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Biology and predatory potential of *Eocanthecona furcellata* on semi-looper, *Chrysodeixis eriosoma* in Sarangani, Mindanao Island, Philippines

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[2]College of Forestry and Environmental Science, Central Mindanao University. University Town, Musuan, Maramag 8701, Bukidnon, Philippines. Tel.: +63-88-356-1910, Fax.: +63-88-356-1912, ♥♥email: parluchajason@cmu.edu.ph

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Abstract. *Paslon Jr FV, Parlucha JA. 2025. Biology and predatory potential of* Eocanthecona furcellata *on semi-looper,* Chrysodeixis eriosoma *in Sarangani, Mindanao Island, Philippines. Biodiversitas 26: 6197-6204.* Predatory bugs play an important role in Integrated Pest Management (IPM) by naturally regulating populations of agricultural insect pests. Their use promotes sustainable agriculture by enhancing biodiversity and minimizing environmental impact. This study documents the first recorded observation of a predatory stink bug, *Eocanthecona furcellata* in Sarangani Province, Mindanao Island, Southern Philippines, collected from Sunn hemp (*Crotalaria juncea*) fields. The life cycle and predatory potential of *E. furcellata* were assessed under laboratory conditions using the corn semi-looper, *Chrysodeixis eriosoma* as prey. The freshly laid eggs of *E. furcellata* were initially white, gradually turning light brown, and measured 1 mm in length and 0.89 mm in width. Eggs became dark red just before hatching, with an incubation period of six days. The nymphs progressed through five instars, completing their development in an average of 15.7±0.46 days. Adult female *E. furcellata* were larger and lived up to 36.8±1.81 days, while male adult *E. furcellata* had a shorter lifespan of up to 32.3±1.34 days. Predation rates varied significantly among developmental stages, with the fifth-instar nymphs exhibiting the highest predatory efficiency, consuming an average of 23.27 second-instar *C. eriosoma* larvae within 48 hours. The results indicate that *C. eriosoma* serves as a suitable alternative prey for mass-rearing *E. furcellata*. Furthermore, the study highlights the potential of *E. furcellata* as an augmentative biological control agent for managing *C. eriosoma* populations in agricultural ecosystems.

Keywords: Biological control, natural enemies, pest management, predatory bug

INTRODUCTION

The agriculture landscape is heavily reliant on synthetic pesticides to ensure the optimum productivity of economically important crops. As the world's population reaches 8.6 billion in 2030 (UN 2024), efforts from industry, academia, and institutions are in place to ensure agricultural production. Crop yield losses due to plant diseases and insect pests have been estimated to range between 20% and 40% in important food crops like wheat (*Triticum aestivum* L.), rice (*Oryza sativa* L.), maize, (*Zea mays* L.) potato (*Solanum tuberosum* L.), and soybean (*Glycine max* (L.) Merr.) (Savary et al. 2019). This underscores the critical need for effective pest management strategies that integrate the use of both natural and synthetic pesticides. However, overdependence on these synthetic chemicals has changed the agriculture landscape dramatically and fueled agrochemical companies to invest in rigorous research on new molecules that cost roughly USD 286 million for 11 years which were spent on research and development before reaching the market (McDougall 2016). Without the use of pesticides, there would be a 78% loss in fruit production, a 54% loss in vegetable production, and a 32% loss in cereal production (Tudi et al. 2021). However, injudicious use of pesticides accumulate in plant parts, water, soil, air, and biota in due course of time (Sharma et al. 2019). Pesticides can be a threat to aquatic and terrestrial biodiversity and pose a negative impact on human health (Mahmood et al. 2016).

As an alternative, the potential use of entomophagous insects as biocontrol agents can be augmented in the current agricultural system for a sustainable insect pest management program. Entomophagous insects are insect species that derive their nutrition by feeding on other insects. They are natural predators or parasitoids, which play a vital role in maintaining ecological balance through their interactions within multi-trophic systems (Segura et al. 2024). They are widely considered an effective pest control method due to their target specificity, self-perpetuation, and environmental safety (Halder et al. 2020).

