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Effects of Honey and Sucrose on Longevity and Fecundity of *Apanteles metesae* (Nixon), a Major Parasitoid of the Oil Palm Bagworm, *Metisa plana* (Walker)

(Kesan Madu dan Sukrosa ke atas Jangka Hayat dan Kesuburan *Apanteles metesae* (Nixon), Parasitoid Utama Ulat Bungkus Kelapa Sawit, *Metisa plana* (Walker))

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ABSTRACT

The effects of various concentrations of honey and sucrose on the longevity and fecundity of Apanteles metesae *(Nixon), an endoparasitoid of oil palm bagworm,* Metisa plana *(Walker) (Lepidoptera: Psychidae) were studied in the laboratory. Our results showed that there were a significant difference (*p<*0.05) in the longevity of* A. metesae *fed on various concentrations of honey solutions. Longevity of* A. metesae *was significantly longer when fed on 50% honey than on pure honey. Nonetheless, longevity of* A. metesae *females fed on 50% honey was relatively longer than other honey concentrations. The parasitoid lived significantly longer when fed on 20% sucrose than when fed on 50% sucrose and distilled water. However, the parasitoid fed on 50% honey had a longevity that was statistically similar to 20% sucrose and 50% sucrose. Fecundity of* A. metesae *differed significantly (*p<*0.05) when fed on 50% honey, 20% sucrose and 50% sucrose. The highest and lowest fecundity was when the parasitoids fed on 20% sucrose and distilled water, respectively. Overall, the result showed that 20% sucrose was a more suitable diet for* A. metesae *females as compared with other diets.*

Keywords: Apanteles metesae*; diet; fecundity; longevity;* Metisa plana

ABSTRAK

Kesan pelbagai larutan madu dan sukrosa terhadap jangka hayat dan kesuburan Apanteles metesae *(Nixon), sejenis endoparasitoid ulat bungkus kelapa sawit,* Metisa plana *(Walker) (Lepidoptera: Psychidae) telah dikaji di dalam makmal. Hasil menunjukkan bahawa terdapat perbezaan yang bererti (*p<*0.05) terhadap jangka hayat* A. metesae *yang diberi makan pelbagai kepekatan larutan madu. Jangka hayat* A. metesae *adalah lebih lama secara bererti apabila diberi makan 50% madu berbanding madu asli. Meskipun begitu, jangka hayat* A. metesae *betina yang diberi makan 50% madu adalah lebih lama daripada kepekatan madu yang lain. Parasitoid hidup lebih lama secara bererti apabila diberi makan 20% sukrosa berbanding yang diberi makan 50% sukrosa dan air suling. Namun, parasitoid yang diberi makan 50% madu mempunyai jangka hayat yang setara secara statistik dengan 20% sukrosa dan 50% sukrosa. Kesuburan* A. metesae *berbeza secara bererti (*p<*0.05) apabila diberi makan 50% madu, 20% sukrosa dan 50% sukrosa. Kesuburan paling tinggi dan paling rendah masing-masing adalah apabila diberi makan 20% sukrosa dan air suling. Secara keseluruhannya, hasil kajian telah menunjukkan bahawa 20% sukrosa adalah diet yang lebih sesuai untuk* A. metesae *betina berbanding diet-diet yang lain.*

Kata kunci: Apanteles metesae*; diet; jangka hayat; kesuburan;* Metisa plana

INTRODUCTION

Apanteles metesae (= *Dolichogenidae metesae*) (Nixon) is an important parasitoid of the oil palm bagworm, *Metisa plana* (Walker). The bagworm is capable of causing an outbreak, which could cause a crop loss of up to 44% (Basri et al. 1995). Although several methods can be used to control *M. plana*, most oil palm plantation managements spray chemical insecticides such as trichlorfon for younger oil palm or monocrotophos and acephate through trunk injection for older oil palms (Chong et al. 1991). However, method of using biological control agents (BCA) to control *M. plana* has become an increasingly important pest management strategy because of an increasing concern on overuse of chemical pesticides (Hu & Vinson 1998). The BCA could indirectly reduce pesticide usage and production costs. The BCA is also environmental friendly. Biological control using natural enemies has always been regarded as the use of organisms including parasitoids, predators and pathogens for the control of pest population.

