CHARACTERIZATION OF *Pulvinaria tenuivalvata* (Newstead) (HEMIPTERA: COCOMORPHA: COCCIDAE), ITS DAMAGE, ENDOPARASITOID, AND BRIDGING HOSTS, AS A NEW AND EMERGING PEST OF SUGARCANE IN LUZON ISLAND, PHILIPPINES

Michelle S. Guerrero[1*], Randolph N. Candano[1], Normandy M. Barbecho[1], Jerrimae A. Vicente[2], Agnes M. Casupanan[2], Melissa P. Montecalvo[1], Romalene L. Miras[1], Gideon Aries S. Burgonio[1], Maricon dP. Javier[1], Jose Mari M. Navasero[1], Raphael Henri B. Mundo[2], Barbara L. Caoili[1] and Marcela M. Navasero[1]

[1]National Crop Protection Center, College of Agriculture and Food Science, University of the Philippines Los Baños, College, Laguna, Philippines 4031

[2]Sugar Regulatory Administration - Luzon Agricultural Research and Extension Center, Floridablanca, Pampanga, Philippines 2006

*Corresponding author: msguerrero1@up.edu.ph

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ABSTRACT

The red-striped soft scale insect, *Pulvinaria tenuivalvata* (Newstead), has recently emerged as a significant pest of sugarcane (*Saccharum officinarum* L.) in Luzon Island, Philippines. Initially observed in June 2022, this pest has quickly spread, with recent detections in Calamba City, Laguna. Despite its growing impact, there is a significant lack of studies on *P. tenuivalvata* in sugarcane, making this the first study to investigate its occurrence and potential threat to sugarcane production in the region. The red-striped soft scale specimens were collected in Pampanga in September 2023, and subsequently processed in the laboratory. Morphological and molecular characterizations were conducted to identify this new pest of sugarcane. Notably, natural control measures are at play, as an endoparasitoid has shown parasitism rates exceeding 30% in Sugarcane Regulatory Administration - Luzon Agricultural Research and Extension Center (SRA-LAREC) and 67% in Porac, Pampanga. Furthermore, mycosed *P. tenuivalvata* were collected and processed for possible infection by entomopathogenic fungi. In addition, possible bridging hosts of *P. tenuivalvata* which are associated with sugarcane production were listed and identified. Prevalent diseases in sugarcane were also observed. This study recommends urgent actions and strategies including rapid pest assessment, strategic release of parasitoid, capacity building on pest diagnostics, and comprehensive research and development. These measures are crucial for mitigating the impact of *P. tenuivalvata* and ensuring sustainable sugarcane production in the Philippines.

Key words: pest identification**,** red-striped soft scale

INTRODUCTION

Sugarcane, *Saccharum officinarum* L., holds significant agricultural importance in the Philippines by directly supporting the livelihoods of approximately 700,000 Filipinos in farming and over 25,000 in sugar mills and refineries. Additionally, around five million are indirectly employed within this industry (UPLB-CEM 2019). Recently, a pressing issue has arisen with the infestation of a red-striped soft scale pest in sugarcane crops in Tarlac, Pampanga, Laguna, and Batangas, necessitating immediate attention (Navasero et al. 2023). The initial detection of this insect pest occurred in Bacolor, Pampanga, in June 2022. Subsequently, formal documentation of its presence was made within the Sugarcane Regulatory Administration - Luzon Agricultural Research and Extension Center (SRA-LAREC) screen house in February 2023, with the first official report from Balayan, Batangas. Moreover, reports from various municipalities in Pampanga have underscored the widespread occurrence and gravity of the infestation. Other affected municipalities include Porac and Maliwalu in Pampanga, Calaca in Batangas, and Capas in Tarlac (SRA-LAREC 2023). Recent sightings of the pest on sugarcane in Calamba, Laguna were also reported.

The red-striped soft scale or sugarcane soft scale emerged as a significant sugarcane pest in Egypt (Watson and Fonti 2002) since its initial observation in 1992 when it was named *Pulvinaria elongata* Newstead (Karam and Abu-Elkhair 1992; Ghabbour and Hudgson 2001; Abdel-Razak et al. 2017). However, the red-striped soft scale found on sugarcane in Egypt is more accurately identified as *P. tenuivalvata* (Watson and Foldi 2002). This pest primarily infests sugarcane leaves, causing sap loss, honeydew production, growth of sooty molds, and, in severe cases, complete yield loss (El-Serwy et al. 2008, Abdel-Razak et al. 2017). Other species of soft scales, such as *Parthenolecanium rufulum*, *Pulvinaria iceryi*, and *Saccharolecanium krugeri*, are also recognized as serious pests in Southern Asia, India, and Turkey (Abdel-Moniem 2003).

Originally described as *Lecanium tenuivalvatum* in Uganda (Newstead 1911), *P. tenuivalvata* underwent further taxonomic examination and was described and illustrated for the first time as *P. saccharia* from leaves of sugarcane in Durban, KwaZulu Natal (South Africa) (De Lotto 1964). De Lotto noted that this new species resembled *P. tenuivalvata* and based his redescription on a single specimen from the locality and host plant (Abdel-Razak et al. 2017). *Pulvinaria tenuivalvata* shares significant similarity with *P. elongata* Newstead, *P. iceryi* (Signoret), *P. saccharia* De Lotto, and *P. sorghicola* De Lotto (Williams 1982). Abdel-Razak et al. (2017) working on a redescription and illustration of the adult female of *P. tenuivalvata* and two paratypes of *P. saccharia,* concluded that *P. saccharia* is a junior synonym of *P. tenuivalvata.* *Pulvinaria elongata* (Newstead) (Karam and Abu-Elkhair 1992) and *Saccharolecanium krugeri* (Zehhntner) (Ali et al. 2000) were found to be misidentifications for *P. tenuivalvata* (Abdel-Razak et al. 2017).