To reduce reliance on synthetic insecticides, natural enemies like *Eocanthecona furcellata* (Wolff, 1811) (Hemiptera: Pentatomidae) can be used as an alternative approach to manage the destructive insect pests in agricultural and forest ecosystems. *Eocanthecona furcellata* is a native predator that attacks and kills its prey by first inserting its stylet into the prey's body and then injecting saliva into its prey (Gao et al. 2020). *Eocanthecona furcellata* is a zoophytophagous predatory stink bug frequently occurring in India, Philippines, Thailand, Japan, and China (Shophiya and Sahayaraj 2014). In India, *E. furcellata* has been considered an important polyphagous predator of several important lepidopteran pests including the fall armyworm

(*Spodoptera frugiperda* (J.E.Smith, 1797)) (Keerthi et al. 2020) and coleopteran pests including *Henosepilachna vigintioctopunctata* (Fabricius, 1775) in eggplant (Kalaiyarasi et al. 2017). The seasonal abundance and predatory efficiency of *E. furcellata* align with the population cycles of its prey in tea ecosystems and effective pest control, particularly against the later stages of the prey (Sarkar et al. 2021).

The semilooper, *Chrysodeixis eriosoma* (Doubleday, 1843) is a polyphagous insect pest feed on a number of species from families including Asteraceae, Fabaceae, and Solanaceae (Zink et al. 2023). The pest is considered a secondary pest in corn in the Philippines (Caasi-Lit 2019). However, it is considered a serious pest in some Asian countries targeting the cabbage (*Brassica oleracea* var. *capitata* L.) and chickpea (*Cicer arietinum* L.) farms in India (Twinkle et al. 2020); and Indonesia and China (CABI 2022). *Chrysodeixis eriosoma* is also listed as harmful in Japan (JMAFF 2016), and a watch list as potential threat to agriculture in South Korea (Kim et al. 2022). In Hawaii, it is has a potential impact on the production of sweet potato field (McQuate and Sylva 2018). A few parasitoids have been reported to parasitize *C. eriosoma*, including *Copidosoma floridanum* (Ashmead, 1900), *C. truncatellus* (Dalman, 1820), and *Cotesia ruficrus* (Haliday, 1834). Additionally, the cytoplasmic polyhedrosis virus is also known to infect *C. eriosoma* (Raj et al. 2022). However, information about using *E. furcellata* against *C. eriosoma* in the Philippines and abroad is scarce. Hence, this study aims to determine the life cycle of *E. furcellata,* generate data on local bioefficacy as on biological control agents against *C. eriosoma,* and establish a mass-rearing protocol for *E. furcellata.*

MATERIALS AND METHODS

Study area

Laboratory studies on the biology and predatory potential of *E. furcellata* were conducted at the Entomology Laboratory, Syngenta R&D Station, Alabel, Sarangani Province, in Mindanao Island, Philippines. The initial population of the predatory bug, *E. furcellata* feeding on unknown larvae were collected in the Sunn hemp (*Crotalaria juncea* L.) fields in Sarangani Province (6°6’52’’N, 125°15’34’’E) in Mindanao Island, Philippines during the dry season from January to March of 2024 (Figure 1). The individuals of *E. furcellata* were brought to the laboratory for mass rearing and were fed with laboratory-reared, *S. frugiperda* larvae temporarily (Figure 2).

