Disruption of Sex Attraction in the
Rice Stem Borer Moth,
Chilo suppressalis WALKER, with
Components of the Sex Pheromone
and Related Chemicals¹

Hiroo KANNO

Laboratory of Applied Entomology,
Hokuriku National Agricultural
Experiment Station, Joetsu,
Niigata 943-01, Japan

Sadahiro TATSUKI, Kyoichi UCHIUMI, Masaaki
KURIHARA and Jun-ichi FUKAMI

Insect Physiology and Toxicology
Laboratory, The Institute of Physical
and Chemical Research, Wako,
Saitama 351, Japan

Yasuo FUJIMOTO and Takashi TATSUNO

Pesticides Synthesis 1st Laboratory,
The Institute of Physical and
Chemical Research, Wako,
Saitama 351, Japan

(Received, 1978)

Recent research on insect sex pheromones has demonstrated that the sex pheromones in several insect species are composed of multiple components. As reviewed by ROELOFS and CARDÉ (1977), in many lepidopterous species, components of the sex pheromone as well as the sex pheromone and analogues have been used as "attraction disruptants".

The rice stem borer, *Chilo suppressalis* WALKER, is one of the most serious pests of the rice plant in Japan. The female sex pheromone of this insect was identified as two olefinic aldehydes, Z-11-hexadecenal and Z-13-octadecenal (NESBITT et al., 1975; OHTA et al., 1976). In field tests, the synthetic Z-11-hexadecenal and Z-13-octadecenal were attractive when mixed together in ratios of 1:1 to 20:1, with 3:1, 5:1 and 7:1 being most effective (TATSUKI et al., 1977). Recently, BEEVOR et al. (1977) reported the disruptive effect of the pheromone components and two

structurally similar compounds, Z-9-tetradecenyl formate and Z-11-hexadecenyl formate, on male trap catches by surrounding a trap baited with a virgin female with these chemicals. In the present test, the authors also investigated the disruptive effect of these components of the sex pheromone and 12 structurally related chemicals on male attraction to the virgin female.

Comments on the chemicals used in this test are provided in Table 1. All the chemicals were synthesized at the Institute of Physical and Chemical Research as follows. Z- and E-11-hexadecenal (1 and 3), Z- and E-13-octadecenal (2 and 4), Z-11-hexadecenol (11), and Z-13-octadecenol (12) were synthesized from commercially available 1,10-decanediol, 1,12-dodecanediol and 1-hexyne by a variation of NESBITT's method (NESBITT et al., 1975). Acetylation of compounds 11 and 12 with acetic anhydride-pyridine gave the corresponding acetates (13 and 14). Hexadecanal (5) and octadecanal (6) were prepared by oxidation for the corresponding alcohols with the chromium trioxide-pyridine complex (RATCLIFFE et al., 1970). Z- and E-5-hexadecene (7 and 9) and Z- and E-5-octadecene (8 and 10) were synthesized from lauryl chloride and decyl chloride. Lauryl chloride and decyl chloride were reacted with 1-hexyne to give 5-hexadecyne and 5-octadecyne by using n-butyl lithium in tetrahydrofuran-hexamethylphosphoric triamide. Hydrogenation of 5-hexadecyne and 5-octadecyne with Lindlar catalyst in n-hexane gave Z-5-hexadecene (7) and Z-5-octadecene (8), while reduction of these alkynes with sodium in liquid ammonia-tetrahydrofuran afforded E-5-hexadecene (9) and E-5-octadecene (10). All the synthetic compounds showed reasonable spectral data on their infra red, mass and nuclear magnetic resonance spectra.

The female adults used in this experiment as the attractive source were obtained from a rearing program which utilizes rice seedlings as the larval diet at the Institute of Physical and Chemical Research (UCHIUMI, 1974).

