FIELD RESPONSE OF FERAL MALE BANDED CUCUMBER BEETLES TO THE SEX PHEROMONE 6,12-DIMETHYLPENTADECAN-2-ONE

J. M. Schalk
U. S. Vegetable Laboratory
2875 Savannah Highway
Charleston, S. C. 29414

J. R. McLaughlin and J. H. Tumlinson
Insect Attractants, Behavior, and Basic Biology Research Laboratory
USDA, ARS
P. O. Box 14565
Gainesville, FL 32604

Abstract

Capture of male banded cucumber beetles Diabrotica balteata LaConte in sex pheromone-baited traps or in virgin female baited traps peaked at the beginning of the scotophase (2100-2200h) and declined thereafter. Virgin females (1 or 2) were not as effective as the racemic synthetic sex pheromone (0.5mg/septum) in attracting males. The most efficient design of capturing males was the Sentry wing trap and no differences in captures were found among traps placed 25.4, 50.8 or 101.6cm from the ground. Field tests showed that a rubber septum bait containing 0.5mg of the pheromone was attractive to males for a 12 month period and high captures occurred in August and September. Males were collected in pheromone traps from October through February in Charleston, SC.
La captura de machos del escarabajo *Diabrotica balteata* LeConte en trampas cebadas con feromonas sexuales o en trampas cebadas con hembras vírgenes, tuvo el auge al comienzo de la escotofase (2100-2200h) y después declinó. Hembras vírgenes (1 ó 2) no fueron tan efectivas en atraer machos como la feromona sexual sintética racémica (0.5mg/Septum). El diseño más efectivo para capturar machos fue la trampa de ala Sentry, y no hubo diferencia en la captura entre trampas puestas a 25.4, 50.8, o a 101.6 cm del suelo. Pruebas de campo demostraron que la trampa cebada con septum de goma conteniendo 0.5 mg de la feromona, fue atractiva para los machos por un periodo de 12 meses, ocurriendo muchas capturas en Agosto y Septiembre. Se colectaron machos en trampas de feromona de Octubre a Febrero en Charleston, SC.

The banded cucumber beetle (*Diabrotica balteata* LeConte) is a polyphagous species which is a serious pest of root crops in the southern states (Metcalfe et al. 1962, Krysan & Branson 1983). Control of the soil inhabiting larvae of this beetle is difficult because of the nonpersistent nature of the currently registered insecticides. However, it may be possible to reduce larval populations by controlling adult beetles, as they are easily killed with foliar insecticides. The recent identification and synthesis of the banded cucumber beetle sex pheromone (6,12-dimethylpentadecan-2-one) (Chuman et al. 1987) could enhance adult control programs by making possible more effective timing of insecticide treatments. The pheromone may also be useful for direct control of adults as a component of an IPM program. This paper reports basic information on the diel and seasonal responses of males to sex pheromone, the longevity of a pheromonal formulation, and the efficacy of several types of traps.

**MATERIALS AND METHODS**

The racemic pheromone used in the tests of 1987 was synthesized according to Chuman et al. (1987). The synthetic pheromone used in the 1988 tests was racemic 6,12-dimethylpentadecan-2-one which was purchased from Fuji Flavor Co., Ltd., Tokyo, Japan. Its structure was confirmed by mass spectroscopy (Chuman et al. 1987) and its purity assessed by gas chromatography on two 50 m x 0.25 mm fused silica capillary columns, one coated with OV101 and the other with CPS-2 (Quadrex Scientific, New Haven, CT). The pheromone comprised 84% of the synthetic material. The remainder consisted of one unknown impurity of 12% and several minor (1% or less) impurities. Rubber septa (A. H. Thomas #8753-D22) were extracted for 48 h with methylene chloride in a soxhlet extractor to remove any impurities and dried at ambient temperature in a fume hood. The synthetic pheromone, in the amounts indicated for the various experiments, was loaded into the septa by pipetting 100 ul of hexane solution into the well of the large end of each septum. Septa were allowed to equilibrate in a fume hood at ambient temperature for 48 h after loading.

The tests were conducted at the U. S. Vegetable Laboratory, Charleston, SC.

