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Influenced of Different Live Prey Diets on Development and Reproductive Capacity of the Predatory Asopin Bug *Cantheconidea furcellata* (Wolff.) (Hemiptera: Pentatomidae)

Pengaruh Pelbagai Diet Mangsa Hidup kepada Perkembangan dan Kapasiti Pembiakan Kepinding Pemangsa Asopin Cantheconidea furcellata (Wolff.) (Hemiptera: Pentatomidae)

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Abstract

The population survivorship and demographic parameters of the predatory asopin bug, *Cantheconidea furcellata* (Wolff.) (Hemiptera: Pentatomidae), was determined using larvae of selected species, individually or in combinations, as prey under laboratory conditions of 28 ± 2°C, 60-80% RH and a photoperiod of 12L:12D. Initial mortality of the nonfeeding first instar nymph occurred between 3rd and 4th day after emergence. The female bugs when fed on mealworms, *Tenebrio molitor* (L) (Coleoptera: Tenebrionidae) alone, showed the longest lifespan (40 days). However, the lifespan shortened to 35-36 days when the bugs were fed rice moth larvae, *Corcyra cephalonica* Stainton (Lepidoptera: Pyralidae) or supplemented with banana leaf rollers, *Erionata thrax* (L.) (Lepidoptera: Hesperiidae). Fecundity of the female bugs was influenced by the food preyed upon. Total number of eggs laid was the highest (1013 eggs) when the bugs fed on the mealworms, whereas 349 and 901 eggs were produced on rice moth larvae and mealworm in combination with banana leaf rollers, respectively. The provision of macrolepidopteran larvae to the last nymphal instar of *C. furcellata* , i.e. under supplemented conditions, markedly improved demographic parameters: the net reproductive rate (R_0), generation time (T), intrinsic rate of increase (r), innate capacity of increase (r_m), finite rate of increase (λ) and doubling time (DT) were 45.05 female offsprings female^{-1}, 12.97 d, 0.294 day^{-1}, 0.610 day^{-1}, 1.34 female offsprings female^{-1} day^{-1} and 2.36 d, respectively. The provision of the banana leaf roller to the last nymphal instar of *C. furcellata* was necessary to provide sufficient nutrients required for the production of a healthy culture of the predatory asopine bugs.

Keywords Demographic parameters, *Cantheconidea furcellata*, oil palm, *Corcyra cephalonica*, *Erionata thrax, Tenebrio molitor*

Abstrak

Kemandirian populasi dan parameter demografi kepinding pemangsa asopin, *Cantheconidea furcellata* (Wolff.) (Hemiptera: Pentatomidae), telah ditentukan dengan mengguna larva dari spesies terpilih, sama ada berasingan atau dalam kombinasi, sebagai mangsa di bawah keadaan makmal 28 ± 2°C, 60-80% KB and 12S:12M fotokala. Mortaliti awal nimfa instar

pertama yang tidak makan berlaku di antara hari ketiga dan keempat selepas penjelmaan. Kepinding betina apabila hanya diberi makan ulat bijirin, *Tenebrio molitor* (L) (Coleoptera: Tenebrionidae) menunjukkan jangka hayat yang terpanjang (40 hari). Walau bagaimanapun, jangka hayat dipendekkan kepada 35-36 hari apabila kepinding ini diberi makan ulat beras, *Corcyra cephalonica* Stainton (Lepidoptera: Pyralidae) atau diberi makanan tambahan dengan ulat kelolong daun pisang, *Erionata thrax* (L) (Lepidoptera: Hesperiidae). Fekunditi kepinding betina telah dipengaruhi oleh mangsa yang dimakan. Jumlah telur adalah tertinggi (1013 biji) apabila kepinding diberi makan ulat bijirin, manakala 349 dan 901 biji telah dihasilkan apabila masing-masing diberi ulat beras dan ulat bijirin dalam gabungan dengan ulat kelolong daun pisang. Pemberian larva makrolepidoptera kepada instar nimfa terakhir *C. furcellata*, iaitu dalam keadaan tambahan, nyata memperbaiki parameter demografi: nilai kadar pembiakan bersih (R_0), jangka masa generasi (T), kadar intrinsik peningkatan (r), peningkatan kapasiti dasar (r_m), kadar peningkatan akhir (λ), dan jangka masa ganda (DT) yang mana masing-masing adalah 45.05 anak betina betina^{-1}, 12.97 j, 0.294 j^{-1}, 0.610 j^{-1}, 1.34 anak betina betina^{-1} hari^{-1} dan 2.36 j. Penambahan ulat kelolong daun pisang kepada instar terakhir *C. furcellata* adalah perlu bagi melengkapkan keperluan nutrien untuk menghasilkan kultur kepinding pemangsa asopin yang sihat.