Pulvinaria tenuivalvata has been reported in ten countries including Egypt, Ethiopia, Kenya, Mali, Senegal, Sierra Leone, South Africa, Tanzania, Uganda and Zimbabwe (scalenet.info/catalogue/Pulvinaria tenuivalvata, nd). Its presence was reported to be exclusively in the Ethiopian and Paleartic regions, with the Philippines falling outside its distribution (Kondo and Watson 2022). *P. polygonate* was listed as a pest of caimito, citrus and mango while *P. psidii* on bignay, coffee, duhat, guava, jackfruit as well as caimito and citrus in the Philippines (Gabriel 1997). However, the recent emergence of *P. tenuivalvata* as a significant pest of sugarcane in Luzon Island is a novel occurrence in the Philippines. The detection of this pest is significant as *P. tenuivalvata* has become a major insect pest of sugarcane in Egypt, causing substantial economic losses (Ghabbour and Hodgson 2001). Despite the significant threat of *P. tenuivalvata* to sugarcane production, there is a notable research gap regarding the identification, occurrence, control measures and potential impact of *P. tenuivalvata* on sugarcane cultivation in the Philippines.

In this study, the first documented occurrence of *P. tenuivalvata* as an emerging sugarcane pest in Luzon Island, Philippines was presented. Molecular and morphological identification were conducted to provide insights into the identity of the pest. Nature of damage, population density and precent parasitism of the endoparasitoid were observed and analyzed. Additionally, three potential bridging hosts in sugarcane fields were identified and recommendations were provided for further research and development in this context. This study provides critical insights that contribute to the development of effective management strategies for *P. tenuivalvat*a in sugarcane production.

MATERIALS AND METHODS

Pest samples collected in September 2023 by both LAREC personnel and National Crop Protection Center (NCPC) researchers underwent a comprehensive analysis to ascertain the identity of the soft scale pest affecting sugarcane in SRA-LAREC, Floridablanca, Pampanga, and neighboring regions. This included morphological and molecular characterizations, as well as a rapid assessment of pest population density and its endoparasitoid. Additionally, other pests and diseases affecting sugarcane, along with potential bridging host weeds, were collected in September 2023 for documentation. Observations of field/screenhouse damage on sugarcane were also recorded and documented.

Morphological characterization. The specimens were processed and mounted on microscope slides following the steps outlined by Barbecho and Lit (2015) with some modifications. After macerating the specimens in 10% potassium hydroxide and rinsing in distilled water, these were soaked in acidified 80% alcohol before staining to acidify the cuticle and then after the process to fix and remove excess stain as suggested by Sirisena et al. (2013). Finally, the specimens were mounted on microscope slides in synthetic Canada balsam. The specimens were examined under a trinocular phase-contrast microscope (PrimoStar; Carl Zeiss Microscopy, GmbH, Germany) equipped with a microscope camera (Axiocam ERc5s; Carl Zeiss Microscopy, GmbH, Germany) and processed using an image-processing software (Labscope version 3.2; Carl Zeiss Microscopy, GmbH, Germany). Several images were captured at varying distances of 2 mm and then stacked into a single image using an image-stacking software (Zerene Stacker version 1.04; Zerene Systems LLC, Richland, Washington, USA). Some of the images were post-processed using the Photos application in Windows 11. The specimens were identified by consulting the species descriptions of De Lotto (1964), De Lotto (1965), keys and descriptions of Williams (1982), and the redescription of *P. tenuivalvata* by Abdel-Razak et al. (2017).

Molecular characterization. For molecular characterization, ten young adult individuals of the red-striped soft scale were separately subjected to genomic DNA extraction using the GF-1 Nucleic Acid Extraction Kit (Vivantis Technologies, website). Polymerase chain reaction (PCR) was employed to amplify the partial 28S of the insect. The PCR was carried out by Q-Cycler 96 Thermal Cycler (Hain Lifescience, website). To amplify the target DNA region, forward and reverse primer concentrations of 10 pmol/uL were combined with Taq DNA Polymerase (Biolabs New England, Inc. for a final reaction volume of 25 uL. The primer pairs, 28s3a and 28sb were used to amplify the partial region of 28S using the following PCR conditions: an initial denaturation step at 95°C for 2 minutes, followed by 30 amplification cycles consisting of denaturation at 94°C for 30 seconds, annealing at 48°C for 50 seconds, extension at 72°C for 1 minute and 15 seconds, and a final extension step at 72°C for 10 minutes (Campbell et al. 1994).

The positive amplicon was viewed using 1.2% agarose gel dissolved in TBA and viewed using the gel documentation system. The positive amplicons were sent to Macrogen, a biotechnology laboratory based in South Korea, for nucleotide sequencing. Sequence data were imported as applied biology information (ABI) files into the software package Geneious Prime® 2023.2.1 (Biomatters Ltd., Auckland, New Zealand) (Kearse et al., 2012) and was viewed and edited to obtain high quality sequences of >99% identity. Furthermore, sequence alignment was conducted using the Nucleotide Basic Local Alignment Search Tool (BLASTn) available on GenBank. This analysis was performed on the 761 to 770 bp-long *28S* gene region using data from seven samples. Additional species reference sequences from the genus *Pulvinaria* and the related genus, *Coccus*, were obtained from GenBank to create a comparison of percent identity (percent bases identical) using pairwise matrix.

