Mating Behavior of the Tea Tussock Moth, *Euproctis pseudoconspersa* (STRAND) 
(Lepidoptera: Lymantriidae)^1^  

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The tea tussock moth, *Euproctis pseudoconspersa* (STRAND), is distributed in Japan (Honshu, Shikoku and Kyushu), Korea, Taiwan and China. The larvae of this species feed on leaves of Theacca family plants including the tea plant, *Thea sinensis* L., the Japanese camellia, *Camellia japonica* L., and the sasanqua camellia, *C. sasanqua* THUMB. In addition to the damage caused by defoliation, human contact with larval setae can result in severe dermatitis (MINAMIKAWA, 1952; HOSOYA, 1956).  

We identified the sex pheromone components of *E. pseudoconspersa* and examined their attractiveness in the fields (WAKAMURA et al., 1992). In order to control this insect with synthetic sex pheromones, it is first necessary to clarify its reproductive characteristics. In the present paper, the initiation and termination of copulation in the field and the relationship between moth age and mating activity are described.  

**MATERIALS AND METHODS**  

**Insects.** *E. pseudoconspersa* larvae were collected from a wild population on the Japanese camellia, *Camellia japonica* L., in Tsukuba in mid-June, 1992, and fed camellia leaves until pupation under room temperature and natural light-conditions in the laboratory. Pupae were treated with 1%-sodium hypochlorite solution to dissolve the cocoons and washed in tap water to remove the hazardous larval setae. Pupae were then sexed and kept in separate containers. Since emergence mainly took place between 1500 h and 1800 h, emerged females and males were collected in separate containers and provided with moistened cotton swabs at about 1800 h.  

**Tethered females and marked males.** Females were tethered according to the method described by OYAMA (1974). Right or left wings of 0- to 4-d-old females were tied with ca. 20 cm of waxed cotton thread (No. 80, Japan Industrial Standard) between 1500 h and 1800 h, but females immediately after emergence (0-d-old) were tied at least 30 min after wing extension (see Table 1 for the number of females used). They were individually tethered on the tops of bamboo sticks (1–2 cm diam. × 1 m height) at about 1900 h, using adhesive tape to leave about 10 cm space between the moth and stick. The bamboo sticks were set in a row at 1-m intervals on a grassy lawn near camellia trees.  

Since the field population appeared to be low, judging from the level of damage to camellia leaves, laboratory reared males were released in the experiments. Zero- to 4-d-old males were marked on their forewing(s) with an oily dye using a felt-tip pen (Magic Ink® line markers). Marked males (655 on July 6–7 and 616 on July 8–9) were released at a site about 20 m away from the nearest tethered females at 2400 h.  

**Field experiment.** The tethered females were observed to verify whether they had copulated, using a dim red light torch. Observations were conducted at 30-min intervals from 2400 h to 0600 h since no mating was observed before 0100 h and copulation continued for more than several hours in a preliminary laboratory observation. After 0600 h, observations were conducted at 1-h intervals until 1800 h.  

Experiments were repeated on July 6–7 and 8–9, 1992. Sunset and sunrise times were 1858 h and 0430 h on July 6–7, and 1858 h and 0431 h on July 8–9, respectively. On July 6–7 and 8–9, temperature fell from 20.7°C and 21.2°C at 2300 h to 19.6°C and 20.0°C at 0400 h, respectively, and then rose again after sunrise.  

**RESULTS AND DISCUSSION**  

Copulation of the tethered female started between 2400 h and 0700 h, occurring most frequently between 0300 h and 0400 h (Fig. 1). Initiation of copulation was observed even after sunrise, which suggested that light conditions may not suppress mating.
behavior in *E. pseudocospsersa*.

Copulation continued for longer than 5 h. On July 7, 48% of the pairs (10/21) stopped copulating by 1800 h but the other 52% continued for some time thereafter (Fig. 2). In the second experiment, 95% of the copulating pairs (42/44) separated by 1500 h, probably because of winds which became so strong in the afternoon that some of the tethered females were forcibly fluttered and lost their mate. In a preliminary observation, males often flew away when disturbed during copulation, so that strong wind probably stimulated the mating pairs to separate early.