Kata kunci Parameter demografi, *Cantheconidea furcellata*, kelapa sawit, *Corcyra cephalonica*, *Erionata thrax, Tenebrio molitor*

Introduction

Oil palm, *Elaeis guineensis* (Arecaceae), is one of the most significant crops in Malaysia. By 1971 Malaysia emerged as the world's leading producer and exporter of palm oil, producing over 400.000 tons of crude palm oil (CPO). Since then more than 4.17 million hectares of agricultural areas were under oil palm plantations, capable of supplying 15.9 million tons of CPO and 1.96 million tons of PKOil in 2006, and generating in excess of RM 31.8 billion (Mohd. Basri, 2008).

Nettle caterpillars, bagworms and beetles are the most destructive pests infesting oil palms. They attack the foliage and easily build up in numbers due to abundance of food. Outbreaks are usually sporadic, but these pests are normally suppressed by their natural enemies. Utilization of broad-spectrum long-residual contact insecticides is detrimental to natural enemies, resulting in the overall biological disturbance and breakdown of natural enemy control, hence the outburst of pest numbers (Wood and Nesbit, 1969). The first major outbreaks of these pests were observed in the late 1950s in West Malaysia (Teh, 1969). Therefore an ecological-based control approach is extremely crucial to control these pests. Oil palm is the most suitable agroecosystem for polyphagous predators such as the asopin bugs (Pentatomidae) which feed on all species of leaf-eating limacodid caterpillars. *Cantheconidea furcellata* Wolff. is considered the most promising predatory asopin candidate for augmentative biocontrol of oil palm caterpillars in west Malaysia due to its comparatively short life-cycle of less than two months and laying eggs directly on the foliage of the palms (Wiwat Suasa, 1989; Sipayung *et al*., 1992). Previous study of mass rearing technique was based on the provision of frozen limacodid larvae collected during outbreaks in the fields (Sudharto *et al*., 1990). More attempts should be done to overcome the difficulties in mass rearing and maintenance of this predator.

To improve the efficiency of mass rearing of *C. furcellata* as a biocontrol agent of limacodid caterpillars, more information is certainly required on diets for immatures and adults of this predatory bug. The objective of this study was to determine the reproductive capacity and life

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table parameters of *C. furcellata* feeding on selected species of insect larvae as alternative and supplementary diets under laboratory conditions.

Materials and Methods

Study area

This study was carried out in the Plant Protection laboratory, Faculty of Agriculture, Universiti Putra Malaysia at ambient temperature of 27-32°C, relative humidity of 60-80% and photoperiod of 12L:12D monitored with a hygrothermograph. The predatory asopin bugs, *C. furcellata* used in the experiments were initially obtained from Sime Darby OPRS, Banting, Selangor, Malaysia.