Population density assessment of the red-striped soft scale and its parasitoid. Investigations were conducted within the screenhouse at SRA-LAREC and at a farmer's field in Porac, Pampanga to evaluate the population density of *P. tenuivalvata* in sugarcane. The following methodology was employed:

Ten random samples of sugarcane leaves infested with the soft scale were carefully clipped from the plants. These samples were placed in plastic bags with aeration tubes to ensure the insects' survival for later observation and counting in the laboratory. From each collected leaf, three leaf sections, each measuring 6cm in length and 1cm in width, were excised. The number of adults and nymphs of soft scale on both leaf surfaces were meticulously recorded. Additionally, the number of parasitized individuals was also counted on the same leaf samples. Percent parasitism was computed based on these observations.

Nature of damage. The study closely monitored sugarcane plants within the SRA-LAREC screenhouse for signs of damage caused by the soft scale pest. This observation sp anned from February 2023 to August 2023. Sugarcane plants were systematically examined for symptoms of damage inflicted by the soft scale pest. The onset of infestation was duly noted and recorded. Special attention was given to the unique feeding damage caused by the soft scale pest. These observations were carefully documented.

Search for potential entomopathogenic fungi. Colonies of soft scale insects were closely examined in the sugarcane leaves during the field collections. A number of soft scale individuals were observed to be covered with fungal growth. Sugarcane leaves with these soft scales, which were potentially infected with entomopathogenic fungi, were carefully cut and placed in a polyethylene bag lined with tissue. After collection, they were immediately brought to the Mycology Laboratory at the National Crop Protection Center, College of Agriculture and Food Science, University of the Philippines Los Baños, College, Laguna, Philippines for microscopic examination and isolation of potential entomopathogenic fungi.

Bridging host. Weeds associated with sugarcane cultivation were investigated and documented to identify potential bridging hosts of the soft scale pest. Weeds growing alongside sugarcane were observed and photographed. These weed species were identified to determine whether these harbored the red-striped soft scale pest. Weed species found to host the pest were collected from the wild and established in pots within a greenhouse for further verification and study.

Observation on other pests and diseases of sugarcane. In addition to the soft scale pest, other insects associated with sugarcane were collected and documented. Diseases observed on sugarcane plants in the field were also documented. These collected samples were subsequently brought to the NCPC laboratory for further examination, isolation, and identification of the causal pathogens responsible for the observed diseases.

The comprehensive assessment and documentation process were conducted to understand the impact of the red-striped soft scale pest on sugarcane, its potential hosts, and its interactions with other pests and diseases in sugarcane cultivation.

RESULTS AND DISCUSSION

Morphological characterization. The morphology of specimens largely conforms to the redescription of *P. tenuivalvata* by Abdel-Razak et al. (2017) (Fig. 1). It is argued that *P. saccharia* is a junior synonym of *P. tenuivalvata* because of the overlapping character traits observed in both species, especially the lanceolate dorsal setae that supposedly characterize *P. saccharia* but were found to be conical, which characterize *P. tenuivalvata,* in two paratypes of *P. saccharia*. This paper follows the premise established by the aforementioned authors that *P. tenuivalvata* is the valid name.

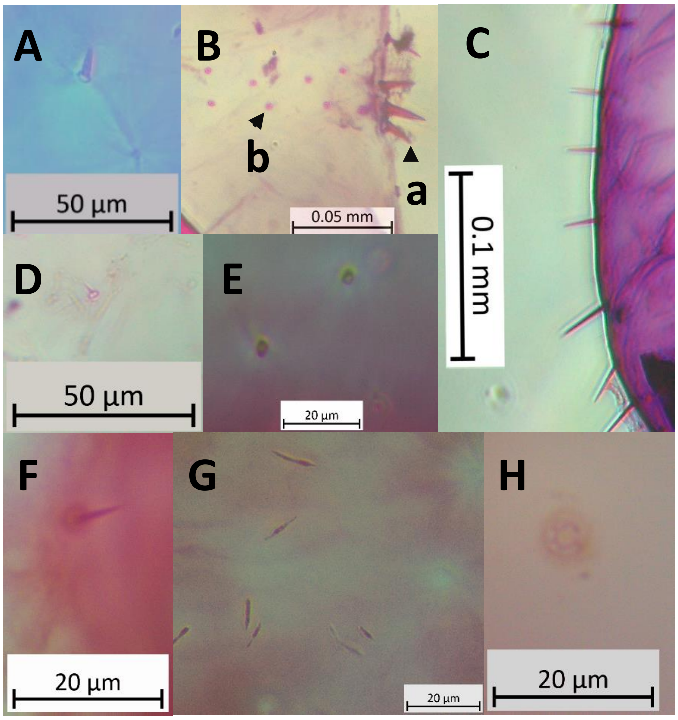

Figure 1. Morphological characteristics of *Pulvinaria tenuivalvata*. A) Dorsal conical seta, B) Poorly developed stigmatic cleft, **a** three stigmatic spines or spiracular setae, **b** quinquelocular spiracular disc pore, C) Marginal setae, D) Dorsal filamentous pore, E) Paraopercular or preopercular pores, F) Ventral submarginal seta, G) Ventral tubular ducts, primarily of type L1, and H) Ventral multilocular disc pore.

