In the Philippines, additional host plants serving as bridging hosts—*Megathyrsus maximus*, *Rottboellia cochinchinensis*, and *Sida acuta*—have been reported in infested sugarcane fields (Navasero et al. 2023; Guerrero et al. 2024).

The pest is active from May until December (Ghabbour and Hodgson 2000; Watson and Foldi 2002). It is parthenogenetic, and each female produces about 200 eggs. The RSSI is attacked by several aphelinid endoparasitoids, the more important are *Coccophagus scutellaris* (Dalman) and *Coccophagus semicircularis* (Förster) (Hymenoptera: Aphelinidae), which may kill up to 70% of the scales (Abd-Rabou 2011, 2008; Shalaby and Saleh 2009). Earlier, El-Samea (2006) reported an indigenous species, *Coccophagus ochraceus* Howard, as endoparasitoid of RSSI but not evaluated its impact on the pest. The neuropteran *Nimboa adelae* (Monserrat) (Neuroptera: Coniopterygidae) was also reported as a predator of RSSI in Egypt (El-Serwy and Monserrat 2009). These natural enemies can play important roles in biological control when conserved or incorporated into integrated pest management programs. A proper understanding of soft scale insect biology is essential for accurate identification of the different nymphal stages, which are critical for monitoring pest populations and determining appropriate management timing (Ghabbour and Hodgson 2000; Abdel-Razak et al. 2017). Although Abd El Samea (2004) reported on the biological parameters of *P. tenuivalvata* reared on sugarcane under laboratory conditions in Egypt, the data generated cannot apply under Philippine conditions due to differences in environmental conditions, variety and cultural practices, among others, in sugarcane cultivation. This study, therefore, aims to generate local data on life history traits and habits/behavior that are crucial for the development of effective strategies for managing pest populations in sugarcane fields in the country.

The importance of this study lies in addressing the urgent need for locally generated scientific information on the biology, ecology, and behavior of *P. tenuivalvata* under Philippine agroecological conditions. As the pest continues to expand its distribution in major sugarcane-growing regions, the absence of region-specific biological data limits the development of effective monitoring systems, economic threshold levels, and integrated pest management (IPM) strategies. Understanding the pest's life history traits, including reproductive capacity, seasonal activity, and developmental stages, will allow for accurate timing of control measures, particularly targeting vulnerable nymphal instars thereby improving management efficiency and reducing unnecessary pesticide applications.

Moreover, documenting the pest's interaction with local natural enemies and environmental factors is essential to evaluate the potential role of biological control agents under Philippine conditions. While parasitoids such as *Coccophagus scutellariss* (Dalman) and *Coccophagus semicircularis* (Förster) have demonstrated significant impact elsewhere (Abd-Rabou 2011; Shalaby and Saleh 2009; Abd-Rabou 2008), their effectiveness, establishment, and ecological compatibility in local ecosystems remain insufficiently understood. Generating such knowledge can support the conservation or introduction of beneficial organisms and strengthen sustainable pest management approaches.

In addition, the economic implications of *P. tenuivalvata* infestation underscore the importance of this research. By reducing photosynthetic efficiency through honeydew accumulation and sap depletion (Ghabbour and Hodgson 2000; Watson and Foldi 2002), the pest directly threatens yield and sucrose content (Ali et al. 2000), which may affect farmer income, milling efficiency, and overall sugar industry productivity. Localized research will enable the formulation of evidence-based recommendations tailored to Philippine sugarcane varieties, climatic conditions, and cultivation practices, ensuring that management strategies are practical and effective for growers.

This study aimed to characterize the biology, developmental stages, and reproductive capacity of *Pulvinaria tenuivalvata* on sugarcane under laboratory conditions and to generate baseline information useful for pest monitoring and integrated pest management development. The study contributes to the scientific understanding of this emerging invasive pest by providing essential biological data needed for the development of effective management strategies. Addressing existing knowledge gaps, the findings support early detection, evidence-based decision-making, and the development of long-term integrated pest management approaches aimed at minimizing economic losses while promoting environmentally sound control practices.

MATERIALS AND METHODS

Test insect. Samples of *P. tenuivalvata* were obtained from the existing population in the screenhouse, collected from sugarcane fields in Batangas and Laguna, Luzon Island, Philippines which have been maintained since 2023 until now. The use of an established colony ensured a continuous and reliable source of experimental insects, allowing consistency in observations while minimizing variability associated with newly collected field populations. Maintaining the colony over an extended period also enabled the insects to acclimatize to controlled laboratory rearing conditions, thereby facilitating detailed monitoring of their developmental stages and biological traits.

