Effect of single and multiple species release on the capture of *P. interpunctella* and *C. cautella* in pheromone-baited traps

M.A. Mullen*

Abstract

The effect of the presence of the Indianmeal moth, *Plodia interpunctella* (Hübner), on the capture of the almond moth, *Cadra cautella* (Walker), in pheromone-baited traps was evaluated. It was found that when both sexes of each species were released into a large warehouse simultaneously, the capture of male *C. cautella* was reduced to 5.5 ± 0.8 in traps baited with a two-component lure as compared with 11.4 ± 2.2 when only *C. cautella* were released. This decrease in response may have been caused by an inhibitory substance produced by the female *P. interpunctella* that affects the response of male *C. cautella* to the pheromone, or to confusion caused by an increase in the amount of pheromone present. The reduced response of *C. cautella* must be considered when using pheromone-baited traps to estimate population levels when both species are present.

Introduction

The use of pheromone-baited traps to monitor stored-product insects is an important part of a pest management program (Ahmad 1987; Vick et al. 1986). The Indianmeal moth, *Plodia interpunctella* (Hübner), and the almond moth, *Cadra cautella* (Walker), are serious pests of stored food in warehouses in the United States and throughout the world. Both share the same major sex pheromone component (Z,E)-9,12-tetradecdien-1-ol-acetate (Brady and Nordlund 1971; Brady et al. 1971; Kuwahara et al. 1971 a, b).

Cogburn and Vick (1981) monitored population trends of Angoumois grain moth, *Sitotroga cerealla* (Olivier), in traps baited with (Z,E)-7,11- hexadecadien-ol acetate and also *C. cautella* and *P. interpunctella* in pheromone-baited traps containing (Z,E)-9,12-tetradecadien-1-ol acetate. Levinson and Buchelos (1981) and Sifner and Zdarek (1982) demonstrated the feasibility of monitoring multiple pest species of pyralid moths in traps baited with species specific pheromones. In some cases, closely related species can be attracted to a single pheromone. However, Mullen et al. (1991) found the presence of male and female *P. interpunctella* in equal numbers with *C. cautella* reduced capture of *C. cautella* males in traps baited with the same pheromone to less than 1% of the number released. At the same time 39% of the *P. interpunctella* males were recaptured. We speculated that this reduction in capture was caused by an inhibitory influence by the female *P. interpunctella*. Thus, while the value of moth pheromones for monitoring populations has been demonstrated, additional work on the composition of the pheromone is needed (Chambers 1990).

In this study we attempted to determine if the presence of female *P. interpunctella* inhibited the capture of male *C. cautella*. We also tested the effectiveness of a specific pheromone blend on the capture of male *C. cautella*. This information will be used as part of a study to develop an effective pest monitoring system for use in warehouses containing both packaged and unpackaged foods susceptible to infestation by these two pests.

Materials and Methods

Test facility

All lures were tested in a 22100 m^3 (7 × 61 × 51 m) warehouse. The roof of the warehouse had three arches with skylights extending along the entire length. Because of the arches the ceiling height varied from 4.6 to 7.3 m. Six small windows and three overhead doors were spaced evenly over each 51 m length. The windows were never opened and only one door was used during the test. At the centre of each 61-m width were large doors that led to other warehouse space. One door was opened during the day and both were closed at night. The warehouse was used for storing furniture and office items. The traffic in the warehouse was generally low but varied from week to week. Lights were often left on at night by warehouse workers.

Traps and lures

The rubber septa lures (Trécé Inc., Salinas, CA USA) contained either (Z,E) 9,12-Tetradecadien-1-ol-acetate as a single component for *P. interpunctella* or a two-component pheromone containing 85% (Z,E) 9,12-Tetradecadien-1-ol-acetate and 15% Z-9-Tetradecadien-1-ol-acetate for *C. cautella*. Each lure type was loaded with 1 mg of pheromone. The trap used was the Pherocon 1C wing trap (Trécé Inc.). Traps and lures were replaced every three weeks at the beginning of each new test.

