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PREDATION EFFICIENCY AND FEEDING PREFERENCES OF LABORATORY-REARED *Sycanus dichotomus* (HEMIPTERA: REDUVIIDAE) ON OIL PALM BAGWORM, *Metisa plana* (LEPIDOPTERA: PSYCHIDAE)

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Abstract: The predatory reduviid bug, *Sycanus dichotomus* (Hemiptera: Reduviidae), is a biological control agent against the oil palm pest bagworm (*Metisa plana*). This study investigates the predation efficiency and feeding preferences of laboratory-reared and wild *S. dichotomus* towards *M. plana* larvae under laboratory conditions. The results showed that wild *S. dichotomus* had a higher predation efficiency compared with laboratory-reared *S. dichotomus* towards *M. plana* larvae ($F = 10.39$, $df = 1,191$, $p < 0.05$). Compared with male *S. dichotomus*, females consumed more *M. plana* larvae ($F = 13.51$; $df = 1, 191$; $p < 0.05$). The mortality rate of *M. plana* was positively correlated with the nymph stage of *S. dichotomus*, although immature and adult *S. dichotomus* are capable of causing a significant mortality rate for *M. plana* ($R^2 = 0.76$; $F = 158.83$; $df = 1, 49$; $p < 0.05$). Meanwhile, *S. dichotomus* showed high predation rates toward *M. plana* larvae compared with the other prey larvae. This indicates that *S. dichotomus* have the capability and potential to become a biological agent in controlling oil palm bagworms.

Keywords: Natural predator, biological control, agriculture, feeding preferences, insect pest.

Introduction

In Malaysia, *Metisa plana*, which is commonly known as the bagworm, is the most serious and dominant pest species of oil palm (Norman *et al.,* 1994; Tan *et al.,* 2008). It is well known for its destructive effect on oil palm (Wood, 1968). The bagworm larvae are sessile caterpillars that feed on oil palm foliage, and leaves are used to make silken cases, in which the larvae resides (Basri *et al.,* 1995; Rhainds *et al.,* 2009; Kamarudin *et al.,* 2010). Their presence causes serious damage to oil palm leaves, which could significantly result in 10% - 13% yield losses (Norman & Othman, 2006; Cheong *et al.,* 2010). Some treatment and preventive measures for bagworm infestation include the use of chemical insecticides, such as trichlorfon and acephate, on young oil palms and trunk injections using monocrotophus or methamidophos for older oil palm (Hasber *et al.,* 2015). However, the use of insecticide is costly and there has been a growing concern of the side effects to the environment (Igbedioh, 1991).

In recent years, biological control application has been highlighted as a modern pest management strategy. Natural enemies, such as parasitoids, entomopathogenic fungi and other organisms, have been used in many management practices as it is environmentally friendly (Singh, 1992; Basri *et al.,* 1996; Tiong, 1996; Cheong *et al.,* 2010; Ishak *et al.,* 2020). Among the known potential biological agents for controlling the population of insect pests are the reduviid groups (Biever & Chauvin, 1992; Cloutier & Bauduin, 1995; Ambrose, 2002), or commonly referred as "assassin bugs" (Ambrose, 2003). Assassin bugs have been recognised as important natural enemies, preying on several pests, especially lepidopteran insects (Ambrose, 1996). They also have the ability to consume a large quantity of prey (James, 1994).

Several previous studies have reported that the *Sycanus* sp. predator can effectively kill a significant number of bagworm larvae (Sankaran & Syed, 1972; Tiong, 1996; Wood *et al.,* 1976). They are known to feed on insect pests, such as *Pteroma pendula*, *M. plana*, *Mahasena corbetti*, *Seteroa setothosea* and *Darna trima* (Wood *et al.*, 1976; Wood, 1982; Desmier *et al.,* 1989; Norman *et al.,* 1998; Zulkefli *et al.,* 2004; Syari *et al.,* 2010). One of the known species belonging to this group is the *Sycanus dichotomus*. Desmier *et al.* (1989) reported that a single *S. dichotomus* is capable of killing at least 430 *M. plana* larvae throughout its lifetime. Compared with other predatory hemipteran species, the elongated mouthparts, i.e. a rostrum of *S. dichotomus*, had been attributed with efficiency in handling and killing the bagworm larvae (Singh, 1992; Zulkefli, 1996). However, information on predatory efficiency of laboratory-reared *S. dichotomus* on *M. plana* has yet to be explored. This study aims to investigate the predatory efficiency and feeding preference between laboratory-reared and wild *S. dichotomus* towards *M. plana* larvae under laboratory conditions. Information from this study can lead to the potential use of these predators to manage the bagworm population in oil palm plantations.

