MODIFICATIONS TO PHEROMONE TRAPS TO IMPROVE EFFICIENCY IN TRAPPING *PLODIA INTERPUNCTELLA* (LEPIDOPTERA: PYRALIDAE)

Iliyasu Mohammed Utono[1], Kabiru Kaka Aliyu[2], Alan Cork[3]

ABSTRACT

This study was conducted to evaluate the effect of pheromone trap modification on the catch of male *Plodia Interpunctella*. Laboratory experiments were conducted comparing pairs of different trap designs, each having different modifications, to determine the effect on moths catches Moths catch of standard funnel trap compared with a sticky delta trap was not significantly different ($p>0.05$). Delta trap modified with windows cut (12cm long x 7cm height) on the sides panel of trap proved to significantly caught more moths than the funnel trap ($p<0.05$). Changing a lure position within the modified delta trap from a suspended position to one directly on the sticky surface significantly increased moth catches ($p<0.05$). When the same two lure positions were compared in terms of the time elapsed between moths entering and eventually being trapped, it was found that trap with lure on the sticky surface caught moths more quickly than the other lure position ($p<0.05$). In the comparison of three traps heights, a modified delta trap placed on the cage floor proved to significantly catch more moths than the other two traps height. The results presented here recommended modified delta trap for use in the field.

Key words: Plodia Interpunctella; Pheromone trap; Lure; optimization, Searching time

[1] College of Agriculture, Nigeria, imutono@yahoo.com
[2] Agricultural Research Council of Nigeria
[3] Natural Resources Institute (NRI), UK

INTRODUCTION

The Pyralid moths such as *Plodia interpunctella* is an important pest of stored grain and other food industries that causes a great damage and losses to the stored food (Gwinner *et al*., 1990; Trdan *et al*., 2010). Early detection and obtaining other valuable information that can lead to a successful management of storage pests depend on the efficiency of monitoring techniques used (White, 2011). Hence, effective pests monitoring devices are required for a successful storage pests management. Pheromone traps baited with synthetic pheromone of *P. interpunctella* and *Ephestia species* have been used in monitoring to provide considerable valuable information about these storage species (Nansen *et al*., 2006; Witzgall *et al*., 2010). However, the effectiveness of trap baited with pheromone in monitoring depends on many factors such as lure characteristics (Manken *et al*.1980; Nansen and Phillips, 2004), trap positioning, trap height and trap designs (Mullen *et al*., 1998; Nansen *et al*., 2004) which may influenced the ability of traps to attract and retain moths.

Different insect species respond differently to different trap designs and it is as a result of this, Foster *et al.* (1991) and Phillip and Wyatt (1992) recommended the need to study the behaviour of a pest insect before designing or applying a trap system for its monitoring and control. For instance, Foster *et al.* (1995) had observed that male *Ctenopseustis obliquanna* approach delta traps by flying in a wide zigzag just around the top narrow end of the trap, resulting in a low catch. The response and approach behaviours were found to be different when the top barrier of the trap was removed and the design was changed to a rectangular shape which resulted to greater male catch. Foster and Muggleston (1993) found that increase in length of a trap by increasing the size area of sticky surface influenced the behaviours by which male *Epiphyas postvittana* enter and exit from trap. The response and approaches may be different with other species. Hence this may indicates that a minor change on trapping system could affect its catching efficiency (Phillips *et al*., 1992; VanRyckeghem, 2011).

The approach and entrance of *P. interpunctella* to a pheromone trap were found to be highly influenced by a trap physical surface which stimulated a landing plat form (Nansen *et al*., 2004). Cork *et al*. (2003) noted that modifying a delta trap lading plat form to have more entry window to increased moths entry and catch efficiency of the trap. However since moths attracted moved more directly to the pheromone source; this modification may resulted to a moth used the same entry window to fly out without being trapped; a factor that may reduce the trapping efficiency. This research, therefore, presents a work done with *P. interpunctella* to investigate effect of creating a window on entry and catch of *P. interpunctella* with a delta trap and also to evaluate the effect of the window on escape of the moths from trap. The overall aim is to explore how to maximise catch efficiency of *P. interpunctella* using a sticky delta trap. A bioassay was developed and tested in the laboratory, where the behavioural responses of *P. interpunctella* to different trap designs and positions were observed.