Trap arrangement

Twenty-four traps were placed in the warehouse so that a density of approximately one trap per 920 m^3 was achieved. Each trap was suspended at a height of 4 m. Traps were baited with pheromone lures in the following sequence *P. interpunctella* (one-component), *C. cautella* (two-component) and blank. This was repeated so that there were 8 one-component, 8 two-component, and 8 unbaited traps.

Insects

The insects were reared on artificial moth medium (Boles and Marske 1966) at 27 ± 2°C and at 60 ± 10% r.h. with a 12:12(L:D) hour photoperiod. Pupae were collected in corru-

* U. S. Department of Agriculture, Agricultural Research Service, Stored-Product Insects Research and Development Laboratory, Savannah, Georgia USA.

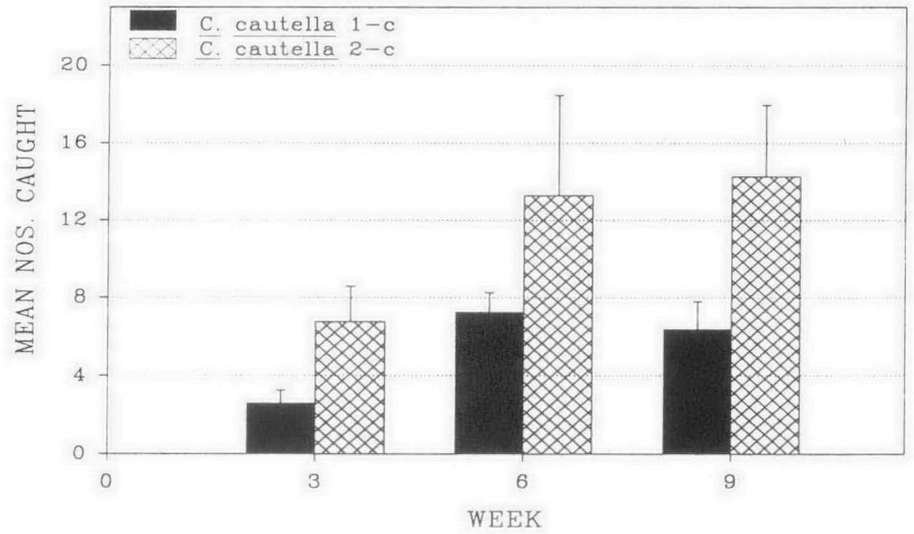

Fig. 1. Mean (±SEM) catch of released *C. cautella* in traps baited with either a one component (1-C) or a two-component pheromone (2-C). The data are totals for three replicates and are separated by lure type.

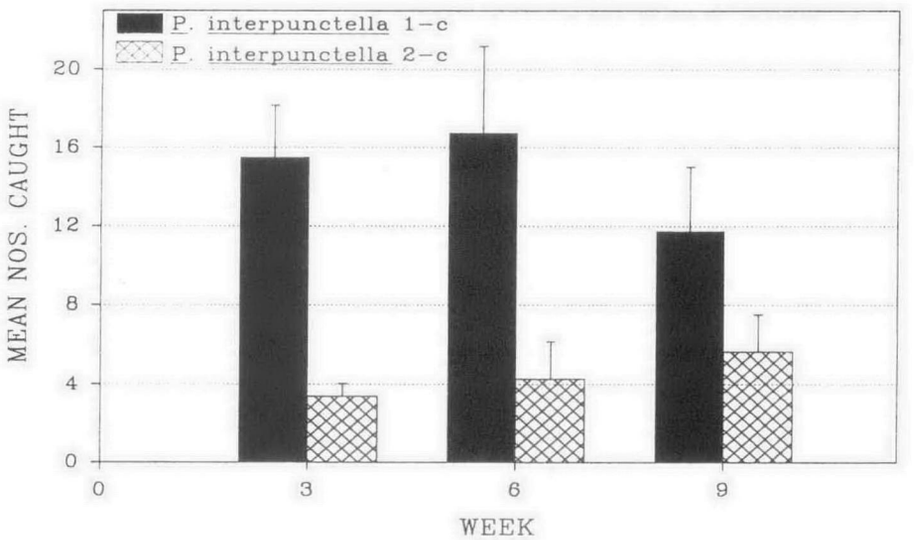

Fig. 2. Mean catch (±SEM) of released *P. interpunctella* in traps baited with either a single component lure (1-C) or a two-component pheromone (2-C). The totals for the three replicates are separated by lure type.

