PREY PREFERENCE OF CHECKERED BEETLE, *Callimerus arcufer* (COLEOPTERA: CLERIDAE)

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ABSTRACT

Oil palm Lepidopteran species were reported to attack oil palm, which caused substantial crop loss. The biological control approach is mainly the encouragement of natural enemies' population build-up, including insect predators, which will result in the natural suppression of the Lepidopteran pest population. There is insufficient evidence on the preference of insect predator, *Callimerus arcufer* Chalpin (Coleoptera: Cleridae) against Lepidopteran leaf defoliators, hence this study determined the prey species preference of *C. arcufer*. The experiment was conducted through choice and non-choice prey acceptability by *C. arcufer* at constant densities of different Lepidopteran prey species. When the predator was not given choices of prey, the predator consumed all prey species given, with an insignificant difference in percentage consumed. The predator, however, has a significantly higher preference towards both bagworm species, *Metisa plana*, and *Pteroma pendula* compared to other Lepidopteran species tested, implying that *C. arcufer* could be an important predator species for oil palm bagworm, and could sustain in the environment when its main food source is inadequate.

Keywords: Beetle, biological control, oil palm, Lepidopteran prey

ABSTRAK

Spesies Lepidoptera pemakan daun sawit dilaporkan menyerang kelapa sawit dan boleh menyebabkan kerugian tanaman yang besar. Pendekatan kawalan biologi secara utamanya ialah menggalakkan pembentukan populasi musuh semula jadi, termasuk pemangsa serangga, yang boleh mengawal populasi perosak Lepidoptera secara semulajadi. Terdapat kekurangan rujukan mengenai keutamaan pemangsaan serangga, *Callimerus arcufer* Chalpin (Coleoptera: Cleridae) terhadap pemakan daun Lepidopteran, justeru kajian ini dijalankan untuk menentukan keutamaan pemangsaan oleh serangga pemangsa *C. arcufer*. Eksperimen telah dijalankan menggunakan kaedah kebolehpilihan dan tiada pilihan spesies mangsa oleh *C. arcufer* pada spesies mangsa Lepidopteran yang berbeza, mengunakan ketumpatan malar. Apabila pemangsa tidak diberi pilihan mangsa, pemangsa memakan semua spesies mangsa yang diberikan, dengan perbezaan peratusan yang tidak signifikan. Pemangsa, bagaimanapun, mempunyai keutamaan terhadap kedua-dua spesies ulat bungkus, *Metisa plana* dan *Pteroma pendula* berbanding spesies Lepidopteran lain yang diuji, membuktikan bahawa *C. arcufer* berpotensi sebagai spesies pemangsa ulat pemakan daun kelapa sawit, dan boleh bertahan di persekitaran kelapa sawit apabila sumber makanan utamanya tidak mencukupi.

Kata kunci: Kumbang, kawalan biologi, kelapa sawit, mangsa Lepidoptera

INTRODUCTION

There are several Lepidopteran species that attacks oil palm, that causes substantial crop loss indirectly through loss of leaf surface; three of the families identified are namely Limacodidae (nettle caterpillar), Psychidae (bagworm) and Lymantriidae (hairy caterpillar) (Sahari et al. 2019). Yield loss caused by nettle caterpillar for example, may reach 70% on the first attempt, and further yield loss up to 90% on the subsequent attack in the same year (Sudharto et al. 2003). The yield loss due to leaf eating caterpillar in Malaysia is mainly caused by Psychidae caterpillars, also known as bagworms.

One of the biological approaches in Integrated Pest Management (IPM) of bagworms is by encouraging natural enemies' population build-up in plantations. Natural enemies are important biological agents in sustaining the population of oil palm bagworms and has been repeatedly emphasized (Siti Nurulhidayah et al. 2020; Wood & Norman 2019a). Outbreaks of bagworms could be controlled if the natural equilibrium between natural enemies and bagworm are maintained (Chung 2012; Wood & Norman 2019a, 2019b).