Molecular characterization. The utilization of molecular techniques, specifically the use of *28S* molecular marker, has been proven to be instrumental in accurate species identification (Guerrero et al. 2023). Analysis of the nucleotide sequences of soft scale samples utilizing the 28S rRNA genes revealed a high identity match of 99.8 to 100% with *P. saccharia* (GenBank Accession Number JQ651285.1) (Table 1). *P. saccharia* was recognized as a junior synonym of *P. tenuivalvata* (Abdel-Razak et al. 2017). Hence, the soft scale pest affecting sugarcane in SRA-LAREC is confirmed to be the red-striped soft scale, *P. tenuivalvata*. The partial 28S sequences generated from this study were deposited in GenBank as *P. tenuivalvata*, and accession numbers OR625533 to OR625539 were assigned. These accessions are the very first reference sequence for *P. tenuivalvata* using 28S in GenBank, making it a significant scientific contribution.

Pairwise identity matrix revealed a percent identity of only 96% with *Pulvinaria aurantii* Cockerell (Table 2). *Pulvinaria aurantii* is a species of soft scale insect that affects citrus orchards and other host plants (Tanaka and Kamitani 2021). It is known to be a pest of citrus crops, causing damage to leaves, fruits, branches, main stems, trunks, and roots (Tanaka and Kamitani 2021). In addition, it is worth noting that this species differs significantly from two other soft scale species from the genus *Coccus*, with only a 96% identity match to *Coccus praetermissus*, a recently described species based on adult females from Australia, Malaysia, and Thailand (Lin et al. 2017), and *C. hesperidium* L., 1758. *C. hesperidium* is a cosmopolitan and polyphagous species, with extensive studies focusing on its life history, population dynamics, parasitoid wasps, and management (Ben-Dov 1993; Garcia Morales et al. 2016) (Table 2). The pairwise identity results revealed interesting genetic similarity and divergence patterns among the analyzed soft scale species. Further investigation is warranted to determine the similarity in genetic composition of these soft scale species, potentially cryptic and representing the same species.

The comprehensive morphological and molecular characterizations were essential for precisely identifying the soft scale pest infesting sugarcane in the study area. The combination of morphological and molecular analyses enhances the accuracy of species identification and provides valuable insights into its genetic composition and relationships with other soft scale pests.

Table 1. Summary of the most significant BLAST hit of the *28S* gene region of the red-striped soft scale collected in Pampanga, Luzon, Philippines with the published reference sequence from GenBank.

Query Sequence	Percent Identity	E-value	Description	GenBank Accession Number	Author/ Locality, Country
OR625533	99.8%	0	*Pulvinaria saccharia* voucher ARCPPRI SB237_4, partial gene sequence of the 28S ribosomal RNA	JQ651285.1	Sethusa et al. 2014. Malelane, Mpumalanga, South Africa
OR625534	99.8%				
OR625535	99.8%				
OR625536	99.8%				
OR625537	100%				
OR625538	100%				
OR625539	100%				

Table 2. Pairwise alignment of the Philippine soft scale insect collected from sugarcane compared to other *Pulvinaria* and *Coccus* species (MT317046, JQ65128 MT31702 and MF594313).

	C. hesperidum (MT317020)	*C. praetermissus* (MF594313)	*P. aurantii* (MT317046)	***Philippine Soft Scale*** **(**OR625539)	*P. saccharia* (JQ651285)
C. hesperidum MT317020		99	95	**96**	96
C. praetermissus MF594313	99	—	96	**96**	96
P. aurantii MT317046	95	96	—	**96**	96
Philippine Soft Scale OR625539	**96**	**96**	**96**	—	**100**
P. saccharia JQ651285	96	96	96	**100**	

Laboratory assessment of field samples. Colonies of *P. tenuivalvata* were observed from the field samples and the life stages (Fig. 2). Colonies were primarily located on the lower leaf surfaces in the middle leaf portion predominantly consisting of nymphs in the SRA-LAREC screenhouse. However, some colonies were also found at the upper leaf surfaces. Outside the SRA-LAREC greenhouse, colonies were still developing. In barangay Salu, Porac, Pampanga colonies were relatively low, although some samples contained a higher number of nymphs. It was also noteworthy that an endoparasitic parasitoid to have parasitized adult *P. tenuivalvata* in SRA-LAREC and Porac (Fig. 3a and b).

