SHORT COMMUNICATIONS

Effect of Photoperiodic Shifts on Egg Production in a Semi-Aquatic Bug, *Microvelia douglasi* (Heteroptera: Veliidae)\(^1\)\(^2\)

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A semi-aquatic bug, *Microvelia douglasi*, is known as a predator of homopteran rice insect pests (Nakasuji and Dyck, 1984) and mosquito larvae (Kurihara, 1974). In southwestern Japan, this bug occurs from mid-April to mid-October and produces three or four generations (Muraji et al., 1989a). Recently we reported that reproductive diapause of this bug was induced by photoperiods with less than 12.5 hr of light under laboratory conditions at 24°C (Muraji et al., 1989b). In this study, we examined the effect of photoperiodic shifts on egg production of *M. douglasi* under laboratory conditions.

MATERIALS AND METHODS

Adults of *M. douglasi* were collected from ponds around Matsue City, southwestern Japan, in 1983; more than 90% of the individuals were apterous (*n* = 120). They were reared in groups of 30–50 individuals in containers (15 cm dia × 6.5 cm ht.) filled to 2 cm with dechlorinated tap water, and kept at 24 ± 1°C, 16L–8D photoperiod. Two or three pieces of filter paper (2 cm × 7.5 cm) were placed on the wall of the container as ovipositing and resting sites for insects. Insects were fed a mixture of various kinds of arthropods (0.5–1.0 g/day) such as chironomid flies and planthoppers, which had been collected from grass fields and stored in a freezer. Food and water were changed daily. Each week eggs attached to the filter paper were removed from containers and stored separately.

To examine the effect of photoperiod on egg production, groups of 30–50 first instar nymphs were introduced into containers within 24 hr after hatching and reared until adult emergence in long (16 L–8 D) or short (8 L–16 D) photoperiods. Only a few macropterous adults emerged at either photoperiod, so we used only apterous individuals for the analysis. Within 24 hr after adult emergence, apterous females and males were paired in plastic cups (5 cm dia × 4 cm ht.) and kept in short or long day conditions. Some pairs were transferred from short to long days and vice versa on later dates. Each pair was given about 0.1–0.2 g of food every day. Dead males were replaced immediately upon discovery. Ten to fifteen replicate pairs were used for each treatment. The number of eggs laid by each female was counted every day. Several females which died during the period were omitted from calculation.

RESULTS AND DISCUSSION

When the bugs were reared in long days throughout their life span, all the females started laying eggs within an average of 3.2 days (Range: 2–4, S.E. = 0.21, *n* = 12) after adult emergence and continued to do so for as long as 70 days (Fig. 1A). When reared in short days, however, the females never laid eggs during the observation period (Fig. 1F).

When insects were transferred from short to long days at adult emergence (Fig. 1D), the prepupal period (Mean = 9.1, Range: 4–17, S.E. = 0.76, *n* = 15) became about three times longer than that for bugs constantly kept in long days from the beginning of the nymphal stage. On the other hand, the females transferred from long to short days started laying eggs without any significant delay (Mean = 2.6, S.E. = 0.28, Range: 2–7, *n* = 18). They ceased doing so within 25.5 days on average (Range: 19–30, S.E. = 0.896, *n* = 15; Fig. 1E). When photoperiod was altered during the adult stage, short days always suppressed egg laying and long days promoted it, irrespective of insect age.

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Fig. 1. Oviposition pattern of *M. douglasi* under various photoperiodic conditions at 24°C. Open and shaded zones indicate the periods during which insects were kept at 16L–8D and 8L–16D, respectively.

(Fig. 1B–1E). These results indicate that photoperiodic sensitivity exists in both the nymphal and adult stages and that the cessation of oviposition may be due to induction of diapause by short days, as often observed in other bugs (NUMATA and HIDAKA, 1982). This suggests a possibility that, under natural conditions in early autumn, both females which have initiated oviposition and those which have not enter a reproductive diapause and reproduce in the following spring.

Figure 1 also shows that responsiveness to short days persisted throughout adult life. In some cases (Fig. 1C–1E), the transfer of bugs to short days interrupted oviposition, indicating that females which have terminated diapause can undergo a second diapause when living in short days. A similar response was reported for other insects, such as *Riptortus clavatus* (NUMATA and HIDAKA, 1982) and *Epilachna vigintioctomaculata* (MAKI et al., 1964).

This phenomenon has been considered to be adaptive, enabling the insects to enter a second diapause for the next winter (HODEX, 1974; NUMATA and HIDAKA, 1982).

In *M. douglasi*, this pattern may not hold true. The responsiveness to photoperiod in overwintering females changed greatly as the season progressed and overwintered females collected in early spring began to lay eggs even at 12L–12D (MURAI et al., 1989 b). Adult longevity of *M. douglasi* at 16L–8D and 25°C was about 2 months: 63.0 and 74.8 days for apterous and macropterous females, respectively (MURAI and NAKASHIJI, 1988). Therefore it seems unlikely that overwintered adults survive until the autumn and enter a second diapause in response to the short autumnal daylength.

Table 1 shows the time required for oviposition to start after transfer from short to long days. This period tended to increase with the delay of time of transfer until ten days after adult emergence, and decreased slightly when the transfer was delayed thereafter. This may suggest that a slight change in physiological state of insects occurred in short days. According to our data (MURAI et al., 1989 b), when bugs were transferred from overwintering sites to laboratory conditions of 24°C and 16L–8D on different dates, the time required for oviposition to start decreased more rapidly. At present, there is no experimental evidence to explain the differences in photoperiodic response between laboratory and field populations. Further studies are needed to know what kind of factors promote diapause development more rapidly in the field.

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Means with the same letter are not significantly different at 5% (DUNCAN's multiple range test).
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Shimane University, and T. YOSHIDA of Okayama University for their helpful suggestions.

REFERENCES


Reproductive Potential of *Aphytis yanonensis* DeBach et Rosen and *Coccusius fulvus* (ComperE et ANNECKE) (Hy- menoptera: Aphelinidae), Parasitoids of *Unasps yanonensis* (KuwANA) (Homoptera: Diaspididae).

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*Aphytis yanonensis* DeBach et Rosen and *Coccusius fulvus* (ComperE et ANNECKE) were introduced from China into Japan as biological control agents of the arrowhead scale, *Unasps yanonensis* Kuwana which was one of the most important pests of citrus in Japan (Furuhashi and Nishino, 1983). The introduction resulted in successful biological control of the pest (Furuhashi et al., 1984; Takagi and Ujibe, 1986). However, reproductive potential of the two parasitoids has been little investigated. Furuhashi and Nishino (1983) investigated the developmental velocity and fecundity of *A. yanonensis* but did not determine its reproductive potential. On the other hands, there is no information on the reproductive potential of *C. fulvus*. In this study we investigate the reproductive potential of the two parasitoids.

Adult females of *A. yanonensis* and *C. fulvus* obtained from laboratory cultures were used in this study. The cultures were originated from individuals collected in the field in Fukuoka, Japan. Pupae of the parasitoids were removed from the host scale and individually held in glass vials (5 cm in length and 5 mm in diameter) until the adult parasitoids emerged. Females of *C. fulvus* were mated after emergence but those of *A. yanonensis* needed no mate to deposit female eggs because of thelytokous reproduction. Hosts provided to the

Fig. 1. Survivorship curve and daily oviposition per survivor in female *A. yanonensis* (A) and *C. fulvus* (B) at 25°C and 16L:8D. Vertical lines indicate 95% confidential intervals.

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