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Biology of Predatory Fire Caterpillar, *Sycanus* sp. (Hemiptera: Reduviidae), when fed Alternative with Black Soldier Fly Maggots (*Hermetia illucens*)

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Abstract

Fire caterpillars (*Sethotosea asigna,* Lepidoptera: Limacodidae) are a major pest of oil palms and cause harvesting losses. Natural enemies such as *Sycanus* sp. are reported to control fire caterpillars. The biological of *Sycanus* sp. were observed in the laboratory when fed using the alternative feed, maggot Black Soldier Fly (*Hermetia illucens* Linnaeus). Variables observed were egg, nymph, imago stadia, and the life cycle of *Sycanus* sp. The data were calculated, displayed as figures and tables, and given descriptive analysis. The results showed that predatory insects, *Sycanus* sp., can thrive well by providing alternative feed, such as Black Soldier Fly (BSF) (*Hermetia illucens*) maggots. Based on the results, it was known that one female *Sycanus* sp. could produce 101 eggs after being fed BSF maggots, with an incubation period of 17 days. The duration of the nymph stage was around 64.16 days, with a relatively low mortality rate (2-12%). Morphologically, *Sycanus* sp. grew and developed well. The body length was about twice the width of the body. The age of the male was shorter than that of the female, as was the body size. The sex ratio also showed fewer males than females (2:3).

Keywords: Limacodidae, biological control, natural enemies, rearing, *Sethotosea asigna*

Introduction

Palm oil (*Elaeis guineensis* Jacq.) is one of the forestry commodities that contributes significantly to the country's foreign exchange earnings growth in the export sector. Palm oil has a strategic position in Indonesia's economic development; it can provide extensive employment opportunities. Indonesia is also the country with the largest area of palm oil plantations in the world (Fauzi et al., 2012). In 2020, Indonesia has shipped 25.94 million tons of crude palm oil (CPO) to several countries, including Bangladesh, China, India, European, and Pakistan (Directorate General of Plantations, 2021).

According to data from the Central Statistics Agency (2022), palm oil production in Indonesia fluctuates from year to year. In 2019, palm oil production in Riau Province was recorded at 9,152,900 tons with an area of 2,706,900 hectares. Palm oil production 2020 increased to 9,984,300 tons, with an area increasing to 2,853,800 hectares. In 2021, palm oil production decreased to 8,629,100 tons, with an area increasing to 2,860,800 hectares. The current decrease in the amount of palm oil production is caused by attacks by plant pests (OPT), such as oil palm leaf-eating caterpillars (UPDKS), classified as the Limacodidae (Lepidoptera)

One type of caterpillar that eats leaves and causes significant losses in oil palm plantations is the fire caterpillar. According to Hasibuan (2019), the fire caterpillars commonly attacking oil palm in Indonesia are *Setothosea asigna, Setora nitens, Darna trima,* and *Darma diducta*. The symptoms of "melidi" are a sign of *S. asigna* attack; the leaf blades are perforated and eaten so that only the stems remain (Defitri et al., 2017). Due to this attack, oil palm yields decreased by 40% in the second year after the attack and to 78% in the first year (Arsi et al., 2022).