The insects were reared at 27–29°C at 60–70% RH, and 12D:12D photoperiod, to approximate environmental conditions favorable for sugarcane cultivation and scale insect development. Maintaining stable temperature, humidity, and light regimes allowed the study to minimize environmental variability and ensured that observed biological responses were attributable primarily to intrinsic developmental processes rather than external fluctuations. Such controlled rearing conditions are essential for generating reproducible data on life history traits, developmental timing, and behavior, which are critical for understanding the biology of *P. tenuivalvata* and for developing effective management strategies.

Life history study. Infested leaves of sugarcane from the greenhouse were detached and brought to the laboratory to allow close handling and standardized processing under controlled/laboratory conditions. Adult females were turned upside down using a micro pin, and the eggs were dislodged onto small plastic plates for holding and incubation. This careful manipulation ensured minimal damage to the eggs while allowing efficient collection and separation from the maternal body. Isolating the eggs on plastic plates provided a clean and observable environment where hatching could be monitored accurately.

After hatching, any remaining unhatched eggs were carefully removed using a fine-pointed camel's hairbrush, and the plate containing the crawlers was placed between the leaf and stem of a potted seedling to allow them to transfer freely onto the plant. The use of a soft camel's hairbrush minimized physical injury to delicate crawler-stage nymphs, which are highly mobile yet fragile. Positioning the plates between the leaf and stem simulated natural conditions and encouraged voluntary movement of crawlers onto the host plant, reducing handling stress and ensuring successful establishment. At least 200 crawlers per potted sugarcane seedling were transferred in this manner to maintain adequate sample size and to ensure sufficient individuals for monitoring survival, development, and behavioral observations. Ten potted seedlings were prepared and labeled consecutively from 1 to 10.

After 24 h of infesting newly hatched crawlers and daily thereafter, 20 individuals were observed under the microscope, and pictures were taken using an iPad attached to the microscope (Zeiss, Stemi 305). The initial 24 h interval allowed the crawlers to settle and establish on the host plant before detailed observations commenced, ensuring that measurements and documentation reflected normal development rather than handling-induced stress. Daily observations thereafter enabled continuous tracking of morphological changes and developmental progression throughout the insect's life cycle.

Microscopic examination provided clear visualization of external morphological features, while digital imaging facilitated accurate documentation of each developmental stage. Measurements of the head, body length, and body width (in millimeters) were taken from individual images to ensure precision and consistency. Using photographic records minimized repeated handling of live specimens and allowed measurements to be verified or reanalyzed, if necessary, thereby improving data reliability.

Molting events were closely monitored, and the developmental periods and durations of the different stages (in days) were recorded and computed. Careful documentation of each molt made it possible to distinguish between successive instars and to determine the length of time spent in each stage. These data are essential for understanding growth patterns, stage-specific development rates, and the timing of vulnerable life stages that may be targeted in management strategies.

Morphological documentation. From the day of hatching until the death of the last adult in the culture, at least 20 individuals were photographed daily using an iPad attached to a microscope to document salient behavioral patterns and morphological changes throughout the life cycle of RSSI. Continuous photographic documentation from emergence to adult death ensured that all developmental stages were recorded systematically, allowing detailed observation of gradual morphological transformations as well as behavioral patterns associated with feeding, movement, settlement, and molting. This approach provided a visual record that complemented numerical measurements and facilitated accurate stage identification, particularly for subtle transitions between instars.

Capturing images throughout the life cycle also allowed comparison among individuals and across time, helping to identify variation in development and behavior within the population. The use of an iPad attached to a microscope enabled efficient image capture while maintaining sufficient magnification and clarity for analysis, ensuring that fine morphological features could be examined without excessive disturbance to the insects. Photographic records further served as permanent reference material that could be used for validation, illustration, and future comparative studies involving RSSI or related scale insect species.

About 3,000 photographs were taken from the egg stage until death of RSSI, representing a comprehensive visual dataset documenting the biology of the species under laboratory conditions. This extensive collection of images supports accurate interpretation of life history traits and provides valuable material for describing morphological characteristics, developmental stages, and enhancing understanding of the habits and behavior of RSSI throughout its life cycle.

Oviposition in RSSI. Adult female RSSI were monitored for oviposition from the day they molted into adults until the end of their lifespan. Eggs were observed on the ventral aspect of the female body and made visible by gently puncturing the cuticle using a bent micro pin. Dislodged eggs were collected onto small plastic plates for incubation. After hatching, the remaining unhatched eggs were removed using a fine-pointed camel's hairbrush, and crawlers were transferred onto potted sugarcane seedlings to allow natural settlement and feeding. The number of eggs and timing of oviposition were recorded daily, and representative photographs of egg deposition and ovisacs were captured using an iPad attached to a microscope. Counting started on the fourth day after molting of the third nymphal instar into young adult until the 29th day, allowing documentation of the onset, duration, and pattern of oviposition under laboratory conditions (27–29°C, 60–70% RH, 12D:12D photoperiod). Daily egg counts from the fourth day until the 29th represented the total number of eggs laid per female throughout its reproductive period.