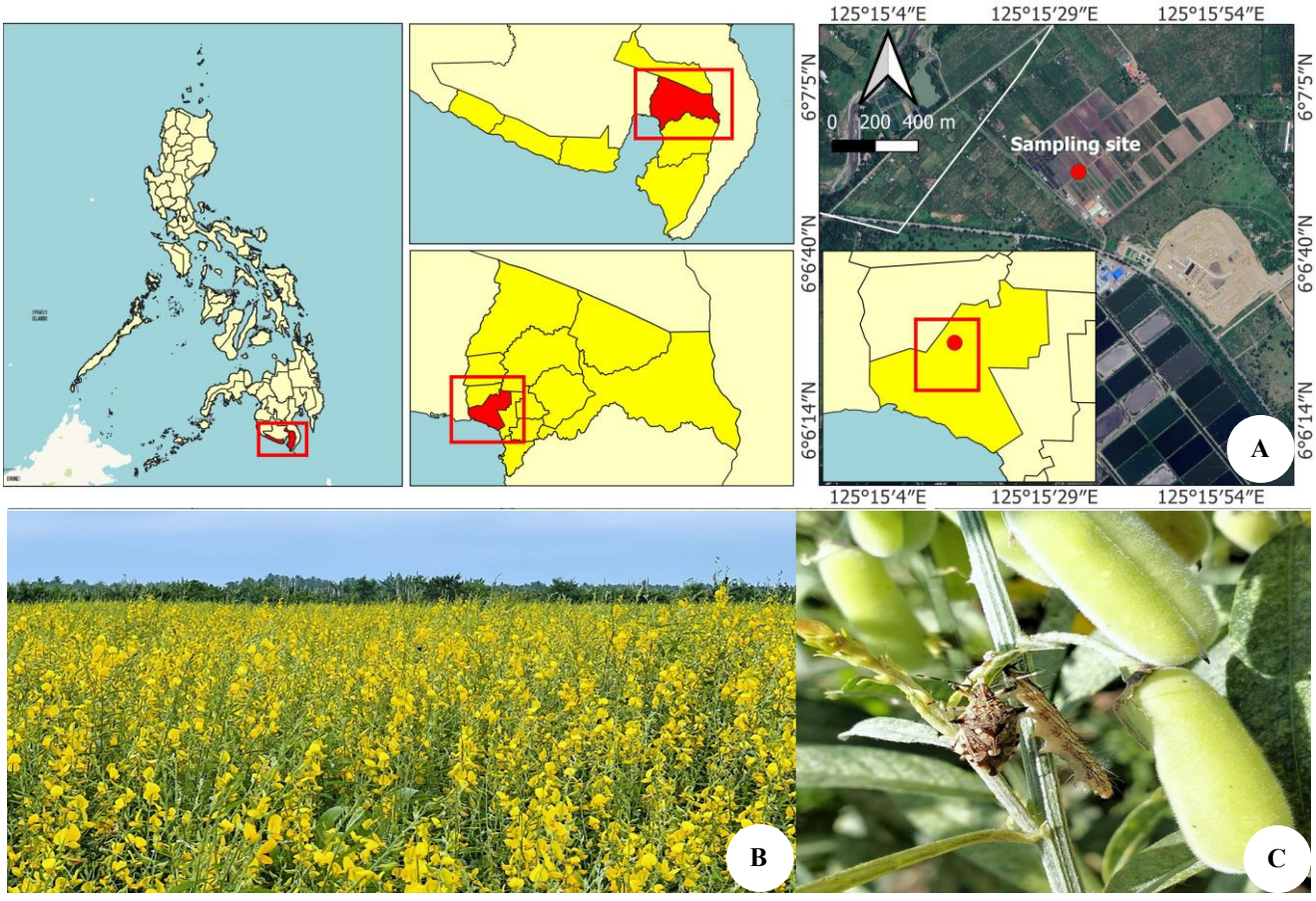

Figure 1. Sampling site. A. Map of Sarangani Province in Mindanao Island, Philippines; B. Habitat where individuals of *Eocanthecona furcellata* were observed; C. *Eocanthecona furcellata* feeding on unknown larva, in situ

Biology of *Eocanthecona furcellata*

Freshly laid eggs from the first generation of *E. furcellata* were separated and allowed to hatch on a Petri dish (Pyrex 20 mm × 100 mm) lined with moistened filter paper (Whatman™ filter paper No.1). After hatching, neonate nymphs (n = 10) were collected with a fine-tipped camel brush and transferred individually into a plastic container (90 mm × 50 mm) covered with perforated lid (Figure 3). The setup was replicated four times and was maintained under laboratory conditions at 28±2°C, with 70% relative humidity and a photoperiod of 13:11 (L:D) hour. Daily observations on the duration of larval-pupal, pupal, larva-adult, and egg-to-adult were recorded.

Predatory potential of *Eocanthecona furcellata* on *Chrysodeixis eriosoma* larvae

The first generation of the second, third, fourth, and fifth nymphal instars of *E. furcellata* were used to study the predation rate on *C. eriosoma*. The individual nymphal instar (n = 15) of *E. furcellata*, were placed in separate plastic containers (90 mm × 50 mm) along with *C. eriosoma* larvae (II, III, and IV instar) in each container. We introduced first the *E. furcellata* before releasing the *C. eriosoma* larvae, during the predation test. The setup was replicated four times and was maintained under laboratory conditions at 28±2°C, with 70% relative humidity and a photoperiod of 13:11 (L:D) hour. Numbers of larvae consumed by each nymphal were recorded daily, and fresh larvae were provided for further feeding for 48 h (Halder et al. 2020).