Apanteles metesae seems to be the most prominent primary parasitoid of *M. plana* (Basri et al. 1995). It attacks the host from the second to the sixth instars, which are the most destructive stages to oil palm (Gauld & Bolton 1988). Although *A. metesae* is normally scarce, they can build up in numbers and exert control to host population (Basri et al. 1995). The potential of *A. metesae* to be used as biological control agent of the *M. plana* may be realized through mass rearing for field release.

The successful growth, development and reproduction of insects obviously depend on their nutrition, the attainment of their qualitative and quantitative requirements (Barbehenn et al. 1999). The provision of supplementary foods for adult natural enemies in the habitat is of paramount importance in their distribution, manipulation and effectiveness (Idris & Grafius 1995; Temerak 1983). Generally, the natural foods such as the nectar of beneficial plants are the best diets for parasitoid growth and development. It is because of the high sugar content in the nectar, which the major sugars are glucose, fructose and sucrose (Barbehenn et al. 1999). Hagen et al. (1984) stated that floral nectar, extrafloral nectar, honeydew and pollens are natural foods for many adult Diptera and Hymenoptera. Basri et al. (1999) found that the longevity of *A. metesae* fed on flower nectar of the *Cassia cobanensis* (Britton) Lundell, a plant that can be easily found in oil palm plantation was significantly longer than *A. metesae* fed on diluted honey, or on other plants nectar such as *Crotalaria usaramoensis, Euphorbia heterophylla, Euphorbia hirta, Asystasia intrusa, Hedyotis corymbosa, Cleome rutidosperma, Ageratum conyzoides* and *Hedyotis verticellata*. Several wildflowers, including *Brassica kaber* (D.C.) Wheeler, *Barbarea vulgaris* R. Br. and *Daucus carota* L. supplied nectar and resulted in *Diadegma insulare* Cresson longevity and fecundity equal to when honey-water was supplied as food (Idris & Grafius 1995). Normally, honey composed primarily of the sugars glucose (38.5%) and fructose (38.5%) with its third greatest component is water (17.0%). The rest are sucrose (1%), other sugars (7%), amino acids, vitamins and minerals (National Honey Board 2010).

The artificial diets such as honey solution can also increase parasitoid longevity at a maximum level when provided with suitable concentrations (Idris & Grafius 1995). The development of artificial diets on which insects can be reared in a laboratory has allowed researchers to determine the nutrient necessary to support the growth and reproduction of numerous species (Barbehenn et al. 1999).

The objective of this study was to investigate the effects of various concentrations of honey and sucrose on longevity and fecundity of *A. metesae* female adults. Results of this study could provide information for further study on the mass rearing of *A. metesae* which could be vital for integrated management of *M. plana* in oil palm plantation.

Materials and Methods

The Host and Parasitoid

The larvae of *M. plana* were collected from oil palm plantations in Felda Gunong Besout, Sungkai, Perak, Peninsular Malaysia. The third to sixth instars larvae, the preferred stages for parasitism (Basri et al. 1995) by the *A. metesae*, were reared separately in transparent plastic cylinders (24 × 13 × 13 cm^3). Larvae were fed fresh oil palm leaflets, which were replenished every week until pupation and kept at 25 ± 1°C, 60 ± 5% RH and a photoperiod of 12:12 (L:D) h until the emergence of *A. metesae* adults (only adult parasitoid was collected).

Effect of Various Concentrations of Honey on Longevity of *A. metesae*

A total of 40 one-day-old females adults of *A. metesae* (from above procedure) were held in plastic vials (8.5 × 4.5 × 4.5 cm^3) individually and given one of the following treatments (diets) immediately after emergence: 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90% honey-water solutions and pure honey. Each diet was presented in absorbent cotton ball and was replenished every two days. All treatments were arranged following the randomized complete block design with four replicates (four individual parasitoid female adults) per treatment and kept at 25 ± 1°C, 60 ± 5% RH and a photoperiod of 12:12 (L:D) h. The longevity was recorded everyday until all parasitoids died.

Effect of Various Types of Diets on Longevity and Fecundity

The 50% honey-water solution, from the above result which provided longer life to parasitoid was used to study its effect on the longevity and fecundity of *A. met*esae females in comparison to 20% and 50% sucrose (UNIVAR®, Canada) and distilled water as a control treatment. The method used in this experiment was adopted from Idris and Grafius (1995). They used wildflowers as the nectar sources and honey-water as a control treatment to test the longevity and fecundity of the parasitoid *D. insulare*.

