the same area, that of the other local populations should be tested.

The incidence of reproductive diapause in the field population was not incompatible with the laboratory experiments. The photoperiod in Kurume becomes 12.5L–11.5D around September 10. Considering that the sensitive period for the photoperiodic reaction is presumed to be the nymphal stage, that twilight hour may function as day-time for the reproductive diapause induction, and that non-diapausing females survive and lay eggs even in short photoperiods, the result that the proportion of egg-laying females decreased abruptly in early October is fairly compatible with the laboratory experiments.

Although both *O. sauteri* and *O. minutus* exhibited a dull response to photoperiod in the laboratory, the field population exhibited an abrupt response. Gradually decreasing photoperiod and temperature in the field might have affected the incidence of diapause induction.

Both the Kurume populations of *O. sauteri* and *O. minutus* exhibited reproductive diapause when reared under short photoperiod. Most females of the field population of these species exhibited reproductive diapause by mid October. Therefore, avoiding the induction of reproductive diapause appears to be very important for using these species as biological control agents in greenhouses under short photope-

riod in winter. Artificial lighting may have a good effect on this. Selection for a non-diapausing strain should be considered in the future, as well.

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Attraction of Males to Females in the Rice Leaf Bug, *Trigonotylus caelestialium* (KIRKALDY) (Heteroptera: Miridae)¹

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The rice leaf bug, *Trigonotylus caelestialium*, is one of the major pests causing a pecky rice, and also injures wheat and gramineous forage grasses in northern parts of Japan.

In Pentatomidae, Alydidae, Rhopalidae, Reduviidae and Coreidae, it is known that males secrete an aggregation pheromone or a sex pheromone (ALDRICH, 1988). Some of these pheromones have been chemically identified as attractants (ALDRICH et al., 1991; KOCHANSKY et al., 1989; LEAL et al., 1995; SUGIE et al., 1996). In Miridae, it was reported that females attract males of the same species, e.g., *Lygus lineolaris* (SCALES, 1968), *Ligocoris communis* (BOIVIN and STEWART, 1982), *Campylomma verbasici* (THISTLEWOOD et al., 1989), and five other species. However, the mating behavior in *T. caelestialium* has not been reported.

In this paper, we describe mating behavior and

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female's attractiveness to males in *T. caelestialium*.

MATERIALS AND METHODS

Observation of mating behavior. Adults of *T. caelestialium* were collected using insect nets in wheat fields (Hokkaido Central Agricultural Research Station, Naganuma) on 1 August 1995. Mating behavior was observed in the laboratory under natural photoperiod and room temperature. About 110 pairs of adults were released in an acryl rearing box (H 28×W 30×D 25 cm, Sanshin) with wheat leaves. Mating behavior was observed for 30 h from 18:00 on 1 August. The number of mating pairs was counted at 15-min intervals. The duration of mating in 14 pairs was also investigated at 1-min intervals from 18:00 to 24:00 on the first day. The sun set at 18:57 and rose at 4:24.

Further, the behavior of adults clustering in an insect collecting tube (3 cm diam.×8 cm length) was observed. The adult bugs were collected near a light at night on 10 August 1995.

Insect-baited traps. Attractiveness of the adults and nymphs of *T. caelestialium* to conspecifics was examined in the field. These observations were carried out in 1996 on the second generation of *T. caelestialium* in a spring wheat field (variety was "Haruyutaka") where this species occurred. Field size was 7,500 m² (75×100 m). Traps were set between 13–21 August.

Ten females, 10 males or 20 middle stadium nymphs were used as bait for this examination. Nymphs of this species were collected in the spring wheat field using insect nets. Two to 3-d old adults were put into cages with spring wheat leaves and the

bugs were not changed during this examination.

The traps used in this examination were water pan type (white, 35 cm diam. and 6 cm in depth) and were placed on the ground. A wire net cage (7×15 cm, 1 mm mesh) was used for maintaining the adults, and a spherical tea strainer made of stainless steel net (7 cm diam., 0.5 mm mesh) was used for the nymphs to prevent escape through the mesh. These cages were hung about 5 cm above the water pans. Three traps were used for each bait and these traps were placed linearly at intervals of 7–8 m on the ground along the wheat field. The numbers of this species captured by each trap were counted at intervals of 2–3 d, and the locations of the traps were rotated at that time.

Trap data (x) was transformed to the square root ($x + 0.5$) before analysis of variance, and was compared by TUKEY's test.

RESULTS AND DISCUSSION

Mating behavior

Although mating was observed more in the nighttime than in the daytime during this observation (Fig. 1), the peak mating time was not clear. The mean duration of mating for 14 pairs was 37.1 ± 20.5 (SD) min with a range from 19 to 93 min. This species mated as follows. A male near a female jumped and mounted the female instantly. Then, the male adjusted his body axis to that of the female, and attempted to copulate with her. Neither mating dance of males nor calling behavior of females was observed.

Fig. 1. Beginning time of matings of *Trigonotylus caelestialium* observed in a rearing box at the laboratory under natural photoperiod and room temperature (1–2 August 1995, Naganuma, Hokkaido).