MATERIALS AND METHODS

P. interpunctella culture

The *P. interpunctella* culture was obtained from Ian Baxter, from a culture held at the University of Southampton, and which originated from the Danish Pest Infestation Laboratory at Lyngby, Denmark. The culture was reared in 2.5 L glass jar at the NRI insectary on organic whole wheat flour, glycerol and yeast in the ratio 10:2:1 respectively, in total amounts of approximately 200g. The cultures were maintained at a constant room temperature of 26^{o}C, and relative humidity of 50%, and the light period was 12hrs (00:00hrs-12:00hrs).

Pupae production and sexing

After eggs developed to larvae, the larvae were allowed to develop for some days before they became fully matured and 4 – 5 rolled strips of corrugated paper (18 × 3 cm) were placed in the jar for pupation. Seven to ten days later, the larvae began to develop into pupae, which were removed on a daily basis for sexing and bioassay. Sexing of pupae was done using a stereo light microscope (Leitz Wetzlar, Germany, 16-x magnification). Sexes were examined to determine the morphology of the terminal abdominal segments, which distinguished the two sexes. The sexed pupae (male) were put into separate dishes, which were labelled with the name and symbol of the sex and kept in a separate room to prevent experimental males from becoming habituated to pheromone when they emerged as adults. Later, the emerged male adults were taken to the bioassay room for experiments. The same room condition was used as in the culture room.

Trap design and modification used

The trap designs used for the experiment are standard plastic funnel uni-traps (11.5cm and 3cm top and base diameters and 18cm height of insect collector, 2cm height in between the top of the insect collector and the roof of the trap, Agrisense BCS Ltd, UK); sticky delta trap (20 x 21cm base and 28 x 15cm sides, Agrisense BCS Ltd, UK). About two modifications were made to the delta trap just to improve the catching efficiency of the trap: 1. by cutting a rectangular shape hole (12cm long x 7cm height) on both sides of the trap panel, 2. Lure position was changed from being suspended 4cm from the centre of the top of the trap (conventional method) to the bottom of the trap surface at the centre of the sticky surface.

Bioassay experiments

Different bioassay experiments were performed to assess the efficiency of the different trap designs and medication on moth catches. The first experiment (Figure1) was comparison of different trap designs (funnel trap and delta trap). This was to test the ability of the two traps to trap male *P. interpunctella*. In the second experiment (Figure 2), comparison was made between standard funnel trap, un-modified delta trap and modified delta trap to assess the effect of modification on trapping efficiency. The third experiment (Figure 3) was conducted to assess the effect of window cut on the two sides of the trap panel on moths catches; and change in the position of lure (lure suspended from the top on the centre of the trap and lure at the bottom surface of the trap on the centre of sticky surface) on the moths entry to the trap and time eventually trapped. The parameters assessed were number of visit and searching time before the moths were eventually trapped. In the fourth experiment (Figure 4) comparison were made for height, to assess the correct position for placing modified trap.

A wire frame (90cm long x 45cm height x 45cm width) stretched over with a transparent polythene bag placed on top of a laboratory bench was used as the experimental cage. The traps were compared by placing one of each in the cage, at either side of the cage opposite to each other at a distance of 40cm in between. Except when indicated otherwise i.e. for the height experiment, where traps were placed at equal heights within the cages. For each experiment, this arrangement was run in triplicate, over three successive days, i.e. making nine replicates in all. Each time the position of the trap in each cage was varied randomly. Each time 30-40 males of between 1-2 days old were released into the cages from the centre (in the morning) and the number trapped in each trap was recorded after 8 hours. Un-trapped males were removed daily.

To evaluate the effect of trap modification on moths entry, escape and searching time i.e. the number of visit to the trap and the time taken by the moth from the time it entered the trap (start searching) and the time it was eventually trapped, the cage was partitioned into two (each measured 45cm long x 45cm height x 45cm width). Each modified trap with differing lure position was placed in the centre of each cage. Each time one 1-2 day old moth was released from the centre of the cage. Observation was made and recorded simultaneously on the number of visit to the trap, number trapped and time taken searching for the phenomenon source before eventually trapped. This was repeated ten times with the assistance of two colleagues.