Most farmers and businesses still use synthetic chemical pesticides to control the *S. asigna* population. According to Kardinan (2000), the continuous use of synthetic pesticides will pollute the soil, water, and air, kill non-target organisms such as natural enemies, cause pest resistance and resurgence, and carry residues in agricultural products that are harmful to human health. Biological pest control (biocontrol) is recommended because it is more effective and efficient, environmentally friendly, and supports the concept of integrated pest control (IPM) against the spread of pests (Amrullah, 2019). Biological control can be carried out by utilizing biological agents such as natural enemies, one of which is a predator. The periodic release of several appropriate predators in large numbers can control S. asigna, which is intended to change the balance of nature so that it is beneficial and can directly suppress the pest population (Kembaren et al., 2013). Predatory insects that are often seen in oil palm plantations are *Sycanus* sp. (Hemiptera: Reduviidae) and are polyphagous insects because they have a range of prey in several orders such as Coleoptera, Diptera, Lepidoptera, and Hemiptera (Sahid, 2019). Based on the results of research by Rustam et al. (2018), the average hatching power of *Sycanus* sp. eggs with alternative feed *Helicoverpa armigera* is 71.9%, with an average of one group of eggs producing 81.4 eggs, while according to Sahid (2019), after *S. annulicornis* Dohrn. Given alternative feed for *Alphitobius diaperinus*, Panzer larvae produced 88.1 ± 46.0 eggs in one group, with a hatching rate of 41.8% for each group of eggs. Based on the results of this study, differences in predator feed are thought to affect the biology of predators caused by differences in nutrition from each feed given (Sahayaraj, 2012). Black Soldier Fly maggots are one of the substitute foods that can be used to propagate *Sycanus* sp. predators for reproduction. Black Soldier Fly (BSF) maggots (*Hermetia illucens*, Diptera: Stratiomydae) are widely used in the composting process of organic waste. The growth of BSF maggots lasts around 12-13 days, consisting of 5 instars. BSF maggots can adapt to foods with different nutritional content (Bali Agriculture and Food Security Service, 2021). BSF maggots are easy to maintain and reproduce, so they can be used as alternative feed for *Sycanus* sp. This study aimed to obtain biological information on *Sycanus* sp. by providing an alternative feed of BSF maggots for mass propagation of predators in the laboratory.

Methods

The study was conducted from September 2023 to January 2024 at the Plant Pest Laboratory, Faculty of Agriculture, Universitas Riau, Pekanbaru, Riau Province, Indonesia. During the study, we noted an average temperature of 27.320C and an average humidity of 74.82%.

Methods

The research employed observational and descriptive methods to examine the biological characteristics related to the growth and development of Sycanus sp. These insects were bred and nourished using BSF maggots as an alternative food source in a controlled laboratory environment. The study focused on observing 50 early instars of *Sycanus* sp. nymphs as the primary experimental unit.

Provision of Black Soldier Fly (BSF) Maggots

This study involved the use of BSF maggots sourced from PT. Bio Cycle Indo in Sei Putih Village, Tapung District, Kampar Regency, Riau, Indonesia. The BSF maggots served as the alternative feeding for Sycanus sp. from their nymph to adult. The maggots were kept in a plastic container measuring 28 cm in length, 22.4 cm in width, and 7.5 cm in height and were fed 30 grams of fish pellets.

Collection of *Sycanus* sp.

A total of 5 pairs of *Sycanus* sp. collected from oil palm plantations at PTPN V Sei Lindai, Riau, were infested into containers (top diameter: 9 cm, bottom diameter: 5.5 cm, height: 11.5 cm) containing 2 cm diameter moist cotton, then placed in the laboratory.

Propagation of *Sycanus* sp.

The feed provided for *Sycanus* sp. was 4 individual BSF maggots every two days; 08.00 AM and 14.00 AM. The number given depends on the instar of *Sycanus* sp. nymphs; 1stinstar was fed one BSF, 2nd instar was fed two BSF, 3rd instar was fed three BSF, while 4th - 5th instars were fed 4 BSF (Sahid et al. 2017). A piece of moist cotton was placed in each container to maintain humidity. The egg group was laid by the female, moved into another container, and observed daily. The 50 nymphs produced were transferred to a new container. Each nymph was fed BSF maggots, moist cotton was added, and it was followed until it became an adult.

Variable Observed

Egg number and incubation period

The number and incubation period of eggs produced by adult Sycanus sp. and the incubation period were calculated daily. The size of the egg is observed directly on a millimeter graph of paper.

The incubation period was monitored by noting the time needed by a female to lay the egg till the hatch. We are dedicated to making daily observations to ensure the well-being of the eggs.

Morphology of nymph

The development of nymphs was observed daily based on color, body size, and lifespan. Observations of nymph color were documented using an iPhone camera 11 2019 12+12 MP with 5X magnification. The body size of the nymphs was observed directly on millimeter graph paper.

Nymph length

Observation of the nymph stage was calculated based on how many days the nymph took by each instar to become an adult.

Morphology of adult

Observations were made daily by observing the morphology of males and females. The body size of the adult was observed directly on millimeter graph paper, focusing on the shape of the abdomen of each adult.

Adult duration

Observation of the adult duration was calculated after the end of the fifth instar nymph stage until the adult death.

