ENTOMOLOGY

Predatory ability of *Sycanus annulicornis* Dohrn. (Hemiptera: Reduviidae) on nettle caterpillar prey (*Setora nitens* Walker.) (Lepidoptera: Noctuidae) in the laboratory

Rusli Rustam, Dwi Yuwanda Nasution, Yunandra, Mukhlis Ibrahim

Department of Agrotechnology, Faculty of Agriculture, Binawidya Campus, University of Riau, Pekanbaru, Riau, Indonesia

Correspondence: Rusli Rustam, Department of Agrotechnology, Faculty of Agriculture, University of Riau, Bina Widya Campus km 12.5, Pekanbaru, Riau, 28293, Indonesia.
E-mail: rusli.rustam@lecturer.unri.ac.id

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Abstract

The nettle caterpillar (*Setora nitens*) is a major pest affecting oil palm plants and is predominantly found in oil palm plantations in Riau. The predator *Sycanus annulicornis* Dohrn is a potential natural enemy for controlling *S. nitens*. This study aims to evaluate the predatory ability of *S. annulicornis* imago when preying on *S. nitens*. The research was conducted at the Plant Pest Laboratory, Faculty of Agriculture, Riau University, from March to July 2023. The experiment was designed using a completely randomized design method consisting of three treatments with seven replications. The treatments involved *S. annulicornis* imago [N1=one male imago, N2=one female imago, and N3=one pair of imago (male and female)], with observation parameters including first and second prey search time, prey handling time, predation ability, and total predation. Results showed that the handling time for one *S. nitens* by *S. annulicornis* ranged from 3.86 to 5.14 hours. The treatment involving one pair of *S. annulicornis* imago was the most effective, as it resulted in the fastest prey search times (0.79 minutes for the first prey and 0.71 minutes for the second prey), as well as the fastest prey handling time (3.86 hours), with a total predation rate of 100% for *S. nitens*.

Introduction

Oil palm (*Elaeis guineensis* Jacq.) is the most popular and widespread plantation commodity in Indonesia. It is valued for producing food products (such as cooking oil and margarine), non-food products (candles, cosmetics, lubricants, oleochemicals, and biodiesel), and by-products/waste (compost, raw material for pulp production, raw material for organic solvents, and activated charcoal) (Nora & Mual, 2018). In 2020, the total oil palm production in the Riau province was 8.86 million tons, but it decreased to 8.78 million tons in 2021 (Direktorat Jenderal Perkebunan, 2022). This decline was due to several factors, one of which was the attack of pests like the fire nettle caterpillar (*Setora nitens* Walker).

The nettle caterpillar (*S. nitens*) is the main pest that attacks oil palm plants (Buana, 2003) and is predominantly found in oil palm plantations in Riau (Taftazani, 2006). These caterpillars feed on the leaves, damaging them and leaving only the stems behind. During its life cycle, a nettle caterpillar (*S. nitens*) can consume up to 400 cm^2 of leaves [unpublished thesis by Cendramadi, 2011 - *Observation of the abundance of fire caterpillars (Limacodidae) and bagworms (Psychidae) and their pred-*

ators in oil palm plantations under rubber tree shade]. Their attacks can lead to a 70% reduction in production during the first attack, and up to a 93% reduction if there is a second attack within the same year (Pahan, 2008).

The most common method of controlling nettle caterpillar pests (*S. nitens*) in oil palm plantations in Indonesia is the use of synthetic insecticides. However, the use of these insecticides can lead to negative effects such as pest resistance, resurgence (or population increase beyond the economic threshold), secondary pest outbreaks, and environmental pollution (Roiyan *et al*., 2018). An alternative method to mitigate the negative impacts of synthetic insecticides is through biological control using natural enemies, such as the predator *Sycanus annulicornis* Dohrn.