Rearing of *C. furcellata* under laboratory conditions

Adults of asopin bugs, *C. furcellata* were reared in a plastic aquarium tank measuring 36 x 20 x 30 cm. The bottom of the tank was covered with paper towels to facilitate cleaning as well as to provide refuge. A piece of muslin cloth was placed between the lid and the tank to prevent the escape of the bugs. Pieces of cotton saturated with distilled water in a shallow Petri dish served as the source of water for the bugs. Intact flowers and leaves of the nectariferous Honolulu creeper, *Antigonon leptopus*, were provided in the tank as a substrate for oviposition as well as to supply additional nutrition. Newly laid eggs were transferred individually using a soft brush into Petri dishes containing a cotton roll saturated with water until hatching. To avoid cannibalism, only last instar nymphs were reintroduced into the stock culture tank.

Prey sources of *C. furcellata*

The bugs, *C. furcellata* were daily provided with three different diets in this study including: (1) mealworms, *Tenebrio molitor* (L). (Coleoptera: Tenebrionidae), which were purchased from a pet shop were provided *ad libitum* as the standard daily food, (2) 3-4 week old larvae of rice moth, *Corcyra cephalonica*, (Lepidoptera: Pyralidae) and (3) banana leaf rollers, *Erionata thrax* (Lepidoptera: Hesperiidae) were provided as the supplementary life diets. Rice moth culture has been maintained in the laboratory on a 50:50 mixture of rice grain and ground maize, while the banana leaf rollers were collected from the banana field of UPM research farm.

Three to four pairs of *C. furcellata* from the stock colony were initially kept overnight in a separate plastic container to allow for oviposition. Forty eggs were collected using a soft brush on the following day and placed individually in a plastic cup (5 cm diameter x 4 cm high). Upon hatching, the first instar nymphs were provided water from a moist cotton wool.

The presence of exuvium indicated moulting. Biological parameters such as developmental duration, nymphal mortality and progress in growth of each individual were monitored daily. When a female emerged, a male from the stock colony was introduced into the plastic cup with supply of food and water. Thereafter, number of eggs produced and survival of eggs were recorded after hatching. Demographic parameters such as innate capacity of increase (r_m), finite rate of increase (λ), net reproductive rate (R_0), mean generation time (T) of *C. furcellata* feeding on three different diets were determined to provide information for mass rearing of the

predator. For diet 1, mealworms were provided *ad libitum* with small sized mealworms given to first and second instars; the mealworms were replaced with rice moth larvae in diet 2, while for diet 3 the last nymphal instar was provided with the banana leaf rollers. Calculations of pertinent demographic parameters were according to Laughlin (1965) and Southwood (1977).

Results and Discussion

Survivorship and fecundity of *C. furcellata* fed diet 1

Under continuous feeding, it was observed that approximately 25% of the nymphal instars died by the 7th day; only 28 individuals (18♀:10♂) reached adulthood. The survivorship stabilised from the 16th to 55th day, at which time about 70% of the population survived. A 50% natural mortality of the female (NM_{50}) was reached on the 38th day. Thereafter, the population experienced a fast decline and completely deceased by the 64th day.

Population survivorship and fecundity of adult *C. furcellata* fed live mealworms are shown in Figure 1. The females started oviposiiting on the 12th day after they became mature. During the oviposition, total number of eggs laid during the female lifespan was 1013 eggs (Table 1), the highest produced by the cohort was 206 eggs day^{-1} with a mean of 11.44 eggs $female^{-1}$ on the 14th day. The lowest number of eggs produced was observed on the 20th day (49 eggs) with an average of 2.72 eggs $female^{-1}$; the highest number of eggs produced was 56.3 eggs $female^{-1}$. Oviposition was ceased on the 41st day when only a total of 53 eggs were laid by the cohort, with a mean of 2.94 eggs $female^{-1}$ day^{-1}. Since no more oviposition occurred thereafter, it is assumed that the female ceased to oviposit during the last few days of survival even though it continued feeding.