Fecundity

This observation was carried out on each female of *Sycanus* sp. in the container.

Observations were made to determine the first time the female lays eggs (pre-oviposition), the number of egg groups, and the number of female eggs until the adult death. Observations of the number of egg groups and the number of eggs were carried out by marking each egg produced by the female using label paper, then the eggs were counted and recorded.

Sex ratio

This observation compares the number of adult males and females produced from each egg group. This observation was carried out after the nymph stage changed to adult.

Data Analysis

Data from the propagation of Sycanus sp. by feeding BSF larvae are reported as descriptive analysis and presented in tables and figures. The data obtained are calculated for average, and the standard error was determined using the Microsoft Excel 2010 application.

Results

Egg Number and Incubation Period

The research revealed that one female Sycanus sp. could produce 101 eggs. The percentage of hatched eggs was 88.97%, with an incubation period of 17 days (Table 1). The shape of the egg cluster produced is presented in Figure 1.

Table 1. Egg number and incubation period of Sycanus sp. fed with black soldier fly (bsf) maggots

Obervation	Average ± SE
Number of eggs/ group	101.00 ± 4.58
Number of eggs hatched (invidual)	85.67 ± 9.33
Hatchability (%)	88.97 ± 5.88
Incubation period (day)	17.00 ± 0.00

Note: SE = Standard error

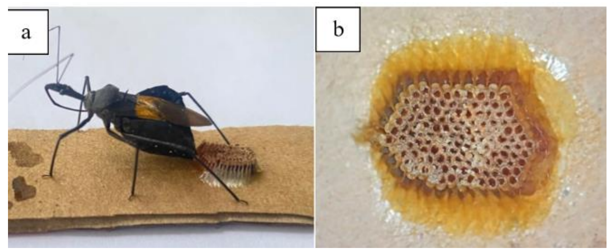

Figure 1. *Sycanus* sp. eggs: (a) When the female lays eggs in groups, (b) the egg groups

Nymph Duration and Mortality

The length of the nymph stage is directly linked to nymph mortality. The nymph stage typically lasts around 64.16 days, with the longest duration observed in *Sycanus* sp. at 5th instar (19.32 days) and the shortest in 1st instar (9.68 days). Notably, the mortality rate among nymphs was relatively low, with 5th instar exhibiting the lowest mortality rate at 2%, while 1st instar showed the highest mortality rate at 12% (Table 2).

Table 2. Life duration of *Sycanus* sp. nymphs at the instar stage fed with black soldier fly (BSF) maggots

Instar	Duration (day) Average ± SE	Number of dead (individual)	Mortality (%)
1st Instar	9.68 ± 0.07	6	12
2nd Instar	10.55 ± 0.11	4	8
3rd Instar	11.53 ± 0.10	2	4
4th Instar	13.08 ± 0.09	2	4
5th Instar	19.32 ± 0.14	1	2
Total	64.16 ± 0.52	15	30

Note: SE = Standard error

There was a gradual change in size from 1st instar to 5th instar. The body length reached 16.12 mm when entering 5th instar. The body length was about twice the width of the body (Table 3, Figure 2).

Table 3. Body size of each instar of *Sycanus* sp. nymphs with black soldier fly (BSF) maggots

Instar	length	Witdh
	Average ± SE (mm)	Average ± SE (mm)
1st Instar	2.08 ± 0.04	1.1 ± 0.03
2nd Instar	4.06 ± 0.04	2.02 ± 0.06
3rd Instar	6.02 ± 0.02	3.04 ± 0.05
4th Instar	10.8 ± 0.24	4.08 ± 0.04
5th Instar	16.12 ± 0.24	5.16 ± 0.05