Sycanus annulicornis is an important predatory insect used to manage pests in food crops, horticulture, plantations, and forestry. It is polyphagous, meaning it can target a wide variety of prey from different orders, including Lepidoptera, Diptera, Coleoptera, Homoptera, and Hemiptera (Sahid, 2019). The feeding preference of *S. annulicornis* involves piercing and sucking the hemolymph fluid from its prey (Van Der Laan & Kalshoven, 1981). *Sycanus* predators are reported to feed on several leaf-eating pest larvae in vegetable crops, such as *Crocidolomia pavonana* F. and *Plutella xylostella* L. (Yuliadhi & Sudiarta, 2012). *S. annulicornis* can be mass-reared in the laboratory using alternative prey, such as *Tenebrio molitor* larvae (Sahid *et al*., 2016).

The predatory behavior of *Sycanus* species is observed through the time it takes to attack, kill, and consume prey. According to Syari *et al*. (2010), male *Sycanus dichotomus* imago took an average of 34.4 minutes to start attacking *Metisa plana* larval prey, while females took 22.7 minutes. Male and female *S. dichotomus* required an average of 59.2 and 58.6 minutes, respectively, to finish off *M. plana* larvae. It was found that using a pair of *Sycanus croceovittatus* imago with *S. nitens* prey resulted in an average time of 4.03 hours to finish the prey and a first prey search time of 18.47 minutes [unpublished thesis by Rambe (2018) - *Ecobiology of Sycanus croceovittatus (Dohrn) (Hemiptera: Reduviidae) on fire caterpillars Setora nitens (Walker) in oil palm plants in Riau*].

The ability of *S. annulicornis* to prey on oil palm leaf-eating nettle caterpillars in the field, combined with its high reproductive ability and short lifespan, makes this predator a promising candidate for controlling nettle caterpillar (*S. nitens*) populations (Pratama, 2021). This study aims to determine the predation ability of *S. annulicornis* imago when preying on nettle caterpillars (*S. nitens*).

Materials and Methods

Study area

The research was conducted at the Plant Pest Laboratory, Faculty of Agriculture, Riau University, Binawidya Campus, located 12.5 km from Simpang Baru Village, Tampan sub-district, Pekanbaru, Indonesia. The study was conducted from December 2022 to June 2023.

Procedures

Collection of Setora nitens

S. nitens were collected from the oil palm plantation of PT Peputra Masterindo, Petapahan Estate, Kampar Regency, with permission from the company's pest control officer. The collection was carried out before insecticide spraying. *S. nitens* were collected by cutting palm fronds using scissors and placing them into plastic bottles. Only third instar *S. nitens* were collected. The collection took place over one day, with the number collected corresponding to the treatment or more. *S. nitens* were then transported to the Plant Pest Laboratory, Faculty of Agriculture, Riau University, where they were placed in plastic containers and fed palm fronds.

Collection of Tenebrio molitor

T. molitor larvae were purchased from a bird shop located on Gg. Taman Karya, Jl. Soebrantas, Panam, Pekanbaru. The larvae were transported to the Plant Pest Laboratory, Faculty of Agriculture, Riau University, placed in plastic containers, and fed pieces of bread.

Collection and rearing of Sycanus annulicornis

S. annulicornis predators were collected from the oil palm plantation of PTPN V Sei Lindai, Kampar Regency, using an insect net. Each predator was placed in a plastic container and transported to the Plant Pest Laboratory for rearing. The predators were maintained in the laboratory at a temperature of 26-27°C and 75% humidity. Male and female imagos were housed together in one plastic container for mating. They were fed *T. molitor* larvae and provided with wet cotton as a drinking source and to maintain humidity (Gustianingtyas *et al*., 2021). *T. molitor* larvae and wet cotton were provided every morning at 10:00 AM. Rectangular cardboard pieces (7×2 cm) were placed in the container and covered with gauze. The cardboard served as a place for the female imagos to lay eggs. After egg-laying, the cardboard pieces were moved to an empty container, and the eggs were incubated until they hatched into nymphs. Newly hatched nymphs were given only water using wet cotton. After 2 days, they were fed *T. molitor* larvae (instars 3-9) until they reached instar 3. Nymphs entering instar 4 were fed *T. molitor* larvae (instars 10-13) until they became imagos. These imagos were then used in the predation tests.