Mass rearing of *Eocanthecona furcellata* using *Chrysodeixis eriosoma* larvae as a natural diet

We modified an artificial oviposition cage for the mass rearing of *E. furcellata*. A total of 20 second-generation females and 10 males (2:1 ratio) were placed in a modified oviposition cage made from plastic mylar (Figure 4.A). The oviposition cage was 30 cm tall and 30 cm wide. The water-absorbent foam was installed to maintain optimal humidity levels and replaced regularly to ensure consistent and continuous humidity throughout the study period. The foam and the chicken wire mesh were attached to a 2-inch mylar plastic sheet (Figure 4.D), which secured the top portion of the oviposition cage. Sturdy carton papers were placed in the center of the oviposition cage and served as an oviposition medium. Adults were fed with 15 to 20 head crushed larval instars of *C. eriosoma* every 48 h to ensure ample food supply. Within 3 days, adult *E. furcellata* were observed to initiate copulation, during which unnecessary disturbances were meticulously avoided to ensure natural behaviors of the mating adults. Gravid females began oviposition within 3 to 4 days, depositing eggs in clusters predominantly on the surface of the sturdy carton paper, with occasional oviposition observed on the mylar plastic sheets. The eggs then were collected and allowed to hatch on Petri dish (Pyrex 20 mm × 100 mm) lined with moistened filter paper (Whatman™ filter paper No.1). After hatching, neonate nymphs were collected with a fine-tipped camel brush and transferred into plastic container (25 cm × 15 cm) with moistened cotton balls. The setup was maintained under laboratory conditions at 28±2°C, with 70% relative humidity and a photoperiod of 13:11 (L:D) hour (Halder et al. 2020).

Mass rearing of *Chrysodeixis eriosoma* using insect artificial diet

The local population of *C. eriosoma* was collected in Maribulan Alabel, Sarangani. Late instar larvae were collected to start mother colonies in the laboratory. Collected larvae were fed on an artificial insect diet (General Purpose Lepidoptera, F9772, Frontier Scientific) in a separate plastic cup (90 mm × 50 mm) with perforated cover to avoid cannibalism and held at 25°C with 60% RH with 8:16 (L:D) hour inside the laboratory. Pupae that emerged on the same date were collected, sexed, and placed in a wooden oviposition cage lined with wax paper inside as an oviposition medium with a 1:2 male-female ratio in a 24-hour total darkness allowing to emerge as adults and induce mating. After 48 h, eggs were collected and transferred to a plastic container (25 cm × 15 cm) that contained an artificial insect diet.

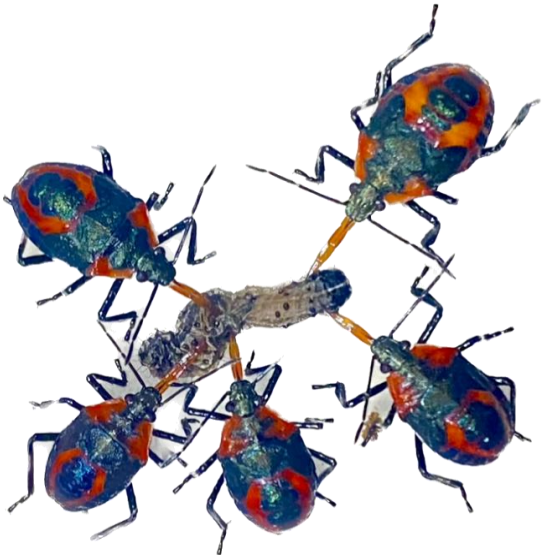

Figure 2. Initial rearing of *Eocanthecona furcellata* fed with laboratory-reared Fall armyworm, *Spodoptera frugiperda*

A **B**

Figure 3. Individual plastic container used in the biology study of *Eocanthecona furcellata*. A. Closed; and B. With perforated cover lid attached to the main container

Table 1. Factor combination

Predator (*E. furcellata*)	Prey (*C. eriosoma*)			
	2nd Instar	3rd Instar	4th Instar	5th Instar
2nd Instar	2nd × 2nd	2nd × 3rd	2nd × 4th	2nd × 5th
3rd Instar	3rd × 2nd	3rd × 3rd	3rd × 4th	3rd × 5th
4th Instar	4th × 2nd	4th × 3rd	4th × 4th	4th × 5th
5th Instar	5th × 2nd	5th × 3rd	5th × 4th	5th × 5th

