Thermal effects on reproductive diapause induction in *Orius sauteri* (Heteroptera: Anthocoridae)\(^1\)

Katsuyuki Kohno\(^2\)

Kurume Branch, National Research Institute of Vegetables, Ornamental Plants and Tea, Kurume, Fukuoka 839-8503, Japan

(Received 11 August 1997; Accepted 5 June 1998)

**Abstract**

All females of *Orius sauteri* exhibited reproductive diapause at 22°C but 37% of them initiated oviposition at 26°C under 10L–14D. Although less females initiated oviposition under 10L–14D than under 14L–10D at 26°C, the mean preoviposition period under 10L–14D was shorter than that under 14L–10D at 26°C. The short photoperiod did not appear to prolong the preoviposition period under 26°C. If *O. sauteri* is used as a biological control agent against non-diapausing thrips like *Thrips palmi* in greenhouses under short photoperiod, maintaining a high temperature should be considered to prevent reproductive diapause induction in *O. sauteri*.

**Key words:** *Orius sauteri*, thermal effect, reproductive diapause, preoviposition period

**INTRODUCTION**

Minute pirate bugs, *Orius* spp., are known as predacious natural enemies of various agricultural pests like thrips, aphids, spider mites and whiteflies (e.g. Barber, 1936). Among these, *O. sauteri* (Poppius) is widely distributed throughout the main islands of Japan and is commonly observed in cultivated fields (Yasunaga and Kashio, 1993; Yasunaga, 1997b). Naturally occurring *Orius* spp. effectively controlled *Thrips palmi* Karny populations on eggplant in the field (Nagai, 1993). Also in a greenhouse, Kawai (1995) demonstrated that the artificial release of last stadium nymphs of *Orius* spp. was effective in controlling *T. palmi* populations on eggplant. However, the effect appeared to be reduced after mid-October. One reason for this is the induction of reproductive diapause in *Orius* spp. under short photoperiod, which may bring about a reduction of predatory activity. In fact, the Kurume (33°18′ N and 130°33′ E) population of *O. sauteri* exhibited reproductive diapause under short photoperiods, and the critical photoperiod for the reproductive diapause induction fell between 12L–12D and 13L–11D at 22°C (Kohno, 1997). In contrast, *T. palmi* has no diapausing developmental stages (Kawai, 1990). Therefore, prevention of reproductive diapause in *O. sauteri* will be required in order to use this species as a biological control agent against *T. palmi* in greenhouses during the winter.

Non-diapausing *Orius* spp. could be an alternative biological control agent against *T. palmi* in greenhouses in winter. Nakashima and Hirose (1997) demonstrated that *O. tantillus* (Motschulsky), which is distributed in the southwestern island of Japan (Yasunaga, 1997c), had no reproductive diapause, even under short photoperiod. They suggested that *O. tantillus* could be an alternative biological control agent against *T. palmi* in greenhouses in winter. However, they also pointed out that prey consumption rate and egg production rate of *O. sauteri* at high prey density are higher than those of *O. tantillus*. Considering such circumstances, *O. sauteri* may, for the first time, be considered as a biological control agent against *T. palmi* in greenhouses during winter.

---

\(^1\)This paper was presented in part at the 40th Annual Meeting of the Japanese Society of Applied Entomology and Zoology, held in Yamaguchi, March, 1996.

\(^2\)Present address: Okinawa Subtropical Station, Japan International Research Center for Agricultural Sciences, Ishigaki, Okinawa 907-0002, Japan
if reproductive diapause induction in *O. sauteri* is avoided.

Thermal conditions affect photoperiodic response in insects (e.g. Beck, 1980; Saunders, 1982; Tauber et al., 1986). In the case of *Orius* spp., thermal and photoperiodic conditions affected the incidence of reproductive diapause in *O. insidiosus* (Say) (Meiracker, 1994); that is, most females entered diapause at 18°C, 21°C, and 25°C under short photoperiod, while diapause incidence was low at 30°C even under short photoperiod. There is no information about thermal effect on the incidence of reproductive diapause in *O. sauteri* to date. If the diapause incidence of *O. sauteri* is also low at higher thermal conditions as in *O. insidiosus*, *O. sauteri* could constitute a biological control agent against *T. palmi* in greenhouses during winter by heating. Therefore, it is important to clarify the effects of a combination of thermal and photoperiodic conditions on the incidence of reproductive diapause induction. In this report, the thermal effects on the incidence of reproductive diapause in the Kurume (33°18' N and 130°33' E) population of *O. sauteri* were examined in the laboratory.

