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Influence of Food on the Longevity and Egg Maturation of the Egg Parasitoid *Ooencyrtus nezarae* (Hymenoptera: Encyrtidae)

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Ooencyrtus nezarae is a parasitoid wasp attacking eggs of several pest Hemiptera in soybean fields, and plays an important role as a main natural enemy of soybean pests. However, many aspects of the biology of the parasitoid remain unknown. Laboratory experiments were carried out to study the influence of food for adult females on the longevity and egg maturation of *O. nezarae*. The mean longevity of the females provided with honey throughout their life span was 40.4 days and was significantly longer than that of females provided with limited food (honey for one day) (means: 5.5 days), water only (3.0 days) or control (2.0 days). The total number of eggs matured within 3 days by honey fed females was 15.9 and was significantly higher than that by one-day honey fed (11.0 mature eggs), water fed (3.0 mature eggs) or control (0 mature egg) females. The present study suggests that life expectancy is extremely limited if the females cannot obtain carbohydrate sources continuously during the adult lifetime. Also, egg maturation is largely restricted under poor food conditions. Thus, the availability of food for adult females should determine the reproductive success of *O. nezarae*.

INTRODUCTION

The main energy source for adult parasitoids is sugar, which can be obtained in the field from nectar or honeydew (Hagley and Barber, 1992; Evans *et al.*, 1993; Jervis *et al.*, 1993). Hymenopteran parasitoids may be categorized into two groups based on their reproductive physiology; pro-ovigenic and synovigenic species. Pro-ovigenic species are short-lived as adults, and emerge with a full complement of mature eggs to be laid during the life time. Thus, the maximum lifetime fecundity is fixed and determined at the time of adult emergence. In contrast, synovigenic species are rather long lived, emerge with few mature eggs, and can produce new eggs when food resources are available (Flanders 1950; Jervis and Kidd, 1986; Ueno, 1999; Ueno and Ueno, 2007). By feeding on food during the adult stage, females can gain nutrients necessary to produce eggs and increase longevity (Leius, 1961a, b; Jervis and Kidd, 1986; Collier, 1995a; Heimpel *et al.*, 1997). In synovigenic species, therefore, the maximum number of eggs potentially laid during the lifetime should largely be determined by food available in the environment. Thus, food is an important determinant of the reproductive success of synovigenic parasitoids.

Ooencyrtus nezarae Ishii (Hymenoptera: Encyrtidae) is a gregarious egg parasitoid of hemipteran bugs attacking soybean (Takasu and Hirose, 1985) and is a good candidate for biological control of pest bugs in soybean (Aung *et al.*, unpublished). Our previous study shows that *O. nezarae* is a synovigenic species because the females

emerge with no mature eggs and the fecundity increases in the presence of food and host (Aung *et al.*, unpublished). Our study also has confirmed that this parasitoid feeds, as a protein source, on host fluids upon oviposition in host eggs (i.e. concurrent feeding) and that host-feeding enhances egg production in *O. nezarae* (Aung *et al.*, unpublished). However, the importance of sugar as a carbohydrate source is not known in the reproduction of *O. nezarae*. In the present study, we focus the effect of sugar feeding on the reproduction of the parasitoid. For this purpose, laboratory experiments were carried out to determine the potential of food for egg maturation and longevity of *O. nezarae*.

MATERIALS AND METHODS

The egg parasitoid *O. nezarae* used in the present study was originated from a culture stock maintained at the Bioresource and Management Laboratory, Kyushu University. We used *Riptortus clavatus* (Heteroptera: Alydidae) as host insect. The host was collected from the campus of Kyushu University. The parasitoid and host were reared as described by Takasu and Hirose (1988); we reared the *R. clavatus* in plastic cages (22×16×20 cm) providing with water, soybean seeds and soybean seedlings.

To examine the effects of food on *O. nezarae* reproduction, the longevity and egg maturation were compared among the following four female groups. On the day of emergence, the first group females were individually put into a test tube (1.5 cm diameter and 10.5 cm long) and starved for one day then provided with honey for one day but thereafter provided with only water until death. In the second group, females were individually put into a test tube, which contained with a droplet of honey until death (honey was replaced once in three days). Females of the

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third group were provided with only water and the fourth group females were kept without food source and water (control). The tubes containing test females were kept in an incubator at 25 °C under a 16L:8D photoregime. Test females were reared until death. The mortality of the females was recorded daily. Twenty females were tested for each treatment.