Note: SE = Standard error

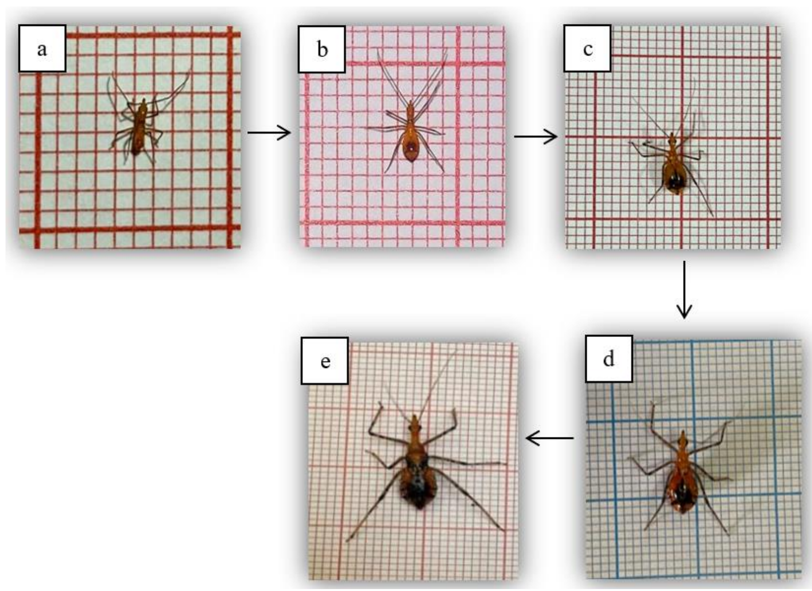

Figure 2. Development of *Sycanus* sp. nymphs: (a) 1^{st} instar, (b) 2^{nd} instar, (c) 3^{rd} instar, (d) 4^{th} instar, (e) 5^{th} instar

The lifespan of male was shorter than female, as was their body size. The sex ratio also showed that there were fewer males than females (Table 5).

Table 5. Life span, body size, and sex ratio of male and female of *Sycanus* sp. fed with black soldier fly (BSF) maggots

Adult	Lifespan	Body size		*Sex ratio*
		Length	Witdh	
	Average ± SE (day)	Average ± SE (mm)	Average ± SE (mm)	
Male	39,86 ± 0,27	22,68 ± 0,11	7,36 ± 0,19	2
Female	44,52± 0,21	26,67 ± 0,13	11,10 ± 0,15	3

Note: SE = Standard error

The number of eggs produced by *Sycanus* sp. fed with BSF was higher than before BSF feeding (Table 1 and Table 6), which came from 2.39 egg groups. The pre-oviposition period lasted for 13 days (Table 6).

Table 6. Fecundity and pre-oviposition of *Sycanus* sp. fed with black soldier fly (BSF) maggots in the laboratory

Observation	Average ± SE
Number of egg groups	2.39 ± 0.30
Egg-laying ability (eggs/ individual)	194.19 ± 19.02
Preoviposition (day)	13.33 ± 0.47

Note: SE = Standard error

In general, it can be seen that *Sycanus* sp. has a long lifespan compared to other insects from the Hemiptera order, which was around 4 months (121.02-125.86 days). The lifespan of males was shorter than that of females (Table 7).

Table 7. The lifespan sex ration of *Sycanus* sp. fed with black soldier fly (BSF) maggots

Lifespan	Average ± SE (day)
Male	121.02
Female	125.86

Note: SE = Standard error

The first eggs produced by female of *Sycanus* sp. were yellowish in color and laid in groups. The eggs changed color to brownish after 16 days (Figure 3).