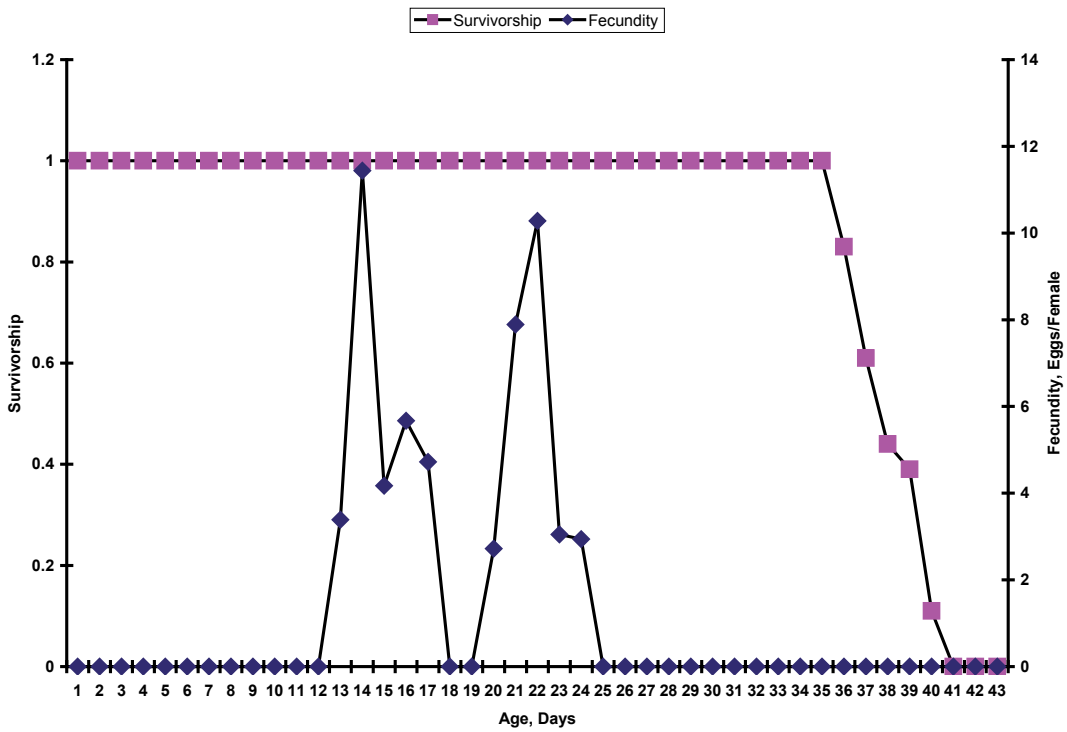

Figure 1. Population survivorship and fecundity of *Cantheconidea furcellata* fed mealworms.

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The net reproductive rate (R_0) of 36.17 female offsprings female^{-1} and the intrinsic rate of increase (r) of 0.197 day^{-1} were calculated within a generation time (T) of 18.21 d. The cohort was capable of doubling its number within 3.52 d. The maximum population growth potential, as indicated by the innate capacity of increase (r_m) was 0.212 day^{-1}, and this was reflected by the finite rate of increase (λ) of 1.218 female offsprings female^{-1} day^{-1}.

