

## Evaluation of the efficacy of different kinds of pheromone traps for the monitoring of *Plodia interpunctella* Hbn. (Lepidoptera: Pyralidae)

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**Abstract:** In food industries, different kinds of pheromone traps are used for the monitoring of *Plodia interpunctella*, but in many cases, it is difficult to relate captured adults with the real density of moth's population. In this work, the results of laboratory tests of four kinds of pheromone traps have been reported. Three kinds of sticky trap (wing trap, delta trap, strip trap) and a funnel trap have been tested in two Peet & Grady chambers of 28 and 30 m<sup>3</sup> with a known number of adults. The wing trap has been tested in three different ways: with only adhesive base, with only adhesive top and with both base and top glued. Captured adults have been counted after 24 and 48 hours. The results are discussed.

**Key words:** *Plodia interpunctella*, pheromone trap, efficacy, monitoring.

### Introduction

The monitoring has assumed in the last years a more and more important role in the integrated pest management strategies, which suggest a limited use of chemicals to the advance of alternative methodologies. In warehouses and food industries, pheromone traps represent an essential instrument to monitor insect populations and to give useful information for struggle.

On the market, it is possible to find different kinds of moth's traps; the choice to use one or the other depends on the infesting species, on the environmental characteristics (e.g. much or little dust) and on the area to keep under monitoring.

Usually, the most used traps are those to hang up in the room's centre at 2-2.50 m from the floor, but there are also traps to be put under the shelves or in confined areas that, as underlined by Mullen & Dowdy (2001), remain out of view in order not to give the impression that the surrounding area is dirty or insect-infested. Besides this trap, there are oil traps that, activated with more pheromones, are able to catch different insects simultaneously.

Whatever the trap's type may be, in presence of a certain number of trapped insects, it is essential to have an idea of the insect population density, as reported by Pereira *et al.* (2002) who have used the pheromone traps to estimate moth population density at different points within a flour mill. It is also important to know the efficacy of each trap's type: many researchers have evaluated the effectiveness of some traps in warehouse or laboratory. Cogan & Hartley (1984) have experimented the efficacy of funnel trap in laboratory, on *Ephestia kuehniella* Zell., with a comparison of sticky and non-sticky trap models; a multifunnel trap was compared by Trematerra *et al.* (1994) in a warehouse with the effectiveness of other traps baited with pheromones of some moths and beetles infesting stored products and with the same traps without baits. Papadopoulou & Buchelos (2002) have made a comparison of trapping efficacy for *Lasioderma serricornis* (F.) adults with electric, pheromone, food attractant baited and control-adhesive traps; Ryne *et al.* (2002) have demonstrated the efficacy of water trap that caught more *Ephestia cautella* than pheromone trap without water and more than the one with water plus pheromone. Athanassiou *et al.* (2003) have examined the efficiency of the multisurface trap for the capture of *Ephestia kuehniella*.

The aim of this work was to compare four kinds of traps, commonly used for monitoring the Indian Meal Moth, *Plodia interpunctella* Hbn. (Lepidoptera: Pyralidae), and to estimate, in presence of a known number of males, the catch percentage of each trap. Therefore, it was possible a direct comparison with different traps to establish the most efficient one at the same experimental conditions. It is known, in fact, that there are many factors which may affect the captures: trap design and colour, location in the warehouse, ability to retain the insects after the capture, type of storage facility, food inside the facility, environmental temperature, type of lure, etc. (Levinson & Hoppe, 1983; Trematerra *et al.*, 1994; Mullen *et al.*, 1998).

## Materials and methods

The four traps tested were funnel, wing, delta and strip traps. The first three are usually used for monitoring the moths in warehouses and food industries, the last one is an experimental trap, consisting of a yellow strip of 0.4 mm thick paperboard, 10 cm width and 25 cm height, with one surface glued. An adhesive trap consisting of vertically suspended strip was successfully used for the monitoring of moths populations in a chocolate factory by Hoppe & Levinson (1979) and in a flour mill by Levinson & Buchelos (1981).