Materials and Methods

Field Collection and Rearing of S. Dichotomus

To prepare laboratory-reared *S. dichotomus*, 30 adults were collected in oil palm plantations by using sweep nets. The adult *S. dichotomus* were reared in the laboratory using plastic containers (15 cm x 9 cm x 7 cm) and were maintained by feeding them *Tenebrio molitor* (Coleoptera: Tenebrionidae) larvae. The method was carried out according to Zulkifli *et al.* (2004). Each container housed a pair of adult *S. dichotomus*. Food was replenished every three days to ensure it was sufficient and to prevent cannibalism. The eggs laid by the female adult *S. dichotomus* were transferred into a petri dish. Upon hatching, the nymphs in the petri dish were provided with water-diluted honey for sustenance. After five days, the nymphs were then transferred into a rearing cage (14 cm x 10 cm x 8 cm) until the nymphs grew into adults. As for the preparation of wild *S. dichotomus*, which acted as control, 30 adults were collected later from the field and were maintained by feeding them *T. molitor* before the experiment begun (when both types were ready for the study).

Predation Efficiency of S. Dichotomus on M. Plana Larvae

A total of 48 individuals (12 males and 12 females for each wild and reared type) of *S. dichotomus* were used in this study. The treatment arrangement followed a complete randomised design (CRD) and were maintained in a standard laboratory environment with a temperature of 25±2°C, relative humidity of 70±5% and photoperiod of 12:12 (Light : Day) hour (Harith-Fadzilah *et al.,* 2020). Predation by laboratory-reared and wild male and female adults of *S. dichotomus* towards bagworm (*M. plana*) larvae was observed in a container (15.5 cm x 8.5 cm x 9 cm). The predators were left without food for starvation 24 hours before the experiment, according to the method by Haris *et al.* (2014).

The experiment was begun by providing five *M. plana* larvae to *S. dichotomus* individually for each assay and the number of *M. plana* larvae killed by the predators were recorded after 24 hours of experiment. The experiments were repeated with 10, 15 and 20 *M. plana* larvae given to each *S. dichotomus*. The laboratory-reared and wild male and female adults of *S. dichotomus* were replicated 12 times for every amount of *M. plana* larvae, respectively. For the *S. dichotomus* nymphal consumption of *M. plana* larvae, 10 individuals from every different development stages of the *S. dichotomus* nymph (five nymphal stages) were individually exposed to 20 *M. plana* larvae in rearing cages (15 cm x 9 cm x 7 cm) with ten replicates per treatment, respectively. The numbers of *M. plana* larvae killed by *S. dichotomus* nymph were recorded after 24 hours of experiment.

Feeding Preference of Adult S. Dichotomus on Different Prey Larvae

The study on the feeding preferences of *S. dichotomus* was done in a no-choice experiment approach under laboratory conditions. A total of 20 adult *S. dichotomu* were given different larvae insect pest species *M. plana, Tenebrio molitor, Corcyra cephalonica* and *Spodoptera exigua*. The *S. dichotomus* were starved for 24 hours and then exposed to 10 larvae of different pest species after 24 hours. The experiments were conducted with five replicates and the number of larvae of the pest species killed were recorded after 24 hours.

Statistical Analyses

The percentages of prey mortality caused by *S. dichotomus* were analysed using three-way analysis of variance (ANOVA). Regression analysis was carried out to determine the relationship between the mortality of *M. plana* larvae and the nymphal stages of the *S. dichotomus*. The significance of differences between treatments ($p < 0.05$) of each experiment was determined by Tukey's test. All data analyses were performed using the Minitab programme (Minitab Inc., 1998).