**MATERIALS AND METHODS**

Female adults of *O. sauteri* were collected at the eggplant field of the Kurume branch, National Research Institute of Vegetables, Ornamental Plants, and Tea in July, August, September and October, 1994 and in September, 1995. The field-collected females were kept in individual containers under 22±1°C and 14L–10D conditions and their eggs were kept under the same conditions until hatching. Nymphs within 24 h after hatching were transferred to two thermal (low thermal [L] and high thermal [H]) and two photoperiodic (long photoperiod [L] and short photoperiod [S]) conditions: LL (22±1°C and 14L–10D); LS (22±1°C and 10L–14D); HL (26±1°C and 14L–10D) and HS (26±1°C and 10L–14D). Nymphs were kept together with some siblings until emergence. Each emerged female adult was kept with a male adult to achieve copulation within 24 h after adult emergence. The male was replaced if he died before the female started oviposition. Containers were examined 20 days after copulation to determine whether or not females had laid eggs.

Insects were reared in plastic containers (55 mm in diameter and 10 mm in depth). A piece of filter paper (55 mm in diameter) was set at the bottom of the container. The mold mite, *Tyrophagus putrescentiae* (Schrank), and the stamen of the dishcloth gourd, *Luffa cylindrica* Roem., were amply supplied as the diet. An eggplant leaflet with a leaf vein (ca. 2 cm² in area) as the substrate for oviposition was put on the filter paper. Water was provided at the base of the leaf vein and on the filter paper using a fine brush every one to three days. The leaf and the diet were exchanged every two or three days and the filter paper was exchanged once a week.

Since the identification of field collected *Orius* females was very difficult using only morphological characters (Yasunaga, 1993, 1997a, b, c; Yasunaga and Kashio, 1993), they were identified by observing the genitalia of the male individuals of the next generation of field-collected females under a binocular microscope. Only individuals that were identified as *O. sauteri* were provided for the experiment.

**RESULTS AND DISCUSSION**

The incidence of oviposition of *O. sauteri* under each photoperiodic and thermal condition is shown in Table 1. The proportions of individuals which laid eggs were high under LL and HL. The proportion of individuals that laid eggs did not differ significantly (*p* > 0.05 by χ²-test) between LL and HL. No individuals laid eggs when reared under LS, however, more than one third of the individuals laid eggs under HS. The proportion of individuals that laid eggs differed significantly (*p* < 0.01 by χ²-test) between LS and HS.

The preoviposition periods of female *O. sauteri* that did not enter reproductive diapause under each thermal and photoperiodic condition are shown in Table 2. The variance of the preoviposition periods were large under every environmental conditions tested. Since one individual under LL and six individuals under HS were still alive without having oviposited at the 20th day after the start of the experiment, the preoviposition periods under LL or HS might have been underestimated. However, this does
Table 1. Incidence of oviposition in *O. sauteri* females under various photoperiodic and thermal conditions

<table>
<thead>
<tr>
<th>Photoperiod</th>
<th>Temperature</th>
<th>Abbreviation</th>
<th>No. of individuals</th>
<th>% Oviposition*</th>
</tr>
</thead>
<tbody>
<tr>
<td>14L–10D</td>
<td>22°C</td>
<td>LL</td>
<td>26</td>
<td>81.3 x</td>
</tr>
<tr>
<td></td>
<td>26°C</td>
<td>HL</td>
<td>13</td>
<td>61.9 x</td>
</tr>
<tr>
<td>10L–14D</td>
<td>22°C</td>
<td>LS</td>
<td>0</td>
<td>0.0 x</td>
</tr>
<tr>
<td></td>
<td>26°C</td>
<td>HS</td>
<td>10</td>
<td>37.0 y</td>
</tr>
</tbody>
</table>

*a* These abbreviations are used in the text.

