

FIELD TRAPPING OF THE DIAMONDBACK MOTH *PLUTELLA XYLOSTELLA* (LINNAEUS) AND *PSEUDALETIA SEPARATA* WALKER USING THE SYNTHETIC SEX PHEROMONE OF THE DIAMONDBACK MOTH¹

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Yuh-Meei Lin, Yien-Shing Chow and Horng-Chang Tzeng (1982) Field trapping of the diamondback moth *Plutella xylostella* (Linnaeus) and *Pseudaletia separata* Walker using the Synthetic Sex Pheromone of the diamondback moth. *Bull. Inst. Zool., Academia Sinica* 21(2): 121-127. The optimal dose of the sex pheromone of the diamondback moth in the field trapping were 50-100 μg of the mixture, (Z)-11-hexadecenal, (Z)-11-hexadecenyl acetate and (Z)-11-hexadecenol in the ratio of 5:5:0.1, dispensing in polyethylene (PE) caps or PE microtubes. Under ordinary condition, the synthetic pheromone was attractive to males only about ten days. When the antioxidant BHT was added to the pheromone mixture, the longevity of the attractant bait was increased to five weeks.

The males of rice armyworm, *Pseudaletia separata* Walker, were attracted by the above synthetic lure of the diamondback moth, but not attracted by the single component alone, or the binary mixture of (Z)-11-hexadecenal and (Z)-11-hexadecenyl acetate in the ratio between 9:1 and 1:9. The males of *Leucania separata* Walker were attracted by the mixture of (Z)-11-hexadecenyl acetate and (Z)-11-hexadecenol in the ratio of 4:1 and males of *L. loreyi* Duponchel were attracted by a 9:1 mixture of (Z)-9-tetradecenyl acetate and (Z)-7-dodecenyl acetate and also a 0.8:8:2 mixture of (Z)-7-dodecenyl acetate, (Z)-9-tetradecenyl acetate and (Z)-11-hexadecenyl acetate in cabbage field in the vicinity of paddy field at Nankang, Taipei.

The diamondback moth, *Plutella xylostella*, is a serious pest of cruciferous vegetable in many parts of the world. In order to control it, various kinds of insecticides have been applied in large quantity in Taiwan. However, the controlling measurement has become more difficult due to the high resistance developed in diamondback moth to insecticides. Therefore it is necessary to develop a more efficient method for controlling of this pest.

The sex pheromone of the female moth was first isolated by us in 1974⁽⁵⁾. Later Tamaki

et al. identified the chemical structure as a mixture of (Z)-11-hexadecenal (Z-11-16:Ald) and (Z)-11-hexadecenyl acetate (Z-11-16:Ac)⁽¹³⁾. We also confirmed their results that the best attractive ratio of the above two compounds in field is from 1:1 to 1:2 at the total amount of 10 μg ⁽⁶⁾. Chisholm *et al.* reported that the best binary lure tested was 100 μg 7:3 aldehyde: acetate dispensed from rubber septa and the optimal trap height was 0.3 m⁽³⁾. Because the attractiveness of the synthesized chemicals is inferior to that of four live virgin females,

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minor components of the diamondback moth might play an important role in the male attraction^(6,13). We have found that when methyl (Z)-11-hexadecenoate was added at low concentration to the mixture of Z-11-16:Ald and Z-11-16:Ac in the ratio of 1:1 a synergistic effect displayed by field screen tests⁽⁷⁾. Then, Ando *et al.* reported that field attractiveness of the 5:5 mixture of Z-11-16:Ald and Z-11-16:Ac at 10 μg level was obviously enhanced by adding 1-10% of (Z)-11-hexadecenol (Z-11-16:OH)⁽¹¹⁾.

In order to establish the most effective dosage and lure dispenser for mass trapping in Taiwan, field tests of the formula, the mixture of Z-11-16:Ald, Z-11-16:Ac and Z-11-16:OH in the ratio of 5:5:0.1 at various quantities with or without antioxidant BHT were carried out. During this investigation, the male rice armyworm, *Pseudaletia separata* (identified by Prof. Y. I. Chu, Dept. of Phytopathology and Entomology, NTU) were also attracted by the synthetic lure of the diamondback moth. So the attractiveness to the male rice armyworm by the sex pheromone *Leucania separata* and *L. loreyi* was also investigated. The results are reported here.

MATERIALS AND METHODS

Chemicals

Pheromones used were synthesized with acetylenic route from 1, 10-decandiol as starting material in our laboratory. The purity is ca. 98% by gas liquid chromatography.

