Seasonal changes in the intensity of adult diapause in a parasitoid wasp, *Ooencyrtus nezarae* Ishii (Hymenoptera: Encyrtidae)

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Abstract

Eggs of *Riptortus clavatus* parasitized by *Ooencyrtus nezarae* were placed in an outdoor cage in Osaka City from early September to late October at intervals of about 10 days. The female adults of *O. nezarae* emerging from these hosts were transferred to 25°C and 16L–8D at intervals of about 30 days and their oviposition was recorded. Female adults did not enter diapause until November or December, and therefore they were capable of parasitizing eggs even in late autumn. The preoviposition period after transfer to 25°C and 16L–8D was longer from January to March, even though the median value was only 4 or 5 days. We concluded, therefore, that diapause in female adults of *O. nezarae* was most intense during these periods. The changes in intensity of diapause are considered to be an adaptation to avoid untimely termination of diapause on warm days in winter or early spring.

Key words: Parasitoid wasp, *Ooencyrtus nezarae*, adult diapause, diapause intensity

INTRODUCTION

*Ooencyrtus nezarae* Ishii (Hymenoptera: Encyrtidae) is an egg parasitoid of phytophagous heteropterans (Takasu and Hirose, 1985). Female adults of this species enter diapause under conditions of low temperature and short-day photoperiod in the laboratory (Numata, 1993). Teraoka and Numata (1995) showed that female adults of *O. nezarae* enter diapause in autumn under natural photoperiod and temperature. However, adults were in diapause with immature ovaries only when they had emerged from parasitized host eggs placed in an outdoor cage in mid-October (Teraoka and Numata, 1995). Adults of the bean bug, *Riptortus clavatus* (Thunberg) (Heteroptera: Alydidae), the major host of *O. nezarae*, have already entered diapause in September, and there are no host eggs in the field in mid-October. Therefore, the time course of diapause induction and termination in this species under natural conditions is still unclear. Furthermore, the termination of adult diapause has not been examined in any parasitoid wasp.

Many authors transferred diapause adults from natural conditions to those that promptly induced oviposition in the laboratory, and used the period to the first oviposition as an index of diapause intensity before transfer (e.g., Hodek, 1971; Tauber and Tauber, 1972; see Hodek, 1983 for review). In the present study, therefore, we transferred female adults of *O. nezarae* from an outdoor cage to a long-day photoperiod and a high temperature in the laboratory at various times from September to May, and recorded their oviposition. The time course of diapause induction and termination under natural conditions was estimated from the preoviposition period.

MATERIALS AND METHODS

A laboratory culture of *O. nezarae* originating from parasitized eggs of *R. clavatus* collected in Kyoto City, Japan (35°00'N, 135°45'E), was maintained under 16L–8D at 25 ± 1°C (Teraoka and Numata, 1995), and relative humidity was kept at 95% with a saturated solution of Na₂HPO₄. In the experiments, adult wasps were kept in glass tubes with a droplet of honey as food. Eggs of *R. clavatus* within 24 h after oviposition were used as hosts. In this paper, adult

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emergence does not mean pupal-adult ecdysis but egression of adult wasps from host eggs. Female adults of *O. nezarae* three days after emergence were used for parasitization. Host eggs were supplied for these adults and removed after 24 h.

From 1 September to 10 October 1995, parasitized host eggs were placed in an outdoor cage in the Campus of Osaka City University. Within 24 h after emergence, female adults were placed in glass tubes and given a droplet of honey as food. These adults were transferred to 16L-8D and 25°C at intervals of about 30 days, and reared individually in glass tubes until the first oviposition or death. A host egg was supplied to each female adult daily. The host egg was removed after 24 h, dissected under a stereoscopic microscope and it was examined to determine whether parasitoid eggs had been laid. The term “preoviposition period” is used for the period from transfer to the laboratory conditions to the onset of oviposition, i.e., the preoviposition period was one day in adults laying eggs within 24 h after transfer.