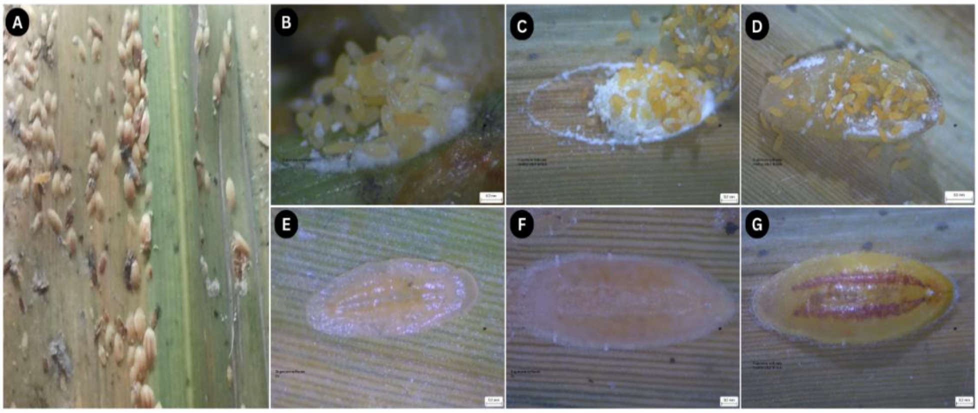

Figure 2. (A) *Pulvinaria tenuivalvata* colonies and its life stages observed in sugarcane plantation in Pampanga. (B) eggs, (C) about to hatch eggs, (D) newly hatched first instar, (E) settled nymph, (F) young adult, and (G) full grown adult female of *Pulvinaria tenuivalvata.* (Photo credit: Maricon dP. Javier and Randolph Candano).

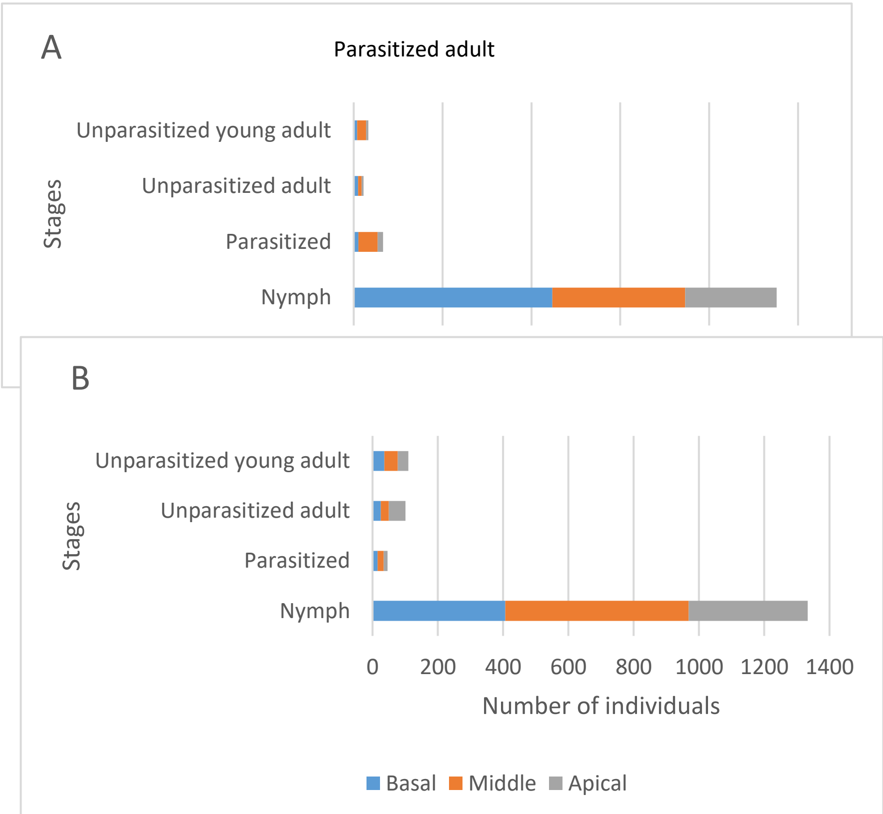

Figure 3. Mean number of nymphs and adults (parasitized, unparasitized) *Pulvinaria tenuivalvata*: A) at Sugar Regulatory Administration-Luzon Agricultural Research and Extension Center, Floridablanca, Pampanga. B) Barangay Salu, Porac, Pampanga.

The endoparasitoid was found to parasitize teneral or young adult soft scale individuals but was not observed on fully mature ones (Fig. 4). The percentage parasitism of *P. tenuivalvata* was 34.85% in the SRA-LAREC screenhouse and higher at 66.8% in farmer's fields in Porac, Pampanga. However, it is worth noting that nymphs, particularly the crawlers, were not parasitized by the endoparasitoid. The role of biotic factors such as the parasitoid *Coccophagus scutellaris* in reducing soft scale population, has been highlighted by Bragard et. al. (2022) offering insights in potential natural control strategies.