Results and Discussion

Predation Efficiency of S. Dichotomus on M. Plana Larvae

Most predatory hemipteran species of the family Reduviidae need to consume large quantities of larval pests, attributed to their large body sizes compared with other terrestrial insect predators (James, 1994; Sahayaraj, 2014). In this study, there was a significant ($F = 10.39$, df = 1,191, $p < 0.05$) difference in the percentage mortality of *M. plana* larvae consumed by different types of *S. dichotomus*. Wild *Sycanus dichotomus* killed more than 90% of bagworm larvae and were significantly different ($p < 0.05$) from that of laboratory-reared *S. dichotomus* (Figure 1). However, no significant difference ($F = 0.68$, df = 3,191, $p > 0.05$) was recorded in the mortality percentage of different individual numbers of *M. plana* larvae killed by *S. dichotomus* adults. There was also no interaction ($F = 2.22$; df = 3,191; $p > 0.05$) between the different types of the predator and the various numbers of *M. plana* larvae in influencing the predation rate of *S. dichotomus*.

According to Sahayaraj and Ambrose (1994) and Srikumar *et al.* (2014), predatory insects' past experiences in identifying and

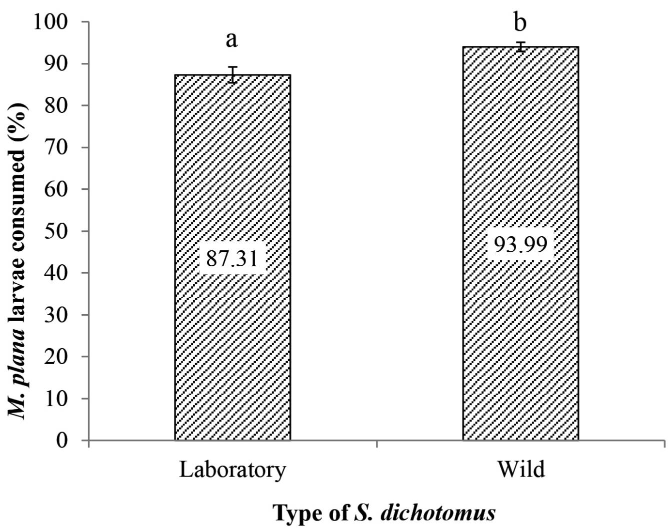

Figure 1: Percentage (Mean ± SE) of *M. plana* larvae consumed by laboratory-reared and wild *S. dichotomus*

attacking several different larvae pest species in their natural habitat influenced the overall predatory behaviour patterns, and increased the effectiveness of the predation rates. Predatory insects that live in natural habitats are more active and aggressive in searching and attacking prey compared with the laboratory-reared predatory insects (Cohen, 1990; Gamez-Virues & Eben, 2005). It was shown between the laboratory-reared and wild *S. dichotomus*, the wild insects consumed significantly more bagworms' larvae than the laboratory-reared insects. This study suggests that the laboratory-reared *S. dichotomus* possibly took longer to attack the larvae because they lacked experience.

The mean percentage of *M. plana* larvae mortality by *S. dichotomus* showed significant difference ($F = 13.51$; df = 1, 191; $p < 0.05$) among the sexes of the predator. The female adult *S. dichotomus* killed more than 90% of bagworms larvae and was significantly different ($p < 0.05$) to male adult *S. dichotomus* (Figure 2). However, no interaction between the sexes of the predator with various numbers of *M. plana* larvae ($F = 2.17$; df = 3, 191; $p > 0.05$) or with different types of the predator ($F = 0.58$; 1, 191; $p > 0.05$influenced the mean percentage mortality of bagworm larvae consumed by the *S. dichotomus*. There was also no interaction ($F = 1.47$; df = 3, 191; $p > 0.05$) among the treatments (various numbers of *M. plana* larvae, sexes, and types of the predator) that influenced the predation of *S. dichotomus* on *M. plana* larvae.

The factor of sex also has a significant influence on the overall number of individuals consumed, where female *S. dichotomus* consumed more bagworm larvae compared with males. This is coherent with George *et al.* (1998) and Syari *et al.* (2010), who identified that female of *Sycanus* sp. killed more larvae pests compared with the males**,** which in turn contributed to the larger female body sizes. The difference in body sizes between the two sexes is correlated with the ability of the female to produce eggs (Ambrose *et al.,* 1988; Ambrose, 1999). Hence, the killing and feeding capacities of female *S. dichotomus* were much higher.