Predation test

Imagos of *S. annulicornis* were placed in individual plastic containers and fasted for 24 hours before testing. *S. nitens* were collected from the plastic containers using an insect brush and placed in jars with palm fronds. After fasting, the imago was transferred from the plastic container into the jar containing the fireworm. The jars were covered with gauze, and wet cotton was placed on top. The number of predators in the jar was determined by the treatment, and five *S. nitens* were placed in each experimental unit.

Observations

Prey search duration

The time taken by the predator to capture its first prey and the interval between capturing the second prey were recorded (minutes). Observations started when the predator was placed in the jar and ended when it captured *S. nitens*. The timing was done using a stopwatch, with measurements taken each minute after the application.

Prey handling duration

The time taken by the predator to kill one prey was recorded (hours). Observations began when the predator first attacked the fireworm and ended when the fireworm died. The timing was done using a stopwatch, with measurements taken each hour after the application.

Predation rate

The number of *S. nitens* consumed by *S. annulicornis* was recorded according to the treatment. Observations were made daily for 3 days after the application.

Total predation

The total number of *S. nitens* consumed by *S. annulicornis* during the entire 3-day observation period was recorded.

Data analysis

The data from the predation rate observations were analyzed descriptively using graphs. The data on prey search duration, prey handling duration, and total predation were analyzed statistically using analysis of variance (ANOVA). Significant results from the ANOVA were further analyzed using the least significant difference test at a 5% significance level, using SAS version 9.1 (SAS Software, Cary, NC, USA). The linear model used was [Eq. 1]:

$$Yij=\mu + Ţi + Ɛij \quad [Eq. 1]$$

Where, Yij is the observation value for the treatment of the i-th *S. annulicornis* imago in the j-th replication; μ is the overall mean; Ţi is the effect of the i-th treatment; and Ɛij is the experimental error for the i-th treatment and j-th replication.

Results and Discussion

Prey search time

The results of observations on the time taken by *S. annulicornis* imago to locate the first and second prey indicate that some treatments had a significant effect, as determined by variance analysis. The average results of the Boston naming test (BNT) (honestly significant difference) for the search time of the first and second prey at the 5% significance level are presented in Table 1.

Table 1 shows that several treatments of *S. annulicornis* imagos found their first prey within different time ranges. The time taken to find the first prey in the treatment with one male was not significantly different from the treatment with one female, which took 2.44 minutes and 2.26 minutes, respectively. However, it was significantly different from the treatment with one pair, which took 0.79 minutes, the fastest prey search. Table 1 also shows that the time taken to find the second prey in each treatment was faster compared to the first prey search. The time to find the second prey in the treatment with one male was 2.37 minutes, which was not significantly different from the treatment with one female (2.11 minutes), but significantly different from the treatment with one pair, which took 0.71 minutes.

The observation results showed that the time to find the first prey was the fastest for the pair treatment compared to one male or one female. This is related to the predator's behavior when searching for prey. In the first prey search, the male and female imagos in the pair treatment became more aggressive due to competition in securing the prey, making the time to find prey faster. Gani *et al.* (2019), in their study on the predation of *Eocanthecona furcellata* on fireworms, reported that the treatment with one male and one female imago required less time to find prey than the one male or one female treatments.

The *S. annulicornis* predator will then search for the second prey after consuming the first. The time to find the second prey is faster than the first search. This is because the predator is still familiarizing itself with the habitat and prey during the first search. Once adapted to the environment, the predator can search for and find the second prey faster. Tobing *et al.* (2009) state that after a predator finds its first prey, it will move more quickly to find the next prey because it has recognized its prey.

The time taken to find both the first and second prey by the *S. annulicornis* predator was relatively fast. This rapid prey search is related to the predator being starved (fasted) for 24 hours before the experiment. Predators that are hungry are usually very eager and more aggressive in searching for their prey. According to Wahyuningsih (2018), hunger in predators is a prerequisite for them to search for, find, and consume prey to meet their survival and reproduction needs. Muharam and Setiawati (2007) also state that a predator's activity is influenced by its hunger, and the predator will remain inactive if it is full.