Pheromone lures were rubber septa containing 0.1mg of *P. interpunctella* pheromone blend, Z9, E12 – 14:Ac (NRI, UK); they were suspended 8cm above the trap bottom in a central position. Except when indicated otherwise i.e. in the experiment on lure positioning, lure position was varied upside-down to the bottom of the trap at the middle of the sticky surface. Lures were changed in every experiment. Chi-square test was used to compare and test the difference in mean number of insects entering each trap design and independent t-test (unrelated) for data from number of moths visit to the trap and searching time.

Figure 1: Comparing catch of two standard traps

Figure 2: funnel trap and modified delta trap

Figure 3: comparing traps with differing lure

Figure 4: Comparing catch of trap at three position heights

RESULTS

In the comparison of two trap designs (standard funnel trap and sticky delta trap), the result in (Table 4.1) shows that delta trap caught higher number of male moths than the funnel trap. However, the difference in catches between the two traps was found not to be statistically significant ($\chi^2 = 0.89$, df = 1, P > 0.35), suggesting that both traps were equally capable of catching moths. The second experiment compared captures by a modified delta trap (with two side windows) with those in a standard funnel trap. In contrast to the first experiment the result given in Table 4.2 shows that moth caught in the modified delta trap were significantly greater than in the standard funnel trap ($\chi^2 = 4.48$, d.f = 1, p < 0.03). Thus, change in the shape of delta trap can significantly improve catches.

The result in Table 4.3 shows that, change in the position of a lure within a trap can significantly affect moth catches. The trap with lure placed directly on a sticky surface significantly caught more moths than the trap with lure suspended above a sticky surface ($\chi^2 = 4.84$, d.f = 1, p < 0.028). In association with this experiment we further evaluated the effect of lure position on the number of visit to a trap and time between the moths entering the trap and the time it was eventually stuck to the sticky surface, this being considered as 'searching time'. The result in Table 4.4 shows that more moths significantly visited trap with suspended lure than trap with lure on the sticky surface (t=2.74, df=18, p<0.01). In addition the result shows that it took a moth an average of 18.6 seconds before becoming stuck to the adhesive substance in the trap with suspended lure, which was significantly longer than in trap with lure on the sticky surface (12.3 seconds) (t=2.104, df=18, p<0.04), which emphasized the importance of closeness of attracting substance to the trapping material.

In testing the best position for placing the modified trap for effective moth detection, the traps were tested on three height positions. The results in Table 4.5, shows that traps placed on the cage floor

(0.0cm) caught the most moths, while those at the intermediate height of 45cm caught least. These differences were found to be highly significant when subjected to a χ^{2}-test (χ^2 = 4.21, d.f =2, p < 0.04).

Table 4.1. Effect of trap designs on catch of male *P. interpunctella*

Trap type	Mean catch per trap per day	χ^2- value	P value
Funnel trap	7	0.89	0.35
Delta trap	11		

Mean number of male *P. interpunctella* caught per trap design, n=30 males released in three replicates over each of three days. A significant difference between the catches of each trap was attained when P < 0.05. χ^2 and P values are those calculated for a 2 × 2 goodness of fit test, with one degree of freedom, where the null hypothesis is an equal distribution of captures in the two traps.

Table 4.2 Effect of trap modification on catch male *P. interpunctella*

Trap type	Mean catch per trap per day	χ^2- value	P- value
Funnel trap	8	4.48	0.034
Modified delta trap	19		

Mean number of male *P. interpunctella* caught per trap design, n=40 males released in three replicates over each of three days. A significant difference between the catches of each trap was attained when P < 0.05. χ^2 and P values are those calculated for a 2 × 2 goodness of fit test, with one degree of freedom, where the null hypothesis is an equal distribution of captures in the two traps

Table 4.3 Effect of changing position of lure in the modified delta trap on catch of *P. interpunctella*

Lure position in modified delta trap	Mean catch per trap per day	χ^2- value	P- value
Suspended lure	7	4.84	0.028
On sticky surface	23		

Mean number of male *P. interpunctella* caught per trap with deferring lure position, n=40 males released in three replicates over each of three days.