Field tests were conducted in a paddy field of the Hokuriku National Agricultural Experiment Station, Joetsu, Niigata Prefecture in June, 1977. TAKEDA water traps at a height of 20 cm were placed at 20-m intervals in two parallel straight lines which were about 300 m apart. A hexane solution of 0.5 or 1 mg of each chemical was used

¹ Appl. Ent. Zool. **13** (4): 321~323 (1978)

Table 1. EFFECT OF SEX PHEROMONE COMPONENTS AND RELATED CHEMICALS ON MALE
ATTRACTION TO VIRGIN FEMALE TRAPS

No.	Compound	No. of males caught		Total	Reduction %	Note
		1 mg chemical per trap (Total in 5 nights)	0.5 mg chemical per trap (Total in 9 nights)			
1.	Z-11-hexadecenal	0	0	0	100	} Pheromone components
2.	Z-13-octadecenal	11	4	15	89	
3.	E-11-hexadecenal	2	5	7	95	} Geometrical isomers of 1, 2
4.	E-13-octadecenal	2	5	7	95	
5.	Hexadecanal	13	24	37	73	} Saturated aldehydes of 1, 2
6.	Octadecanal	6	20	26	81	
7.	Z-5-hexadecene	4	9	13	90	} EAG active (OHTA et al., 1976)
8.	Z-5-octadecene	1	0	1	99	
9.	E-5-hexadecene	15	17	32	77	} Geometrical isomers of 7, 8
10.	E-5-octadecene	24	11	35	74	
11.	Z-11-hexadecenol	0	3	3	98	} Alcohols corresponding to 1, 2
12.	Z-13-octadecenol	0	2	2	99	
13.	Z-11-hexadecenyl acetate	0	1	1	99	} Acetates of 13, 14
14.	Z-13-octadecenyl acetate	3	4	7	95	
15.	Control	74	62	136	—	

to soak a small holder of absorbent cotton. As a control, the solvent alone was treated on the holder. This holder and 2 virgin females (1-day-old) were placed in a nylon cage which was hung in the middle of the trap. Two traps in both lines were used with each treatment and trap positions in each line were rotated nightly. The traps were bated in about 1 hour between 18:00 to 19:00. The number of males caught in the traps during the night was counted the next morning.

The results are shown in Table 1. All of the synthetic chemicals used in this experiment had a more or less disruptive effect on male attraction when the materials were dispensed in the same air currents that were carrying natural pheromone from calling females. The total number of males caught in the traps with 2 virgin females plus a synthetic chemical were 30 percent less than that of the control traps with virgin females alone. The components of the sex pheromone were very effective as inhibitors to male attraction. Z-11-hexadecenal, the major component of the sex pheromone, completely disrupted the attractiveness of the virgin female, while the effect of Z-13-octadecenal was slightly lower than that of the former.

The results on the related chemicals were as

follows. The E-isomers of the sex pheromone, E-11-hexadecenal and E-13-octadecenal, the two alcohols, Z-11-hexadecenol and Z-13-octadecenol, and their acetates, Z-11-hexadecenyl acetate and Z-13-octadecenyl acetate, were also highly effective as the sex pheromone components. Two of the hydrocarbons, Z-5-hexadecene and Z-5-octadecene, which were previously observed to have EAG activity on the male adult (OHTA et al., 1976), also strongly disrupted male attraction. With other related chemicals, the number of males caught was 70 percent less than with the control. With all chemicals, no significant difference in effectiveness between the two doses used was found.

It should be emphasized that all compounds having the same carbon chain length (C:16 and C:18) with Z-unsaturation at the same ω -distance (ω -5) as the pheromone components showed potent disruptive effects. The hydrocarbons will possibly be more convenient tools for the practical use since these compounds are easily synthesized and are degraded more slowly in the environment than the other compounds. Evaluation of the effect of the hydrocarbon group on male attraction in other Lepidoptera should be made.

TAMAKI et al. (1975) reported that the individual pheromone component in the smaller tea

tortrix, *Adoxophyes fasciata* WALSINGHAM, strongly inhibited the orientation behavior of male moths to the virgin females. Furthermore, Z-9-tetradecenyl acetate, the major component of the sex pheromone, was more potent than the minor pheromone component, Z-11-tetradecenyl acetate. These phenomena coincided with the results in our present test. In the armyworm, *Spodoptera litura* FABRICIUS, YUSHIMA et al. (1975) also observed that male attraction was greatly repressed by the two individual components of the sex pheromone. In this case, however, the repressive effect of compound A (Z-9, E-11-tetradecadienyl acetate: major component) was lower than that of compound B (Z-9, E-12-tetradecadienyl acetate: minor component). This difference is of significant interest. Regarding the disruption of the mating behavior of a few species by one component of a multi-component pheromone, TAMAKI and NAKAMURA (1976) discussed a combination of three possible mechanisms: sensory adaptation by a single component, modification of the natural signal by a change of the natural ratio of the pheromone components, and functional differences in each pheromone component. Other mechanisms have not yet been elucidated.