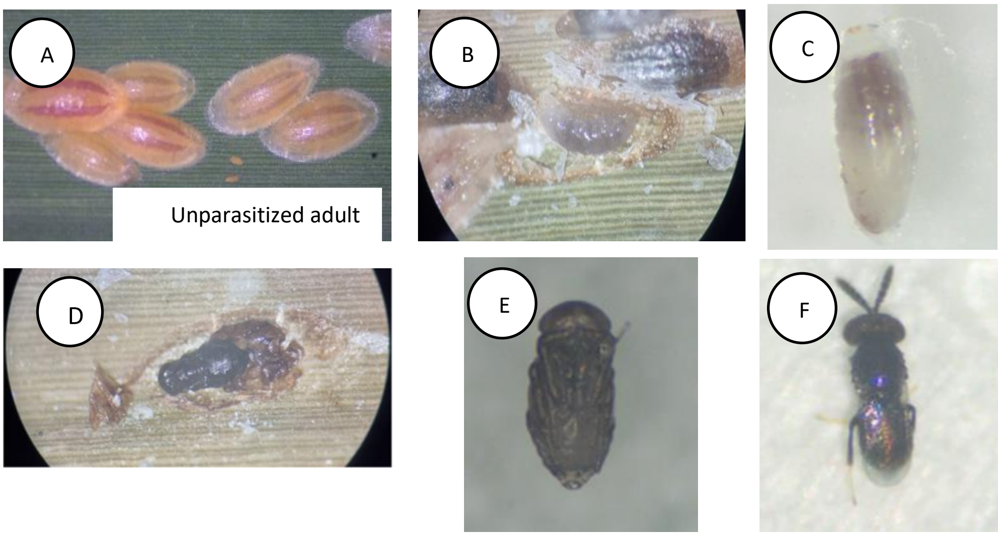

Figure 4. Unparasitized *Pulvinaria tenuivalvata* adults (A), B) parasitized colony, C) larval parasitoid, D) partially exposed pupa of the parasitoid, E) about to emerge pupa, and F) adult parasitoid Hymenoptera (Photo credit: Randolph Candano and Maricon dP. Javier).

Several mycosed red-striped soft scale insects were collected in both the SRA-LAREC screenhouse and sugarcane fields in Porac, Pampanga (Fig. 5). These mycosed soft scales displayed white, pink, and black fungal growth covering their bodies, leading to their demise. These mycosed specimens are currently undergoing processing at the Mycology Laboratory of NCPC-UPLB to isolate and identify potential entomopathogenic fungi. *Beauveria bassiana* (Abdel-Rahman et al. 2017) and *Lecanicillium lecanii* (Schmutterer 2000; Subramaniam et. al. 2021) are some of the entomopathogenic fungi that infect scale insects.

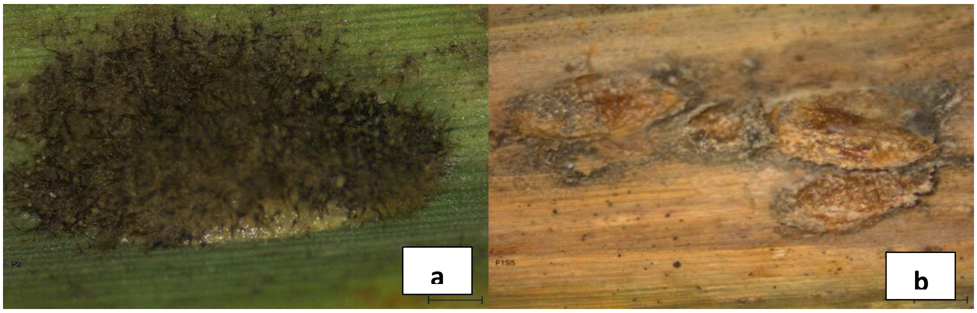

Figure 5. Mycosed red-striped soft scale insects collected in SRA-LAREC screenhouse and sugarcane field in Porac, Pampanga with black (a) and white to pinkish (b) fungal growth were. (Photo credit: Melissa Montecalvo)

Observation of field damage. The damage caused by the red-striped soft scale initially appeared at the lower leaves of sugarcane (Fig. 6). These damage were apparent from the borders of sugarcane fields. When the affected leaves dried-out or detrashed, the nymphs (crawlers) moved to the upper leaves and caused further damage. Susceptible sugarcane varieties were severely impacted, with mature plants hosting significant colonies of *P. tenuivalvata* and associated sooty molds. Current observations show that there is no resistant sugarcane variety against the pest yet. It was observed on Phil 8013, 75-44, 06-2289, 99, other varieties released in 2006, VMC 84524, and other new sugarcane clones that are still being studied for release.

The affected leaves showed chlorosis, which started as yellow, wide streaks that were parallel to the midrib. Compared to other sugarcane diseases, the affected leaves display brighter shades of yellow. Even one single adult soft scale can produce this kind of damage. The chlorotic leaves eventually dried out and drooped. Severe cases of thin and stunted stalks were observed on younger canes than on canes that were already in their stalk elongation stage (4-7 months). During the entire observation period, there were no records of cane mortality rates that can be associated with the pest. However, effects of early soft scale infestation on canes during the germination stage is yet to be done.