Table 4.4 Indicates difference in mean of number of moths visit to the trap and time taken searching for the pheromone source between two modified delta trap with different lure position

	Position of lure in the trap			
	Lure suspended Mean ± SE	Lure on sticky surface Mean±SE	t-value	P-value
Numb of visit to trap	2.7 ± 0.33	1.5 ± 0.22	2.104	0.04
Searching time (seconds)	18.6 ± 2.79	12.3 ± 1.06	2.74	0.01

Mean± SE number of male *P. interpunctella* showing difference in number of visit and searching time to a trap with differing lure position. P and t values are those calculated for an Independent t-test (variance not equal) analysis at n=10. Significant difference between the two mean was attained when P < 0.05

Table 4.5 Effect of trap height on catch of male *P. interpunctella*

Trap height (cm)	Moth catch	χ^2 - value	P- value
0.0	18	4.21	0.040
45	4		
90	10		

Mean number of male *P. interpunctella* caught per trap height, n=40 males released in three replicates over each of three days. A significant difference between the catches of each trap was attained when P < 0.05.

DISCUSSIONS

Pheromone traps, are valuable tools in monitoring and control of stored product pests (Nansen *et al*., 2006; Witzgall *et al*., 2010). However, effectiveness of pheromone traps catch is affected by many factors notably; trap designs, which often influenced the kind of approach of insect to a trap (Foster *et al.*, 1995; VanRyckeghem (2011). The result of this research demostrated that modifying a pheromone trap can significantly improve moth catches.

Our results shows that both standard delta and funnel traps have equal chance of catching male *P. interpunctella*. However when two same size windows were created on the both sides of delta trap, the moth caught in the modified delta trap were significantly different from the catch in standard funnel trap. This correspond with the finding of Cork *et al*. (2003) working on trap optimization for the brinjal shoot and fruit borer, *Leucinodes orbonalis.* They observed that changing the shape of a delta trap by creation of two small windows increased *L. orbonalis* catches more than the other trap designs tested. Although it is quite true that trap modification can increase moths catch, however, creation of windows on the side of traps seemed to create chance for the moths to escape. This was exactly noted during this experiment when some of the moths that entered the trap escaped after a few seconds of searching. A phenomenon that Cork *et al*. (2003) did not looked at and addressed. Hence Devising a means which can reduced, if not prevent the moth from escaping through these holes, could add more to the catch efficiency of the modified trap. To do this we hypothesize that entry windows created close to the pheromone source allowed moth easy movement in and out to the trap; therefore change in the lure position which serves as the source of attractant close to the trapping materials could enhance the catch efficiency of the trap. Hence the position of the lure used was changed to directly on the sticky surface, such that when moths were attracted to the lure their chances of being trapped by the glue could be increased. Therefore a high catch obtained in the trap with lure on the sticky surface could be due to the closeness of the pheromone source to the glue substance. In the trap with suspended lure, the moths had a higher probability of searching round for the pheromone source without contacting the sticky surface and then easily escape.

The result for number of visits to the trap and searching time by the moths to the trap with different lure position suggested that moths visited trap with suspended lure more often than trap with lure on the sticky surface. However trap with lure on the sticky surface proved to trap moths more quickly than when it was suspended within the trap. In a trap with suspended lure, pheromone source was more close to the landing plat form and will more readily be dispersed to all directions, thus improving the probability of attracting moths to the vicinity of the trap. This can be interpreted to mean that in both cases, moths went directly to the pheromone source, but because the glue was closer to the lure in one case, they were captured more quickly.

To evaluate the correct position for placing traps in a store for best moth catch, the modified trap placed at three heights within the bioassay cage demonstrated more moths catch at lower height. This finding is in common with that of Nansen *et al.* (2004) who found that placing a diamond trap near the ceiling or near the ground in a warehouse gave the best catch. The low catches by traps placed at height of 45cm could be due to the influence of competition from the other traps, where as each of the upper and lower traps only had one competing neighbour. Some weak moths, which cannot fly are drawn by the pheromone and can crawl down to trace the pheromone source. This could explain the high catches in traps at 0.0cm.