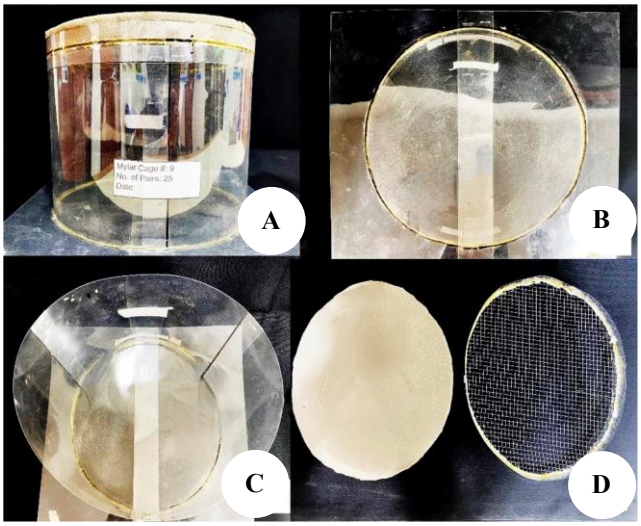

Figure 4. Modified oviposition cage made from mylar plastic used for mass rearing of *Eocanthecona furcellata.* A. Oviposition cage set; B. Base; C. Interior; and D. Absorbent foam to hold moisture, and chicken wire mesh as the lid

Artificial diet components

Artificial diet (General Purpose Lepidoptera, F9772, Frontier Scientific), containing 19.0 gm/L agar-agar and total of 144.0 gm/L dry mix ingredients containing sucrose, soy flour, 50% wheat germ, stabilized salt mix (Wesson, USDA) vitamin premix, fiber, sorbic acid, methylparaben, and ascorbic acid.

Data analysis and experimental design

The experiment was laid out in a two-factor factorial experiment in Complete Randomized Design (CRD). It aimed to evaluate the number of different larval stages of *C. eriosoma* consumed by the corresponding developmental stages of *E. furcellata* . Both factors- Factor A (Predator: *E. furcellata*) and Factor B (Prey: *C. eriosoma*)—included four levels each, resulting in 16 factor combinations, as presented in Table 1. The experiment was conducted under controlled laboratory conditions to ensure consistency and minimize external variability.

Analysis

The Two-way Analysis of Variance (Two-Way ANOVA) was generated using R Studio 2024.09.1 Build 394 Software (open source). Before performing the ANOVA, Shapiro-Wilk Test of Normality was performed to evaluate whether the data follow a normal distribution with results showing w = 0.946 with p-value = 0.2094 indicating normality of data thus we accept that the residuals are normally distributed and conforms to the assumptions of ANOVA. Levene's test was performed to determine the homogeneity of variances resulting to p-value = 0.7476 thus, there is no significant evidence of variance heterogeneity among groups. Since normality and homogeneity tests were met, the ANOVA proceeded with corresponding post-hoc analysis using Tukey HSD for the significant interaction of factor combinations.

RESULTS AND DISCUSSION

Biology of *Eocanthecona furcellata*

In our present study, we investigated the life cycle of *E. furcellata* under laboratory conditions First generation of *E. furcellata* were used in the study and biological parameters like egg incubation and size measurement, nymphal duration, and adult longevity for the life cycle of *E. furcellata* and body measurements for all stadia were recorded in Table 2. After 48 h, freshly laid eggs were white in color and gradually turned creamy to light brown (Figure 5.A) measuring 1 mm × 0.89 mm (L × W). The eggs appeared dark reddish immediately before hatching with an incubation period of 6 days. This finding corroborates the study of Siddaiah and Devi (2015), Lenin and Rajan (2016) and Vanitha et al. (2018). The newly- emerged nymphs were red with black patches on the dorsal surface (Figure 5.B) and tend to gravitate toward one another, often gathering in close-knit groups. This gravitation behavior was also observed by Vanitha et al. (2018). The nymphs passed through five instars, which corroborates the observations of Siddaiah and Devi (2015), Tuan et al. (2016), Kalaiyarasi et al. (2020) and Sarkar et al. (2020). The nymphal stage incubation period lasted 15.7±0.46 days before developing into adults. The first and third instar nymphs had the shortest duration with 2±0.22 and 2.0±0.44 days, respectively while the fifth instar took a maximum of 4.7±0.68 days to complete, while the second, and fourth instars were completed in 4 and 3 days, respectively. Wing pads were observed in the fifth nymphal instar (Figure 5.F). Female bugs lived longer (36.8±1.81days) than their male counterparts (32.3±1.34 days) under laboratory conditions. In general, the life cycle of an insect is influenced by several factors like temperature, photoperiod, diet, hormones, (Couret and Benedict 2014) and genetics (Lemke and Schnorrer 2017). Additionally, research has shown that insect aging and lifespan are sensitive to environmental factors such as temperature, humidity, and diet (Promislow et al. 2022).

