SHORT COMMUNICATIONS

Effect of Wild Virgin Females on Pheromone Trap Efficiency in Two Annual Generations of the Rice Stem Borer Moth, *Chilo suppressalis* (WALKER) (Lepidoptera: Pyralidae)¹

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The adults of *Chilo suppressalis* emerge mainly in June and August in two generation areas of Japan; in the overwintered and the first generation, respectively. The pheromone trap efficiency in *Chilo suppressalis* tends to be relatively low in the first generation compared to that in the overwintered one (KANNO et al., 1984, 1985; NAKANO et al., 1986; KONDO and TANAKA, 1993). In a previous paper (KONDO et al., 1993), we clarified that the female population density was one of the critical factors affecting the pheromone trap efficiency. Most of the female moths of the overwintered generation colonize in paddy fields after mating outside the paddy fields; e.g. on piles of rice plant straws

placed in orchards nearby the paddy fields (TANAKA et al., 1987), but the first generation moths emerge from rice plants growing in paddy fields. Therefore, the ratio of virgin females in paddy fields may be higher in the first generation and thus the virgin females in the first generation may work as competitors with pheromone traps (KONDO et al., 1993). In this paper, we compared the ratio of virgin females between the two annual generations, the overwintered and the first, to verify the above hypothesis. The pheromone trap efficiency between the two generations in paddy fields was also compared by setting virgin females around a trap.

Virgin female ratio. Moths were collected in 1992 in Sanyo-cho (Okayama Pref.). Moths from the overwintered generation were collected with a test tube in the daytime on 11, 12 and 14 June, which were near the peak day of moth emergence, from rice seedling beds just before planting inside paddy fields. The moths were immediately immersed in 70% ethyl alcohol in an erlenmeyer flask. Similarly, moths from the first generation were collected with a test tube at 8–10 p.m. on 16, 17 and 20 August, which were also near the peak day of moth emergence, from upper parts of the rice plants growing in paddy fields. The sex of the moths was determined under binoculars and females were dissected to check for virgins in the absence of spermatophore.

As shown in Table 1, no virgin females were found in the overwintered generation, but virgin females were found on every sampling date in the first generation, although the ratios were as low as 4.9% on average. Thus, the ratio of virgin females

Table 1. Comparison of ratios of males and virgin females between two generations of *C. suppressalis* in the paddy field

Overwintered generation			First generation		
Date ^a	% virgin ♀	% male	Date ^a	% virgin ♀	% male
11 Jun.	0 (25) ^b	28.6 (35) ^c	16 Aug.	5.6 (72) ^b	53.5 (155) ^c
12 Jun.	0 (95)	50.0 (190)	17 Aug.	6.3 (16)	67.3 (49)
14 Jun.	0 (125)	31.3 (182)	20 Aug.	4.0 (75)	51.0 (153)
Total	0 (245)	39.8 (407)	Total	4.9 (163)**	54.3 (357)*

^a Sampling date.

^b Number of female moths sampled.

^c Number of female and male moths sampled.

** $p < 0.01$, * $p < 0.05$ (χ^2 test).

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in the first generation in paddy fields was significantly higher than that in the overwintered one ($p < 0.01$). In the overwintered generation, the moths could be easily detected, because the rice plants were very small and gathered in the seedling beds. Whereas in the first generation, as the rice plants were much thicker, the moths within the rice plants could be hardly detected and then most moths were sampled from upper parts of the rice plants. Therefore, the moth samplings in the first were incomplete to represent the whole population when compared with those in the overwintered one. If the moths can be sampled from entire parts of the rice plants, the ratio of virgin females in the first generation may be much higher than 4.9%, because of the fact that the moths of this generation emerge from the rice plants. The ratio of males was significantly lower in the overwintered generation than in the first one ($p < 0.05$). However, considering that no virgin females were found in the overwintered generation, the ratio of males in this generation was fairly high. This may be due to the following two reasons. Firstly, most of the female moths mate only once, but rarely, some of the female moths mate two times and the male moths were capable of mating for several nights (MIYASHITA, 1982). Therefore, it may be possible that the male moths are attracted to such female moths which show the secondary mating. Secondly, the male moths are also highly chemotactic to the rice plant as with the female moths (KABURAKI et al., 1939).