gated paper rolls. For each test 1000 unsexed pupae were removed from the rolls, separated into groups of approximately 28 each, and released at 36 locations in the warehouse. The sex ratio was assumed to be 1:1 as found by Mullen et al. (1991). Adult emergence from the released pupae ranged from 96–100% throughout the tests as determined by counting exuvia.

Experimental procedure

During week one, *C. cautella* pupae only were released from 36 locations in the warehouse. After three weeks, trap catch for each type of lure was recorded. Lures and traps were replaced and the procedure was repeated for a total of three replications. The same procedure was repeated for the *P. interpunctella*. For the final test a total of 1000 *P. interpunctella* and 1000 *C. cautella* were released from 36 locations with approximately 28 of each species at each location. The trap configuration was the same as in the previous tests and the trapped moths were counted and separated by species and lure type. Temperature and relative humidity were monitored using a hygrotheromograph The temperature averaged 26°C and the humidity ranged from 40–90% for the duration of this test. Data for the capture by lure type for single species releases were analyzed using chi-square as an index of dispersion and the data for the combined species releases was analysed using a Spearman Rank correlation (SAS Institute 1987).

Results

Cadra cautella were captured in the traps baited with the two-component *C. cautella* lure and in traps with the one-component *P. interpunctella* lure. The number of moths of either species caught in the blank (control) traps averaged less than one moth per trap per week and was not considered significant. *Cadra cautella* were captured in greater numbers in all traps baited with the two-component lure with a mean (±SEM) of 11.4 ± 2.2 per trap compared to 5.4 ± 0.7 (χ^2 = 70.0; P > 0.00001) (Fig. 1) in traps baited with the commer-

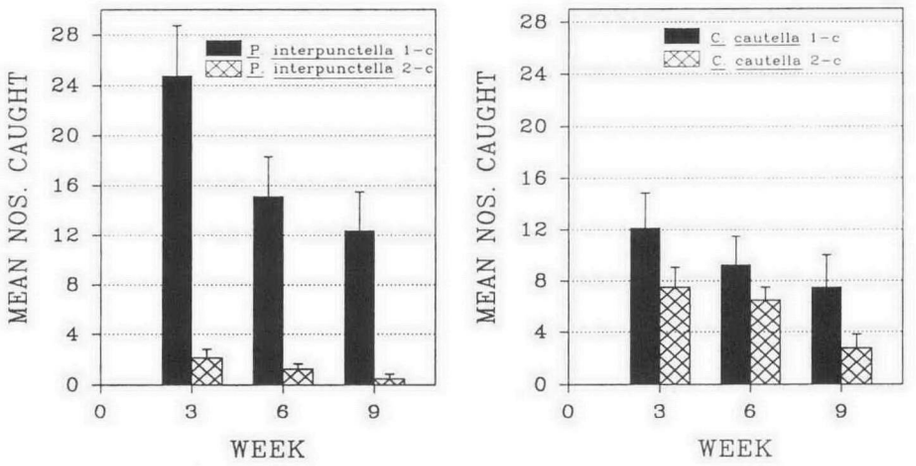

Fig. 3. Trap catch when both *C. cautella* and *P. interpunctella* released simultaneously in a large warehouse. (a) Totals for insects attracted and captured in traps baited with the *P. interpunctella* one-component lure. (b) Totals for insects attracted and captured in traps baited with the *C. cautella* two-component lure.

cially available single component formulation sold for both *P. interpunctella* and *C. cautella*. These results suggest that the two-part formulation is more effective for attracting and capturing male *C. cautella* than the single component pheromone now marketed.