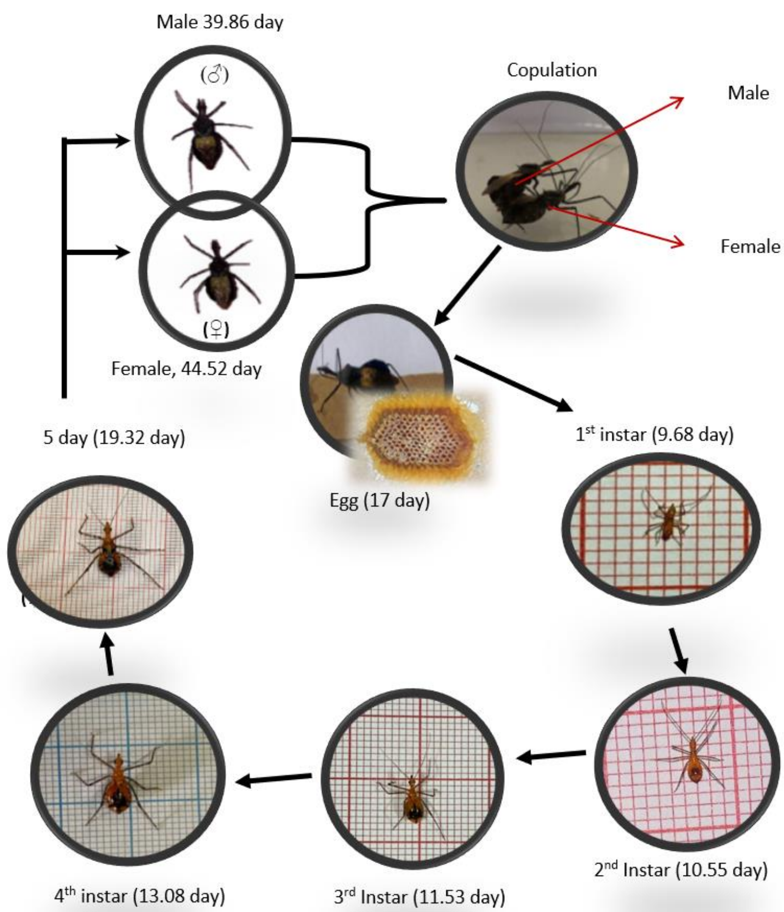

Figure 3. Lifespan of *Sycanus* sp. fed with alternative feed of black soldier fly (BSF) maggots and the changes that occur.

Discussion

Based on the research, it was known that one female *Sycanus* sp. could produce 101 eggs. The percentage of hatched eggs was 88.97% (Table 1). According to Sahid (2019), *S. annulicornis* that was fed by *Alphitobius diaperinus* Panzer (Tenebrionidae, Coleoptera) could produce 81.1 ± 46.0 egg groups, with an egg hatching rate of 41.6%.

These results indicate *Sycanus* sp. could produce more eggs by providing BSF maggot as prey and a higher hatching rate than *S. annulicornis* with *A. diaperinus* prey. The difference in prey provided will be related to the nutritional content, which will affect the number of eggs and hatching rate. According to Bonte et al. (2010), the variation in available prey has different effects on the fecundity (number of eggs) and fertilization (egg-hatching rate) of the predatory insect *Adalia bipunctata*.

The incubation period of *Sycanus sp*. eggs. occurred for 17 days (Table 1). The provision of different feeds will likely affect the length or shortness of the incubation period. Sahid (2019) states that the average incubation period of *S. annulicornis* eggs is 19.0 ± 2.1 days. Incubation of *S. dichotomus* eggs provided *Corcyra cephalonica* and *Plutella xylostella* has an incubation period of 11–39 days (Zulkefli et al., 2004). The incubation period of *Sycanus* sp. eggs with the provision of BSF maggot is faster than the incubation period of *S. annulicornis* eggs with the provision of *A. diaperinus* prey. One of the causes of the difference in the incubation period is different environmental conditions. According to Oktarina and Pramayudi (2012), the environment affects the length of the egg stage, especially temperature. The average temperature in the laboratory in the propagation of *Sycanus* sp. ranges from 26.930C–27.350C, the optimum temperature. According to Natawigena (1990), the effective temperature for insect development is 15ºC, 25ºC, and 45ºC (minimum, optimum and maximum temperatures respectively).

The length of the stage is related to nymph mortality. The nymph stage was around 64.16 days; the longest time was *Sycanus* sp. at the 5th instar (19.32 days), and the shortest one was at the 1st instar (9.68 days) (Table 2). This nymph stage length was faster than the results of the investigation by Rustam et al. (2018); the age of the *Sycanus* sp. nymph stage is longer when fed *H. armiger*a. Based on the research of Purwaningrum (2006, unpublished data), the nymph stage of *S. annulicornis* fed with *S. litura* lasted faster (58.31 ± 6.49 days). The life span of *Sycanus* sp. fed with BSF maggots was faster than *Sycanus* sp. fed with *H. armigera*, and then *S. annulicornis* fed with *Spodoptera litura*. This is assumed due to differences in essential nutrients in the prey provided and environmental conditions. Bursell (1970) emphasized that if the nutrients in the food fed by an organism are optimal for its growth and development, the organism will reproduce successfully.

