



Influence of Trap Design and Location on the Capture of *Plodia interpunctella* (Indian Meal Moth) (Lepidoptera: Pyralidae) in a Release–Recapture Study*

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Abstract—Five commercial pheromone trap designs were tested simultaneously in a warehouse to determine the most effective design for capturing *Plodia interpunctella* (Hübner) (the Indian meal moth). About 72% of the males released were recaptured. The most effective trap was the wing trap (Pherocon 1c), which significantly exceeded the expected value. The remaining trap designs in order of effectiveness were the diamond trap (Pherocon II), Multiplier, Delta and Unitrap. Of these four traps, only the diamond trap equalled or slightly surpassed the expected catch number. The location of the traps affected the catch, with traps located near the walls of the warehouse capturing the most insects. Unbaited traps caught few insects, and the necessity of using unbaited traps in tests is discussed. © 1998 Elsevier Science Ltd. All rights reserved

Key words—insect detection, insect monitoring, pheromone-baited traps, *Plodia interpunctella*, warehouse

INTRODUCTION

The monitoring of stored product insects with pheromone-baited traps is an integral part of many stored product pest management programs (Brady *et al.*, 1975; Read and Haines, 1976; Vick *et al.*, 1986; Ahmad, 1987; Mullen, 1994). *Plodia interpunctella* (Hübner), the Indian meal moth, is a worldwide pest of processed and unprocessed foods. The major component of the sex pheromone of this and other phycitid moths is (Z,E)-9,12-tetradecadien-1-yl-acetate (ZETA) (Brady and Nordlund, 1971; Brady *et al.*, 1971; Kuwahara *et al.*, 1971a,b). The optimum effectiveness of the pheromone in attracting male moths is often a function of the trap design and trap placement within storage facilities. The objective of this project was to evaluate five popular commercial trap designs for the sampling and monitoring of *P. interpunctella* in storage facilities and to determine whether unbaited traps caught significant numbers of insects. The information presented will be useful in the development and implementation of an integrated pest management system to control stored product moths.

MATERIALS AND METHODS

The research was conducted at the former USDA, ARS Stored-Product Insects Research and Development Laboratory in Savannah, GA. The five trap types tested were the Trécé Pherocon

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1c wing trap and the Pherocon II diamond trap, the Trappit Delta trap, the universal trap (Unitrap) by International Pheromone Systems Limited and the Multiplier M-1 by Bio-Control Services. The wing, diamond and Delta traps are sticky traps. The wing trap requires assembly and has a large glued surface on which the male moths are trapped. The diamond trap is a small trap that can be pulled open to expose a glued surface. Because it is small, it can be hidden so that the trap is not noticeable. The Delta trap is constructed from corrugated plastic and has a replaceable sticky liner. The Unitrap and Multiplier traps are pitfall traps with a large trapping reservoir. Both are made of durable plastic, but require a killing agent, which could be a disadvantage in some situations.

All tests were conducted in an empty 20.4 m × 33.5 m (683.4 m² and 16 722 m³) warehouse. The traps were hung from wires across the warehouse at a height of 2.5 m. The warehouse was divided into four blocks, with each block having one baited and one unbaited trap of each design (Fig. 1). The blocks were designated as 1–4 and the traps were placed either on the inside of the block (in the center of the warehouse) or on the outside of the block (next to the wall). All baited traps contained a single rubber septum pheromone lure supplied by Trécé of Salinas, CA, U.S.A. which contained 1 mg of ZETA (Mullen *et al.*, 1991). Blank traps were included to determine whether unbaited traps captured significant numbers of insects. A total of 1000 unsexed *P. interpunctella* pupae were placed in groups of 200 at five points in the warehouse for adult emergence. Tests were run for 13 d, and the total trap catch for each design and the number of pupae that failed to produce adults were recorded. Four replicates were spaced 3 weeks apart to avoid overlapping populations. After each replication, the plastic traps were cleaned for reuse by dumping the insects and wiping the inside of the trap with a cloth (Multiplier trap and Unitrap), replacing the sticky liner (Delta trap) or replacing the trap (Pherocon 1c and Pherocon II). Lures were replaced after each replication. The data were analyzed for both catch and position effect using a log linear chi-square model (SAS Institute, 1987).

RESULTS AND DISCUSSION

In each test, a mean of 300 insects (7.5%) failed to emerge or were caught in unbaited traps. A total of 1338 male moths were captured in the four replications. The captures within replications were 394, 250, 344 and 350 and, because the male to female ratio is assumed to be 1 : 1 (Mullen

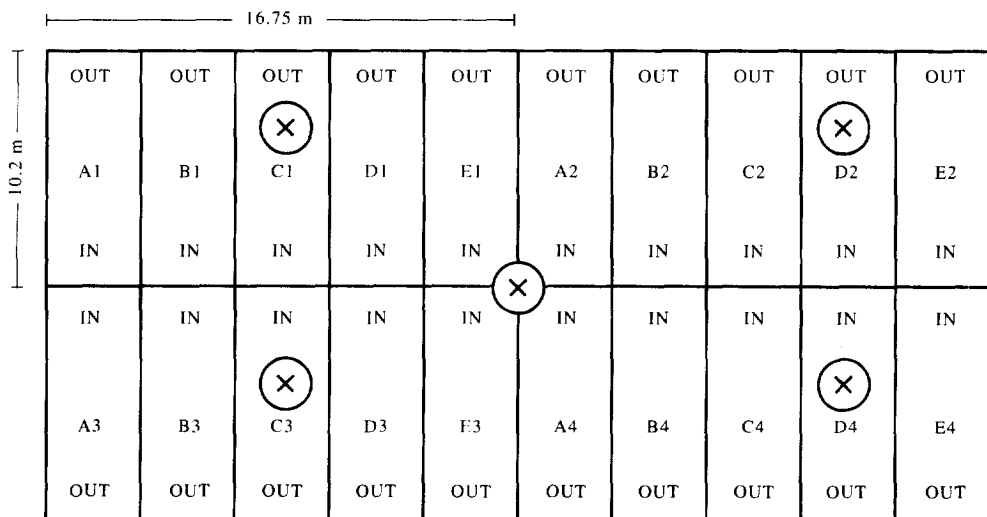


Fig. 1. Layout of traps in the warehouse showing four blocks with inside and outside positions within each block for each trap type. The position of each trap was randomized between replicates. X, release points for Indian meal moth pupae.