Longevity of RSSI adults. Adult female RSSI were monitored from the day of adult emergence until death. Individuals were maintained on potted sugarcane seedlings under laboratory conditions (27–29°C, 60–70% RH, 12D:12D photoperiod). Daily observations were made to record survival, and any morphological or behavioral changes were documented. Photographs of at least 20 individuals were taken using an iPad attached to a microscope to capture developmental and behavioral traits throughout their lifespan. Adult longevity was recorded in days for each individual RSSI until all test insects had died. Adult longevity was recorded, providing information on the lifespan of adult females under controlled conditions. This parameter is critical for estimating reproductive potential and population growth, especially for a parthenogenetic species such as *P. tenuivalvata*.

Statistical analysis. The experiments were laid out in Completely Randomized Design (CRD). Mean values and standard deviations for the data on egg, nymphal and adult measurements, and egg counts of *P. tenuivalvata* were calculated to summarize developmental characteristics and variability among individuals. These descriptive statistics were essential for interpreting developmental trends, comparing life stages, and presenting quantitative evidence supporting the biological observations generated in the study. Two trials were conducted to validate the consistency and reproducibility of the observations, allowing comparison between trials and strengthening the robustness of the results generated from the study.

RESULTS AND DISCUSSION

Life cycle of RSSI. The RSSI underwent the egg, three nymphal instars, and adult stages observed across the two trials in the biological culture experiment, and the life cycle is shown in Figure 1.

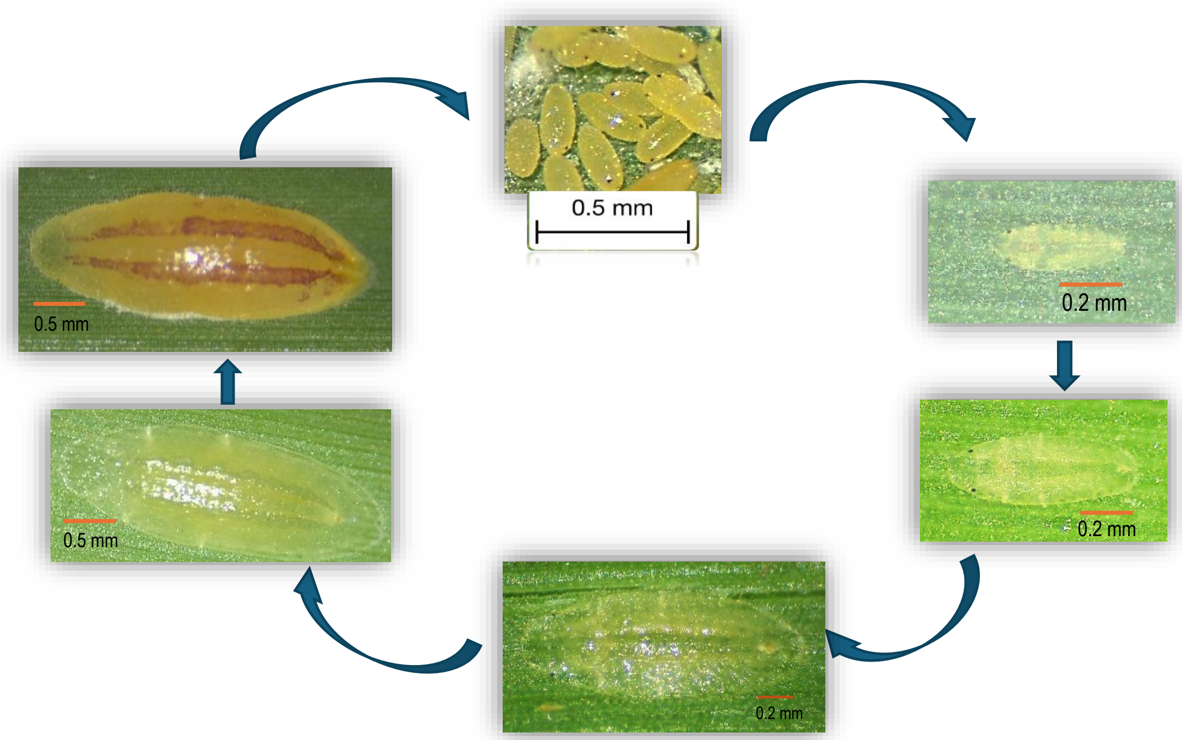

Figure 1. Life cycle of *Pulvinaria tenuivalvata*: a) eggs, b) first instar nymph, c) second instar, d) third instar, and adult (e) young, f) mature

The egg. Eggs are small, cylindrical with rounded ends; light yellow when newly laid turning darker when about to hatch (Fig. 2 and Table 1). The anterior portion of the egg is visible through two dark eye spots on the dorsum; each 0.27±0.01 mm in length and 0.12±0.00 mm in width; hatched in 2 to 3 days.