**RESULTS**

The results are summarized in Fig. 1. In series A, parasitized host eggs were placed outdoors on 1 September, and adults emerged on 13 September. In September and October, most or all females laid eggs within 2 days after transfer to 16L-8D and 25°C. In November and December, some females began to lay eggs more than 2 days after transfer. From January to March, the preoviposition period was more than 2 days in all females except one in January, and the median preoviposition period was 4 or 5 days. In April, the preoviposition period again became shorter. In series B, we placed parasitized host eggs on 11 September, and adults emerged on 26 September. Seasonal trends in the preoviposition period were similar to those in series A, although most females laid eggs within 2 days after transfer in November. In these 2 series, the mortality before transfer to the laboratory was high during winter (data not shown), and only a small number of females were available in March and April. In March, many females died without oviposition in these 2 series.

In series C and D, parasitized host eggs were placed outdoors on 21 September and 1 October, and adults emerged on 18 and 30 October, respectively. Seasonal trends in the preoviposition period were similar to those in series A and B. In series E, we placed parasitized host eggs on 10 October, and adults emerged on 25 November. Most females began to lay eggs more than 2 days after transfer on the day of emergence, and the range in the preoviposition period was large. Some females died without oviposition regardless of the transfer date, especially in March.

**DISCUSSION**

Female adults of *O. nezarae* began to lay eggs within 2 days when they were transferred to 16L-8D and 25°C on the day of emergence, except in series E in which adults emerged in late November. These adults did not seem to be in
diapause, because their preoviposition period was similar to that in nondiapause adults reared continuously under 16L–8D at 25°C (Numata, 1993). Diapause adults of *Drosophila melanogaster* Meigen reared under 10L–14D at 12°C developed mature ovaries within 1 day when transferred to 25°C (Saunders et al., 1989). Therefore, the short preoviposition period after transfer to 16L–8D and 25°C was not sufficient to conclude that the insects were in a nondiapause state. However, all females kept continuously under natural temperature and photoperiod laid eggs in September and early October, and about 80% of females emerging on 23 October laid eggs (Teraoka and Numata, 1995). Therefore, all female adults, except those in series E, were in a nondiapause state on the day of emergence.

Female adults of *O. nezarae* enter diapause in November or December under natural photoperiod and temperature, and timing of diapause induction is dependent on the date of adult emergence; females emerging as adults earlier entered diapause earlier. Some female adults emerging in September survived winter. However, their winter mortality was high, and many died without oviposition after transfer to 16L–8D and 25°C in March (series A and B). A greater proportion of female adults emerging in October laid eggs after transfer to 16L–8D and 25°C in March (series C and D). These females emerged from host eggs parasitized in late September or early October, i.e., the latest season when eggs of *R. clavatus* were found in the field. Therefore, adults emerging in October may account for the principal part of overwintering adults under natural conditions.

In many other insects, winter diapause has been shown to be most intense in the earlier period after its induction in early autumn, and this was explained as an adaptation to avoid the untimely termination of diapause on warm days in autumn (Hodek, 1971, 1979; Tauber and Tauber, 1976; Ichijo et al., 1980; Nechols et al., 1980). In *O. nezarae*, however, females emerge as nondiapause adults in early autumn. Some female adults emerging on 25 November survived winter and laid eggs after transfer to 16L–8D and 25°C in April (series E). These adults emerged from host eggs parasitized on 10 October. Furthermore, some female adults emerging on 11 November survived winter after oviposition and laid eggs again in April under natural photoperiod and temperature (Teraoka and Numata, in preparation). Therefore, if female adults of *O. nezarae* find host eggs and parasitize them in October, it is likely that both these adults and their progeny would survive the winter. This may explain why female adults of *O. nezarae* are in nondiapause state until late autumn. No eggs of *R. clavatus* were found in the field in late October or November. In spring, after overwintering, adults of *O. nezarae* parasitize eggs of *Megacopta punctatissima* (Montandon) until *R. clavatus* eggs become available (Takasu and Hirose, 1986). It is unclear whether *O. nezarae* also has such an alternate host in late autumn, although being in a nondiapause state until late autumn allows reproduction in later seasons without negative effects on overwintering.

Adult diapause of *O. nezarae* was most intense from January to March, even though the median preoviposition period was only 4 or 5 days in these periods. In April, the preoviposition period was 2 days or less, and therefore the adults had already terminated diapause. The changes in intensity of diapause are considered to be an adaptation to avoid untimely termination of diapause on warm days in winter or early spring.

**REFERENCES**


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