Field tests

Various concentrations of the pheromones (the mixtures of Z-11-16:Ald, Z-11-16:Ac and Z-11-16:OH in the ratio of 5:5:0.1) ranging from 10 μg to 1 mg were dissolved in hexane and dispensed in PE caps, PE microtubes, spurr or mineral oil (absorbed in cotton wicks). Spurr was prepared by adding 1% or 10% of the pheromone to the plastic mixture⁽⁴⁾, 10 g of UNOX Epoxide 206 or ERL 4206, 26 g of hardner NAS, 6 g of plasticizer DER 736 and 0.4 g of accelerator S-1, and then incubated in

an oven at 70°C for eight hours to hardness, and then slicing the spurr into pieces. One milligram of the spurr (1%) pieces equals to 10 μg of the pheromone.

All of the formulation combined with sticky traps were tested in 36 replicated in randomly experimental design in cabbage fields Chu-Pei and Nankang in the vicinity of Academia Sinica from March to April in 1982. Each trap was set 5 meters apart. While attractive tests of *P. separata* and *L. loreyi* were carried out from March to July in 1982.

RESULTS

Optimal dosage and dispenser

The lure with various quantities such 10 μg , 50 μg , 100 μg and 1 mg were dispensed in PE caps, PE microtubes, spurr or mineral oil. The results of the field tests were shown in Fig. 1 and Fig. 2. Fifty microgram of pheromone dispensing in PE caps or PE microtubes showed the better attractive effect in cabbage field at Chu-Pei (see Fig. 1). While in the vicinity of Academia Sinica in Nankang, 50 μg of the lure dispensed in PE caps or 100 μg of the pheromone dispensing in PE microtubes attracted more male moths.

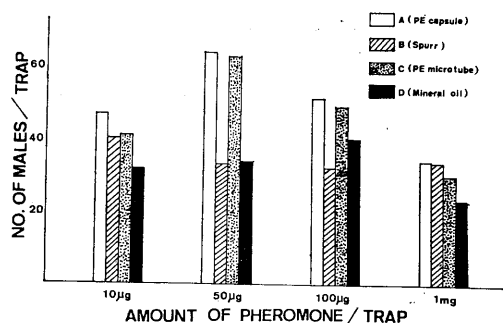


Fig. 1. - The Males of *Plutella xylostella* Attracted by 10 μg , 50 μg , 100 μg and 1 mg of the Synthetic Pheromone, Z-11-16:Ald, Z-11-16:Ac and Z-11-16:OH in the Ratio of 5:5:0.1, Loaded in PE capsule, Spurr, PE microtube and Mineral Oil from Feb. 9 to Mar. 5 in 1982. (Chu-pei Vegetable Plantation).

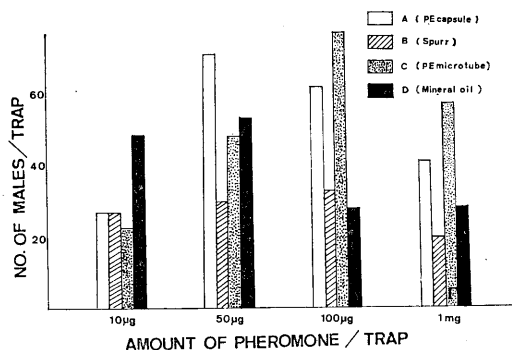


Fig. 2. The Males of *Plutella xylostella* Attracted by 10 µg, 50 µg, 100 µg and 1 mg of the Synthetic Pheromone, Z-11-16:Alb, Z-11-16:Ac and Z-11-16:OH in the Ratio of 5:5:0.1, Loaded in PE capsule, Spurr PE microtube and Mineral Oil from Jan. 29 to Feb. 27 in 1982. (Academia Sinica, Nankang).

Effect of the antioxidant BHT to the lure

Various amounts of antioxidant BHT were admixed with 50 µg or 100 µg of the lure in the ratio of 0:1, 1:1, 10:1 and 20:1 dispensed in PE caps or PE microtubes. The attractancy of those baits to the male moth was shown in Fig. 3. Fifty microgram of the pheromone admixed with BHT (in the ratio of 1:1-1:20) in PE caps and 50 µg of the pheromone admixed with BHT in the ratio of 1:20

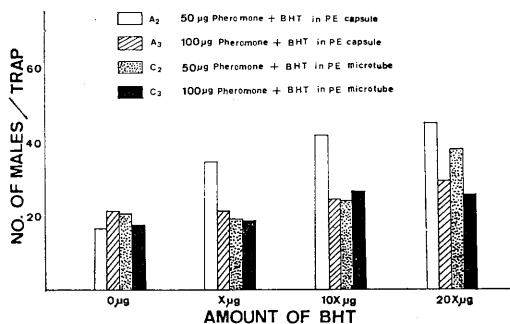


Fig. 3. The Males of *Plutella xylostella* Attracted by various Dosages of BHT added to The Pheromone from Mar. 16 to Apr. 3. (Chu-pei Vegetable Plantation).

in PE microtubes showed the better attractancy than the others.