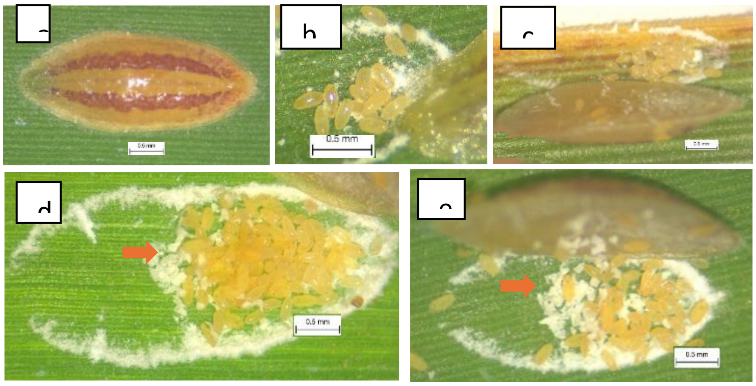

Figure 2. Eggs of (a) *Pulvinaria tenuivalvata*: b, c) newly laid eggs, d, e) egg clusters with newly hatched neonates as indicated by white chorions (orange arrows).

The nymph. No significant changes in body color among the nymphal instars were observed, except for the first instar or crawler stage (Fig. 3). The first-instar nymphs exhibit yellowish body color upon hatching, transforming to hyaline after 48 hours (Fig. 3a). First-instar nymphs with a very long apical seta on each anal plate. The initial yellowish coloration likely reflects newly emerged crawler-stage physiology, while the transition to a hyaline appearance indicates cuticular development and adaptation after settlement. This change may also be associated with feeding initiation and stabilization on the host plant.

However, upon transforming or molting to the second-instar nymph, subtle changes were observed, such as the eyes becoming smaller but solid, observed along the lateral side of the dorsum (Fig. 3b), accompanied by an elongated body form and settlement in a preferred feeding site toward the midrib on the nether surface of sugarcane leaf. These morphological changes suggest progression toward a more sessile feeding habit, with structural adaptations that favor attachment and sustained sap feeding. The third-instar nymph is similar in color and shape to the second-instar nymph but larger in size (Fig. 3c) and likewise settled on the preferred feeding site, indicating continued growth without dramatic external color differentiation. The body of the three nymphal stages was generally flattened, a characteristic that may facilitate close adherence to the leaf surface and reduce exposure to environmental disturbances.

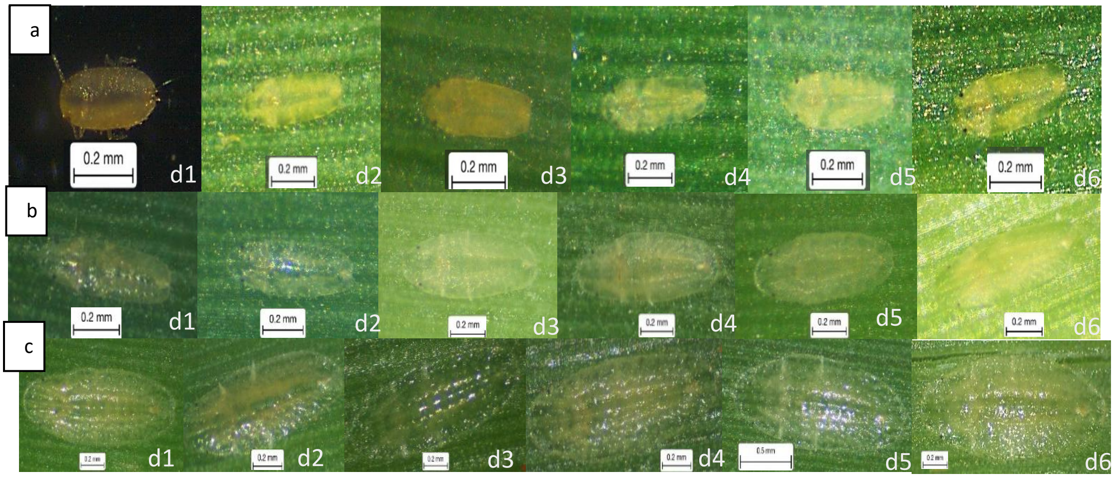

Figure 3. *Pulvinaria tenuivalvata*: first instar nymph (a) at day 1 to 6 (d1 to d6); second instar (b) at day 1 to 6 (d1 to d6); and third instar (c) at day 1 to 6 (d1 to d6).