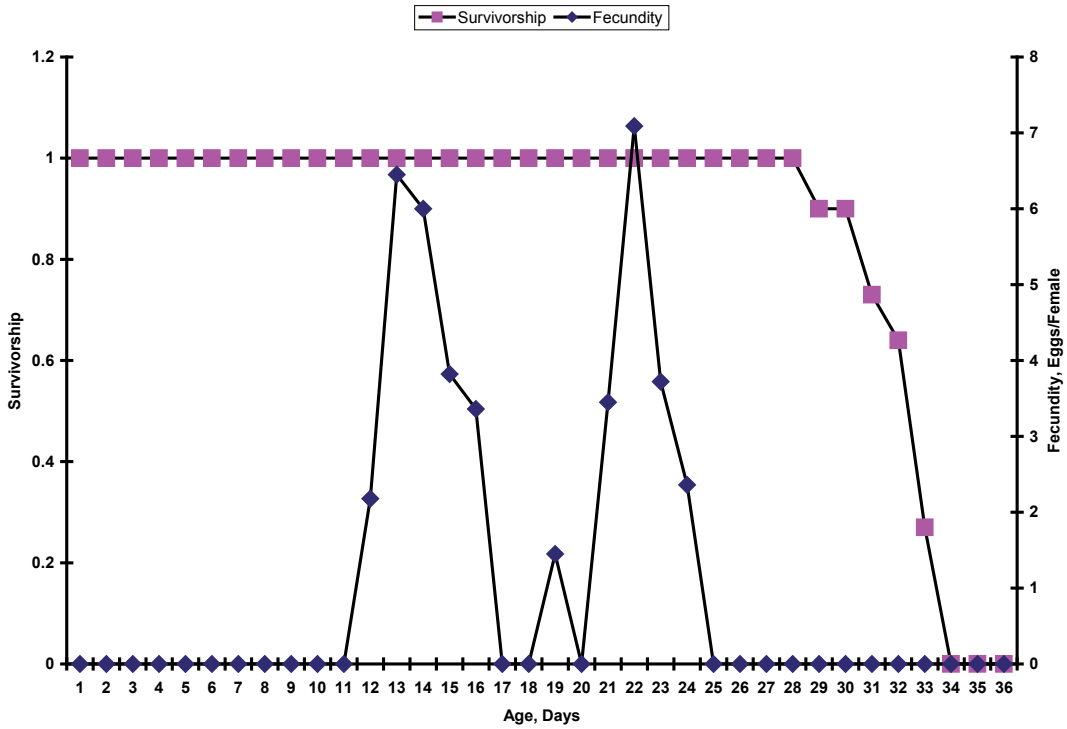

Figure 2 Population survivorship and fecundity of *Cantheconidea furcellata* fed rice moth larvae.

Survivorship and fecundity of *C. furcellata* fed diet 2

Nymphal mortality of 7% of *C. furcellata* was observed when fed rice moth larvae. Mortality was recorded as early as day 4, and about 30% died by day 6. By day 7 only 55% of the bugs survived with 50% natural mortality of the female (NM_{50}) was reached on the 33rd day. Thereafter, the population became stable up to day 56.

Clearly, the rice moth larva was comparatively a poor alternative; the last individual died by day 36 (Figure 2). Similarly, the onset of oviposition occurred on the 12th day after female emergence. The oviposition period lasted for 13 days, with total number of 439 eggs. The highest number of eggs (78 eggs) was produced by the cohort on day 22, with a mean of 7.09 eggs female^{-1} (Table 1). Maximum number of eggs produced per female during its lifespan was 39.9 eggs. The lowest number of eggs was produced on day 19 (16 eggs) with a mean of 1.45 eggs female^{-1}. On the last day of oviposition (day 34), the cohort produced 26 eggs with a mean of 2.94 eggs female^{-1} day^{-1}. The females continued to survive, but stopped ovipositing for the remaining 12 days. Continuous provision with the rice moth larvae produced a lower net reproductive rate (R_0) of 19.94 female offsprings female^{-1}, with reduced intrinsic rate of increase (r) of 0.170 day^{-1} within a generation time (T) of 17.63 d. The cohort took slightly longer to

double its number within 4.08 d, indicating that even under controlled environment, the rice moth larvae did not provide nutrients sufficient enough to improve demographic parameters; the maximum population growth potential, as indicated by the innate capacity of increase (r_m) was reduced to 0.185 day^{-1}, and this was reflected by the lower finite rate of increase (λ) of 1.185 female offsprings female^{-1} day^{-1}.