The first experiment was conducted in 1987 to determine the diel periodicity of male response to synthetic pheromone-baited traps and to traps baited with virgin female beetles. Traps for these tests were 450 ml white styrofoam cups externally covered with insect trapping adhesive and suspended upside down on wooden stakes with cup orifices 15 cm above the plant canopy. Traps were baited with rubber septa containing 0.5 mg of racemic pheromone or with nylon mesh cages (5La 2D cm, containing a moist dental role wick) confining 1 or 2, 10 to 26 day-old virgin females. Cuthbert & Reid (1964) found that the mean attractiveness to males for recently emerged females was 10 days, however, the range of attractiveness was 4 to 79 days and depended on the females.
These baits were placed on top of the inverted cup. Five of each type of trap were placed 15 m apart consecutively in the center of sweet potato fields. Treatments were placed in the fields after 1500 h and data recorded every 30 min from 1600 to 2400 and from 0800 to 1500 h the following day. Four tests were conducted in July (July 20, 21, 29 and 30), and 3 in September (September 13, 15, and 16) which assessed male response to both the pheromone and virgin females. In another study male response to only the pheromone was investigated on July 29, 30, August 3, 4 and September 1, 2. The onset of the scotophase occurred about 2130 h on 20 July and 2100 h on 1 September. Average temperature for the test period ranged from 25 to 31°C with only traces of moisture reported for 1 September. Average wind speed did not exceed 22 k/h. Captured adults were counted, removed from the trap and brought into the laboratory for sex confirmation.

In a second test, conducted in 1988, six trap designs were compared with the 450-ml cup trap for efficacy in capturing males: Sentry wing (Pherocon IC, Albany International Co.); a boll weevil trap (Techical Precision Plastics); Jansson sweetpotato weevil trap (Jansson et al. 1989); Multi-pher trap (Bio-control Services); Japanese beetle-Biolure trap (Reuter Laboratories, Inc.); and Delta-Biolure trap (Consep Membranes, Inc.). Each trap was baited with a septum containing 300 ug of pheromone and an unbaited 450 ml cup trap was included. Three trapping lines, each with 8 trap locations, were established in a field of sweet corn at the silk stage on 22 June (corn 1.5 m high, with traps placed 61 cm from the ground). The trap locations within each line were 36 m apart and the trap lines were 45 m apart. Each trap design was randomly assigned to a trap location within each line to establish a randomized complete-block experiment. The captured males were counted and removed from the traps daily and each trap was then moved to the next location in its trap line for 8 days. The trap captures were transformed to $\sqrt{X + 0.1}$ to stabilize the variance and analyzed using PROC ANOVA (SAS 1985) to determine effects of trap design, block and position.

Mean separation for trap design was by the SNK (Student-Newman-Keuls) procedure. During the test, the average daily temperature was 27°C with trace amounts of precipitation on June 24 and 27. Wind speed averaged less than 22 k/h during this period. The third test, conducted on 1 August, 1988, determined the effect of placing traps at various heights in a snap bean (45 cm tall) field (spacing was 15 m between traps and 8 m between replicates) by positioning the wing design at 25.4, 50.8 and 101.6 cm above the ground. Each trap contained 300 ug of pheromone. Trap data were collected daily for 12 consecutive days and trapped insects were removed daily. The average daily temperature and precipitation for the test period was 28.4°C and 1.8 cm respectively. Wind speed did not exceed 24 k/h. The experimental design was a 3 x 3 Latin square.

In the final test, pheromone activity was investigated by leaving five baited traps (450 ml cups, 0.5 mg pheromone/trap) with the original septa continuously in the field, spaced 15 m apart and positioned on top of ditch banks (91 cm above ground), from July 1987 through May 1988. Data were recorded 3 times/week and traps were periodically cleaned of beetles or replaced.

**Results and Discussion**

Peak captures of males in pheromone baited traps and virgin female traps occurred during the scotophase between 2100 through 0400h and subsequently declined (Fig. 1). Howard (1982) found similar activity with sweep net captures of unsexed adult banded cucumber beetles. Cuthbert (1964) stated that females released their pheromone during at least a portion of the night. Chuman et al. (1987) captured large numbers of males during both morning and afternoon tests in south Florida. They attributed this pattern
Fig. 1. Field evaluation of the pheromone (racemic 6,12-dimethylpentadecan-2-one) (0.5 mg/septa/trap) used continually for a 12 month period to capture males of *Diabrotica balteata* LeConte, 1987-1988.

of response to cool night temperatures in November which presumably inhibited beetle flight. Subsequent trapping tests during the summer months in Florida (McLaughlin, unpublished) revealed a male response similar to that presented here for South Carolina. These findings suggest that males adjust their response under the influence of environmental cues, however, we do not know if female pheromone release is similarly affected. Virgin females were not as effective as the synthetic pheromone as demonstrated by total numbers of captured males per season (Fig. 1, Table 1).