The crawler stage or first-instar nymph is highly mobile, settling only for a while to suck plant sap then moved again upward along the leaf and settled when about to molt to the second instar. The preferred site was usually the youngest leaf along the midrib, and at the middle part of the nether surface. Nevertheless, both the second- and third-instars nymphs are stationary in their feeding sites, but changed feeding sites when disturbed, indicating retained mobility despite their tendency toward a more sedentary lifestyle. This behavior suggests an adaptive response that allows individuals to relocate to favorable feeding positions or escape unfavorable conditions. The first- and second-instar nymphs with attached molted skin on their dorsum, with very thin, hyaline-white chlorotic exuviae that were readily dislodged when touched or agitated are shown in Figure 4. The presence of exuviae provides clear visual confirmation of molting events and served as a useful diagnostic feature for identifying recently molted individuals.

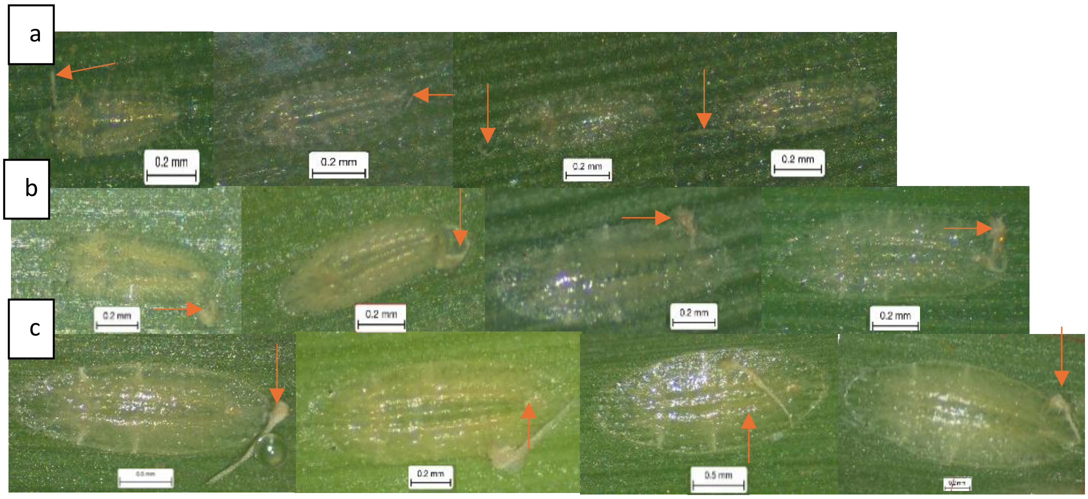

Figure 4. Representative samples of molting in *Pulvinaria tenuivalvata*: from first instar to second (a), second instar to third (b), and third instar to adult (c). Molted skin indicated by an arrow

The adult female. The elongated body of the young adult female was initially light yellow (Figure 5a), which later becomes convex and darker, with two distinct longitudinal light red to deep red stripes on the dorsum (Figure 5b and 5c). These progressive changes in body shape and pigmentation reflect maturation and physiological development toward the adult reproductive stage. The scale oviposited into a thin, whitish ovisac surrounding the periphery of the female's body (Figure 6). The microscopic morphological features of the adult RSSI (dorsal setae conical; the ventral tubular ducts narrow, submarginal, and the anal plates longer than wide) have been discussed in Navasero et al. (2023) and Guerrero et al. (2024). These morphological characteristics are important diagnostic features for species identification and provide additional confirmation of RSSI identity while also describing structural adaptations associated with reproduction, protection, and secretion. Such morphological structures are widely used as key diagnostic characters in the taxonomy and identification of soft scale insects (Coccidae), where detailed examination of dermal structures and tubular ducts is essential for distinguishing species and understanding relationships among taxa (Kondo et al. 2026).