A one day old *A. metesae* female adult was exposed individually to ten 4th instar larvae of *M. plana* placed in a transparent plastic cylinder (24 × 13 × 13 cm^3) (parasitism arena). The parasitoid adults were fed with the best honey solution from the above experiment, 20% and 50% sucrose and distilled water (as treatments) which all soaked on a piece of cotton ball and replenished every 2 days while the *M. plana* larva was fed with fresh oil palm leaflets. The 4th instar *M. plana* was selected because it has the highest percentage individual parasitized by *A. metesae* and had higher percentage of *A. metesae* emerged compared with other instars (Salmah et al. 2006).

Survival of the *A. metesae* females was recorded daily to measure longevity. After 24 h of exposure to parasitoid, the ten *M. plana* 4th instar larvae were collected and put back into the transparent plastic cylinder. Another ten 4th instar larvae were put into the parasitism arena to replenish the earlier batch of larvae. This process continued until *A. metesae* died. The presumably parasitized instars were reared in a plastic cylinder and fed with fresh oil palm leaflets until pupation and the number of *A. metesae* adult emerged was recorded. Fecundity was calculated as the sum of all *A. metesae* adults emerged from *M. plana* pupae during her lifetime (10 host larvae offered every 1 day).

The above treatments were arranged following the randomized complete block design, with four replicates per treatment (diet). All treatments were done in a control environment room (CER) at 25 ± 1°C, 60 ± 5% RH and photoperiod of 12:12 (L:D) h.

Data Analysis

Data for measuring longevity and fecundity of *A. metesae* were analyzed using one-way analysis of variance (ANOVA) which was run on a computer software, MINITAB® version 12.1 (Leimich & Dugard 1999).

Results

Effect of various concentrations of honey

Figure 1 shows that there was a significant ($f = 4.50$; df = 9, 30; $p<0.05$) difference in longevity of *A. metesae* fed on various concentrations of honey solutions. Parasitoid females fed on 50% honey lived significantly ($p<0.05$) longer than those fed on pure honey. However, longevity of the parasitoid was not significantly ($p>0.05$) different when fed on either pure honey, 10-40% or 60-90% honey solutions.

Effect of various types of diets on longevity and fecundity

There was a significant ($f = 10.28$; df = 3, 12; $p<0.05$) difference in longevity of *A. metesae* fed on various diets concentrations (Figure 2). The parasitoid lived significantly ($p<0.05$) longer when fed on 20% sucrose than fed on 50% sucrose and distilled water. However, the parasitoid fed on 50% honey had longevity that was statistically similar to all other diets except distilled water.

There was a significant ($f = 42.81$; df = 3, 12; $p<0.05$) difference in fecundity of *A. metesae* fed on various types of diets (Figure 3). Fecundity of *A. metesae* was significantly ($p<0.05$) higher when fed with 20% sucrose solution than fed with other diets. Fecundity of *A. metesae* was the lowest when fed distilled water. However, the parasitoid fecundity was not significantly ($p>0.05$) different when fed 50% honey and 50% sucrose.

Discussion

The results showed that different honey solutions did cause significant different in longevity of *A. metesae* females except between those fed with 50% and pure honey (Figure 1). Females fed on 50% honey solution lived relatively longer than females fed with all diluted honey solutions although the longevity was not significantly difference. This indicated that 50% honey was a better diet for *A. metesae* and its longevity decreased with increase or decrease in honey concentration. This was probably attributed to the sugar and water content of the honey (Barbehenn et al. 1999). Lower concentration of honey contains more water than carbohydrates. Higher concentration of honey contains more energy than water, i.e. too much energy or lack of water which will shorten the parasitoid longevity. Similar result was reported by Leatemia et al. (1995) in which the longevity of females *Trichogramma minutum* Riley (Hym: Trichogrammatidae) fed with 20% honey was at 26.5 ± 5.4 days, 40% honey was at 28.5 ± 5.4 days, 60% honey was at 25.4 ± 6.1 days and 80% honey was at 20.7 ± 6.1 days.