Table 1. Chi-square analysis of variance showing the interaction among the traps studied by row location and replication

Source	DF	Chi-square	Probability
Pheromone (presence or absence)	1	414.49	0.0001
Trap type	4	102.96	0.0001
Row	1	3.50	0.0612
Location (inside or outside)	1	28.46	0.0001
Row * location	1	11.38	0.0007
Rep * lure	3	7.93	0.0474
Rep * trap	12	115.63	0.0001
Rep * row	3	8.52	0.0364
Rep * location	3	3.76	0.2890
Likelihood ratio	112	1209.61	0.0001

et al., 1991), 72% (1338) of the total number of males that emerged (1851) were caught in the traps. The chi-square analysis shows that the presence or absence of the pheromone, the type of trap, the location of the trap, the row by location interaction and several replicate by parameter interactions were statistically significant (Table 1).

The presence or absence of a pheromone lure was an obvious factor that affected trap catch. Using blank or unbaited traps for comparison doubles the time and labor required to conduct evaluations of pheromone traps in field storages and may not be necessary to determine the effectiveness among traps. Mullen *et al.* (1991) showed that unbaited traps caught less than 1% of the total insects that were released in a warehouse used to store non-food items. Similar results were found in this study with a total of 37 (<1%) moths caught in unbaited traps presumably from random capture.

Assuming a random distribution, the expected trapping frequency for the four replications was 267 males per baited trap type (Fig. 2). A total of 414 males were caught in the wing trap in the four replications, which was significantly more than the expected value of 267 ($P < 0.05$). A total of 274 males were caught in the diamond trap, which was not significantly different from the expected value ($P \geq 0.05$). The total numbers caught in the four replications of the remaining three traps were Multipher (228), Delta (217) and Unitrap (205), and all were significantly less than the expected value ($P < 0.05$).

The location of the traps also affected trap catch. The traps were arranged inside the warehouse so that two rows were near the walls and the remaining two rows ran down the middle of the

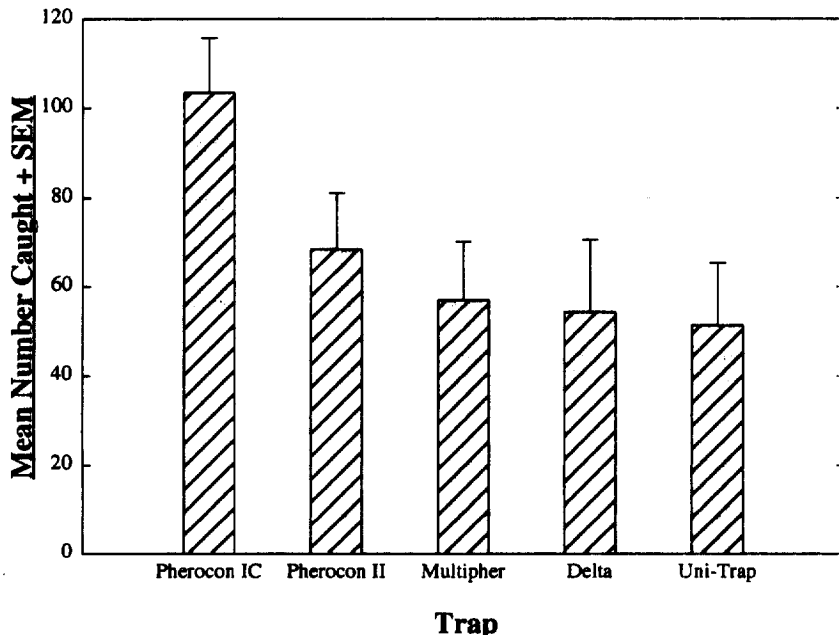


Fig. 2. Mean trap catches \pm SEM for male *P. interpunctella* in the five trap types in the test. Data for the unbaited traps are not included.

warehouse. Significantly more males were caught in the outside rows than in the inside rows. The reason for this position effect was not clear, but it could have been partly due to the fact that the walls provided a place for the adults to rest. Insects that were resting on the walls were therefore closer to the pheromone attractants in outside traps as compared with the attractants in inside traps. The resting insects would also have a shorter flight distance to the outside traps. This effect may not be noticeable when the warehouse is full, because stacked cartons would provide a resting place and essentially act as walls for resting moths. However, additional research would be necessary to clarify this effect.

The results of this study indicate that there is considerable variation in trap catch among the commercial trap designs available to monitor *P. interpunctella* in food warehouses. This particular test indicated that the standard wing trap was the most effective design among the five traps that were tested. However, additional data are required to make widespread recommendations. The type of storage facility, the food inside the facility, the inside ambient temperature and other similar biological and environmental factors may also affect trap catch. Data obtained from trap catch can be used to estimate pest populations. Several methods have been proposed to interpret trap catch data, but they require extensive statistical and computer analyses (Hagstrum *et al.*, 1990; Wileyto *et al.*, 1994) which may not be practical for field situations.

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