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# EVALUATING A REMOTE MONITORING DEVICE FOR STORED GRAIN INSECTS IN A COMMERCIAL FACILITY

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## ABSTRACT

The StorMax Insector is an electronic device for remotely monitoring insects in stored grain. Arthropods migrating within the grain mass encounter the probe trap body and are electronically counted by a computer as they fall through and interrupt infrared beams. A study in two large commercial steel bins containing stored wheat was conducted in Oklahoma to determine the accuracy of electronic counts recorded by Insector compared to actual counts of arthropods collected in the probe collecting tip. Electronic counts were approximately two times higher than actual counts over a range of counts. The probable cause of overestimation was the extremely high number of insects in the family Psocidae that entered the traps. Refinement of the discriminating values entered into the software program will be able to filter out counts of these small insects and remove them from the reported counts to make the estimate more accurate for stored grain beetles counted. Insectors with collecting tips with holes near the bottom for insect release allowed insects to escape after passing through the sensor, including the high number of Psocidae. Using Insector technology to monitor insect activity will determine when treatment is necessary and improve safety by reducing the need for workers to enter grain bins.

## INTRODUCTION

Stored grain pest management relies on effective sampling to determine the species present and the relative number of these species in a grain mass. Commercially available probe traps are used for detecting insect populations in stored grain (White *et al.,* 1990) but these traps must be inspected periodically to determine the number and kinds of arthropods captured. Shuman *et al.* (1996) developed an electronic probe trap that generates an electronic count whenever an arthropod falls through a single infrared beam in the sensor head. The original Electronic Grain Probe Insect Counter (EGPIC) was a major improvement over other probe traps used to detect insect infestations in grain bins (Toews *et al.*, 2003). The newest version of EGPIC, the StorMax Insector, incorporates two infrared beams and a microcontroller chip built into the new system's probe that analyze the signals from the beams to determine the relative size of counted insects and infer species identification (Shuman and Crompton, 2004).

Most of the preliminary Insector testing occurred in 10 cm diameter mini-silos in the laboratory. These laboratory tests were conducted in very clean grain with only one insect species per experiment. To be accepted for use by a variety of grain managers, Insector needed to be evaluated in field tests in different commodities and under different environmental conditions with various populations of insects. The objective of our research was to evaluate the performance of Insector in capturing stored grain insects in naturally infested commercial wheat bins in Oklahoma.

## MATERIALS AND METHODS

This field test was conducted from 25 Aug – 8 Oct 2003 in central Oklahoma. Eleven sampling periods varying from 2-5 days in length were evaluated. Initially, five probes were placed in each of two bins that each contained 6,804 mt of hard red winter wheat that had been harvested during June 2003. One probe was placed in the center of the bin and one probe was place in each cardinal direction approximately 3 m from the bin wall. Each probe was inserted vertically into the grain mass approximately 5 cm below the grain surface. The bins were naturally infested with insects. Bin 1 was fumigated on 15 Sept 2003 prior to selling the grain. The probes in Bin 1 were removed from the bin prior to fumigation and four of the probes were moved to an inner circle in Bin 2 and placed approximately 7.5 m from the bin wall in the four cardinal directions.

At the end of a sampling period, the contents of each Insector receptacle were removed and placed in a vial to take to the laboratory for processing, and samples of grain were collected using a spear-type grain trier. Three grain samples of approximately 1 kg each were collected near each Insector probe from the top 0.7 m of grain. Grain samples were sealed in plastic bags and taken to the laboratory where the grain weights and moisture contents were recorded. The samples were then sieved twice using an InsectoMat (Samplex Ltd., Norfolk, UK). Beetles and parasitic Hymenoptera captured in the traps were identified by species. Members of the family Psocidae and mites were not identified by species, but were categorized into the two respective groups and their numbers estimated.

Some Insector probes were also tested with probe tip receptacles that contained holes near the bottom of the tip. The purpose for this test was to determine if insects would leave the receptacle and return to the grain mass.

Data files generated by the Insector software were downloaded to disk after every sampling period. These data contained insect counts and species identification that were compared to actual counts of insects in the Insector collecting tip.

## RESULTS AND DISCUSSION

Several stored grain beetle species were captured in the Insector receptacles during this field study. The most common species were *Cryptolestes ferrugineus* (Stephens), *Tribolium castaneum* (Herbst), *Rhyzopertha dominica* (Fabricius), and *Oryzaephilus surinamensis* (Linnaeus). An example of the accuracy of actual insect counts compared to electronic counts is shown in Fig. 1 for *C. ferrugineus* during one sampling period. As the number of insects counted in the probe receptacles increased, the electronic counts also increased linearly with a very high $R^2$ value. However, the electronic counts were overestimating the actual insect counts by a factor of approximately two. All sampling periods had a similar overestimation of actual counts.

The probable cause for the overestimation was because there was a very high population of Psocidae in the bins in comparison to the number of beetles. Thousands of electronic counts were recorded for each probe during the study. Accurate actual counts of Psocidae from the probe receptacles were difficult to make because so many Psocidae were captured that the contents became a paste with individuals difficult to separate. Some of these Psocidae may have been mistakenly identified by size as *C. ferrugineus*, the smallest of the beetle species captured. It is also likely that the large number of Psocidae entering probes caused grain particles or other debris that were the same size as target insects, thus causing an increase in counts. Subsequent laboratory tests with Psocidae have been conducted to determine the size threshold value to set in the software to eliminate most Psocidae from being counted electronically.