Moreover, female predatory bugs were bigger than their male counterparts (Figure 5.G). These observations on the body sizes of female and male *E. furcellata* corroborate the observations of Lee et al. (2015), Rustam et al. (2019) and Halder et al. (2020). Generally, insect taxa, size is an indicator of fitness (Beukeboom 2018). Females are bigger than males, this lies in the huge number of eggs females lay; a larger body size enables the adult female insect to lay more eggs. However, the different body sizes of sexually dimorphic traits of species like *E. furcellata*, are widespread form (Teder 2014) across class Insecta.

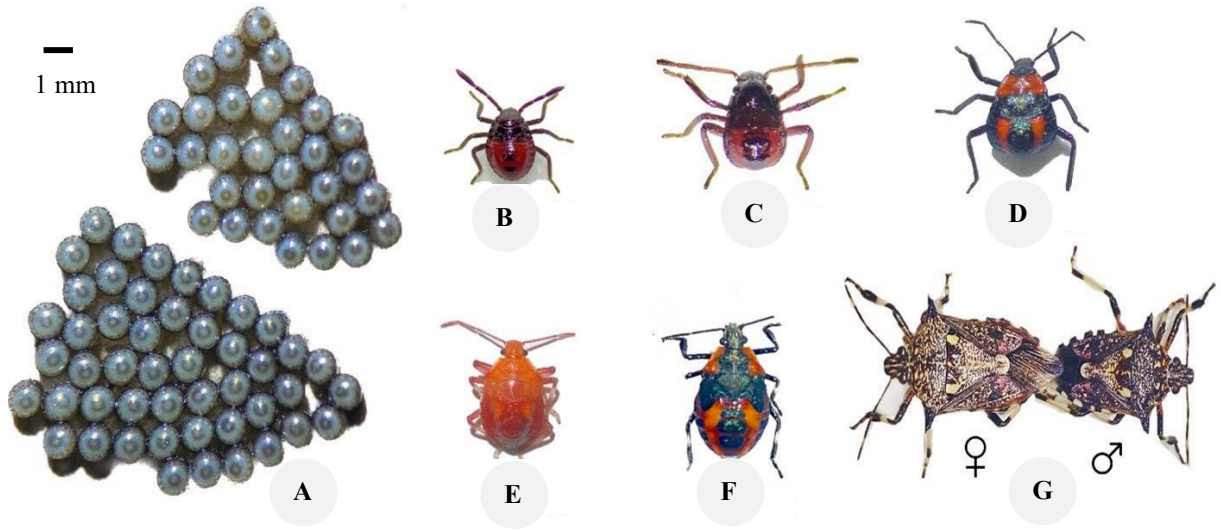

Figure 5. Different stadia of *Eocanthecona furcellata*: A. Egg masses; B. First instar; C. Second instar; D. Third instar; E. Newly molted fourth instar; F. Fifth instar; and G. Mating adults

Table 2. Life cycle and body measurement of each stadium of *Eocanthecona furcellata*

Stage	Number of days	Measurements (mm)	
		Length	Width
Eggs	6.0±0.43	1.00±0.00	0.89±0.01
Nymphs			
1st instar	2.0±0.22	1.05±0.01	0.98±0.001
2nd instar	4.0±0.60	2.04±0.009	1.06±0.002
3rd instar	2.0±0.44	4.69±0.228	3.94±0.169
4th instar	3.0±0.67	6.10±0.767	4.55±0.810
5th instar	4.7±0.68	9.00±0.50	5.30±0.178
Nymphal stage	15.7±0.46		
Adult male	32.3±1.34	11.20±0.50	7.70±0.289
Adult female	36.8±1.81	13.60±0.267	8.80±0.344
Eggs to adult	54±1.93-58.5±2.28		

Predatory potential of *Eocanthecona furcellata* on *Chrysodeixis eriosoma* larvae