More *P. interpunctella* were captured in traps baited with one-component *P. interpunctella* pheromone than with the two-component *C. cautella* pheromone. An average of 14.7 ± 2.0 males were trapped in the *P. interpunctella*-baited traps and 4.4 ± 0.9 in the two-component *C. cautella*-baited traps (χ^2 = 20.92; P > 0.00001) (Fig. 2). From the data it appears that the best lure for *P. interpunctella* is the single component lure.

When both species were released simultaneously the capture of *C. cautella* in was significantly reduced in traps baited with either lure. An average of 1.3 ± 0.3 *C. cautella* were captured with one-component lures and 5.5 ± 0.8 in traps with a two-component lure. This is a reduction from 5.4 ± 0.7 and 11.4 ± 2.2 in one-component and two-component baited traps, respectively, when only *C. cautella* were released. This compares to 17.4 ± 2.2 *P. interpunctella* in one-component baited traps and 9.6 ± 1.4 in two- component baited traps (Fig. 3). The lack of a positive and significant correlation coefficient (R^2= – 0.24329; P = 0.0957) between lure types is consistent with the hypothesis that the reduction in the number of male *C. cautella* captured was the result of confusion caused by the presence of the *P. interpunctella* females and not the pheromone bait.

Discussion

The presence of female *P. interpunctella* may have inhibited the attraction and capture of male *C. cautella*. Nakajima (1970) observed that male *P. interpunctella* were highly responsive to extracts of female *C. cautella*. Although no reason was given, male *C. cautella* were much less responsive to extracts from female *P. interpunctella*. However, Coffelt and Vick (1987) found that the synthetic pheromone in commercially produced lures does not exactly mimic that produced by the female. Mullen et al. (1991) reported that when both species were released simultaneously, commercially produced *P. interpunctella* lures caught less than 1% of the male *C. cautella* compared to 39% of the male *P. interpunctella* in the same study. Ahmad (1987) reported the capture of male *C. cautella* using the single component pheromone when *P. interpunctella* were not present.

Sower et al. (1974a) reported that the responses by males of both *P. interpunctella* and *C. cautella* became habituated to the naturally produced sex pheromone. Roelofs and Comeau (1970) suggested that this habituation may be due to the presence of structurally similar components that interfere with specific sex pheromone binding sites on the antennal sensilla of males. The suppression of *C. cautella* may be due to the presence of an inhibitor produced by the female *P. interpunctella* as reported by Ganyard and Brady (1971) and later identified as (Z,E)-9,12-tetradecadien-1-ol by Sower et al. (1974b) and Krasnoff et al. (1984). Because *P. interpunctella* were present in equal numbers, the females may have produced enough of this inhibitor to affect the response of the male *C. cautella*. Suppression was evident although the two component pheromone specific for the *C. cautella* was present. Alternatively, because both species share the same major pheromone component, the apparent decrease in response by *C. cautella* may have been the result of confusion resulting from the presence of pheromone producing female *P. interpunctella*. Even though cross mating is not known to occur, female *P. interpunctella* may have been considered by the male *C. cautella* as mates, or the increased amount of pheromone present made it more difficult to find the appropriate trap.

The single component *P. interpunctella* lure is very effective for attracting and capturing male *P. interpunctella*. However, when both species are present, a reduction in the capture of *C. cautella* can be expected. This reduction could be especially important in studies that attempt to estimate actual populations based on trap catch alone.

References

Ahmad, T.R. 1987. Effect of pheromone trap design and placement on capture of almond moth, *Cadra cautella* (Lepidoptera: Pyralidae). Journal of Economic Entomology 80, 897–900.

Boles, H.P. and Marske, F.O. 1966. Lepidoptera infesting stored products. In: C.N. Smith ed., Insect colonization and mass production. Academic Press, New York, 255–70.

Brady, U.E. and Nordlund, D.A. 1971. Cis-9, trans-12-tetradecadienyl acetate in the female tobacco moth, *Ephestia elutella* (Hübner) and evidence for an additional component of the sex pheromone. Life Sciences 10 (part II), 797–801.