The laboratory experiment with modified delta traps with lure positioned on the stick surface proved to be effective in quickly identifying and catching male *P. interpunctella*, which may be a useful tool for monitoring. However it is highly recommended a similar trap should be tested in storage to validate the efficacy of the trap with these new modifications.

REFERENCES

Cork, A., Alam, S.N F., Rouf, M.A. and Talekar, N.S. (2003). Female sex pheromone of brinlal fruit and shoot borer, *Leucinode orbonalis* (Lepidoptera: Pyralidae): trap optimization and applications in IPM trials. *Bulletin of Entomological Research* 93**,** 107-113.

Foster, S.P., Ayers, R.H. and Muggleston, S.J. (1995). Trapping and sex pheromone mediated flight and landing behaviour of male *Ctenopseustis obliquana*. *Entomologia Experimentalis et Applicata* 74, 125-135.

Foster, S.P., Muggleston, S.J. and Ball, R.D. (1991). Behavioural responses of male *Epiphyas postvittana* (walker) to sex pheromone baited delta trap in a wind tunnel. *Journal of Chemical Ecology* 17, 1449-1468.

Foster, S.P., Muggleston, S.J. (1993). Effect of design of a sex pheromone baited delta trap on behaviour and catch of male *Epiphyas postvittana* (Walker). *Journal of Chemical Ecology* 19, 2617-2633.

Gwinner, J., Harnisch, R. and Mück, O. (1990). *Manual on the prevention of post-harvest grains losses*, post harvest project, pickhuben 4, D-2000 Hamburg. 294pp.

Howse, P. E., Sevens I.D.R. and Jonies, O.T. (1998). *Insects pheromones and their uses in pest management*. Chapman and Hal, London, 369pp.

Mankin, R.W., Vick, K.W., Mayer M.S. and Coffelt, J.A. (1980). Anemotactic response threshold of the Indian meal moth, *Plodia interpunctella* (Hubner) (Lepidoptera: Pyralidae) to its sex pheromone. *Journal of Chemical Ecology* 6, 919-929.

Mullen, M.A., Wileyto, E.P. and Arthur, F.H. (1998). Influence of trap design and location on the capture of *Plodia interpunctella* (Lepidoptera: Pyralidae) in a release-recapture study. *Journal of Stored Products Research* 34 (1), 33-36.

Nansen, C., Phillips, T.W., Morton, P.K. and Bonjour, E.L. (2006). Spatial analysis of pheromone-baited trap captures from controlled releases of male Indianmeal moths. *Environmental Entomology* 35, 516-523.

Nansen, C., Phillips, T. W. and Sanders, S. (2004). Effects of height and adjacent of surfaces on captures of Indian meal moth (Lepidoptera: Pyralidae) in pheromone baited traps. *Journal of Economic Entomology* 97 (4), 1284-1290.

Phillip, A.D.G. and Wyatt, T.D. (1992). Beyond origami: using behavioural observations as a strategy to improve trap designs. *Entomology Experimentalis et Applcata* 62, 67-74.

Savoldelli, S. (2004). Evaluation of the efficacy of different kinds of pheromone traps for the monitoring of *Plodia interpunctella* (Lepidoptera: Pyralidae). *Bulletin OILB/SROP* 27 (9), 103-108.

Trdan, S., Kač, M., Vidrih, M. and Laznik, Z. (2010). Seasonal dynamics of three lepidopteran stored grain pests in Slovenia. The 10th International Working Conference on Stored Products Protection. *Julius-Kühn-Archiv* 425, 197-201.

VanRyckeghem, A. (2011). Pheromones: a resourceful tool in modern urban pests management. In: Dhang, P. (Ed.). *Urban pest management: an environmental perspective*. CABI International, UK, 175pp.

White, A.L.M. (2011). Population dynamics of stored-product insects at a rice mill in northeast Arkansas. Arkansas state university. Arkansas, 130pp.

Witzgall, P., Kirsch, P. and Cork, A. (2010). Sex pheromone and their impact on pest management. *Chemical Ecology* 36, 80-100.