The *S. annulicornis* predator performs several activities while preying on fireworms. The activities performed by the predator include flying randomly up and down and then landing on the oil palm leaf. The predator then moves towards the fireworm seen on the leaf, slowly approaching it. The predator then inserts its stiletto into the fireworm's body when it is in the right position and paralyzes it. Finally, the predator will suck the body fluids from the fireworm until it dies. This process aligns with the stages of predation, which include the predator's search and discovery of prey habitats, the search and discovery of prey insects, the acceptance of prey as food, and the adjustment of prey as food [Huffaker & Messenger, 1989; Driesche *et al*., 2009; unpublished thesis by Daeli, 2010 - *Predation capacity of Sycanus croceovittatus (Hemiptera: Reduviidae) on fire caterpillars Setothosea asigna in oil palm plants in the Insectarium*]. The predation behavior of *S. annulicornis* can be seen in Figure 1.

The discovery and recognition of prey habitat is the initial stage for *S. annulicornis* predators in locating their prey. *S. annulicornis* predators do not immediately attack *S. nitens* when introduced into the experimental jars; instead, they first move around to familiarize themselves with their new environment. The predator uses all of its sensory organs to identify its surroundings and prey. Muliani and Srimurni (2022) state that predators possess senses that help them see and smell everything in their environment. Each of the predator's senses functions as a receptor that converts environmental energy into sensory signals. These sensory signals are then transmitted to the nervous system, prompting the predator to exhibit behavioral responses, such as finding food, avoiding danger, and reacting to changes in the environment. The recognition of prey habitat is also influenced by plants, as they emit characteristic scents, such as volatile oils, which serve as interspecific signals that help predators recognize the shape, color, and taste of prey (Jumar, 2000).

Table 1. Average length of the search for the first and second prey by *Sycanus annulicornis* imago (minutes).

Number of imago *Sycanus annulicornis*	First prey search time (minutes)	Second prey search time (minutes)
1 male	149 a	144 a
1 female	138 a	130 a
1 pair	46 b	43 b

The numbers in the column followed by different lowercase letters are significantly different according to the Boston naming test at the 5% level, after transformation with √y.

Prey handling time

The results of the observations on the duration of prey handling by *S. annulicornis* imago, following variance analysis, indicated that certain treatments had a significant effect. The average results from the BNT (honestly significant difference) for the handling time of nettle caterpillars (*S. nitens*) at the 5% significance level are presented in Table 2.

Table 2 shows that several treatments with *S. annulicornis* adults were able to kill fire caterpillars within different time ranges. The handling time for prey in the treatment with one male adult was 5.14 hours, which was not significantly different from the treatment with one female adult at 4.57 hours. The treatment with one female adult was also not significantly different from the treatment with one pair. The prey handling time in the treatment with one pair was 3.86 hours, tending to be faster than the other treatments.

Observations indicated that the prey handling time by the predator *S. annulicornis* ranged between 3-5 hours. This finding aligns with the statement by Rambe [unpublished thesis (2018) - *Ecobiology of Sycanus croceovittatus (Dohrn) (Hemiptera: Reduviidae) on fire caterpillars Setora nitens (Walker) in oil palm plants in Riau*] that the predator *S. croceovittatus* immediately pierces and sucks the fluid from fire caterpillars within 4-5 hours. The faster prey handling time in the one-pair treatment is likely due to the competition between male and female adults, which made them more aggressive and voracious in attacking and consuming their prey. Rambe [unpublished thesis (2018) - *Ecobiology of Sycanus croceovittatus (Dohrn) (Hemiptera: Reduviidae) on fire caterpillars Setora nitens (Walker) in oil palm plants in Riau*] also reported that the prey handling time in the treatment with one pair of male and female adults of *S. croceovittatus* tended to be faster than treatments with either a single male or a single female adult. An increase in the number of predators could alter predatory behavior, particularly in terms of prey handling and effectiveness [unpublished thesis by Daeli, 2010 - *Predation capacity of Sycanus croceovittatus (Hemiptera: Reduviidae) on fire caterpillars Setothosea asigna in oil palm plants in the Insectarium*].