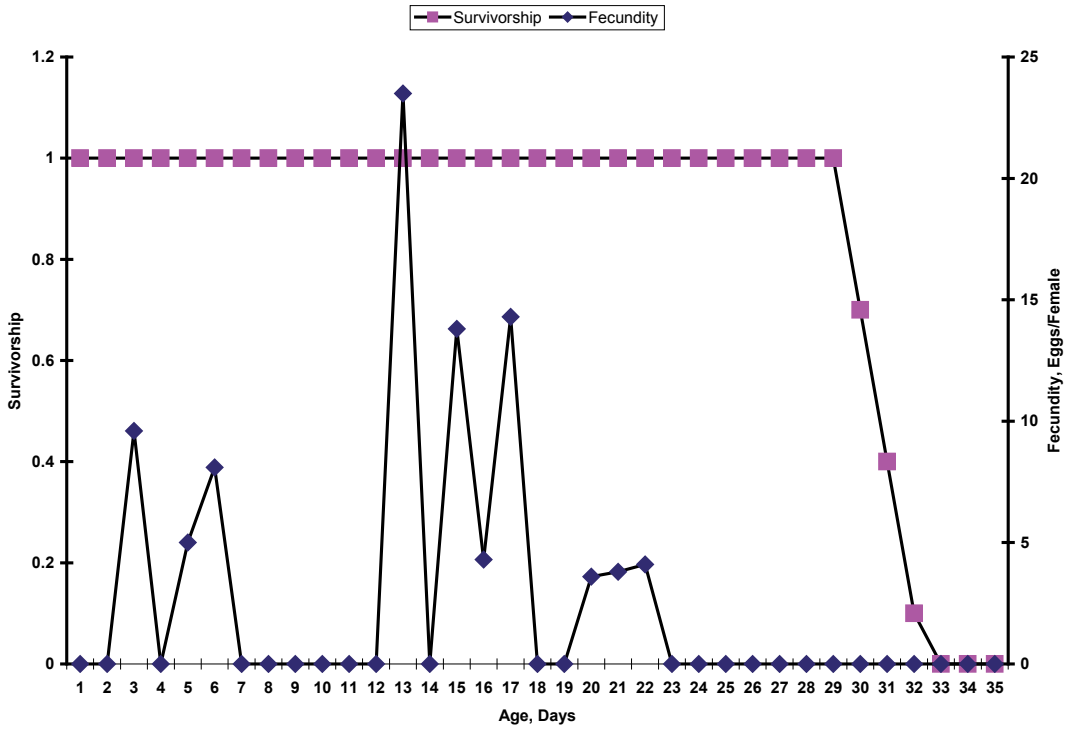

Figure 3 Population survivorship and fecundity of *Cantheconidea furcellata* fed mealworms supplemented with banana leaf rollers for the last nymphal instar.

Table 1 Comparative demographic attributes, female longevity and fecundity of *C. furcellata* fed different live food sources under laboratory conditions

Parameters	Food		
	Mealworm only	**Rice moth only**	**Mealworm + Banana leaf roller**
Days to 50% natural mortality of female (NM_{50})			
Longest lifespan of female			
Maximum oviposition period (days)			
Total number of eggs produced			
Maximum number of eggs/female lifespan			
Maximum number of eggs/female/day			
Net reproductive rate (R_0, $\sum l_x m_x$, FOF)			
Mean generation time (T, $\sum x l_x m_x$,/R_0, days)			

Intrinsic rate of increase (r, $\ln R_0 /T$, d^{-1})
Innate capacity of increase (r_m, $\sum e^{-rx} l_x m_x = 1$, d^{-1})
Finite rate of increase (λ, e^r, FOFD)
Doubling time (DT, ln2/r, d)

x = age (days);
l_x = no. surviving at beginning of x;
m_x = no. living females born per female in each age interval;
FOF: female offsprings $female^{-1}$;
FOFD: female offsprings $female^{-1}$ day^{-1}

Survivorship and fecundity of *C. furcellata* fed diet 3

The survivorship of the predatory bug, *C. furcellata* initially showed approximately 55% of the nymphs survived by the 7th day. Although the banana leaf rollers were provided to the last nymphal instar of *C. furcellata*, no extension in survivorship was observed and it remained stable up to day 29 (Figure 3). Days to 50% natural mortality of the female (NM_{50}) was reached on the 31st day. Finally, all the bugs died by day 35.

