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Suppression of Mating of the Armyworm Moth, *Spodoptera litura* (F.), by a Component of its Sex Pheromone¹

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Recent studies on insect sex pheromones indicate that several insect species possess the same compound(s) as component(s) of their sex pheromone, and many insect sex pheromones are composed of multiple components (JACOBSON, 1972; TAMAKI, 1972). These facts suggest that quantitative relationships between components as well as qualitative differences among components of sex pheromones are important factors, that release mating behavior and permit mate recognition (TAMAKI, 1972).

Spodoptera litura (F.) is distributed in south-east Asia, the Pacific Islands, and India, and is an important pest of various vegetable crops in south-western Japan. Female sex pheromone of this species has been identified as a mixture of *cis*-9, *trans*-11-tetradecadienyl acetate (compound A) and *cis*-9, *trans*-12-tetradecadienyl acetate (compound B) (TAMAKI et al., 1973). The natural ratio of compound A to compound B is 88 : 12 in the extract of female abdominal tips, and this ratio is an important factor in determining the biological activity of the mixture (TAMAKI et al., 1974; YUSHIMA et al., 1974). Compound A alone

shows weak activity as a male attractant. The activity is greatly enhanced by adding a small amount of compound B, and the optimum ratio of compound A to compound B as male attractant ranges from 8 : 2 to 39 : 1 in the field (YUSHIMA et al., 1974). These facts show that a mixture containing the pheromonal components in ratios other than described adversely affects the mating behavior of this insect. Hence, a series of experiments were conducted in order to determine the effect of a single sex pheromone component on attraction of males and mating in *S. litura* in the field of the Shikoku Agricultural Experiment Station, Zentsuji-shi.

An absorbent cotton wick soaked with a hexane solution of synthetic compound A or B was attached to a net cage enclosing ten 2-day-old virgin females, and the cage was set elevated within a trap (34.5 ×

Table 1. EFFECT OF COMPOUNDS A AND B ON ATTRACTION OF MALES TO A TRAP BAITED WITH 2-DAY-OLD VIRGIN FEMALES (SEPTEMBER TO OCTOBER, 1973)

Compound attached to VF-trap	No. of males caught ^a	Percentage of repression of male attraction
Compound A		
control	228	—
0.01mg	151	33.8
0.1	27	88.2
1.0	22	90.3
Compound B		
control	116	—
0.01mg	76	34.5
0.1	1	99.1
1.0	0	100

^a Values indicated are based on two traps for 3 days for compound A and two traps for 2 days for compound B.

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24.0×23.5 cm plastic box having four windows, one on each side) (OYAMA, 1974). Table 1 shows that 1 mg of compound B completely repressed the attractiveness of the virgin females in the virgin female-trap (VF-trap). Attraction was also repressed greatly by 0.1 mg of compound B; two VF-traps with compound B exposed in the field for 2 nights caught only 1 male moth whereas comparable VF-traps without compound B captured 116 males. The repressive effect of compound A was lower than that of compound B.

Experiments were conducted to determine the effect of the sex pheromone and its components on mating suppression of *S. litura* by use of tethered virgin female moths. The left fore-wing of a 2-day-old virgin female moth was tied with thread about 10-cm long and fixed to a bamboo rod 1 m above the ground. The bamboo rods with tethered females were set at 0.7-m intervals in a 3.5×3.5 m grid in the field yielding a 12.25 m² area in which 36 tethered females were evenly distributed. An absorbent cotton wick, treated with 1 mg of compound A, compound B, or a 10:1 mixture of compounds A and B was fixed on a bamboo rod 1 m above ground level at each corner of the grids. The tethered females were fixed on the bamboo rods just before sunset, and all the females were dissected and spermatophores were counted in the next morning. Table 2 shows that 86.1% of the tethered females in the control plot (not treated with compounds) mated. In contrast only 11.4% and 8.4% of the tethered females mated when the four evaporation wicks of compound A and compound B were positioned at

Table 2. MATING SUPPRESSION OF TETHERED FEMALES BY A SEX PHEROMONE AND ITS COMPONENTS

Compound ^a	Mean percentage of mating	Percentage of mating suppression
A	11.4 ^b	86.8±1.2 ^c
B	8.4	90.2±3.3
A + B (10 : 1)	33.4	61.2±1.8
control	86.1	—

^a The compounds were used at the rate of 1 mg per wick, and four wicks were used for each moth grid of 12.25 m² (October, 1974).