Observations on prey handling time also revealed that in the one-pair treatment, male and female adults copulated before competing for the prey. They copulated after being placed together in the experimental jar. The male adult initiated copulation by approaching the female adult and then mounting her. The male remained on top of the female while she continued to prey on the fire caterpillar during copulation. After copulation, the male immediately sought out and consumed the fire caterpillar. Sahid *et al*. (2016) explained that the sequence of mating behaviors in male and female adults begins with arousal by the male, followed by the male approaching the female, mounting her, copulating, and post-copulation behaviors.

Prey handling observations began when the predator *S. annulicornis* inserted its stylet into the fire caterpillar's body. *S. annulicornis* secreted saliva, which functioned to paralyze the fire caterpillar. The predator then sucked the fluid from the fire caterpillar until it was entirely consumed. Fire caterpillars preyed upon by *S. annulicornis* appeared shriveled, dried, and darkened. According to Afandi *et al.* (2019), fire caterpillars consumed by *S. annulicornis* show signs of shriveling, with their bodies becoming increasingly contracted as their fluids are extracted.

Table 2. Average handling time of nettle caterpillars (*Setora nitens*) by *Sycanus annulicornis* imago (hours).

Number of imago *Sycanus annulicornis*	Prey handling time (bottleneck)
1 male	5.14 a
1 female	4.57 ab
1 pair	3.86 b

The numbers in the column followed by different lowercase letters are significantly different according to the Boston naming test at the 5% level, after transformation with √y.

Predation ability

Observations of the predation ability of *S. annulicornis* indicate that treatments involving one male, one female, and one pair were all effective in killing nettle caterpillars (*S. nitens*) on the first day. The cumulative predation ability of *S. annulicornis* over a 3-day period is illustrated in Figure 2.

Figure 2 shows that the predation rate percentage of *S.*

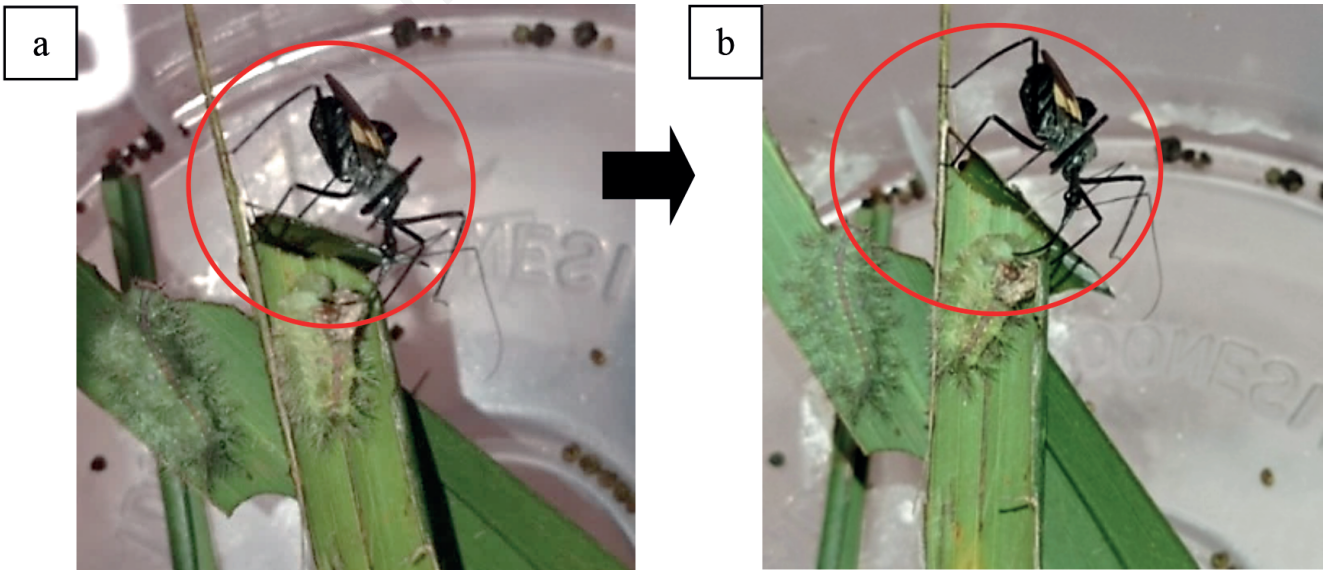

Figure 1. Predation stages of *Sycanus annulicornis* (a) predator approaches prey; (b) predator starts to thrust its stylets.