The duration of the lure with antioxidant

The attractancy of the pheromone mixed BHT in the ratio of 1:20 dispensing in PE caps or PE microtubes after aging for 1, 2 and 3 weeks were compared to that of the fresh prepared baits. The results showed that there is no significant difference in attractancy (Fig. 4). It is indicated when BHT was added to the lure the effective period lasts more than 5 weeks.

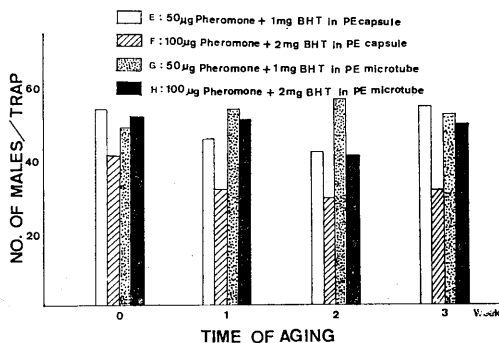


Fig. 4. The males of *Plutella xylostella* Attracted by the Pheromone Mixed with BHT After Aging for 0, 1, 2, 3 Weeks. (Chu-pei Cabbage Field, Apr. 1 to Apr. 23, 1982).

Attractiveness of the synthetic pheromone to the *Pseudaletia separata*

Traps baited with the mixtures of Z-11-16: Ald, Z-11-16:Ac and Z-11-16:OH in the ratio of 5:5:0.1 at 10 µg-1 mg levels, attracted, in addition to *P. xylostella*, some males of the noctuids *P. separata* (Fig. 5a, b). In order to evaluate the attractiveness of each component of the lure, traps baited with single components, Z-11-16:Ald or Z-11-16:Ac, or binary mixture, Z-11-16:Ald and Z-11-16:Ac in the ratio of 1:9, 2:8, 3:7, 4:6, 5:5, 6:4, 7:3, 8:2 and 9:1 were tested in the same cabbage field mentioned above. The results revealed that neither single component nor the binary lure attracted the *P. separata*. While the traps baited with the lure of the diamondback moth at 10 µg and 1 mg levels captured males of *P. separata* (Fig. 6).

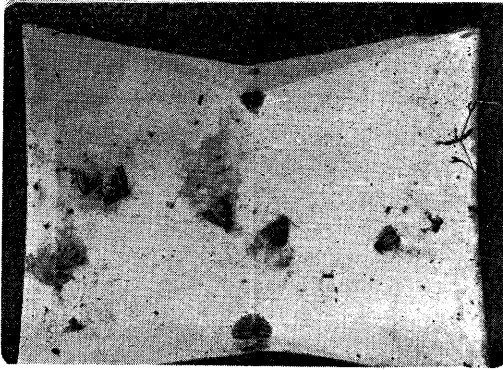


Fig. 5a. Males of *Pseudaletia separata* captured by pheromone trap baited with Z-11-16:Ald, Z-11-16:Ac and Z-11-16:OH in the ratio of 5:5:0.1.

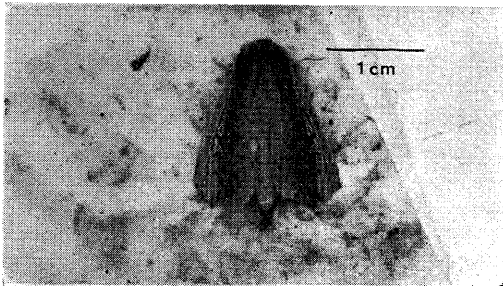


Fig. 5b. Male of *Pseudaletia separata*, a new record in Taiwan.

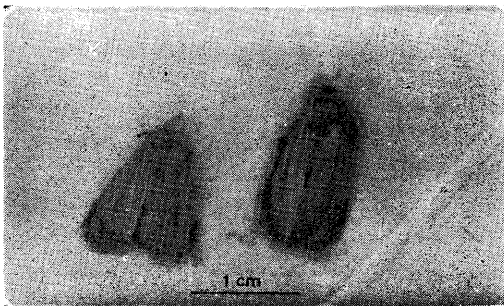


Fig. 5c. Males of *Leucania separata* captured by the mixture of Z-11-16:Ac and Z-11-16:OH in the ratio of 4:1.