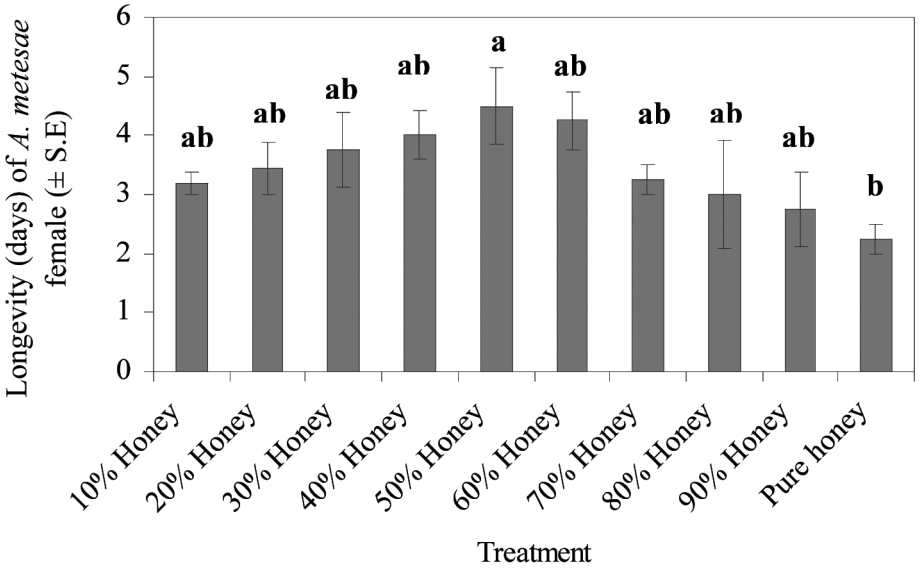

FIGURE 1. Longevity (± SEM) of *A. metesae* females fed on various types of honey concentrations. Columns with different letters are significantly different (Fisher LSD, $p<0.05$) ($n = 40$)

Although the longevity of *A. metesae* females fed on 50% honey and 20% sucrose solutions was not significantly different, the parasitoid on relatively longer when fed on 20% sucrose than fed on 50% honey solution (Figure 2). Similar study by Vatansever Sakin and Ulusoy (2009) showed that the lifespan of parasitoid *Cales noacki* (Hymenoptera: Aphelinidae) was better when fed on sugar water (10%) than fed on honey water (10%). According to Steppuhn and Wackers (2004), sucrose commonly occurs in floral and extrafloral nectars. Basri et al. (1999) showed that the beneficial plants such as *C. cobanensis* and *Crotalaria usaramoensis* produced the extra-floral nectar, which enabled many parasitoids (*A. metesae, Brachymeria carinata, Eupelmus catoxanthae* and *Pediobius imbreus*) to have longevity comparable with those individuals fed with diluted honey. The extra-floral nectar of *C. cobanensis* contained a high level of sucrose (63.4%), with lesser amounts of glucose (11.6%) and fructose (25%) while the nectar of *C. usaramoensis* contained more of sucrose (48.4%) and glucose (41.6%) than of fructose (9.9%). The high nutrient content in the nectar in those beneficial plants especially *C. cobanensis* readily attracts parasitoids.

Interestingly, the fecundity of *A. metesae* fed on 20% sucrose was significantly higher compared with 50% honey, 50% sucrose and distilled water (Figure 3). Leatemia et al. (1995) found that females of *T. minutum* fed on fructose or sucrose significantly increased its longevity and fecundity. Logically fecundity was very low (± 2 days) when only distilled water was given to A. metesae (Figure 3). Similarly, females of *T. minutum* which were only fed

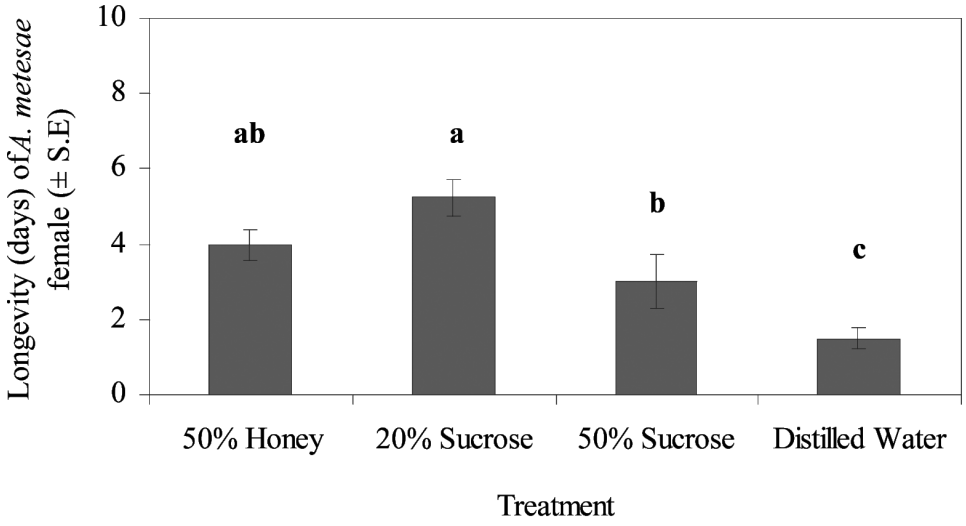

FIGURE 2. Longevity (± SEM) of *A. metesae* females fed on various types of diets concentrations. Columns with different letters are significantly different (Fisher LSD, $p<0.05$) ($n = 16$)