The predation rate of *E. furcellata* varies significantly across its various developmental stages. Illustrated in Figure 6, the fifth nymphal instar of *E. furcellata* exhibits a significant (P<0.0001) consumption rate compared to the other nymphal stages tested under laboratory conditions. It consumed 23.27, 17.13, 8. 73, and 6.4 of the 2nd, 3rd, 4th, and 5th larval instars of *C. eriosoma*, respectively after 48 hours. Similar results were observed when the fifth nymphal instar of *E. furcellata* was fed on *Corcyra cephalonica* (Stainton, 1866), *Spodopetra litura* (Fabricius, 1775) (Suyal et al. 2021), and *S. frugiperda* (Sravika et al. 2020). Moreover, among the predatory nymphs, the trend of predation gradually increased from the second to the fifth nymphal instar in all the exposed larval instars of *C. eriosoma*. Hence, the fifth nymphal instar has more potential than the rest of the nymphal instars of *E. furcellata*. Similar results were observed in the studies of Tuan et al. (2016) and Keerthi et al. (2020) who reported that the fifth nymphs of *E. furcellata* consumed more larvae of *S. litura* and *S. frugiperda*, respectively. The elevated predation rate observed in the fifth nymphal instar of *E. furcellata* maybe necessary to meet the increased energy demands associated with oogenesis and longevity during the adult stage (Keerthi et al. 2020; Sravika et al. 2020). The predation rates of early instars of *E. furcellata* over a 48-h period were notably lower compared to those of the fifth nymphal instar. When early nymphal instars of *E. furcellata* were provided with early larval instars of *C. eriosoma* as prey, the predation rate was initially high. However, prolonged exposure to *C. eriosoma* of different larval instars resulted in a marked decline in predation efficiency. Thus, when we analyzed the interaction effects of the different nymphal instars of *E. furcellata* fed with different larval instars of *C. eriosoma* in Tukey's HSD test of multiple comparison, it showed a highly significant interaction (P<0.0001) as presented in Figure 7.

In addition, even the early nymphs of *E. furcellata* have been observed to exert substantial control over the early instar of *C. eriosoma* larvae during feeding (Figure 8.A). However, the early nymphal instar of *E. furcellata* did not fully consume its prey when fed with fifth larval instar of *C. eriosoma*, leaving behind a blackened and half-consumed larva (Figure 8.B). Moreover, *E. furcellata* demonstrated its potential as a biological control agent against *C. eriosoma* and can be augmented in the current integrated pest management strategy to reduce reliance on chemical pesticides and promote sustainable agriculture.

Mass rearing of *Eocanthecona furcellata* using *Chrysodeixis eriosoma* larvae as food

The feeding behavior of neonate *E. furcellata* showed a tendency to avoid preying on *C. eriosoma* larvae. Instead, they congregated around the moistened cotton ball to access water. Similar observations by Siddaiah and Devi (2015) and Rustam et al. (2019) when newly emerged *E. furcellata* exposed nettle caterpillar, *Setoria nitens* (Walker, 1855), and vapourer tussock moth larvae, *Orgyia antiqua* (Linnaeus, 1758), respectively.

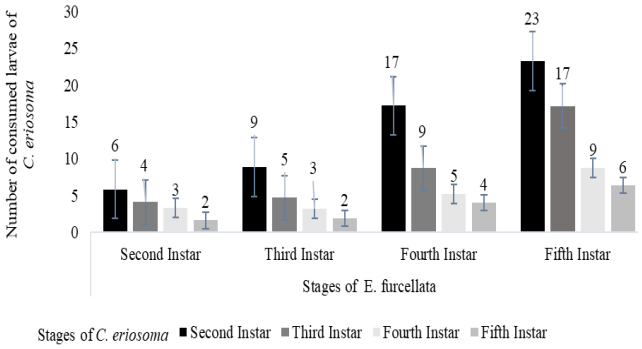

Figure 6. Predation rate of *Eocanthecona furcellata* on different larval instar of *Chrysodeixis eriosoma* after 48 hours

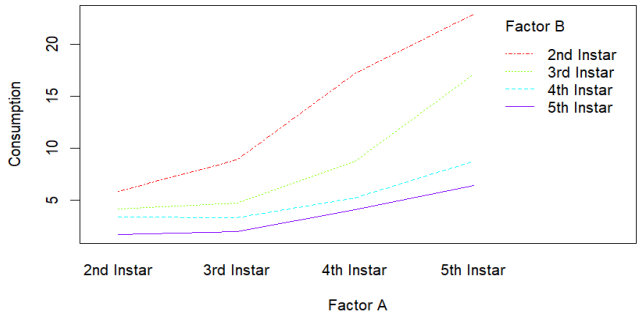

Figure 7. Interaction effects between *Eocanthecona furcellata* (Factor A) and *Chrysodeixis eriosoma* (Factor B) after 48 hours