The mortality rate of nymphs is relatively low. The nymph with the lowest mortality was the 5th instar (2%), while the highest was the 1st instar, with a mortality rate of 12% (Table 2). The total mortality of *Sycanus* sp. nymphs was higher in these results compared to the study by Rustam et al. (2018), which was provided with *H. armigera* (14.25%). One possible cause is that BSF maggots are more active in moving, making it difficult for *Sycanus* sp. to prey on them.

The body length of nymphs was about twice the body's width (Table 3, Figure 2). The body size of *Sycanus* sp. was relatively smaller than fed with *Helicoverpa armigera*, as reported by Rustam et al. (2018). According to Davidowitz et al. (2004), the interaction between environmental and genetic factors, including temperature, humidity, and nutrition, can affect the expression of genes involved in the growth and development of nymphs. BSF maggots contain high protein, which increases the resistance of *Sycanus* sp. According to Mualidiya (2018), protein is a food needed for insect growth, oviposition, and survival, including *Tribolium castaneum*. The research findings showed that the body size of male was smaller than that of female (Table 5). According to Zulkefli et al. (2004), the difference between male and female lies in their body size; male are smaller than female.

The lifespan of males and their body size were shorter than that of females (Table 5). This is due to differences in the physiology. Kawecki et al. (2020) state that specific physiological characteristics in male and female insects contribute to differences in lifespan of adults. Males tend to have a higher metabolic rate than females, which can accelerate aging and shorten the male's life. Compared to males with smaller bodies, females often have larger bodies associated with a longer lifespan. Variations in metabolic rate and body size between sexes are physiological characteristics that are essential in the variation in average lifespan between males and females in many species.

The number of males formed was less than that of females, with a sex ratio of 2:3 (Table 5). Meanwhile, Sahid et al. (2016) reported that the sex ratio of male and female *S. annulicornis* is 3:4. According to Pelealu (2013), the nutritional quality of food influences the development and reproduction of insects, including the sex ratio. Sudarjat et al. (2009) state that more females than males will benefit their reproduction.

In general, *Sycanus sp*. had a long life span, around 4 months (121.02-125.86 days). The life cycle of males was shorter than that of females (Table 7, Figure 3). Yuliadhi et al. (2020) stated that the life cycle of *Sycanus* sp. with the provision of *Crocidolomia pavonana* is 104-113 days. Sahid (2019) noted that the life cycle of *S. annulicornis*, fed with *Tenebrio molitor* is 117.35 days for males and 122.01 days for females. Based on the results, the life cycle of *Sycanus* sp. Fed with BSF maggots was longer, so BSF maggots can be used as alternative prey for the propagation of *Sycanus* sp.

The reproductive potential of female was 194.19 ± 19.02 eggs/individual (Table 6). The average egg produced by female fed with BSF maggots was higher and will reproduce faster. The most significant number of eggs produced by female was 367 eggs. This findings was higher that Rustam et al. (2018) reported, which female of *Sycanus* sp. can produce up to 150.76 eggs.

The adult fed with BSF maggots had a pre-oviposition period of 13.33 ± 0.47 days (Table 6). This finding was higher than Sahid (2019) reported, which female of *S. annulicornis* fed with *A. diaperinus* produced 1–4 egg clusters during their lifespan. Female fed with BSF maggots produced more egg clusters than those given other alternative feeds, presumably due to the nutritional content of the prey provided. Rachmawati et al. (2010) reported that BSF maggots have a nutritional value of 19.80% crude fat, 9.71% ash, and 47.56% crude protein. BSF maggots have a high protein content, increasing female imago's fecundity. According to Mualidiya (2018), protein is a food needed for the growth, oviposition, and survival of *Tribolium castaneum* insects.

Conclusion

Predatory insects, *Sycanus* sp., can thrive well by providing alternative feed, such as Black Soldier Fly (BSF) (*Hermetia illucens*) maggots. Based on the results of this study, it was known that one female *Sycanus* sp. could produce 101 eggs after being fed BSF maggots, with an egg incubation period of 17 days. The duration of the nymph stage was around 64.16 days, with a relatively low mortality rate (2-12%). Morphologically, *Sycanus* sp. grew and developed well. The body length was about twice the width of the body. The age of the male was shorter than that of the female, as was the body size. The sex ratio also showed fewer males than females (2:3).