The utilization of related chemicals of the sex pheromone has also been studied in several insect pests. In the pink ballworm, *Pectinophora gossypiella* SAUNDERS, McLAUGHLIN et al. (1972) noted that the hexalure, Z-7-hexadecenyl acetate, the chemical structure of which resembles the sex pheromone, Z-7, Z-11 and Z-7, E-11-hexadecadienyl acetate, inhibited male attraction. Furthermore, SHOREY et al. (1974) confirmed that damage in a cotton field was decreased by about 80 percent by application of a large quantity of hexalure. Our present experiment clarified that the sex pheromone and many pheromone-like chemicals could disrupt male attraction in *Chilo suppressalis*. However, in the fall armyworm, *Spodoptera frugiperda* SMITH, MITCHELL et al. (1974) observed that the Z-7-dodecenyl acetate that inhibited the male response to traps baited with virgin females did not block pheromone communication when it was evaporated into the atmosphere surrounding traps baited with virgin females. A similar interesting phenomenon was also observed in the oriental fruit moth, *Cydia molesta* BUSCK (ROTHSCHILD, 1974). These reports suggest that, with

Chilo suppressalis, we must observe the effectiveness on male attraction when the chemicals are applied to wide area in the field.

Female calling behavior was observed in the laboratory in the presence of high concentrations of the synthetic chemicals used in this experiment, but no behavioral abnormalities were apparent.

The authors wish to express their sincere gratitude to TAKEDA Chemical Co., Ltd., for providing the traps. They also thank to Mr. HARIYA, The Institute of Physical and Chemical Research, for his assistance in the synthesis of the chemicals.

REFERENCES

- BEEVOR, P. S., D. R. HALL, B. F. NESBITT, V. A. DYCK, G. ARIDA, P. C. LIPPOLD and H. OLOUMI-SADEGHI (1977) *Bull. Ent. Res.* **67**: 439-447.
- McLAUGHLIN, J. R., H. H. SHOREY, L. K. GASTON, R. S. KAAE and F. D. STEWART (1972) *Environ. Entomol.* **1**: 645-650.
- MITCHELL, E. R., W. W. COPELAND, A. N. SPARKS and A. A. SEKUL (1974) *Environ. Entomol.* **3**: 778-780.
- NESBITT, B. F., P. S. BEEVOR, D. R. HALL, R. LESTER and V. A. DYCK (1975) *J. Insect Physiol.* **21**: 1833-1886.
- RATCLIFFE, R. and R. RODEHORST (1970) *J. org. Chem.* **35**: 4000-4002.
- ROELOFS, W. and R. CARDÉ (1977) *Ann. Rev. Entomol.* **22**: 377-405.
- ROTHSCHILD, G. H. L. (1974) *Ent. exp. and Appl.* **17**: 294-302.
- OHTA, K., S. TATSUKI, K. UCHIUMI, M. KURIHARA and J. FUKAMI (1976) *Agr. biol. Chem.* **40**: 1897-1899.
- SHOREY, H. H. (1974) *J. econ. Entomol.* **67**: 347-350.
- TAMAKI, Y., T. ISHIWATARI and M. OSAKABE (1975) *Jap. J. appl. Ent. Zool.* **19**: 187-192.
- TAMAKI, Y. and K. NAKAMURA (1976) *Nogyo-Gijutsu* **31**: 540-545.
- TATSUKI, S., K. OHTA, K. UCHIUMI, M. KURIHARA, J. FUKAMI and K. KISHINO (1977) *Botyu-Kagaku* **42**: 1-3.
- UCHIUMI, K. (1974) *Rikagaku-Kenkyusho Hokoku* **50**: 70-74.
- YUSHIMA, T., Y. TAMAKI, S. KAMANO and M. OYAMA (1975) *Appl. Ent. Zool.* **10**: 237-239.