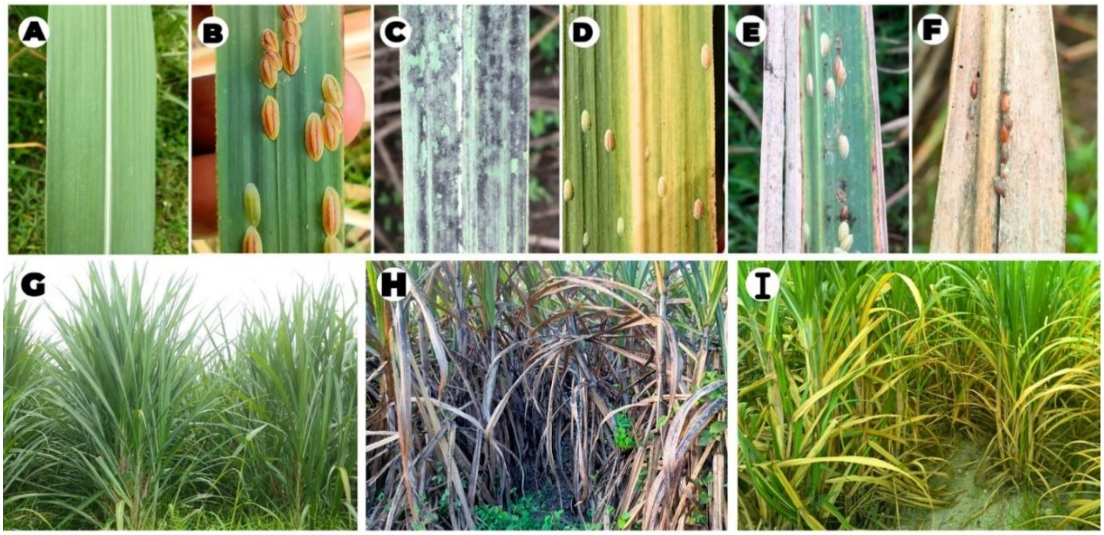

Figure 6. The progression of damage of *P. tenuivalvata* starting from (A, G) healthy leaves. (B) leaf infested with soft scale, (C, H) presence of sooty mold, (D, I) start of yellowing, (E) drying of chlorotic part of leaf, and (F) drying of infested leaves. (Photo credit: Rosemarie Mandac, Jeffrey Serraon and Jerome Mach Perez)

The aforementioned damage of soft scale further affected some yield characteristics of the canes. Infested canes in Balayan, Batangas showed thinning of stalks and stunting of standing canes, which may affect yield and sucrose content but these have not been studied in the country. Earlier studies demonstrated decrease in weight of stalks of infested plants, while glucose and sucrose content were reduced drastically (Dimetry and Abdel-Moniem 2004).

The red-striped sugarcane soft scale is a phloem-sucking insect, obtaining sustenance by piercing and drawing sap from the sugarcane leaves (Abdel-Razak et al. 2017). This feeding process resulted in the impairment of the nutrient translocation process. The pest also excreted honeydew, a sugary, sticky fluid, onto the leaves and stems, which attracted other insects such as bees, flies, and ants. The presence of honeydew also provided a food source for sooty mold fungi, giving the plants a distinct "sooty" black appearance. The sooty molds hindered photosynthesis, adversely affecting the plant's growth. Infested leaves of young seedlings dried up, became covered with sooty molds, and appeared unhealthy within the greenhouse. Sooty molds started to appear after the heavy rains, which provided conducive conditions for fungal growth in the farmers' field. The sooty molds were observed at any stage of the damage progression; but dried out under high temperatures and low relative humidity conditions.

The timing of infestation on the growth stages of sugarcane possibly affects the severity of the soft scale's damage. In cases of other pests and diseases, the most crucial growth stages for infestations are during the germination (1-1.5 months after planting) to tillering stages (1.5-4 months) (SRA 1991).

This field damage observation underscores the economic and agricultural significance of the red-striped soft scale as a pest of sugarcane, highlighting the importance of its management and control in affected areas.

Potential bridging hosts of *P. tenuivalvata*. The red-striped soft scale was found on three (3) out of 31 species of weeds from the sugarcane fields in Pampanga (Table 3) belonging to the 30 genera under 17 families. While few colonies were observed on *Megathyrsus maximus*, *Rottboellia cochinchinensis*, and *Sida acuta,* these weeds are potential bridging hosts of the soft scale pest. However, further verification is required to confirm their role as host plant. These findings represent new host records for the pest. In Egypt, the soft scale pest was recorded on seven plants including five weeds, *Zea mays* L. and *Saccharum officinarum* L. belonging to the Graminae (Poaceae) family (Abdel-Moniem 2003). In the database, three plant families comprising 13 genera, including one Convolvulaceae, one Malvaceae, and 12 Poaceae, are reported as host plants for the soft scale pest (scalenet.info/catalogue/Pulvinaria tenuivalvata/, nd).

This information sheds light on the current state of infestation, the presence of natural enemies like the endoparasitoid and entomopathogenic fungi, and the potential bridging hosts for the red-striped soft scale pest in the study area. These insights are vital for devising effective management strategies and understanding the pest's ecological interactions in sugarcane cultivation.

Table 3. Weeds associated with sugarcane in the SRA-LAREC sugarcane station and Brgy. Salu, Porac, Pampanga.

Family	Scientific name	Common Name
AMARANTHACEAE	*Alternanthera sessilis* (L.) DC.	Sessile joyweed
AMARANTHACEAE	*Amaranthus viridis* L.	Slender amaranth
ASTERACEAE	*Ageratum conyzoides* L.	Billy goat weed
ASTERACEAE	*Cyanthillium cinereum* (L.) H.Robb	Little ironweed
ASTERACEAE	*Tridax procumbens* L.	Coat buttons
CAPPARACEAE	*Cleome rutidosperma* DC	Spindletop
COMMELINACEAE	*Commelina benghalensis* L.	Tropical spiderwort
COMMELINACEAE	*Murdannia nudiflora* (L.) Brenan	Doveweed
CONVOLVULACEAE	*Ipomoea pes-tigridis* L.	Tiger's footprint
CONVOLVULACEAE	*Ipomoea triloba*	Three-lobe morning glory
CUCURBITACEAE	*Coccinia grandis* (L.) Voigt	Ivy gourd
CYPERACEAE	*Cyperus compressus* L.	Annual sedge
EUPHORBIACEAE	*Euphorbia hirta* L.	Snake weed