Oviposition began on the 3rd day of adulthood. The duration of oviposition was 20 days, producing a total number of 901 eggs. The highest number of eggs laid by the cohort was 235 eggs with a mean of 23.5 eggs $female^{-1}$ on day 13 (Table 1). The maximum number of eggs produced per female lifespan was 90.1 eggs. The lowest number of eggs produced was on day 20 with a total number of 36 eggs with a mean of 3.6 eggs $female^{-1}$. The last day of oviposition occurred on day 32 with a total number of 41 eggs laid by the cohort, and a mean of 4.1 eggs $female^{-1}$ day^{-1}.

All demographic attributes markedly improved when macrolepidopteran larvae were supplemented at the last instar of the asopin bug. The net reproductive rate (R_0) and the intrinsic rate of increase (r) increased to 45.05 female offsprings $female^{-1}$ and 0.294 d^{-1}, respectively. Because these growth parameters were achieved within a shorter generation time (T) of 12.97 d, the cohort was capable of doubling its number in just 2.36 d. As a result, the potential for maximum population growth, which is the innate capacity of increase (r_m) also increased to 0.610 d^{-1}, which gave a finite rate of increase (λ) of 1.342 female offsprings $female^{-1}$ day^{-1}.

This study suggests a possible mass culture protocol focused on feeding “juicy” larvae as a complete nutritive diet for the final nymph stage to develop into a highly productive female. Raising quality of the asopin bugs, *C. furcellata* with superior reproductive potential increases the possibility of making augmentative biocontrol programmes in oil palms a success.

Conclusion

Quality and constant availability of food are two important factors determining the success of mass rearing of the asopin bug, *C. furcellata*. This study investigated the effect of nutritive food source provisioned for the last nymphal instar as the way to produce high quality predatory pentatomids under laboratory conditions; superior demographic attributes was demonstrated by the high reproductive performance. In this study, mealworms were readily accepted by the asopin bugs and should be treated as the standard daily food for maintaining a healthy culture.

References

Laughlin, R. (1965). Capacity for increase: a useful population statistic. *Journal of Animal Ecology* 34: 77-91.

Mohd. Basri, W. (2008). *Overview of the Malaysian oil palm industry*. http://mpob.gov.my (retrieved December, 2008).

Sipayung, A.R., Desmier De Chenon, R. and Sudharto, P.S. (1992). Study of the *Eocanthecona-Cantheconidea* (Hemiptera: Pentatomidae; Asopinae) predator complex in Indonesia. *Journal of Plant Protection in the Tropics* 9: 85-103.

Southwood, T.R.E. (1977). *Ecological Methods with particular reference to the study of insect population* (2nd ed.). London: Chapman and Hall.

Sudharto, P.S., Sipayung, A. and Desmier De Chenon, R. (1990). Metode pembiakan massal predator *Eocanthecona furcellata* (Wolff.) (Hemiptera: Pentatomidae; Asopinae) dengan makanan awetan. Kongres I, *Himpuann Tanaman Indonesia*. Jakarta: Makalah 318.

Teh, C.L. (1996). Integrated pest management of leaf-eating caterpillars of oil palms in Sabah. *The Planter* 72: 395-405.

Wiwat Suasa (1989). Utilisation of *Eocanthecona furcellata* (Wolff.) (Hemiptera: Pentatomidae) for augmentative biological control of castor bean semilooper, *Ophiusa janata* (L.) (Lepidoptera: Noctuidae) in Thailand. *Biotrop Special Publication* 36: 191-200.

Wood, B.J. and Nesbit, D.P. (1969). Caterpillar outbreaks on oil palm in eastern Sabah. *The Planter* 45: 285-299.