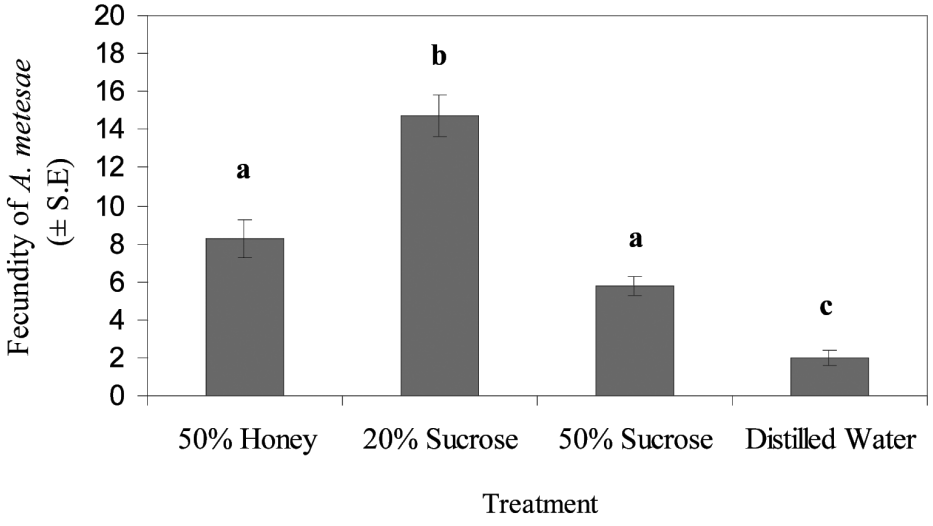

FIGURE 3. Total fecundity (= number of parasitoid emerged from *M. plana* pupae) of *A. metesae* females fed on various types of diets and concentrations. Columns with different letters are significantly different (Fisher LSD, $p<0.05$) ($n = 16$)

on water also had no significant increase in longevity or fecundity (Leatemia et al. 1995). The energy acquired from food helped the parasitoid, within a given time, to parasitize more host larvae than if it was given just water or not given food at all (Idris & Grafius 1995).

In contrast, many researchers had reported that almost all parasitoid species had lived longer when provided with honey solution than sucrose. Temerak (1983) found that honey solution provided to female *Bracon brevicornis* (Hymenoptera: Braconidae) occupied the first rank and the most suitable diet, which can live up to one month at 25°C compared with 10% sucrose. Leatemia et al. (1995) reported that the longevity of honey-fed *T. minutum* was 26.4 days compared with 50% fructose (23 days) and 20% sucrose (21 days). Shaw (1997) stated that honey is an excellent diet for parasitic wasps as it is for bees. It contains proteins and vitamins as well as sugar and seems to be adequate for egg maturation for most, possibly all species that nourish and mature their eggs successively through their adult life. Temerak (1983) showed that honey usually provid a better diet to enhance adult of parasitoid longevity. *Cotesia plutellae* (Hymenoptera: Braconidae) females also had better longevity when fed with 50% honey compared with 20% sucrose although there was no difference in longevity of male wasps (Mitsunaga et al. 2004). However, our results showed that sucrose was still a better food for *A. metesae*. This is because the physiological need of *A. metesae* might have preferred sucrose rather than other types of sugar found in honey. Hagen et al. (1984) stated that the needs of carbohydrates depend on the insect's digestive enzymes. Study by Leatemia et al. (1995) showed that sucrose is easier to be absorbed by parasitoid digestive system because it is a simple sugar, which could increase parasitoid quality. This will allow them to live longer and produce more offspring.

Conclusion

In contrast to previous reports, this study showed that the 20% sucrose solution was found to be a better food than 50% honey-water solution as it relates to parasitoid longevity and fecundity increment. It is hope that the results obtained are useful for mass rearing of *A. metesae* and biological control program in the future.

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