Insect predators are one of the many natural enemies reported in controlling bagworms. Several species of insect predators have been reported as potential biological agents of bagworms including *Callimerus arcufer, Myrmarachne* sp., *Systropus repkei, Sycanus dichotomus, Cantheconidea furcellata* and *Cosmolestes picticeps* (Azlina & Tey 2011; Cheong et al. 2010; Syari 2016). Many studies had been carried out on the identification of potential insect predators and parasitoid as biological control agents against oil palm bagworms (Halim et al. 2018), but only a few studies were done from the biological aspect of the natural enemy species (Aneni et al. 2014; Sahari et al. 2019).

In natural environments, the direct or indirect interactions between species may affect either the abundance or density of the present species as a short-term effect, or population dynamics in the long run (Miranda et al. 2011; Tack et al. 2011). The indirect interactions are usually related to a third organism, or it happens between individuals at different time or space, but also depend on predator preference. The predator preference is usually influenced by several factors including the nutritional quality of the prey and the difficulty of catching the prey. Success in catches somewhat depends on prey movement and the location of capture to the prey's refuge (Jaworski et al. 2013). These cues may come in different forms, including sounds, shapes and sizes, colour, and chemical (Hatano et al. 2008). The chemical cue, such as semiochemicals resulted from the ovipositioning activity by prey or volatiles from plants that was disturbed by herbivory insects (Vet & Dicke1992).

Intra population variation have an impact to the ecological processes including predation strength and intraspecific competition; it will also have an effect on ecological patterns in the community (Bolnick et al. 2011; Hughes et al. 2008; Moleon et al. 2012). The optimal diet theory (Stephens & Krebs 1986) foresees that an individual ought to gain the maximum energy gain given the costs and benefits of a prey, which depends on the energy substance of the food source, the handling, and search times related to the prey. If the individuals do not follow the theory, they should then differ in their preference rank and prey preference (Tinker et al. 2008). Two factors that contribute to the variation in prey preference first of which is that the individuals may differ in their prey preference if the maximization rates associated to each of the prey species differs (Afik & Karasov 1995; Price 1984) and secondly that individuals differ in their readiness to have other prey species into their diet once preferred prey species is limited (Schindler et al.1997; Svanback & Persson 2004).

Callimerus Gorham (Coleoptera: Cleridae) has been recorded and observed by many researchers since 1929 on the potential of the genus *Callimerus* as a predator on coconut moth (Tothill et al. 1930) and coffee shot-hole borer (Sreedharan et al. 1992). The only study done on this predator species against oil palm bagworm was by Cheong and Tey (2011) which showed that *C. arcufer* was able to eat 11 individuals of either *Pteroma pendula* or *Metisa plana.* There was no study done on its preference in terms of Lepidopteran species of oil palm. There is insufficient evidence on the preference of insect predators against Lepidopteran leaf defoliators, hence the real potential of insect predators as biological control agents in oil palm plantations was not made clear. Therefore, the aims of this study are to investigate the efficiency of *C. arcufer* against Lepidopteran pest of oil palm, and to determine the insect species preference of *C. arcufer*.

MATERIALS AND METHODS

The experiments were conducted in the laboratory of Sime Darby Research Sdn. Bhd. located in Banting, Selangor. Choice and non-choice experiments were conducted in this study to determine the preference of *C. arcufer*.

Non-choice Experiment

Callimerus arcufer larvae were transferred to separate plastic cups (5 cm height x 11 cm diameter) and starved for 24 hours before they were used in the experiments. Ten healthy individuals of *M. plana* larvae were placed carefully onto an oil palm leaflet cutting (15 cm long) as their food source and left in an experiment cage (arena) (size 15 cm height x 10 cm width x 10 cm length). 24 hours-starved *C. arcufer* larvae were introduced from the rearing cage to the experimental arena containing *M. plana.* The procedure was repeated by replacing different larvae of other Lepidopteran species, namely *M. plana, P. pendula, D. mendosa* and *S. nitens* with ten replicates for each experiment. Observation for experiments was conducted for 7 days and the numbers of the prey consumed were calculated. Differences between the cumulated prey consumed every day (24 hours, 48 hours up to 7 days) were analyzed by analysis of variance using computer software (MINITAB 14.0 for windows) statistical package.