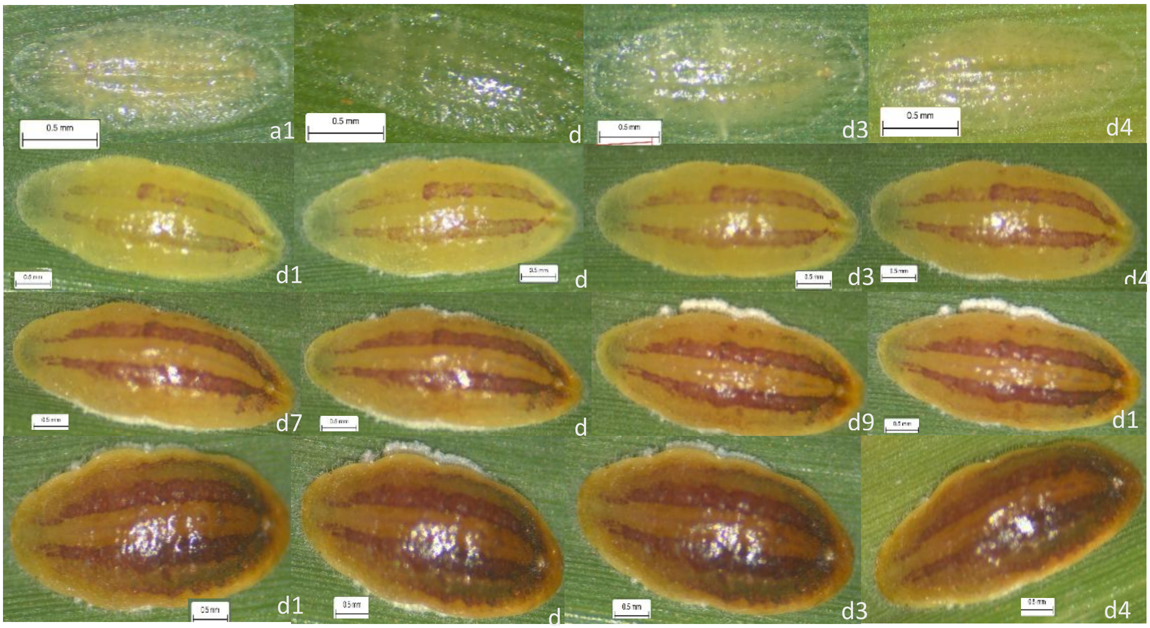

Figure 5. Adult female morphology of *Pulvinaria tenuivalvata*. (a) Newly emerged young adult female with an elongated, light-yellow body; (b) female exhibiting distinct longitudinal light red dorsal stripes; (c) female showing prominent deep red dorsal stripes along the dorsum.

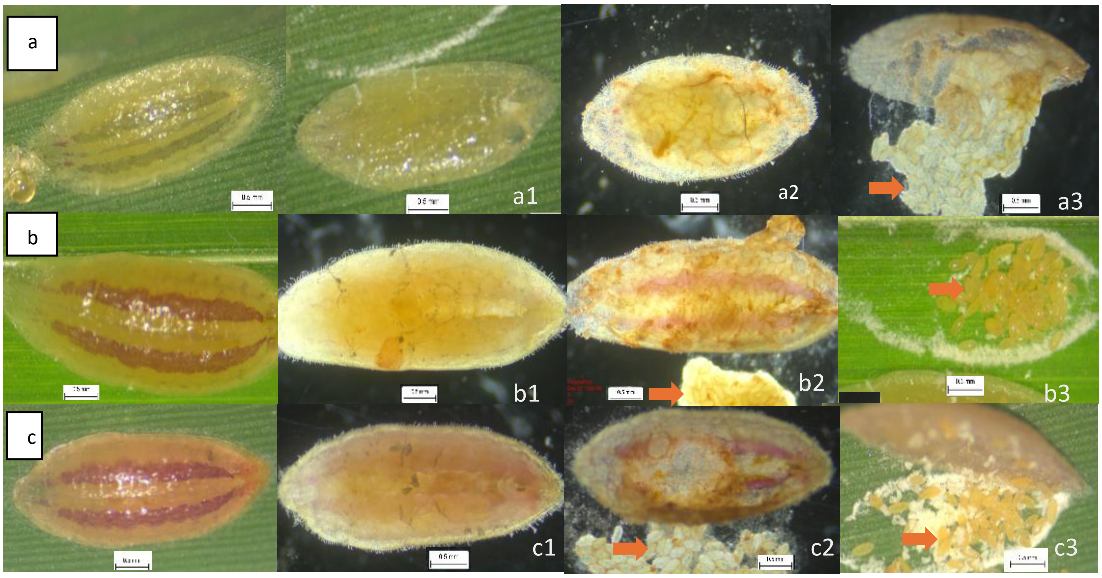

Figure 6. *Pulvinaria tenuivalvata*: Dorsal (a), ventral (a1), developing eggs (a2), and exposed immature eggs of young adult (a3); dorsal (b), ventral (b1), developing eggs (b2), and exposed laid eggs (with arrow) of a mature adult; dorsal (c), ventral (c1), developing eggs (with arrow) (c2), and exposed newly-hatched and about to hatch eggs (c3).