The copulation duration of *E. pseudocospsersa* was much longer compared with that of the congenericous species, *E. similis*, whose mating was reported to continue for about 2 h (Yoshin, 1991). In a separate observation, *E. pseudocospsersa* males left the females just after sunset (unpublished data). Therefore, copulation presumably continues until sunset in the field if the pair is not disturbed. Evaluation of the significance of possible prolonged copulations should be a topic for further research.

The percentages of copulation were low for 0-d-old females, peaked for 1- to 2- and 3-d-old females, and decreased to a very low level for older females (Table 1). A rapid decrease in mating potential with age in females could be an advantage for the use of synthetic sex pheromone for pest control. Mean times of copulation initiation were not significantly different among different ages of females, although 0-d-old females appeared to initiate copulation slightly later

### Table 1. Mating of *Euprotis pseudocospsersa* females tethered on sticks in the field (1992, Tsukuba)

<table>
<thead>
<tr>
<th>Age (d)</th>
<th>% females that copulated&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>July 6-7</td>
</tr>
<tr>
<td>0</td>
<td>20 (20)</td>
</tr>
<tr>
<td>1</td>
<td>38 (21)</td>
</tr>
<tr>
<td>2</td>
<td>41 (22)</td>
</tr>
<tr>
<td>3</td>
<td>5 (21)</td>
</tr>
<tr>
<td>4</td>
<td>0 (14)</td>
</tr>
</tbody>
</table>

<sup>a</sup> Values in parentheses are the number of females used.

### Table 2. Mean time of copulation initiation in *E. pseudocospsersa* females tethered in the field (1992, Tsukuba)

<table>
<thead>
<tr>
<th>Age (d)</th>
<th>Mean time of copulation initiation&lt;sup&gt;a&lt;/sup&gt; (mean h ± SE (min))</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>July 6-7</td>
</tr>
<tr>
<td>0</td>
<td>0438 ± 19 (4)</td>
</tr>
<tr>
<td>1</td>
<td>0341 ± 51 (8)</td>
</tr>
<tr>
<td>2</td>
<td>0315 ± 29 (9)</td>
</tr>
<tr>
<td>3</td>
<td>0415 (1)</td>
</tr>
<tr>
<td>4</td>
<td>—</td>
</tr>
</tbody>
</table>

<sup>a</sup> Japan standard time (h). Values in parentheses are numbers of females that copulated. Means in the same column are not significantly different by a KRUSKAL-WALLIS test at 5% level.
Estimate of Multiple Insemination in a Natural Population of Harmonia axyridis (Coleoptera: Coccinellidae)  

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The degree of multiple insemination in a mating system where one female can receive sperm from several males considerably affects the sexual selection consequences. Parker (1970) reviewed extensive literature and concluded that sperm precedence processes followed by multiple mating are under intensive sexual selection in which sperm competes for fertilization with sperm ejaculated from other males and stored in the female. In order to identify the selection consequences, along with a measurement of sperm precedence parameters, actual mating frequencies under natural conditions are necessarily estimated.

In many insect species, multiple copulation has generally been recognized under experimental conditions. However, the degree of multiple insemination under natural conditions is poorly understood. Direct observation in the field by following marked individuals could possibly underestimate copulation frequency (Osawa, 1994).

The present study reports an estimate of multiple male sperm contribution in the ladybird beetle, Harmonia axyridis. This species has color polymorphism on the elytra which is controlled by four alleles (three melanic alleles and one non-melanic) at a single locus with melanic alleles being dominant over a non-melanic allele (Tan and Li, 1934). Using the variances of gene frequency within and among siblings reproduced by females collected from a natural population, the estimate could reduce the biases that occur in field observations while allowing the activities of the ladybird beetles under natural conditions to remain unaffected.

MATERIALS AND METHODS

In May, 1992, I collected overwintered adult females in a mating population from a suburb of Gifu City, Japan. Among the females collected, recessive homo females were individually reared in a plastic

REFERENCES


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