Choice Experiment

The experiment was later continued by giving food choices to *C. arcufer* to determine their preference. One individual of the third instar of released into an arena containing a combination of two different Lepidopteran species of a similar size (1.5 – 2.0 mm). All Lepidopteran species used in the experiment are common leaf pests that can be found on an oil palm plantation in Malaysia. Therefore, all these species could be potential prey for *C. arcufer*. Species combination tested were *M. plana,* and *D. mendosa, M. plana* and *S. nitens, P. pendula* and *D. mendosa*, *P. pendula* and *S. nitens.* The experiment was replicated five times for each combination, with recording done daily for mortality of prey (Lepidopteran species). The times at which each prey species was first attacked in each treatment were analysed by analysis of variance using computer software (MINITAB 14.0 for windows) statistical package. Treatments with significant differences were compared at *P*=0.05 level of probability using Tukey's test.

RESULTS AND DISCUSSION

Non-choice Experiment

The result of exposure for 7 days of the non-choice prey acceptability test study showed that there is no significant difference in consumption by *C. arcufer* overall (F = 0.14; df = 3; *P=0.93*) when introduced to different Lepidopteran prey species (Table 1). The predation of *M. plana* was the highest, followed by *P. pendula, D. mendosa* and that of *S. nitens* was the lowest. The result of this study proved that *C. arcufer* is polyphagous and does not have a specific preference toward any Lepidopteran species (Wood &Norman 2019a). This study also shows that this predator will be able to regulate pest species in the low population at low densities effectively and sustainably as they also consume Lepidopteran species, otherwise could cause harm to non-targeted insects which could lead to the extinction of the affected non-targeted insect species (Norman & Othman 2016).

Table 1. Mean number (±standard error) of prey consumed by *C. arcufer* in non-choice prey acceptability

	M. plana	***P. pendula***	***D. mendosa***	***S. nitens***
Mean Consumption	1.39±1.43a	1.31±1.63a	1.29±1.44a	1.23±1.27a

Means in the row with the same letters are not significantly different at *P=0.05* level of probability according to Tukey's test

Further analysis of the daily consumption of Lepidopteran pest by *C. arcufer* showed no significant difference between species consumed, except for 24 hours after release (F = 5.19; df = 6; *P<0.001*) (Table 2). At 24 hours after release, significantly higher numbers of bagworm species, *P. pendula* compared to other Lepidopteran species, but not significantly different compared to *M. plana*, was probably due to the smaller size of bagworm larvae (1.5mm – 1.8mm) compared to other Lepidopteran species tested (1.8mm – 2.0mm). Furthermore, the most active stage of bagworm (instar 3) was used in this study compared to neonates (instar 1) of other Lepidopteran species. The vigorous movements of prey and chemical cues from both prey and plants are mainly used during foraging by insect predators (Evangelin 2015; Hagler et al. 2004). Results also showed that within 48 hours after release, both bagworms, *M. plana*, and *P. pendula* were consumed at almost 50% of the total number of prey tested compared to the other Lepidopteran prey species tested. This further proves that bagworm species are preferred by *C. arcufer* than other prey species tested.

