Stored product beetles: How physical and biological factors affect residual efficacy of insecticides

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Abstract
Two formulations of the insecticide chlorfenapyr (Phantom SC or PI) were evaluated for control of the red flour beetle (Tribolium castaneum Herbst) and warehouse beetle (Trogoderma variable Ballion). Studies were done by first constructing concrete exposure arenas in 15 cm plastic petri dishes; these arenas consisted of a solid concrete arena or one in which a crevice was created in the center of the arena. The insecticide formulations were then applied to the entire surface, to the crevice only, to the entire surface except for the crevice, or to the surface and crevice with food in the crevice. An untreated control was also Included. Adults of each species were exposed for 8 hours and 1, 2, 3 and 4 days on the arenas. Survival was assessed daily but only the final counts at day 4 are presented. Phantom PI had more residual efficacy than Phantom SC but there was no difference in response between laboratory strains of the red flour beetle and the warehouse beetle. However, two warehouse beetle field strains were significantly more tolerant to both formulations compared to the laboratory strain, but the PI formulation was still more effective than the SC.

Introduction
In stored product pest control, one scenario which has continued to play a major role in insect control is the problem of crevices. Crevices not only provide a hiding place/shelter for insects, if food and debris are present, a harborage for insect pests is created and related sanitation issues may also become problematic. The purpose of this study was to look at controlling warehouse beetle and red flour beetle on concrete, in a crevice scenario to determine which treatment provided the best control in a crevice scenario.

Materials and Methods
Colonies
Two lab colonies, warehouse beetle (WB-LAB) and red flour beetle (RFB-LAB), which had been reared under lab conditions for over 30 years were selected in addition to two field strains of warehouse beetles collected in August 2012, Arkansas (WB-AR) and central Kansas (WB-CKS). Figure 1.

Treatments
Five treatments were set up for each replication:
untreated control (UTC)
crevice only (C)
surface only (S)
crevice and surface (All)
crevice treatment over food-in-crevice (FC)

Figure 1

Arenas
Arenas were prepared by pouring concrete into 15 cm plastic petri dishes (Figure 3). Crevices were created using plastic drinking straws cut to length (Figure 2).

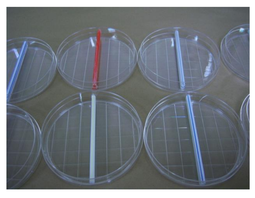


Figure 2

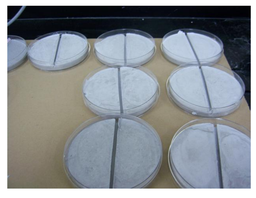


Figure 3

Materials and Methods (continued)
For those plates containing the food-in-crevice, ½ teaspoon of vanilla protein diet was put into the crevice prior to treatment (Figure 4). Diet was spread evenly throughout the crevice using a paint brush (Figure 5).

Figure 4

Figure 5

Five replications of each experiment were conducted.

Insecticides
Phantom SC was used at less than label rate, 55mg AI/m^2 based on finding by Arthur, 2013 (1). Phantom PI was applied at label rate equivalent to 1 second of spray per 154 cm2

Cardboard half circles were custom fit to each plate to avoid spraying surfaces in crevice only treatments. For surface only treatments, straws used to make the crevice were pushed back into the crevice to prevent crevice treatment (Figure 6).

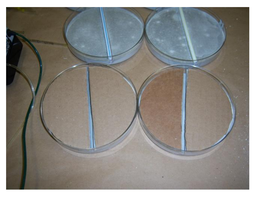


Figure 6

Application if Phantom SC was conducted using an artist air brush, while holding the air brush about 6-inches above the treatment area (Figure 7).

Phantom PI is a ready-to-use insecticide formulation. The applicator tip on the spray can was used, holding the tip about 10-inches from the surface of the plates while making the application (Figure 8).

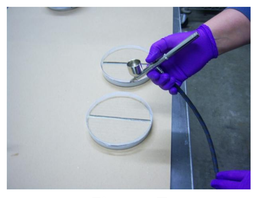


Figure 7

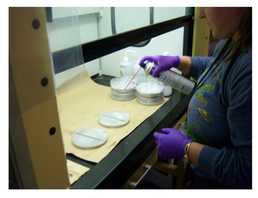
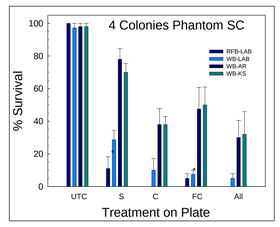


Figure 8

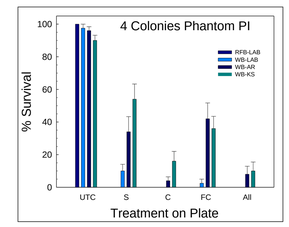
Results
In the Phantom SC treatments, no RFB survived by day 4 in the Crevice only treatment or the surface and crevice (all) treatment. Both field strains of warehouse beetle were more tolerant of Phantom SC with survivorship more than double that of the lab strains. The increased variability in the standard error of food-in-crevice and all treatments are indicative of the increased variability in those treatments. There were no significant differences between the warehouse beetle field strains to Phantom SC. (Graph 1)

The Phantom PI treatment was more effective overall. All populations Were less tolerant of Phantom PI than Phantom SC. No RFB survived In any of the Phantom PI treatments by Day 4.

Results (continued)
In the crevice only and the surface-and-crevice (all) treatment there were also no surviving WB-LAB beetle adults. In all treatments except the food-in-crevice the WB-KS population was more tolerant than the WB-AR population. (Graph 2)



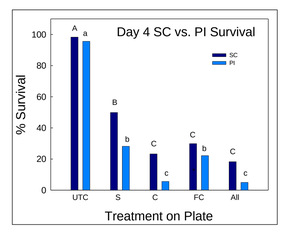
Graph 1



Graph 2

Significant differences in the treatments by pesticide was seen. In Phantom SC, the surface treatment had significantly increased survivorship over the crevice, food-in-crevice, and the surface-and-crevice (all) treatments which were statistically similar. (Graph 3)

In those petri dishes treated with Phantom PI, there were no significant differences between the surface and the food-in-crevice treatments. There was also no significant differences between the crevice only treatment and the entire petri dish treatment. (Graph 3) The untreated controls were significantly different from any of the pesticide treatments.



Graph 3

Discussion
Both Phantom SC and Phantom PI were most effective in crevice and/or all surface treatments. Beetles were usually observed harboring in crevices at the time of evaluation. The amount of time beetles spend wandering in the petri dishes is unknown.

Phantom PI, although more effective, is not labeled for stored grain pest use. Phantom SC is very effective on lab colonies, but less effective on field strains, especially if the crevice was not treated. In Arthur, 2013 (1) red flour beetles exposed to pesticides, with food source present, were less affected by pesticide residues. A similar situation exists in the food-in-crevice treatments, which are less effective. However, this scenario may more closely relate to an in-field application.

A future study to evaluate the wandering behavior of warehouse beetles and red flour beetles in the petri dishes is being considered.

Reference
Arthur, Frank. 2013. Dosage Rate, temperature, and food source provisioning affect susceptibility of *Tribolium castaneum* and *Tribolium confusum* to chlorfenapyr. Journal of pest science. 86:507-513.