The strip trap can be located where the use of other models are uncomfortable, in particular, it can be used in automatic warehouses, developed in vertical direction to exploit all the space, where various products are stored. The traditional traps cannot be employ for monitoring the high flats of these structures because the height of the shelves makes the capture's control difficult. On the contrary, the sticky strip trap, baited with pheromone (the lure was applied in the middle of the strip), can be placed in the highest flats; the caught insects are easily evident from below thanks to the vertical position of the trap and its clear colour.

The wing trap has been tested in three different ways: with only adhesive base, with only adhesive top and with both base and top glued. In the second and third case the lure was applied on the top. The wing traps with adhesive top have been tested for applications in dusty environments.

All traps have been activated with a caoutchouc lure impregnated with 0.2 mg of (Z,E)-9,12-tetra-decadenylacetate (TDA) (average daily release 30 µg/day).

The male larva III-IV can be separated because it shows a dark patch of the sketches of male gonads on the abdominal segments.

The tests have been made in two Peet & Grady chambers with a known number of unmated males of *Plodia interpunctella*. Each trap was tested alone, in presence of 10 or 100 unmated 2-3-day-old males (Levinson & Hoppe, 1983), with four replications for each kind of trap. The lure was changed after the fourth repetition.

The tests in presence of 10 males have been made in the Peet & Grady chamber of 28 m<sup>3</sup>, the tests with 100 males in that of 30 m<sup>3</sup>, at a temperature of 25°C, relative humidity of 50% and natural light. The caught insects have been counted 24 and 48 hours after the release.

The data have been elaborated with ANOVA and Duncan's *post hoc* test; the number of captures was expressed in terms of percentage on the total of released males. In the tables 1 and 2, the different letters represent statistically differences with Duncan's test ( $P \leq 0.05$ )

## Results and discussion

Duncan's *post hoc* test showed that there are significant differences in trap's captures (Table 1). The funnel trap captured the lowest percentage of males. Among the adhesive traps, the highest percentage of captures was with wing and delta traps, the lowest with the strip trap; in

this one, a higher number of adults were captured at the lowest part of the sticky surface, as observed by Athanassiou *et al.* (2003).

The wing traps with adhesive base and top and with only adhesive top have captured a similar percentage of males as the wing with adhesive base. The adhesive base captured less males than the top (Table 2).

Table 1. Cumulative percentage of captured males of *Plodia interpunctella* in 24 and 48 hours after the release of 10 moths.

Trap	% male captured after 24 hours $\pm$ SD	% male captured after 48 hours $\pm$ SD
Funnel	30 $\pm$ 14 a	40 $\pm$ 14 a
Delta	55 $\pm$ 13 b	80 $\pm$ 8 bc
Strip	47 $\pm$ 10 ab	67 $\pm$ 10 b
Wing (adhesive base)	77 $\pm$ 17 c	90 $\pm$ 8 c
Wing (adhesive top)	85 $\pm$ 17 c	87 $\pm$ 15 c
Wing (adhesive base and top)	65 $\pm$ 13 bc	80 $\pm$ 8 bc

Table 2. Cumulative percentage of captured males of *Plodia interpunctella* in 24 and 48 hours after the release of 10 moths with the wing trap (adhesive base and top).

Wing trap with adhesive base and top	% male captured after 24 hours $\pm$ SD	% male captured after 48 hours $\pm$ SD
Base	17.5 $\pm$ 9.6	22.5 $\pm$ 9.6
Top	47.5 $\pm$ 9.6	57.5 $\pm$ 5.0

It was always noticed that the highest number of captured males was in the first 24 hours. In the second 24 hours, trap's captures increased on average only of 14% on the total. However, in presence of 10 males, the average percentage of each trap increased if compared to the test with 100 males. Muirhead-Thomson (1991), in earlier experiences with sex traps for *Choristoneura fumiferana* (Lepidoptera: Tortricidae), reported that the trapping effectiveness of a virgin female is affected by population density: with 70 males/acre, the female attraction was ten times higher than when the density was 4000 males/acre.