Acknowledgement

Thank you to all parties who have contributed to the completion of the propagation of *Sycanus* sp. by providing an alternative feed of Black Soldier Fly (BSF) maggots, which were propagated in the laboratory to be used for biological control in the field.

Declaration

Author contribution

Nadila Hayati is the main contributor for this paper. Rusli Rustam is corresponding author. Irwin Mirza Umami and Andriyani Prasetiyo-wati are the co-authors. All authors read and approved the final paper.

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Competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

Amrullah SH. 2019. Pengendalian hayati (Biocontrol): Pemanfaatan serangga predator sebagai musuh alami untuk serangga hama. Prosiding Seminar Nasional Biodiversitas Indonesia. Universitas Islam Negeri Alauddin Makasar 5(1): 87–90. DOI: 10.24252/psb.v5i1.11890

Badan Pusat Statistik Provinsi Riau. 2022. Provinsi Riau dalam Angka 2022. Provinsi Riau. www. riau.bps.go.id. Diakses pada tanggal 10 Januari 2023.

Bursell E. 1970. An introduction to insect physiology. Academic Press Inc. (London) LTD. London and New York.

Bonte M, PDe Clercq, F Spranghers J Audenaert. 2010. Influence of diet on the reproduction of *Adalia bipunctata* L. (Coleoptera: Coccinellidae). Communications in Agricultural and Applied Biological Science 75(4): 557–563. DOI: 10.35218/caabs.2010.75.4.14

Defitri Y, Y Nengsih, H Saputra. 2017. Intensitas serangan hama ulat api *(Setothosea asigna)* pada tanaman kelapa sawit *(Elaeis guineensis.* Jacq) di Kecamatan Tebo Tengah Kabupaten Tebo. Jurnal Media Pertanian 2(1): 16–23. DOI: 10.33087/jagro.v2i1.23

Dinas Pertanian dan Ketahanan Pangan. 2021. Lalat Tentara Hitam *(Black Soldier Fly)* serangga yang beragam manfaat. www. distanpangan.baliprov.go.id. [Accessed: 17 January 2023].

Davidowitz G, LJ D'Amico, HF Nijhout. 2004. The effects of environmental variation on body size and growth in a seasonal polyphenic insect. Oecologia 139(3): 492-499. DOI: 10.1007/s00442-004-1531-9

Fauzi Y, EW Yustina, I Satyawibawa, RH Paeru. 2012. Kelapa sawit budi daya dan pemanfaatan hasil dan limbah analisis usaha dan pemasaran. Penebar Swadaya. Jakarta.

Gilbert II. 2009. Insect Development: Morphogenesis, molting and metamorphosis. Annual Review of Entomology 54: 379-399. DOI: 10.1146/annurev.ento.54.110807.090612

Kardinan A. 2000. Pestisida nabati, ramuan, dan aplikasinya. Penebar Swadaya. Jakarta.

Kawecki TJ, CW Fox, BP Fahey. 2020. Causes and consequences of differences in lifespan between the sexes in insects. Philosophical Transactions of the Royal Society B 375(1808): 20190460. DOI: 10.1098/rstb.2019.0460.

Kembaren E, D Bakti, L Lubis. 2013. Daya predasi *Rhynocoris fuscipes* F. (Hemiptera: Reduviidae) terhadap ulat api *Setothosea asigna* E. (Lepidoptera: Limacodidae) di laboratorium. Jurnal Agroekoteknologi Universitas Sumatera Utara 2(2): 577–585. DOI: 10.32734/jaet.v3i1.6982

Maulidiya NR. 2018. Pertumbuhan populasi dan keragaman *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae) pada beras putih, merah, dan hitam dalam berbagai proporsi butiran utuh dan patah. Skripsi. Universita Brawijaya. Malang.

Pramayudi N, H Oktarina. 2012. Biologi hama kutu putih pepaya (*Paracoccus marginatus*) pada tanaman pepaya. Jurnal Floratek 7(1): 32–44. DOI: 10.29303/floratek.v7i1.67

Purwaningrum W. 2006. Pengaruh tiga jenis mangsa terhadap kepik predator *Sycanus annulicornis* Dohrn (Hemiptera: Reduviidae). [Tesis]. Institut Pertanian Bogor. Bogor.