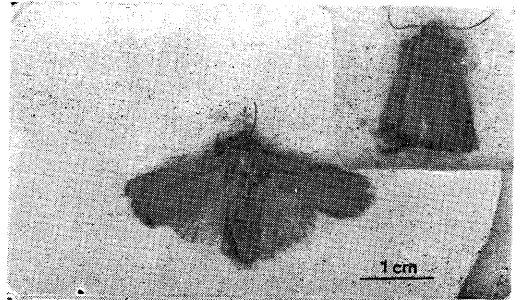


Fig. 5d. Male of *Leucania loreyi* captured by the 9:1 mixture of Z-9-14:Ac and Z-7-12:Ac.

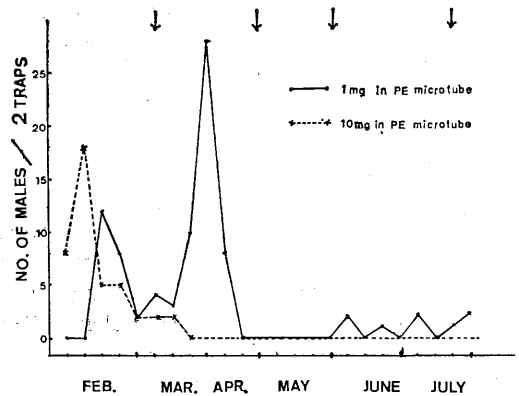


Fig. 6. Males of *Pseudaletia separata* attracted by the synthetic pheromone of the diamondback moth (Z-11-16:Ald : Z-11-16:Ac : Z-11-16:OH=5:5:0.1) from Feb. to July in 1982 in the cabbage field near the paddy field in the vicinity of Academia Sinica. (arrow indicating the baits were renew).

Attraction of *Leucania separata*, *L. loreyi* and *Pseudaletia separata*

Traps baited with the synthetic sex pheromone of *L. separata*, Z-11-16:Ac and A-11-16:OH in the ration of 4:1 and the synthetic sex pheromone of *L. loreyi*, Z-9-14:Ac and A-7-12:Ac in the ratio of 9:1 at 10 μ g, 100 μ g and 1 mg levels or the mixture of Z-7-12:Ac, Z-9-14:Ac and Z-11-16:Ac in the ratio of 0.8:8:2 at 1 mg level, were tested in the cabbage field in the vicinity of paddy field at Nankang. The results

showed that *L. separata* (Fig. 5c) and *L. loreyi* (Fig. 5d) were attracted specifically by their own synthetic sex pheromone but no *P. separata* was captured by those traps. The males of *L. separata* were captured in February only, while the males of *L. loreyi* were attracted from Feb. to July except in May (see Fig. 7).

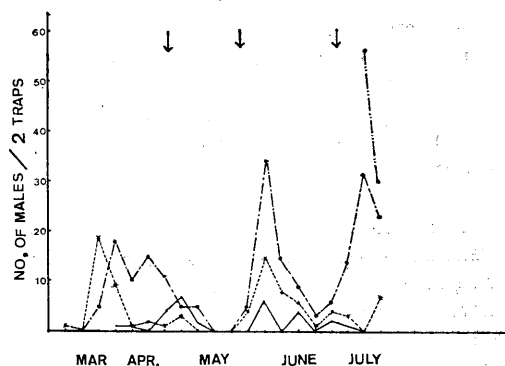


Fig. 7. The males of *Leucania loreyi* attracted by 10 μg (\bullet — \bullet), 100 μg (\times — \times) and 1 mg (\circ — \circ) of the synthetic pheromone, Z-9-14:Ac and Z-7-12:Ac in the ratio of 9:1, loaded in PE microtube from March to July in 1982. and by 1 mg, the mixture of Z-7-12:Ac, Z-9-14:Ac, Z-11-16:Ac in the ratio of 0.8:8:2 dispensing in PE microtube (\circ — \circ).

DISCUSSION

Koshihara *et al.*⁽⁸⁾ reported that the mixture of Z-11-16:Ald and Z-11-16:Ac showed strong attractive activity to the males of the diamondback moth in the ratio of 5:5:0.1 at 0.01 to 0.1 mg levels of rubber septa in the spring and summer except in mid-summer and at 0.1 to 1 mg levels in the winter in Japan⁽⁸⁾. Our results revealed that the 50–100 μg of the lure (the mixture of Z-11-16:Ald, Z-11-16:Ac and Z-11-16:OH in the ratio of 5:5:0.1) dispensed in PE caps or PE microtubes showed better attractance. When the amount of lure increased to 1 mg the attractiveness dropped. The mean lowest temperature and highest temperature were 14°C and 22°C respectively during the experiment period. Those

results are coincidental with those reported by Koshihara *et al.* In the northern region of Taiwan 50–100 μg of the mixture of Z-11-16:Ald, Z-11-16:Ac and Z-11-16:OH in the ratio of 5:5:0.1 dispensed in PE microtubes is suitable for surveying the population density of the diamondback moth or for mass trapping in cabbage field.