Family	Scientific name	Common Name
FABACEAE	*Centrosema pubescens* Benth.	Butterfly pea
FABACEAE	*Mimosa pudica* L.	Sensitive plant
LINDERNIACEAE	*Bonnaya ciliata* (Coslm.)Spreng.	Fringe false pimpernel
MALVACEAE	**Sida acuta* Burman f.	Common wireweed
MOLLUGINACEAE	*Mollugo verticillata* L.	Green carpetweed
NYCTAGINACEAE	*Boerhavia erecta* L.	Erect spiderling
ONAGRANACEAE	*Ludwigia hyssopifolia* (G.Don) Exell	Linear leaf water primrose
PLANTAGINACEAE	*Scoparia dulcis* L.	Licorice weed
POACEAE	*Cynodon dactylon* (L.) Pers.	Bermuda grass
POACEAE	*Dactyloctenium aegyptium (*L.) P.Beauv.	Crowfoot grass
POACEAE	*Digitaria ciliaris* (Retz.) Koeler	Southern crabgrass
POACEAE	*Eleusine indica* (L.) Gaertn.	Indian goosegrass
POACEAE	**Megathyrsus maximus* (Jacq.) B.K. Simon & S.W.L Jacobs	Guinea grass
POACEAE	*Panicum repens* L.	Torpedograss
POACEAE	*Paspalidium flavidum* A. Camus	Yellow watercrown grass
POACEAE	*Paspalum distichum* L.	Knotgrass
POACEAE	**Rottboellia cochinchinensis* (Lour.) Clayton	Itchgrass
RUBIACEAE	*Richardia scabra* L.	Mexican clover

*harbored few adults of *Pulvinaria tenuivalvata*

Pulvinaria tenuivalvata infests *Convolvulus arvensis* (Convolvulaceae); *Corchorus olitorius* (Malvaceae); *Andropogon gayanus*, *Arundo donax*, *Brachiaria brizantha*, *Cymbopogon citratus*, *Digitaria sanguinalis*, *Imperata cyndrica*, *Oryza sativa*, *Pennisetum purpureum*, *Saccharum officinarum, S. vulgare* var. *saccharatum* and *Zea mays* (scalenet.info/catalogue/Pulvinariatenuivalvata nd). Seven species of Graminae (Poaceae) were documented as potential hosts, with *Echinochloa crusgalli* and *Cynodon dactylon* being the unlisted species (Abdiel-Moniem 2003). This paper adds three more potential hosts to the list: *Megathyrsus maximus*, *Rottboellia cochinchinensis*, and *Sida acuta.*

Other insect pests and diseases observed in the field. The field observations revealed that the red-striped soft scale pest was found in association with other insect pests of sugarcane, including aphids and mealybugs. Additionally, symptoms of plant diseases were observed on the sugarcane plants. Leaf scorch, characterized as blighting and browning of the leaf blade, was typically observed in older leaves. Fungal structures were also evident on the upper leaf surface. Red rot lesions in the midrib were also evident in sugarcane plants. In addition, small elongated and oval-shaped lesions were observed in leaves.

About 20-40% prevalence of fungal diseases including rust, scorch, and smut was recorded in sugarcane fields (Dela Cueva et al. 2019). Downy mildew is also considered a serious disease. Those previously considered minor diseases have increased incidences such as pokkah boeng and red rot. Incidences of leaf scald, mosaic, and yellow leaf syndrome were also evident in sugarcane fields.

Furthermore, a weed species, *Ludwigia hyssopifolia* was also observed to be symptomatic, implying that it might serve as an alternate host for some of these pests or diseases. Isolation of pure cultures of the pathogens has been initiated for molecular, cultural, and morphological identification of the causal organisms. Pathogenicity tests will be conducted to verify the symptoms and establish the specific causal organism responsible for each disease. These findings underscore the importance of comprehensive disease management and pest control strategies in sugarcane cultivation, as multiple factors, including insect pests and various diseases, can impact crop health and yield.

CONCLUSION AND RECOMMENDATIONS

The comprehensive morphological and molecular characterizations conducted by this study resolved the species of soft scale insect infesting sugarcane as *Pulvinaria tenuivalvata* (Newstead). This identification lays the foundation for the development of effective management strategies for *P. tenuivalvat*a in sugarcane production. The identification of bridging host sheds light into the dynamics of this pest with other hosts. The presence of the endoparasitic parasitoid demonstrates its significant potential for biological control.

Considering the recent emergence of *P. tenuivalvata*, particularly in Luzon, the conduct of rapid assessments to determine the extent of field damage, understand the population dynamics of the pest, and assess the presence of its parasitoid in identified areas are recommended. Similar assessments should be conducted in other sugarcane-producing provinces across Luzon. Regions with substantial sugarcane production, such as Negros Island, the Panay region, Eastern Visayas, and Mindanao, should be vigilant in monitoring potential pest incursions. Strategic releases of parasitoids in regions where these are not yet established should be implemented to reduce pest populations. In addition, future studies should focus on the investigation and identification of potential weed species acting as bridging hosts for the pest in laboratory settings. Training of all stakeholders focusing on pest and parasitoid recognition and identification, practical demonstrations of rapid assessment and strategic parasitoid release is recommended to enhance the knowledge and skills of provincial SRA-LAREC personnel, other research personnel within SRA, as well as provincial and municipal agricultural officers in sugar producing provinces. Lastly, development of a comprehensive research and development plan in collaboration with SRA-LAREC for the long-term management of the red-striped soft scale pest in sugarcane cultivation throughout the country is essential.

These recommendations aim to provide a strategic approach to understanding, managing, and mitigating the impact of the red-striped soft scale pest on sugarcane cultivation in the Philippines. By implementing these measures, the sugarcane industry can work towards sustaining its productivity and reducing the economic impact of this emerging pest.

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