The most effective trap design for capturing males was the wing type (Table 2). The Delta, Multi-finer trap and 450 ml cup designs were intermediate in male capture while the least effective were the Japanese beetle, Jansson and boll weevil traps. The unbaited 450 ml cup without the pheromone, did not trap any males.

**TABLE 1. NUMBER OF *DIABROTICA BALTEATA* LECONTE MALES CAPTURED DURING A 24-H PERIOD IN TRAPS BAITED WITH 2 VIRGIN FEMALES OR RACEMIC 6,12-DIMETHYLPENTADECAN-2-ONE (0.5 MG/SEPTA), 1987.**

<table>
<thead>
<tr>
<th>Treatment (date)</th>
<th>Males Captured (Mean ± SE/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pheromone</td>
</tr>
<tr>
<td>9/13</td>
<td>94.8 ± 13.3</td>
</tr>
<tr>
<td>9/15</td>
<td>64.6 ± 4.3</td>
</tr>
<tr>
<td>9/16</td>
<td>84.4 ± 10.2</td>
</tr>
<tr>
<td>Total</td>
<td>243.8 ± 21.9</td>
</tr>
</tbody>
</table>

*Traps baited after 1530h each day; 5 traps per treatment; females were 10-26 days old.*
*Means between columns (total captures) not followed by the same letter are significantly different at the 1% level (t-test for paired replicates).*
TABLE 2. Efficacy of trap design in the capture of male *Diabrotica balteata*. Each trap baited with 300 µg of racemic 6,12-dimethylpentadecan-2-one.

<table>
<thead>
<tr>
<th>Trap design</th>
<th>Males captured (Mean ± SE/day)¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wing</td>
<td>11.3 ± 2.7a</td>
</tr>
<tr>
<td>Delta</td>
<td>7.6 ± 2.8b</td>
</tr>
<tr>
<td>Multitrap</td>
<td>5.0 ± 1.4b</td>
</tr>
<tr>
<td>450ml cup</td>
<td>4.9 ± 1.4b</td>
</tr>
<tr>
<td>Japanese beetle</td>
<td>2.1 ± 0.6c</td>
</tr>
<tr>
<td>Jansson</td>
<td>2.1 ± 0.5c</td>
</tr>
<tr>
<td>Boll weevil</td>
<td>1.5 ± 0.4c</td>
</tr>
<tr>
<td>400ml cup (unbaited)</td>
<td>0.0 ± 0.0d</td>
</tr>
</tbody>
</table>

¹Means not followed by a common letter are significantly different. Student-Newman-Keuls procedure, alpha = 0.05, F = 25.7; df = 7.32; P > F = 0.0001.

There were no significant differences in males captured with wing traps positioned at heights of 25.4, 50.8 or 101.6 cm. (means of 8.6 SE ± 12.1, 10.5 SE ± 11.8 and 9.6 SE ± 10.6 males, respectively, per day). This trapping was in a field of snap bean with canopy height of about 45 cm. These findings indicate that in low growing crops the traps can be elevated above the canopy so they may be more easily located by field personnel.

The 0.5 mg baits attracted males continuously from July 1987 through May 1988. Peak captures were observed during the months of August and September of 1987 with a decline into the cooler seasons (Fig. 2). This agrees with the seasonal densities that Elsey (1988) found on cucumber and zucchini squash. However, the effectiveness of the bait was probably reduced due to the length of use. The important observation is capture of males during the months of January, February, and March which demonstrates that

![Graph showing numbers of male *Diabrotica balteata* captured over a 24 h (1600 h through 1500 h) period in traps baited with 0.5 mg of racemic 6,12-dimethylpentadecan-2-one or virgin females.](image-url)
adults can survive the winter in Charleston, SC. Elsey (1988) reported similar findings and also suggested that Charleston, SC. may be one of the northernmost enclaves for the banded cucumber beetle.

The larval stage of this insect is very difficult to control because of the loss of persistent soil insecticides, however, the adults can be effectively controlled with an economical chemical such as Sevin. The male insect’s sensitivity to the pheromone suggests that it may be useful for integrated pest management. It can be employed as bait in wing traps to detect early infestations, to monitor established populations and to assist correct timing of insecticide applications relative to population densities of economic importance. Since the insect is a pest of seasonal crops the pheromone will probably have little value in mass trapping because of the lack of crop continuity. Its value for mating disruption seems poor because of long adult life which enhances greater likelihood of copulation with females.

REFERENCES CITED