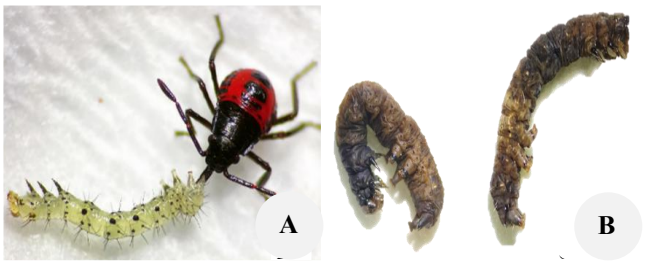

Figure 8. Predation of *Eocanthecona furcellata.* A. Second nymphal instar of *E. furcellata* feeding on the second larval instar of *Chrysodeixis eriosoma*; B. Cadaver of fifth instar larvae of *Chrysodeixis eriosoma* fed to early instar of *E. furcellata*

Upon reaching the second nymphal stage, the nymphs were provided with a diet comprising 10 or more larvae of varying instars of *C. eriosoma*, facilitating the transition to active predation until *E. furcellata* reached adulthood. A moistened cotton ball was maintained inside the plastic container (25 cm × 15 cm) to provide the necessary moisture for *E. furcellata.* There were 15 to 20 nymphs of predatory bugs inside the container, which was maintained under laboratory conditions at 28±2°C, with 70% relative humidity and a photoperiod of 13:11 (L:D) (Halder et al. 2020). In the study conducted by Sravika et al. (2021), they observed that when 35 to 50 individuals of *E. furcellata* were confined together, the likelihood of cannibalistic behavior significantly increased. The occurrence of cannibalism was attributed to factors such as overcrowding, limited prey availability, and increased competition among individuals. These findings emphasize the importance of carefully managing rearing densities in laboratory or mass-rearing conditions to minimize intraspecific predation, which can negatively impact population sustainability and efficiency. The benefits obtained from mass rearing insects have encompassed a wide array of applications, from the early stages of examining different species to the present day of mass production for multiple purposes. One of the most significant applications to date is the large-scale mass rearing of beneficial insect species for use in agricultural production systems (Huynh et al. 2021). Effective insect rearing practices ensure a consistent supply of high-quality biological control agents, which are essential for sustainable pest suppression in agricultural systems (Huynh et al. 2021). In Brazil, success in mass rearing of *Trichogramma galloi* (Zucchi, 1988) (a native parasitoid), and *Cotesia flavipes* (Cameron, 1891) (an exotic parasitoid) to control *Diatraea saccharalis* (Guenée, 1862), the sugarcane borer, gained so much support from private companies to help the sugar industry (Parra and Coelho 2021). Proper rearing techniques not only support the mass propagation of these beneficial insects but also enhance their survival, reproductive capacity, and predatory efficacy when released into the field. Moreover, in our present study, it is evident that *C. eriosoma* could be used as an alternative host to mass rear *E. furcellata* under laboratory conditions and when the main host is scarce or not available.

In conclusion, this study documents the first recorded observation of *E. furcellata* in Sarangani Province, Southern Philippines, and demonstrates its potential as a biological control agent against the corn semi-looper, *C. eriosoma*. Laboratory findings revealed that *E. furcellata* progresses through five nymphal instars within 15.7 days, and adults with 32.3 to 36.8 days, adult females exhibiting longer lifespans than males. The fifth nymphal instar displayed the highest predatory efficiency, consuming an average of 23.27 second-instar *C. eriosoma* larvae over 48 h. Mass rearing protocols for *E. furcellata* using *C. eriosoma* as an alternative prey source were successfully established, providing a viable method for augmentative biological control strategies when primary prey is limited. The initial results provided the predatory potential of *E. furcellata* and further field studies are recommended to evaluate their potential as a sustainable component in Integrated Pest Management (IPM) programs, particularly in tropical agriculture systems. Future research should investigate field applications of *E. furcellata* and evaluate its interactions with other natural enemies within IPM frameworks to further reduce pesticide reliance and enhance pest management efficacy.

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furcellata collected in the local cornfield and Sunn hemp fields in Maribulan, Alabel, Sarangani, Mindanao Island, Philippines.

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