During the attractiveness test of the diamondback moth in the field in Nankang, in addition to the diamondback moth, males of *P. separata* were captured. *P. separata* is a devastating pest of rice, corn, sugarcane, cruciferous vegetable and other crops. Sex pheromones of several species of armyworm have been reported. (Z)-11-Hexadecenyl acetate, hexadecan-1-ol acetate (16:Ac), Z-11-16:OH and Z-9-16:Ac (in the ratio 0.15:0.13:0.02) were identified in extracts of the sex pheromone glands of adult virgin female armyworms, *Pseudaletia unipuncta*. However in field tests Z-11-16:Ac alone was effective to the male moth. The addition of Z-9-16:Ac, Z-11-16:OH or 16:Ac singly or in combination to Z-11-16:Ac in ratios found in the gland did not increase trap capture. The sex pheromone of another armyworm, *L. separata*, has been isolated and identified as Z-11-16:OH and its acetate in the ratio of 8:1. Compounds like Z-7-12:Ac, Z-9-14:Ac and Z-11-16:Ac have been isolated from an extract of the female abdominal tips of *L. loreyi*^(11,12). In field tests, 1 mg of the 9:1 or 4:1 mixture of Z-11-16:OH and its acetate was attractive to *L. separata* as the same potency as 10 virgin females. In greenhouse test the 9:1 mixture of Z-9-14:Ac and Z-7-12:Ac showed a high attractancy as same as the 0.8:8:2 mixture of Z-7-12:Ac, Z-9-14:Ac and Z-11-16:Ac⁽¹⁰⁾. Because males of *L. separata* and *L. loreyi* were captured by the pheromone traps, it reveals that these two species of armyworms are present in Taiwan.

In our experiment *P. separata* was by now only captured by the lure of the diamondback moth, neither by single component nor by binary mixtures. So the sex attractants of *P. separata* probably consists of at least three components.

Recently Ando *et al.* reported that two species of Noctuidae were attracted to the three-component lures (Z-11-16:OH, Z-11-16:Ac and Z-11-16:Ald 9:9:2) in their systematic field tests⁽²⁾. In addition to the diamondback moth, males of *Crymodes devastator*, *Aletia oxygala* and *Acrolepiopsis sapporensis* were also captured by the synthetic pheromone of diamondback moth were also reported^(3,14). The species discrimination of these species may be by the different ratio of the components or the unknown fourth component. The true sex pheromone and the more effective attractant of *P. separata* will be studied further.

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小菜蛾合成性費洛蒙對小菜蛾 (*Plutella xylostella*) 及 栗夜盜蛾 (*Pseudaletia separata*) 之 田間誘蟲試驗

林玉美 周延鑫 曾宏昌

小菜蛾性費洛蒙 z -11-hexadecenal, z -11-hexadecyl acetate, 與 z -11-hexadecenol 5:5:0.1 之混合物在田間誘蟲以費洛蒙總量 50~100 μ g, 放在 PE capsule 或 PE 細管時誘蟲效果最好。正常情況下合成的費洛蒙有效期限約為 10 天, 但如在費洛蒙內加入抗氧化劑 (BHT), 可使其誘蟲有效時間至少增為 35 天。

在南港中研院附近甘藍菜田實驗結果顯示, 以合成之小菜蛾性費洛蒙也可以誘到栗夜盜雄蛾 (*Pseudaletia separata*)。但是若將組成費洛蒙之成分單獨使用或將 z -11-hexadecenal 與 z -11-hexadecenyl acetate, 以 9:1~1:9 的比例混合, 則均誘不到蟲。 z -11-hexadecenyl acetate 與 z -11-hexadecenol 4:1 之混合物可以誘到 *Leucania separata* 雄蟲。而且 z -9-tetradecenyl acetate 與 z -7-dodecenyl acetate 9:1 之混合物以及 z -7-dodecenyl acetate, z -9-tetradecenyl acetate, z -11-hexadecenyl acetate 0.8:8:2 之混合物都可以誘到 *Lecania loreyi*。