Fig. 2. Cluster of *T. caelestialium* observed during mating in a glass tube. Eight males are mounting one female. The individual at the bottom of the cluster is the female.

When adults attracted to a light were collected using an insect collecting tube, it was observed that most of the males responded to some of the females, and several males mounted one female simultaneously (Fig. 2). On the other hand, only a few females stimulated the male's behavior in such a manner. These males responded to the female simultaneously at the beginning of mating. Males which failed to mate also remained on the female until the end of mating. However, other males approaching after the start of mating did not respond to this cluster of adults. When the mating was over, the female began to walk actively and the males on the female scattered away parted from her. From these behaviors, it was considered that males responded to some cue emitted from the female. These behaviors could occasionally be observed in a rearing box, although the number of males mounting one female was smaller than that in the collecting tube.

Trapping tests in the spring wheat field

The female traps using a wire net cage and a tea strainer cage captured significantly more males (57.7 males and 11.3 males/trap during 8 d, respectively) than the other traps (Tables 1, 2). The numbers of males captured by the male traps or the wheat leaf traps were not different from that of the unbaited traps. Also the number of males captured by the nymph traps using the tea strainer cage was not different from that of the unbaited traps (Table 2). On

Table 1. Number of adults captured by traps using a wire net cage (1.0 mm mesh) in the second generation of *T. caelestialium* (13–21 August 1996, Naganuma)

Bait ^a	No. of adults captured (mean $\pm$ SE) ^b	
	Males	Females
10 females	57.7 $\pm$ 26.6 a	0.7 $\pm$ 0.3 a
10 males	3.7 $\pm$ 4.0 b	3.0 $\pm$ 1.0 a
Wheat leaves	2.3 $\pm$ 0.7 b	0.3 $\pm$ 0.3 a
Unbaited	1.7 $\pm$ 0.3 b	2.0 $\pm$ 1.1 a

^a Bugs used for bait were supplied with wheat leaves.

^b Means followed by the same letter in the same column are not significantly different at the 5% level by TUKEY's test.

Table 2. Number of adults captured by traps using a tea strainer cage (0.5 mm mesh) in the second generation of *T. caelestialium* (13–21 August 1996, Naganuma)

Bait ^a	No. of adults captured (mean $\pm$ SE) ^b	
	Males	Females
10 females	11.3 $\pm$ 2.5 a	1.0 $\pm$ 0.6 a
20 nymphs	0.3 $\pm$ 0.3 b	0.0 $\pm$ 0.0 a
Unbaited	1.0 $\pm$ 1.0 b	0.3 $\pm$ 0.3 a

^a Bugs used for bait were supplied with wheat leaves.

^b Means followed by the same letter in the same column are not significantly different at the 5% level by TUKEY's test.

the other hand, no traps captured females significantly (Tables 1, 2), and nymphs were not captured at all. These results indicated that the females attract the males selectively for mating.

As the factor of the attractiveness of these female traps, airborne materials, acoustic signals and visual stimuli were expected. However, the body of this species is too small, 5–6 mm length, with protective coloration, to be seen from outside of the cages. And as described above, males were considered to respond to some cue of the female on mating behavior. Thus other stimuli may be more important than visual stimuli in attraction. Although a acoustic signal has not been reported in any species of Miridae, it as an attraction signal can not be excluded (GOGALA, 1985).

However, the female sex pheromone as a long-range attractant was identified in *Campylopus verbasici* (SMITH et al., 1991). Therefore, it is probable that females of *T. caelestialium* also use a sex pheromone for attracting males.

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Effects of Host Plants on Flight Muscle Size and Flight Activity in the Diamondback Moth, *Plutella xylostella* (Lepidoptera: Yponomeutidae)¹

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The diamondback moth (DBM), *Plutella xylostella*, exploits various wild crucifers in the absence of cultivated cruciferous crops. MUHAMAD et al. (1994) studied the influence of wild host plants on the flight activity and fecundity of the DBM, and reported that female adults grown on some wild host plants had lower fecundity but higher flight activity than those

grown on cabbage. BEGUM et al. (1996) also conducted a flight experiment using adult DBM grown on two wild host plants, *Rorippa indica* and *Lepidium virginicum*, and a cultivated crop, cabbage, and confirmed the results reported by MUHAMAD et al. (1994). The objective of the present study was to clarify the reasons why the DBM grown on the wild crucifers has a higher flight activity. The experiments were designed to measure the size of flight muscles of adult DBM, because these muscles had not been previously studied in the DBM.

MATERIALS AND METHODS

A stock culture of the DBM was established from individuals originally collected in a cabbage field in Okayama, and it was maintained using mature leaves of commercial cabbage for larval food at 25°C under 16L–8D conditions.

One cultivated plant (leaves of young cabbage, *Brassica oleracea* var. *capitata*) and one wild crucifer, Indian marshall, *Rorippa indica* (Japanese name, Inugarashi) were used. The young cabbage was grown in a greenhouse from seeds produced by Tohoku Co. The starting 5 to 6 leaves, taken from young plants about 50 days after seeding, were used for food. The wild host was collected on the campus

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