Pheromone trap efficiency. To know the effect of wild virgin females on the pheromone trap efficiency for each generation, the number of male moths captured in two traps, with and without virgin females around the traps, were compared in the paddy field. The synthetic sex pheromone used was a mixture of (Z)-11-hexadecenal, (Z)-13-octadecenal and (Z)-9-hexadecenal (48:6:5) (TATSUKI et al., 1983). A 0.6 mg of the mixture and 0.06 mg of BHT (butylated hydroxytoluene) were soaked into a rubber septum (Shin-Etsu Chemical Co., Ltd.).

The virgin female moths for experiments were obtained as follows. For the overwintered generation, larvae of *C. suppressalis* were collected from the rice plant stems at the rice harvest in Sanyo-cho on 28 October, 1991. These larvae in the stems were placed for pupation in the field until next spring. For the first generation, egg masses on rice seedling beds were collected in Sanyo-cho on 11,

12 and 14 June, 1992. Those larvae from the egg masses were reared using a standard rearing method (UCHIUMI, 1974) under a 16L-8D photoperiod at 20–25°C until the pupal stage. Female pupae in each generation were isolated and allowed to emerge under a 16L-8D at 25°C.

A sticky pheromone trap (Takeda Chemical Ind., Ltd.) was set at 0.5 m above the ground in a paddy field of Sanyo-cho. A stainless screen cage (5 × 10 × 15 cm, 1.5 mm in mesh) with a virgin female adult of up to 3-day-old was set 3 m apart from the trap on four sides at the same height. Also, only a sticky pheromone trap was set similarly as a control. Two traps, with and without virgin females around the traps, were placed ca. 50 m apart. The traps were set in the evening on 20 June, 1992 for the overwintered generation and on 16 August for the first generation, and the number of male moths caught in the traps was counted in the next morning. Experiments were replicated simultaneously in five places for each generation, the places being ca. 200 m apart.

In five replicates, the overwintered generation had a significantly less number of male moths captured in the traps with virgin females than those without virgin females ($p < 0.01$, Table 2). On the contrary, in the first generation, no significant difference between both traps ($p > 0.05$) was found among the replicates. KONDO et al. (1993) compared the effect of the female population density, evaluated by the light trap catches, on the pheromone trap catches between the two generations, and detected the significant declines in the pheromone trap catches with increasing female population densities in both generations, but the effect was apparently greater in the first generation than in the overwintered one. In this analysis, the female population densities, expressed as the light trap catches, were not so different between the two generations. Since the virgin female ratio in the paddy field was significantly higher in the first generation than in the overwintered one (Table 1), the population densities of the virgin females may also be higher in the first generation, however which were not estimated in this study. From this point of view, since the attracting effect of the wild virgin females in the paddy field may be lower in the overwintered generation, the virgin females set around a pheromone trap would remarkably affect the trap efficiency, which resulted in smaller number of captures in the trap relative to the trap without the virgin females (Table 2). Whereas in

Table 2. Effect of virgin females around a pheromone trap on the captures of male *C. suppressalis* by the pheromone trap

		I	II	III	IV	V	Average
Overwintered generation (20 June)	T ^a	10	1	11	5	3	6.0**
	C ^b	21	21	16	11	26	19.0
First generation (16 August)	T	59	30	41	58	31	43.8 ^{ns}
	C	37	39	51	28	47	40.4

^a Four virgin females in cages were set around a pheromone trap.

^b Virgin females were not set.

** $p < 0.01$, ^{ns} $p > 0.05$ (MANN-WHITNEY's *U* test).

Values indicate the number of males captured by a pheromone trap per night. Arabic numerals indicate replicates.

the first generation, since the population densities of the wild virgin females may be much higher and then the male moths may be attracted to these wild virgin females, the virgin females set around the pheromone trap would not affect the trap efficiency, which resulted in no significant difference in captures between the two traps, with and without the virgin females.

These results support the hypothesis reported in the previous paper (KONDO et al., 1993) that the competition between wild virgin females and the pheromone traps is greater in the first generation than in the overwintered one, and thus the trap efficiency would be lower in the first generation.

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