Levinson and Buchelos (1981) monitored for two years *Ephestia cautella* in a flour mill with TDA-baited traps. During the second year, they observed an increase of trap efficiency that can be related to a relatively low population density, in addition to the increased flight frequency. Sower *et al.* (1975) suggested that the control of the moths in enclosed environments with aid of the pheromone would have been feasible only when population densities were lower than 0.1 pair/m<sup>2</sup> wall surface; the effectiveness of a given dose of pheromone markedly increased as population densities of Indian Meal Moth were decreased from 10 to 0.1 pairs/m<sup>2</sup>. Trematerra (1997) said that pheromone traps are generally effective when pests number is very low.

The monitoring with pheromone traps is particularly useful when population density is low because it makes precociously evident an infestation. When population density is high,

the infestation is evident also through a visual inspection, so the number of captures is less important.

Nearly always, in the tests with 100 males, the average percentage of captures was under 50% (Table 3), only the wing trap with adhesive base caught 50.2% in 48 hours. Also in this case the highest number of captured males was in the first 24 hours. It was confirmed that the most efficacy traps were delta and wing traps.

In these tests, the wing trap with only adhesive top was less effective than the wing trap with adhesive base. In the wing trap with adhesive base and top the adhesive base captured more males than the top (table 4).

The experimental strip sticky trap was the less efficient of all the sticky ones: in fact, although *P. interpunctella* has an orientation preference for narrow rectangles (Levinson & Hoppe, 1983), the vertical position is not the best for the moth's flight.

Table 3. Cumulative percentage of captured males of *Plodia interpunctella* in 24 and 48 hours after the release of 100 moths.

Trap	% male captured after 24 hours $\pm$ SD	% male captured after 48 hours $\pm$ SD
Funnel	20 $\pm$ 13 ab	28 $\pm$ 12 ab
Delta	35.5 $\pm$ 3.2 cd	43.0 $\pm$ 3.2 c
Strip	14.3 $\pm$ 7.3 a	16.5 $\pm$ 7.8 a
Wing (adhesive base)	45.2 $\pm$ 5.5 d	50.2 $\pm$ 6.7 c
Wing (adhesive top)	27.2 $\pm$ 7.9 bc	30.2 $\pm$ 8.7 b
Wing (adhesive base and top)	34.7 $\pm$ 5.8 cd	38.5 $\pm$ 7.8 bc

Table 4. Cumulative percentage of captured males of *Plodia interpunctella* in 24 and 48 hours after the release of 100 moths with the wing trap (adhesive base and top).

Wing trap with adhesive base and top	% male captured after 24 hours $\pm$ SD	% male captured after 48 hours $\pm$ SD
Base	27.0 $\pm$ 3.4	30.0 $\pm$ 6.5
Top	7.7 $\pm$ 7.3	8.5 $\pm$ 7.0

It was confirmed that in presence of a low number of males, the effectiveness of all traps increased. In all tests the highest number of captures was in the first 24 hours.

The funnel trap is not as efficient as sticky traps in capturing Indian Meal Moths, although it is more adaptable in particular situations (e.g. dusty areas) and it has the capacity to contain a lot of insects compared to sticky traps, which become saturated early.

The strip trap has demonstrated a low efficacy compared to other sticky traps. In any case, it can be used in the highest flats of automatic warehouses, where others kinds of traps cannot be useful for the monitoring.

It was confirmed that the wing trap is the most effective for the monitoring of Indian Meal Moth.

The two types of wing traps with adhesive top have demonstrated a similar percentage of captures if compared to the wing trap with adhesive base, although the percentage of the top (in the wing trap with both surfaces glued), with 100 males, was low. They can be applied in dusty environments instead of funnel trap.

These data, associated to those obtained from new monitoring techniques, like spatial and geostatistical analysis, are useful tools to estimate the moths' populations in warehouses and food industries (Arbogast & Manking, 1999; Arbogast *et al.* 2000; Trematerra & Sciarretta, 2002).

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