*b* Values followed by different letters within the same photoperiodic conditions were significantly different by *χ*²-test (*p* < 0.01).

*c* Values include the number of individuals that were still alive without having oviposited at the 20th day after the start of the experiment.

Table 2. Preoviposition periods of non-diapausing female *O. sauteri* under various thermal and photoperiodic regimes

<table>
<thead>
<tr>
<th>Photoperiod</th>
<th>Temperature</th>
<th>Abbreviation</th>
<th>N</th>
<th>Preoviposition period (No. days)</th>
<th>Mean ± SE*</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>14L–10D</td>
<td>22°C</td>
<td>LL</td>
<td>26</td>
<td>8.8 ± 1.0</td>
<td>4–19</td>
<td></td>
</tr>
<tr>
<td></td>
<td>26°C</td>
<td>HL</td>
<td>13</td>
<td>6.2 ± 0.7 x</td>
<td>4–12</td>
<td></td>
</tr>
<tr>
<td>10L–14D</td>
<td>22°C</td>
<td>LS</td>
<td>0</td>
<td>—</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td></td>
<td>26°C</td>
<td>HS</td>
<td>10</td>
<td>4.4 ± 0.4 y</td>
<td>4–8</td>
<td></td>
</tr>
</tbody>
</table>

*a* These abbreviations are used in the text.

*b* No individuals laid eggs under 22°C and 10L–14D (LS).

*c* Values followed by different letters within the same thermal conditions were significantly different by *t*-test (*p* < 0.05).

not necessarily infer misjudgment on overall tendencies. The mean preoviposition period under HS was significantly shorter (*p* < 0.05 by *t*-test) than that under HL. The preoviposition period did not differ significantly between LL and HL.

Thermal conditions affected reproductive diapause in *O. sauteri*, i.e., no individuals laid eggs under short photoperiod (10L–14D) at 22°C, however, more than one third of the individuals laid eggs at 26°C even under short photoperiod (Table 1). This result is similar to the case of *O. insidiosus* (Meiracker, 1994). Meiracker (1994) concluded that the photoperiodic response might have been suppressed in *O. insidiosus* at 30°C. However, he also mentioned that the possibility that the critical photoperiod had been shifted to a shorter length could not be excluded. Also as in the case of *O. sauteri* in this study, each or both of these explanations must be considered here.

Although the proportion of individuals that started oviposition under HS was smaller than that under HL, the mean preoviposition period of the individuals under HS was somewhat shorter than that under HL (Table 2). This may indicate that the short photoperiod (10L–14D) had no prolongation effect on the preoviposition period of *O. sauteri* at 26°C.

The results of this study suggest that maintaining a greenhouse temperature of higher than 26°C in winter should be considered to prevent reproductive diapause induction in *O. sauteri*. However, heating up to 26°C in winter is energy- and cost-consuming. Supplementary lighting in greenhouses for preventing reproductive diapause induction of *O. majusculus* (Reuter) are practically performed under the condition of short photoperiod to control *Frankliniella occidentalis* (Pergande), which has no diapause (Jacobson, 1993). This may also be appropriate for the use of *Orius* species, such as *O. sauteri*, in which reproductive diapause is induced under short photoperiod (Kohn, 1997;
Ito and Nakata, 1998) to control non-diapausing thrips like T. palmi. When choosing heating or lighting in the practical use of O. sauteri in greenhouses in winter to prevent reproductive diapause induction, the performance per cost should be considered.

ACKNOWLEDGEMENTS

I thank Dr. K. Nagai (Okayama Prefectural Agricultural Experiment Station) for providing me with the information on the rearing of Oritus bugs. He and Dr. T. Yasunaga (Hokkaido Kyoriku University) kindly gave me the information on the biology of Oritus bugs. I also thank anonymous referees for giving me valuable comments.

REFERENCES