Consumption of M. Plana According to the Developmental Stages of S. Dichotomus

There was a significant difference ($F = 42.7$; df = 5.19; $p < 0.05$) in the mean percentage of prey consumed by the immature *S. dichotomus* of various stages (Figure 3). The mean percentage of prey consumed was significantly ($p < 0.05$) higher among *S. dichotomus* in the 5^{th} nymphal stage than the younger nymphal stages. The smallest nymphal stage (1^{st} stage) consumed

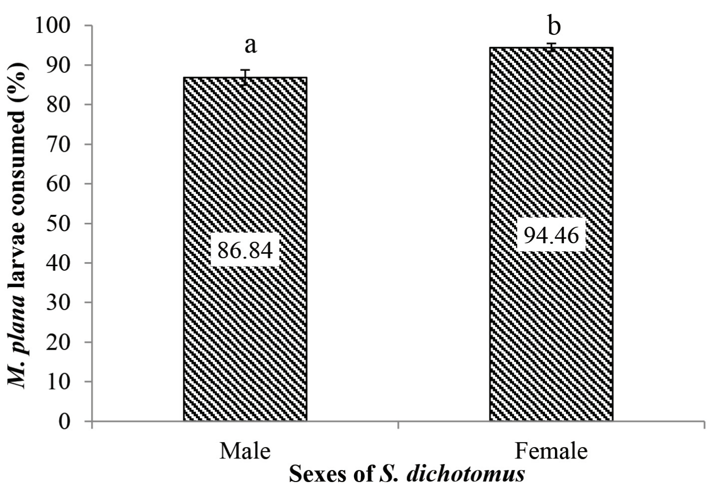

Figure 2: Percentage (Mean ± SE) of *M. plana* larvae consumed by male and female *S. dichotomus*

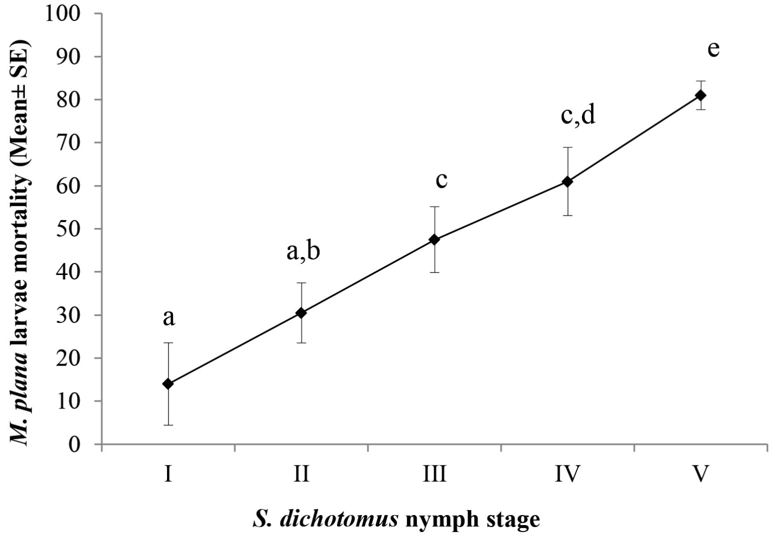

Figure 3: Percentage (Mean ± SE) of *M. plana* larvae exposed to different *S. dichotomus* nymphal stages (Note: Same letter indicates no significant difference)

the lowest number (14%) of prey larvae, but it was not significantly different to the 2nd stage. There was a positive and significant ($R^2 = 0.76$; $F = 158.83$; df = 1, 49; $p < 0.05$) relationship between the number of *M. plana* larvae killed and the nymhal stage of the *S. dichotomus*.

Another criterion in selecting a particular predatory insect species is whether the nymphs are reliable and viable in killing pest insect larvae (Stiling & Cornelissen, 2005). In this study, a significant and positive correlation was shown between the nymph stages and the number of bagworm larvae consumed. The number of bagworm larvae consumed was significantly different from the first to the fifth nymphal stages of the *S. dichotomus*. This is due to the fact that the different body sizes of these nymph stages affected their ability to handle and kill bagworm larvae (Grundy & Maelzer, 2000; Balakrishnan *et al.,* 2011). Larger-sized predators usually have more liquid-form digestive enzymes to disintegrate their preys' internal organs (Sahayaraj *et al.,* 2007; Das & Ambrose, 2008). Therefore, older *S. dichotomus* nymphs would have better capabilities of killing and sucking a higher number of bagworm larvae with ease.