The measurements and durations of the different life stages of RSSI are shown in Tables 1 and 2. The molting process from the nymphal stages to adult is shown in Figure 4.

Table 1. Measurement of the different developmental stages of *Pulvinaria tenuivalvata*

Developmental Stage	Mean+SD		
	Body Length (mm)	Body Width (mm)	
		Thorax	Abdomen
Egg	0.27 ± 0.01 (L) 0.12 ± 0.00 (W)		
First instar	0.49 ± 0.08	0.17 ± 0.03	0.17 ± 0.08
Second instar	0.78 ± 0.09	0.28 ± 0.08	0.26 ±0.04
Third instar	1.11 ± 0.20	0.39 ± 0.07	0.37 ± 0.07
Young adult	2.96 ± 0.46	1.18 ± 0.17	1.14 ± 0.20
Mature adult	3.91 ± 0.44	1.48 ± 0.19	1.99 ± 2.36
Senescing adult	3.99 ± 0.35	0.89 ± 0.08	0.97 ± 0.04

L= Length: W= Width of egg

Table 2. Duration in days of the different life stages of *Pulvinaria tenuivalvata.*

Developmental Stage	Days
Egg	2-3
Nymph	
First Instar	5-6
Second	5-6
Third	4-5
Total nymphal period	16-19
Adult Female	
Young Adult	8-15
Mature Adult	17
Senescing Adult	14
Total Adult Period	44-46

The observed developmental stages of *Pulvinaria tenuivalvata* under Philippine conditions consisted of the egg stage, three nymphal instars, and adult female stage, which is consistent with earlier reports from Egypt describing the general developmental pattern of the species (Abd El-Samea 2004; Ghabbour and Hodgson 2001). The total nymphal period observed in the present study ranged from 16–19 days, while the total adult period ranged from 44–46 days. Comparable developmental durations were also reported in Egyptian populations of *P. tenuivalvata*, although slight variations in developmental time may occur due to differences in environmental conditions, host plant quality, and laboratory rearing conditions (Abdel-Moniem 2003; Abd El-Samea 2004). The progressive increase in body size from first instar to mature adult observed in this study likewise agrees with previous descriptions of the species, where gradual enlargement and morphological differentiation accompany each molt (Ghabbour and Hodgson 2001).

Changes in morphology of RSSI particularly in color, size, and salient features of the dorsum were captured in more than a thousand photographs. The extensive photographic documentation provided a comprehensive visual record of developmental progression, allowing detailed observation of gradual changes that may be difficult to describe through measurements alone. Capturing variations in color enabled clear differentiation between developmental stages and maturation phases, while monitoring changes in size supported quantitative assessment of growth patterns throughout the life cycle. Similar observations on morphological progression and developmental changes of *P. tenuivalvata* were reported in Egypt, particularly on the immature stages and external morphology of the species (Ghabbour and Hodgson 2001; Abdel-Razak et al. 2017).

The focus on salient features of the dorsum allowed identification of diagnostic morphological traits, such as body shape, pigmentation patterns, and structural characteristics that become more pronounced as individuals develop from nymphs to adults. These visual records facilitated accurate comparison among individuals and between developmental stages, helping to confirm stage transitions, molting events, and maturation processes. The large number of photographs ensured that subtle variations and representative conditions were documented, reducing the likelihood of observational bias.

Representative samples illustrate key morphological transformations and serve as reference images for describing the life history of RSSI (Figs 2, 3, 4 and 5). These visual documentation is particularly valuable for future taxonomic verification, training purposes, and in aiding researchers and field practitioners in recognizing developmental stages and identifying the pest accurately under both laboratory and field conditions. Detailed morphological documentation of developmental stages is particularly valuable for scale insects, where subtle morphological characters are essential for accurate species identification and comparison with related taxa (Kondo et al. 2026).

Reproduction in RSSI. The RSSI reproduced without mating due to absence of males, and all progenies produced were females. This method of reproduction is called thelytokous type of parthenogenesis. This was also reported in *Pulvinaria psidii* (El-Menshawy and Moursi 1976), a highly polyphagous pest of guava, among other crops in the Philippines (Gabriel 1997) and *P. floccifera*, an important pest in Egypt (Abd-Rabou et al. 2012). The main advantages of thelytoky include increased population growth, easier establishment in new environments, and the ability to maintain highly adapted genotypes. Parthenogenetic reproduction is relatively common among scale insects and contributes to rapid population growth and successful establishment in new environments (Gullan and Kosztarab 1997).