annulicornis predators in each treatment increases when accumulated over each day. The predation rate percentage for the one male treatment on the first day was 28.57% (1.43 prey), on the second day, it was 25.71% (1.29 prey), which accumulated to 54.28% (2.72 prey), and on the third day, it was 20% (1 prey), which accumulated to 74.28% (3.72 prey). The predation rate percentage for the one female treatment was higher than that of the one male, with 28.57% (1.43 prey) on the first day, 28.57% (1.43 prey) on the second day, accumulating to 57.14% (2.86 prey), and 22.86% (1.14 prey) on the third day, accumulating to 80% (4 prey). The highest predation rate occurred in the one pair treatment, with 48.57% (2.43 prey) on the first day, 31.43% (1.57 prey) on the second day, accumulating to 80% (4 prey), and 20% (1 prey) on the third day, accumulating to 100% (5 prey).

The observations show that a single *S. annulicornis* imago predator can consume an average of 1.06 fireworms per day. According to the unpublished thesis by Aufa [*Preference test of Sycanus dichotomus (Hemiptera: Reduviidae) against several leaf-eating caterpillars*], a single *S. dichotomus* predator in the imago and fourth instar nymph stage can consume an average of 1-3 larvae per day. One *Sycanus* sp. consumes approximately 430 fireworms during its lifetime (Wood, 1971). Based on these results, the treatments of one male, one female, and one pair of *S. annulicornis* imago can be used as a reference and recommendation for the number of imago releases in the field to control fireworms at an economic threshold level.

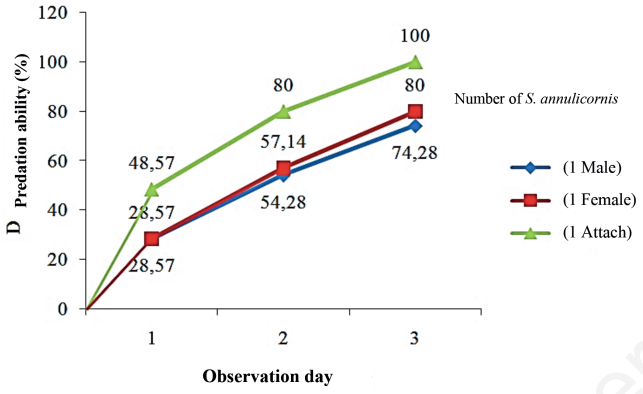

Figure 2. Predation ability of *Sycanus annulicornis* imago after accumulating for three days.

Figure 3. Preying activity of *Sycanus annulicornis* predators on nettle caterpillars.

The development of predation capacity in *S. annulicornis* predators was observed over 3 days. The highest predation capacity occurred on the first day, while on the second and third days, there was a decrease in the number of fireworm individuals consumed. This decrease was due to the reduced availability of fireworms for *S. annulicornis* predators. As prey availability decreases, *S. annulicornis* predators require more time to find prey. Susilo (2007) stated that predators become more efficient when prey populations are highest because most of the time is spent catching prey. Ginting *et al.* (2017) also stated that as prey availability decreases, the time needed for predators to search for prey increases, whereas when more prey is available, the time needed decreases.

The female *S. annulicornis* imago had a higher predation rate in this study than the male imago. The daily predation rate of one female *S. annulicornis* imago was 18%, slightly higher than the 15.05% per day for one male imago [unpublished thesis by Daeli, 2010 - *Predation capacity of Sycanus croceovittatus (Hemiptera: Reduviidae) on fire caterpillars Setothosea asigna in oil palm plants in the Insectarium*]. This is because female *S. annulicornis* imagoes are larger and have a longer lifespan than male imagoes, requiring more nutrients and energy from their prey to sustain life and reproduction.