Pelealu J. 2013. Nutrisi dan reproduksi serangga. Jurnal Entomologi Indonesia 10(1): 37–46. DOI: 10.5994/jei.10.1.37

Rachmawati A. 2010. Potensi lalat *Hermetia illucens* (Linnaeus) (Diptera: Stratiomyidae) sebagai pengurai dan sumber protein pakan ternak. Jurnal Sain Veteriner 28(1): 23–32. DOI: 10.5994/jei.7.1.28

Rustam R, D Salbiah, Polontar. 2018. Biologi *Sycanus* spp. pemangsa ulat api (*Setora nitens* Walker) lokal Riau menggunakan mangsa larva *Helicoverpa armigera* Hubner di laboratorium. Jurnal Online Mahasiswa Fakultas Pertanian. Pekanbaru.

Sahayaraj K. 2012. Arficial rearing on the nymphal developmental time and survival of three reduviid predators of Western Ghats, Tamil Nadu. Jurnal Biopest 5(2): 218–221. DOI: 10.35411/biopest/2012/v5/i2/93388

Sahid A, WD Natawigena, Hersanti, Sudarjad, E Santosa. 2016. Biologi dan perilaku kawin *Sycanus annulicornis* Dohrn. (Hemiptera: Reduvidae) yang diberi pakan larva *Tenebrio molitor* L. (Coleoptera: Tenebrionidae). Proceeding Biology Education Conference 13(1): 587–592:

Sahid A. 2019. Aspek biologi *Sycanus annulicornis* Dohrn. (Hemiptera: Reduviidae) yang dipelihara dengan pakan alternatif larva *Alphitobius diaperinus* Panzer (Coleoptera: Tenebrionidae). Jurnal Agroekoteknologi Tropika Lembab 2(1): 50–54. DOI: 10.35941/jatl.2.1.2019.2535.50-54

Sahid A, WD Natawigena, H Hersanti, S. Sudarjat. 2017. Pengaruh kerapatan pemeliharaan nimfa terhadap pertumbuhan dan perkembangan kepik buas *Sycanus annulicornis* Dohrn. (Hemiptera: Reduviidae). In Proceeding Biology Education Conference: Biology, Science, Enviromental, and Learning 14(1): 58-62.

Sudarjat S, A Utomo, D Dono. 2009. Biologi dan kemampuan memangsa *Paederus fuscipes* Curtis (Coleoptera: Staphylinidae) terhadap *Bemisia tabaci* Gennadi us (Homoptera: Aleyrodidae). Jurnal Agrikultura 20(3): 204–209. DOI: 10.24198/agrikultura.v20i3.959

Wardani N dan EC Lina. 2017. Potensi predator *Sycanus* spp. dan *Rhinocoris* sp. (Hemiptera: Reduviidae) untuk Mengendalikan Hama Tanaman. Prosiding Seminar Nasional Agro Inovasi Spesifik Lokasi untuk Ketahanan Pangan pada Era Masyarakat Ekonomi ASEAN. Institut Pertanian Bogor. Bogor.

Yuliadhi KA, AP Sedana, IP Sudi arta. 2020. The Predation behaviour and biology of predator *Sycanus aurantiacus* (Hemiptera: Reduviidae) on the different larvae of *Tenebrio molitor* L. and *Crocidolomia pavonana* FAB. Jurnal Agroekoteknologi Tropika 9(2): 125-131. https://ojs.unud.ac.id/index.php/JAT/article/view/61337.

Zulkefli M, K Norman M, W Basri. 2004. Life cycle of *Sycanus dichotomus* (Hemiptera: Pentatomidae) a common predator of bagworm in oil palm. Journal of Oil Palm Research 14(2): 50–56. DOI: 10.21894/jopr.2004.14.2.07

Arsi, AD Tama, A Umayah, B Gunawan. 2022. Populasi dan intensitas serangan hama *Setothosea asigna* pada kelapa sawit (*Elaeis guineensis* Jacq.) di Desa Gunung Cahya Kematan Buay Rawan Kabupaten Oku Selatan. Jurnal Planta Simbiosa 4(2): 41-53. DOI: 10.25181/jplantasimbiosa.v4i2.2675

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