Brady, U.E., Tumlinson, J.H.,. Brownlee, R.G. and Silverstein., R.M. 1971. Sex stimulant and attractant in the Indianmeal moth and in the Almond moth. Science 171, 802–804.

Chambers, John 1990. Overview of stored product insect pheromones and food attractants. Journal of the Kansas Entomological Society 63, 490–499.

Coffelt, J.A. and Vick, K.W. 1987. Sex pheromones of *Ephestia cautella* (Walker) (Lepidoptera: Pyralidae): influence of mating on pheromone titer and release rate. Journal of Stored Products Research 23, 119–123.

Cogburn, R.R. and Vick, K.W. 1981. Distribution of angoumois grain moth, almond moth, and Indianmeal moth in rice fields and storages in Texas as indicated by pheromone baited adhesive traps. Environmental Entomology 10, 1003–1007.

Ganyard, M. C.,Jr. and Brady, U.E. 1971. Inhibition of attraction and cross attraction by interspecific sex pheromone communication in Lepidoptera. Nature 234, 415–416.

Krasnoff, S.B., Vick, K.W. and Coffelt, J.A. 1984. (Z,E)–9, 12-tetradecadien 1-ol: A component of the sex pheromone of *Ephestia elutella* (Hübner) (Lepidoptera: Pyralidae). Environmental Entomology 13, 765-767.

Kuwahara, Y., Hara, H., Ishii, S. and Fukami, H. 1971a. The sex pheromone of the Mediterranean flour moth. Agricultural and Biological Chemistry 35, 447–448.

Kuwahara, Y., Kitamura, C., Takahaski, S., Hara, H. Ishii, S. and Fukami, H. 1971b. Sex pheromone of the almond moth and the Indian meal moth: Cis–9, trans-12-tetradecadienyl acetate. Science 171, 801–802.

Levinson, H.Z., and Buchelos, C.Th. 1981. Surveillance of storage moth species (Pyralidae: Gelechidae) in a flour mill by adhesive traps with notes on the pheromone mediated flight behavior of male moths. Zeitschrift Fur Angewandte Entomologie 92, 233–251.

Mullen, M.A., Highland, H.A. and Arthur, F.H. 1991. Efficiency and longevity of two commercial sex pheromone lures for the Indianmeal moth and the almond moth. (Lepidoptera: Pyralidae). Journal Entomological Science 26, 64–68.

Nakajima, Minoru 1970. Studies on the sex pheromone of the stores grain moths. . In: D.L. Wood, R.M. Silverstein, and M. Nakajima ed., Control of insect behavior by natural products. Academic Press, New York, 209–217.

Roelofs, W.L. and Comeau, A. 1970. Sex pheromone perception: Synergists and inhibitors for the red banded leaf roller attractant. Journal Insect Physiology 17, 435–438.

SAS Institute 1987. SAS/STAT guide for personal computers, version 6 edition. SAS Institute, Inc., Cary, NC.

Sifner, F. and Zdarek, J. 1982. Monitoring of stored food moths (Lepidoptera: Pyralidae) in Czechoslovakia by means of pheromone traps. ActaEnt. Bohemoslov. 79, 112–122.

Sower, L.L., Vick, K.W. and Ball, K.A. 1974a. Perception of olfactory stimuli that inhibit the responses of male phycidid moths to sex pheromones. Environmental Entomology 3, 277–279.

Sower, L.L., Vick, K.W. and Tumlinson, J.H. 1974b. (Z,E)-9,12-tetradecadien-1-ol: A chemical released by female *Plodia interpunctella* that inhibits the sex pheromone response of male *Cadra cautella*. Environmental Entomology 3, 120–122.

Vick, K.W., Koehler, P.G. and Neal, J.J. 1986. Incidence of stored-product phycitine moths in food distribution warehouses as determined by sex pheromone baited traps. Journal Economic Entomology 79, 936–939.