Total predation

The analysis of the total predation of nettle caterpillars (*S. nitens*) by *S. annulicornis* imago revealed that certain treatments had a significant impact (Figure 3), as determined by variance analysis. The average results from the BNT (honestly significant difference) for total predation at the 5% significance level are presented in Table 3.

Table 3 shows that different treatments of *S. annulicornis* imago resulted in varying total predation of fireworms. The total predation of fireworms in the one male and one female imago treatments were not significantly different, with 74.28% and 80%, respectively. The one pair treatment was significantly different from the other two, with total predation of 100%, representing the highest total predation.

The total predation of fireworms increased with the number of *S. annulicornis* predators. In the one pair treatment, competition occurred between the male and female imagos for the fireworms as prey, resulting in the highest total predation. In contrast, in the one male and one female treatments, no competition occurred, leading to

Table 3. Mean total predation of nettle caterpillars (*Setora nitens*) by *Sycanus annulicornis* imago (%).

Number of imago *Sycanus annulicornis*	Total predation (%)
1 male	74.29 b
1 female	80.00 b
1 pair	100.00 a

The numbers in the column followed by different lowercase letters are significantly different according to the Boston naming test (honestly significant difference) test at the 5% level, after transformation with arcsin√y.

fewer fireworms being consumed by the end of the observation. The predation capacity of *E. furcellata* as an individual predator does not involve competition, resulting in lower predation [unpublished thesis by Chan (2012) - *Predation ability of Eocanthecona furcellata on Setothosea asigna larvae in oil palm plants*]. This indicates that predation is influenced by the presence of other individuals of the same species. Tobing *et al.* (2009) also stated that predation can increase with the number of predators in the field, and the time needed to handle prey decreases.

S. annulicornis is a highly potential biological control agent. Yuliadhi (2017) reported that *S. aurantiacus* is one of the control alternatives that can reduce the population of cabbage pests such as *P. xylostella* and *C. pavonana* and is an environmentally safe control method. Aufa (2017) stated that *S. dichotomus*, both in the nymph and imago stages, can consume several leaf-eating larvae, such as *Spodoptera litura*, *Erionota thrax*, and *Setora nitens*. Species from the *Sycanus* genus, such as *S. affanis*, *S. pyrrhomelas*, *S. versicolor*, *S. croceovittatus*, *S. annulicornis*, and *S. dichotomus* (Zulkefli *et al.*, 2004), have been reported as potential predators.

During the maintenance of *S. annulicornis* in the laboratory, the food provided was *T. molitor* larvae. When tested with their primary prey, *S. nitens* (fireworm), *S. annulicornis* imago still consumed them, with 100% predation over 3 days in the one pair male and female treatment. This shows that *S. annulicornis* predators will consume fireworms even when initially fed *T. molitor* larvae, indicating that *S. annulicornis* is polyphagous. Polyphagous predators have the advantage of easily finding alternative prey when their main prey population is low, allowing them to sustain their survival [unpublished thesis by Pramono (2018) - *Exploration and characterization of coccinellid predators for biological control of sugarcane scale insects (Aulacaspis tegalensis Zehntner (Hemiptera: Diaspididae)*]. According to Tarumingkeng (1994), several factors determine the predation rate by predators, including prey preference, prey density, food quality, and the presence of alternative prey. Based on this, it can be concluded that *S. annulicornis* can be mass-reared with *T. molitor* larvae as an alternative food source and applied in the field to control *S. nitens* fireworm pests.

Conclusions

S. annulicornis predators reared on *T. molitor* larvae were effective in preying on native nettle caterpillars (*S. nitens*) in the field. The search time for the first prey was fastest with one pair of *S. annulicornis* imago, taking just 0.79 minutes, and for the second prey, it was 0.71 minutes. The handling time for one nettle caterpillar by *S. annulicornis* predators ranged from 3.86 to 5.14 hours. Notably, the treatment involving one pair of *S. annulicornis* imago achieved the shortest handling time of 3.86 hours and resulted in 100% total predation of nettle caterpillars.

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