Feeding Preference of Adult S. Dichotomus on Different Prey Larvae

There was a significant difference ($F = 42.7$; df = 5, 19; $p < 0.05$) in the mean percentage of prey larvae consumed by adult *S. dichotomus* when they were given different diet choices (insect species). The highest predation rate of *S. dichotomus* was recorded on *M. plana* larvae and was significantly different ($p < 0.05$) compared with *C. cephalonica* and *T. molitor* larvae, but not significantly different ($p > 0.05$) with *S. exigua* larvae (Figure 4).

The term preference, which are related to the choice made by predators, are not only based on the ratio of the number of preys available, but are also influenced by other intrinsic factors, including appearances, sizes, taste textures, chemical secretions related to specific pest species (Venkatesan *et al.,* 1999; Chandral *et al.,* 2005), the form of defence employed by the prey species (Laurent *et al.,* 2003), and differential and comparable sizes between prey and predator (Sahayaraj, 2001; Cogni *et al.,* 2002). The *S. dichotomus* are known as a polyphagous predator, and prefer to attack certain larval pest species (Singh, 1992; Syari, 2010).

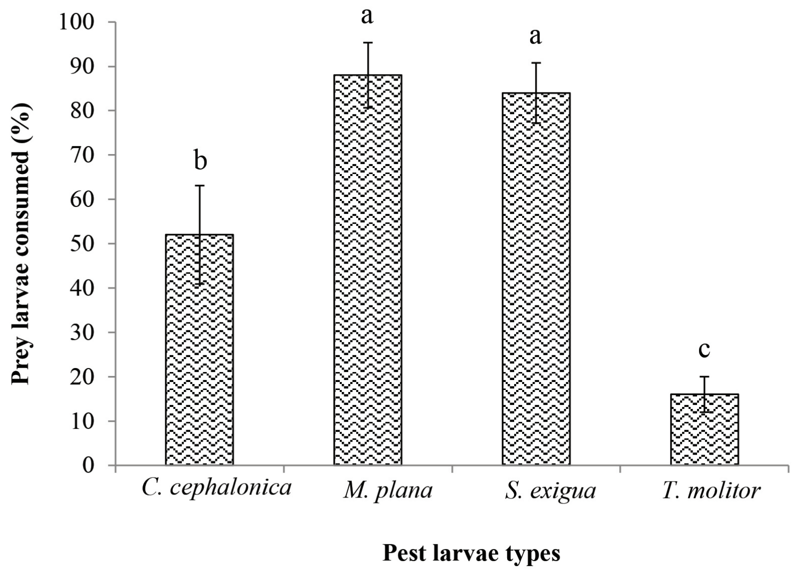

Figure 4: Percentage (Mean ± SE) of different prey larvae species consumed by *S. dichotomus*
(Note: Same letter indicated no significant difference)

The *S. dichotomus* feeding preference under laboratory conditions showed that they preferred to consume *M. plana* larvae compared with the larvae of *S. exigua*, *C. cephalonica* and *T. molitor*. Previous studies also showed that most Reduviid species had preferred lepidopteran larvae as their main food source compared with other insect species (Claver & Ambrose, 2001; Ravichandran & Ambrose, 2006). This is due to the fact that most lepidopteran larvae have specific larval characteristics, i.e. softer cuticle structures, which enables most Reduviid predators to penetrate the larvae's large body parts containing more lipids and protein with ease. Additionally, compared with other insect pest species, such as the coleopteran larvae of *T. molitor*, lepidopteran larvae, such as the larvae of *M. plana*, have slower movement rates and are usually clumped together within any given suitable natural habitat for a prolonged period (Kuppusamy & Kannan, 1995; Rhainds *et al.,* 2009).

Conclusion

In this study, the predatory insect species *S. dichotomus* has been observed to have high potential and capabilities at both the nymph and at adult stages to kill large numbers of larval pest species. It is suggested that the wild predators can be reared and potentially released to the field, especially female adults and also the 5th instar nymphs, to improve the control technique of *M. plana.* The findings on the high preference of *S. dichotomus* for bagworms provide fruitful information in the use of this species as the main predator for the oil palm pest. Therefore, it is important to initiate further field study that evaluates the role of this natural enemy as an effective biological control agent of oil palm bagworm *M. plana* in nature.

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