Choice experiment

Table 3 showed the cumulative numbers of Lepidopteran prey consumed by *C. arcufer* within 7 days observation period. After testing all combinations of prey species, the predator *C. arcufer* consistently preferred bagworm species, *M. plana,* and *P. pendula* but did not consume any of the other Lepidopteran species offered. The result showed that preference was significant among species tested, *M. plana, P. pendula, D. mendosa,* and *S. nitens* (F = 54.00; df = 3; $P<0.001$), but not significantly different between bagworm species (*M. plana* and *P. pendula*) and other caterpillars (*D. mendosa* and *S. nitens*), which could indicate that there is an association between *C. arcufer* to Lepidopteran species of choice. This result agrees with the study done by Cheong and Tey (2012) whereby there is no significant preference between bagworm species when introduced to *C. arcufer.* This shows that the predator *C. arcufer* is more inclined to *M. plana* and *P. pendula,* compared to *S. nitens* and *D. mendosa*, which represents the natural composition of pest in an oil palm plantation, whereby *M. plana* and *P. pendula* has a higher population compared to *S. nitens* and *D. mendosa* (Wood 1968).

Table 2. Daily mean number (±standard error) of prey consumed by *C. arcufer* in non-choice prey acceptability

Prey Species	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
M. plana	1.70±1.57ab	3.10±1.20a	1.10±1.85a	1.10±0.74a	1.60±1.27a	0.60±0.52a	0.50±0.85a
P. pteroma	2.50±2.37b	2.30±2.11a	1.30±0.95a	1.00±1.16a	0.70±0.82a	1.10±1.60a	0.30±0.67a
S. nitens	0.50±0.71a	1.90±0.99a	1.50±1.27a	1.70±1.50a	0.82±1.18a	1.20±1.48a	0.30±0.95a
D. mendosa	0.30±0.48a	1.70±1.49a	1.70±1.64a	2.30±1.70a	1.15±1.29a	0.50±0.85a	0.60±1.08a
F	4.89	1.68	0.31	2.07	1.97	0.86	0.28
P	0.006	0.188	0.819	0.122	0.135	0.469	0.841

Means in the column with same letters are not significantly different at *P=0.05* level of probability according to Tukey's test

Table 3. Cumulative number (±standard error) of prey consumed by *C. arcufer* after given choice simultaneously

Prey species	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
M. plana	2.00±0.42a	6.00±0.52a	8.00±0.42a	9.00±0.32a	10.00±0.00a	10.00±0.00a	10.00±0.00a
P. pteroma	2.00±0.42a	4.00±0.52ab	7.00±0.48a	10.00±0.00a	10.00±0.00a	10.00±0.00a	10.00±0.00a
S. nitens	0.00±0.00a	0.00±0.00b	0.00±0.00b	0.00±0.00b	0.00±0.00b	0.00±0.00b	0.00±0.00b
D. mendosa	0.00±0.00a	0.00±0.00b	0.00±0.00b	0.00±0.00b	0.00±0.00b	0.00±0.00b	0.00±0.00b
F	1.50	6.75	0.31	18.41	121.00	*	*
P	0.231	0.001	0.819	0.00	0.00	*	*

Means in the column with the same letters are not significantly different at *P=0.05* level of probability according to Tukey's test

CONCLUSION

Generalist predator insects have been known to be polyphagous insect. Our result indicated that *C. arcufer* consumed any available Lepidopteran prey species that was given to them, without any choice; and there are no studies done yet on the response of *C. arcufer* when introduced to prey species and their preference when force-fed or given choices. When given a choice between bagworms, *M. plana* and *P. pendula,* and other Lepidopteran species, *S. nitens* and *D. mendosa*, *C. arcufer* very much prefer bagworms. The result of the study showed that the predator has the potential to sustain in the field as they may feed on other available Lepidopteran species when bagworm species are not available. The result of this study is crucial to determine the effectiveness of *C. arcufer* in the oil palm environment and to determine its suitability to be mass reared for biological control purposes.

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AUTHORS DECLARATIONS

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Conflict of Interest

The authors declare that they have no conflict of interest.

Ethics Declarations

No ethical issue required for this research

Data Availability Statement

My manuscript has no associated data

Authors' Contributions

E.g. AZ conceived this research and experiments, performed experiments and interpreted the data and analysis of data. AZ, MBSAR, SA, NAA, RMA and IAB wrote the paper and participated in the revisions of it. All authors read and approved the final manuscript.

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