Eggs of adult female RSSI were observed faintly on the ventral aspect of the body, and by puncturing the skin using a bent micro pin, eggs were easily seen and counted (Fig. 6 and Table 3). The faint visibility of the eggs beneath the ventral surface indicates internal egg development prior to or during oviposition, and the use of a bent micro pin allowed gentle manipulation without excessive damage to the specimen. This method facilitated clear visualization and confirmation of reproductive status, enabling accurate documentation of egg presence and developmental timing within the adult stage.

Eggs were usually observed within the ventral aspect of the abdomen on the 24th day after hatching or after 8 days of becoming a young adult (Table 3). On the 9th day, an average of 21.33±18.90 eggs were dissected; 50.20±31.78 on the 14th day; 84.60±28.70 on the 19th day; 237.86±153.64 on the 24th day; 255.60±53.36 on the 30th day; and 245±131.87 on the 34th day. However, eggs were laid on the 19th day (Table 3) until the 34th day of observation. In total, an average of 197 eggs were produced by a single adult female. The timing suggests that reproductive maturity occurs shortly after adult emergence, reflecting the rapid onset of oviposition typical of parthenogenetic scale insects. Monitoring this period provided valuable information on reproductive biology, including the onset and duration of egg production, which is essential for understanding population growth dynamics. Observations extending until the 63rd day of the culture (day when the body of dead adult become detached from the leaf surface) ensured that the entire reproductive phase was captured, allowing assessment of the length of the oviposition period and contributing to a more comprehensive understanding of the life history and reproductive behavior of the species.

Table 3. Egg counts of adult *Pulvinaria tenuivalvata* dissected from the abdomen and those laid within the egg sac, including hatched eggs (crawlers).

Age of female adult (days)	Day of dissection	Mean+SD		
		Number of eggs dissected	Number of eggs laid	Number of eggs hatched
4	1	0	0	0
9	5	21.33 ± 18.90	0	0
14	10	50.20 ± 31.78	0	0
19	15	84.60 ± 28.70	3.00 ± 0.00	0
24	20	237.86 ± 153.64	30.14 ± 29.47	22.86 ± 19.08
30	25	255.60 ± 53.36	31.4 ± 5.77	17.2 ± 7.76
34	29	245 ± 131.87	27.6 ± 14.50	16.40 ± 4.72

Longevity of adult RSSI. Adult female RSSI lived for more than a month in the experimental samples. However, it was observed from the stock culture that adult lived for more than sixty days, monitored from about 20 marked adults. These observations suggest that when RSSI is not disturbed and the host remained healthy, RSSI lived longer. This extended lifespan indicates a prolonged reproductive phase, allowing females sufficient time to produce and deposit eggs, which contributes to the rapid increase and persistence of populations under favorable conditions. Longer adult longevity may also enhance the pest's capacity to establish stable infestations in sugarcane fields, particularly because individuals remain actively feeding and secreting honeydew over an extended period.

The duration of adult survival is an important biological parameter, as it influences reproductive output, population dynamics, and the timing of management interventions. A lifespan exceeding one month suggests that adult females can overlap with multiple developmental cohorts, potentially leading to continuous infestation pressure. Understanding adult longevity, therefore, provides critical insight into the life cycle of RSSI and supports the development of effective monitoring and control strategies, particularly in determining optimal timing for targeting earlier developmental stages before populations expand significantly. Information on adult longevity and reproductive timing also enhances understanding of population growth potential, particularly considering the parthenogenetic nature of the species, which may facilitate rapid establishment and spread in sugarcane fields.

CONCLUSION

This study documented the life history and biological characteristics of the red-striped soft scale insect, *Pulvinaria tenuivalvata*, under Philippine conditions. The results confirmed that the insect undergoes egg, three nymphal instars, and adult stages and reproduces through thelytokous parthenogenesis, enabling rapid population increase. To our knowledge, this is the first report documenting thelytokous parthenogenesis and complete developmental biology of *P. tenuivalvata* under Philippine conditions. The information generated on developmental stages, reproductive biology, and morphological changes represents the first detailed report of these biological characteristics of *Pulvinaria tenuivalvata* under Philippine conditions and provides important baseline knowledge for accurate life-stage identification and a better understanding of the population dynamics of this emerging sugarcane pest. These findings contribute to improving monitoring systems by providing accurate diagnostic information on the developmental stage and reproductive biology of RSSI and can support the development of integrated pest management strategies for *P. tenuivalvata* in Philippine sugarcane production systems by enabling timely detection, stage-specific control measures, and improved population assessment in the field. The results also provide a scientific basis for informed decision-making and sustainable approaches aimed at minimizing the potential impacts of *P. tenuivalvata* on sugarcane productivity and farmers' income. Further studies on the pest's biology on alternative grass hosts and under different host-plant conditions may help refine management strategies and enhance long-term control efforts.

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