Insector probes tested with receptacles containing holes allowed all beetle species, mites, and members of the family Psocidae to return to the grain mass. Using the receptacles with holes would require less maintenance and fewer trips to the bin to service probes. Electronic data would still be collected from the probe to provide information needed to make management decisions. A study needs to be conducted to determine whether the insects that leave the receptacle will move up through the grain mass and reenter the probe. If insects reenter the probe and thus get counted again, the insect count data would be inflated compared to the actual number of insects. This could lead a manager to make incorrect management decisions or make decisions to fumigate before they were needed.

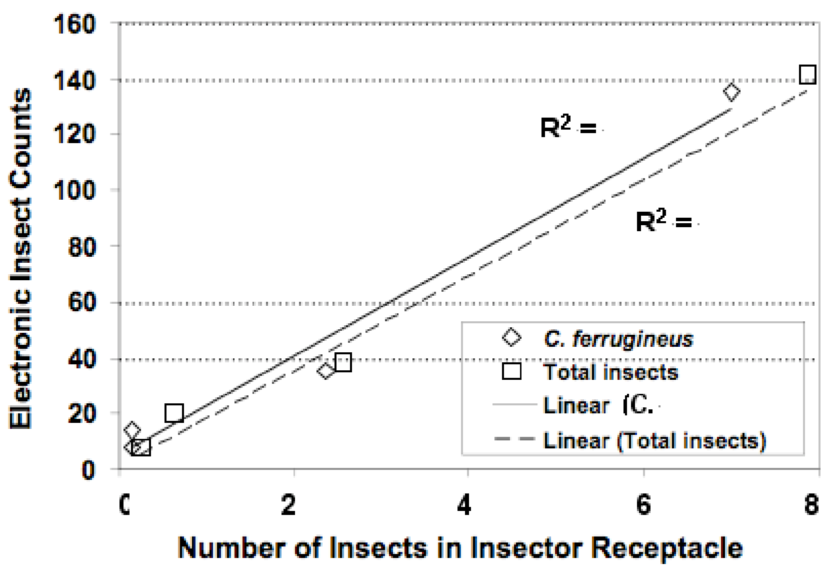


Figure 1. Insector Performance, 10-12 September 2003

Our study contrasted with a concurrent field study in Montana, although similar high $R^2$ values were observed in both studies indicating a good linear fit between actual and electronic counts (D.K. Weaver, personal communication). The actual counts were nearly a 1:1 relationship with the electronic counts in the Montana study while we observed a nearly 2:1 overestimation in Oklahoma. From 30 August – 5 September 2003 in Montana, a maximum of 23 *C. ferrugineus* were captured during this 6-day period while in Oklahoma, 72 *C. ferrugineus* were captured in a 3-

day period. The bins in Montana did not have a high number of Psocidae. Possible explanations may be differences in the arthropod species complex, differences in the physical stored grain environment, and the total number of insects in the bin. Lower insect populations are usually observed in grain stored in Montana while insect populations can be very high in Oklahoma, mainly because of the warmer grain temperatures and the longer storage period when the grain is warm.

Data collected from grain trier samples along with the electronic data will be integrated into the Stored Grain Advisor (SGA), a decision support system for stored grain (Flinn, 1999). That system interprets information from standard sampling procedures, predicts the likelihood of insect infestation, and recommends appropriate preventative and remedial action. The electronic data, especially species identification, will be read and interpreted by SGA, which will then make recommendations to the grain manager.

The interpretation of electronic counts has to be carefully evaluated before developing a management strategy to control pests. Refinement of the discriminating values for the software will filter out electronic counts of small insects and provide more accurate estimates of stored grain beetles. The StorMax Insector should be a useful tool for accurately estimating insect populations to help grain managers make the best decisions for when treatment is necessary. Using this technology will also improve safety at grain storage facilities by reducing the need for workers to enter grain bins. Ultimately, this technology will also improve the quality of stored grain by treating grain only when necessary, by lowering pest populations, by decreasing pest control costs, and by reducing pesticide residues.

## REFERENCES

Flinn, P. W. (1999) Stored Grain Advisor Expert System http://bru.gmprc.ksu.edu/proj/sga/

Shuman, D., Coffelt, J.A. and Weaver, D.K. (1996) A computer-based electronic fall-through probe insect counter for monitoring infestation in stored-products. *Transactions of the American Society of Agricultural Engineers*, **39,** 1773-1780.

Shuman, D. and Crompton, R.D. (2004) Sensor output analog processing -- A microcontroller-based insect monitoring system. U.S. Patent Number 6,707,384.

Toews, M.D., Phillips, T.W. and Shuman, D. (2003) Electronic and manual monitoring of *Cryptolestes ferrugineus* in stored wheat. *Journal of Stored Products Research*, **39**, 541-554.

White, N.D.G, Arbogast, R.T., Fields, P.G., Hillmann, R.C., Loschiavo, S.R., Subramanyam, Bh., Throne, J.E. and Wright, V.F. (1990) The development and use of pitfall and probe traps for capturing insects in stored grain. *Journal of the Kansas Entomological Society*, **63,** 506-525.