Another set of experiments was made to examine the egg maturation of females under different food conditions. As with the former experiment, 4 groups of females were set up. Females from each group were dissected under a binocular microscope and the numbers of mature eggs were counted. For 3 groups, except the 2nd group (honey provided until death), twenty females were dissected on daily basis. For the 2nd group, dissection was made daily for the initial 10 days since emergence and thereafter every 5 days. The females that had emerged from a host with a ratio of 1 male: 3 females were used for the experiment to standardize the size of test females; female size greatly varies with the clutch size and sex ratio. We used survival analysis for the longevity experiment and Tukey–Kramer HSD for fecundity experiment using Stat View (SAS Institute, 1998), a statistical software package for data analysis.

RESULTS AND DISCUSSION

Females that had provided with honey until death had a mean lifetime of 40.4 days and lived significantly longer ($p < 0.001$) than those provided with honey only for one day (mean life time; 5.5 days), those provided with water only (3.3 days) or control females (2.5 days) (Fig. 1). The longevity of females that had provided with honey for one day lived longer than those offered water only or control females (Fig. 1). Thus, food is an important factor affecting the longevity of female *O. nezarae*.

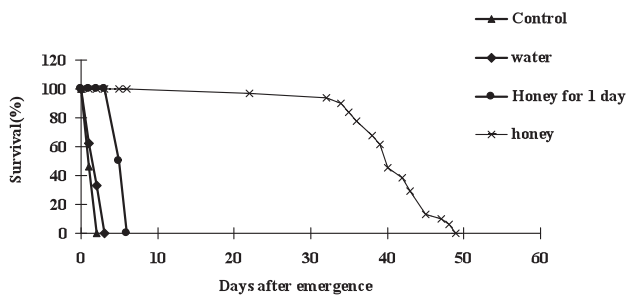


Fig. 1. Influence of food availability on survival of female *O. nezarae*.

Control females and females provided with only water did not produce any mature eggs or, if any, they stored only a few eggs whereas females carried 7–15 eggs if food had been available (Fig. 2). The fecundity of control females (0 mature egg) or those provided with water only (3.0 mature eggs) was significantly lower ($p < 0.001$) than that of females provided with honey for one day (11.0 mature eggs) or females provided with honey throughout their life (15.9 eggs) when the mean values within 3 days were used for data analysis. Egg maturation

of females provided with honey throughout their life can also significantly increase than that of females provided with only limited food (honey for one day) ($p < 0.001$) (Fig. 2).

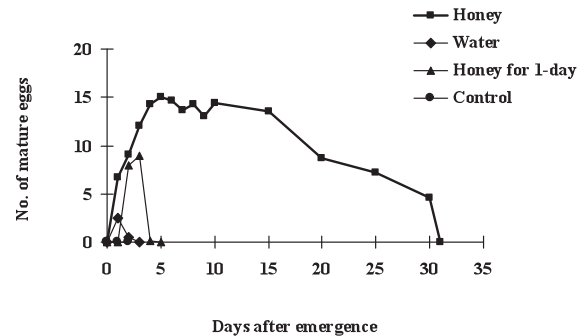


Fig. 2. Effect of food on the egg maturation in female *O. nezarae*.

The present study has revealed that the longevity and egg maturation of the females offered with limited amount of food can be enhanced to some extent than those of water-fed and control females. The present result is in line with previous studies using other egg parasitoids (e.g., Lund, 1938; Ashley and Gonzales, 1974; Hohman *et al.*, 1988). According to the dissecting experiment, starved females (one day honey fed) of *O. nezarae* can also mature the eggs within one day after providing with honey but the eggs once matured were resorped within two days if they cannot obtain food thereafter.

Numerous laboratory studies have shown that the lifespan of adult parasitoids can be increased ten-fold by sugar feeding (e.g., Heimpel *et al.*, 1997; Olson *et al.*, 2000). Similarly, female *O. nezarae* enhances the life span from 6 to 49 days. In other word, the *O. nezarae* life expectancy is extremely limited if the females cannot obtain carbohydrate sources continuously during the adult lifetime. This suggests that the resources acquired during immature development and stored in their fat body (lipids and proteins) are limited and rapidly exhausted for somatic maintenance (Apostolos and Robert, 2008). Evidently, 1–3 days lifetime is too short to search sufficient host eggs. Under food limitation, the reproductive success of *O. nezarae* would largely be limited. Suitable food for *O. nezarae* should thus be present in soybean fields if the parasitoid is used for biological control of soybean pests. However, there is no information on food for the parasitoid in natural habitats or soybean fields. Field investigation is required to reveal food sources of *O. nezarae*.

Some physical factors such as temperature, humidity, etc., which are crucial for the effective use of parasitoids as biological control agents, are also known as a determinant of parasitoid longevity and fecundity (David and Glen, 1991; Hentz *et al.*, 1998; Ivanovic and Nenadovic, 1999; Sagarra *et al.*, 2000). However, the information is lacking how those factors can affect *O. nezarae* reproduction. The impact of such factors should also be studied for better understanding of *O. nezarae*.

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