^b Values indicated are the means of four replicates.

^c Standard error.

Table 3. MATING SUPPRESSION OF TETHERED FEMALES IN THE FIELD BY COMPOUND B, A MINOR COMPONENT OF THE SEX PHEROMONE, WHEN THE AREAS ENCLOSED BY EVAPORATION WICKS WERE VARIED (SEPTEMBER, 1973)

Area enclosed by evaporation wicks	Mean percentage of mating ^a	Percentage of mating suppression
12.25m ²	5.8	92.5
50	16.0	79.2
200	41.7	45.9
control	77.1	—

^a Values indicated are the means of duplicate observations.

corners of grids. Hence, the presence of compound A and compound B suppressed mating by 86.8% and 90.2%, respectively.

In another experiment, two additional grids with tethered females were similarly exposed to compound B but were different from the above-mentioned experiment in that the wicks formed 7.1 and 14.2 m squares, centered on the moth grids. Areas enclosed by the four cotton wicks in the experimental plots were, thus, 12.25 m², 50 m², and 200 m². Table 3 shows that compound B suppressed mating by 45.9% when the area enclosed by the evaporation wicks increased up to 200 m².

It is noteworthy that compound B, the minor component of the sex pheromone, repressed the attractiveness of virgin females more strongly than does compound A, the major component of the sex pheromone. Furthermore, effect of mating suppression of each pheromonal component was greater than the sex pheromone itself. Sexual stimulation of a male tortricid moth, *Adoxophyes fasciata*, was also inhibited by pre-exposure to either *cis*-9-tetradecenyl acetate or *cis*-11-tetradecenyl acetate, components of its sex pheromone (HIRAI et al., 1974). The European corn borer (*Ostrinia nubilalis*), the red-banded leafroller (*Argyrotaenia velutinana*), and the oriental fruit moth (*Grapholitha molesta*) seem to utilize a trace amount of the opposite geometrical isomer as additional components in their sex pheromone (KLUN et al., 1973; BEROZA et al., 1973). Permeation of the air with *trans*-11-tetradecenyl acetate, a suspected minor component of the sex pheromone of the European corn borer and the red-banded leafroller, reduced the number of male moths

caught by the VF-or synthetic lure-traps (KLUN et al., 1973).

We do not know the mechanisms whereby repression of attraction and suppression of mating results from exposure of males to a single component of sex pheromones. The single component released artificially must reach the receptors of the male in combination with the natural sex pheromone released by the females. It is tempting to speculate, therefore, that an imbalance created in the ratio of the pheromonal components can possibly result in reception of a different signal by males. This signal fails to cause the males to orient toward the source or to be sexually stimulated. Pheromonal components in an imbalanced ratio apparently do not evoke any specific behavioral reactions in males. Perhaps such ratios are equivalent to signs from a different species. Hence use of components, especially minor ones, of sex pheromones to disrupt the chemical communication of insects may become an important

aspect of insect control in the near future.

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Bacterial Production of the Ovipositional Attractants for Mosquitoes on Fatty Acid Substrates¹

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The investigation of kairomones inducing mosquito oviposition in the field water is of importance for understanding of the ecology, and the eventual identification of a powerful attractant provides a novel means for assessment and control of mosquito populations.

There has been an ample evidence for the fact that microorganisms, bacteria in particular,

produce the ovipositional attractants and stimulants for mosquito oviposition in the mosquito-breeding waters. IKESHOJI, UMINO and HIRAKOSO (1975) isolated from the mosquito-breeding waters a few *Pseudomonas* spp. which produced the ovipositional stimulants for *Culex pipiens fatigans* Coquillett on a gelatin medium.

While, HAZARD, MAYER and SAVAGE (1967) isolated from hay infusion *Aerobacter aerogens* which, in distilled water, was quite attractive for *Culex pipiens quinquefasciatus* Say and *Aedes aegypti* (L.). Later, MAW (1970) found that n-capric acid, when treated into artificial pools, made the water quite attractive for oviposition of *Culex restuans* Theobald within several days after the treatment. He also proved the water to be attractive for *A. aegypti*, *Culex pipiens* L. and *Culex tarsalis* Coq. in the laboratory and incriminated a few unidentified bacteria of the family Pseudomadaceae as the possible agents producing the attractive kairomones. Although MAW thought n-capric acid to be mere carbon supply for the rapid growth of the bacteria, we suspect that some of the bacterial metabolites become the precursors in the biosynthesis of the ovipositional at-

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