Assessing the long-distance repellency of long-lasting insecticide netting to a suite of post-harvest insects

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Introduction

Insects are our main competitors for food on the planet.[1] In fact, growers lose 10-30% of crops during storage, processing, and marketing after harvest each year to stored product insects.[2,3] Challenges to current management include increasing insecticide resistance to phosphine[4], which is the most common insect fumigant. Another challenge has been an increasing demand for organic or low insecticide-input products by consumers.[5] To meet these challenges we came up with an alternative management approach, a long lasting insecticide netting (LLIN). Insecticide-treated nets have been widely used as a tool for malaria vector control in tropical regions since the early 1990s.[6] These nets are typically treated with a pyrethroid insecticide, such as permethrin or deltamethrin, which repel, incapacitate, and kill mosquitoes that land on the nets. Researchers have recently begun exploring the use of LLINs for management of agricultural pests in high value specialty crops.[7] More recently, work with LLINs in post-harvest settings has demonstrated that this tool can induce mortality, as well as significantly decrease the movement and dispersal capacity of post-harvest insects.[8] Some possible uses for LLIN include being used to line windows, vents, eaves, or other openings into food facilities. However, anecdotal evidence from IPM practitioners has suggested that pyrethroids, which the LLIN contains, may be repellent to specific groups of insects. In order for LLIN to be an effective tool at intercepting and preventing infestation by stored product insects, we must demonstrate that the netting is not repellent to a range of post-harvest insects.

Objective

Our goal was to determine the long-distance repellency of the long-lasting insecticide netting on the suite of four post-harvest species of beetles below.

Study Species

Confused Flour Beetle (CFB)

Saw-Toothed Grain Beetle (STGB)

Maize Weevil (MW)

Red Flour Beetle (RFB)

Materials and Methods

Source Individuals. For all assays, 4-8-week-old individual of each species were used. RFB and CFB were reared on flour (95%) and brewer's yeast (5%), while STGB and MW were reared on 13% tempered wheat (all held at 27.5˚C, 60% RH, and 14:10 L:D).

Wind Tunnel Assay. Long-distance repellency was studied with 5 x 5 cm pieces of long-lasting insecticide netting with deltamethrin or control netting without insecticide (Fig. 1A, B). Odor sources were placed in 20 mL headspace vials without lids, and located 13.5 cm upwind of the stimulus edge of a 21.6 x 27.9 cm paper release arena. The edge on which adults exited was recorded as either the stimulus edge (Fig. 1D), or non-stimulus (one of the other three edges). The time to decision was also recorded for each beetle. Trials lasted 2 min, and non-responders were excluded from the analysis. A total of n=30 (CFB), 30 (STGB), 60 (MW), 280 (RFB) replicate individuals were tested per treatment and species combination.

Statistical Analysis. For the wind tunnel assay, chi-squared tests were performed on the proportion of insects leaving on the stimulus edge of the arena for each species between treatments, under the null hypothesis that equal percentages of beetles would leave for both treatments. To understand whether the time to decision varied between treatments, a t-test was used to compared responses for each species. For all tests, alpha = 0.05.

Fig. 1 A) Long-lasting insecticide netting and **B)** control netting without insecticide tested in wind tunnel; **C)** pulling individual beetles from colonies for testing, and **D)** wind tunnel assay setup.

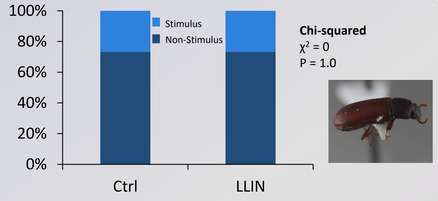
Results & Discussion

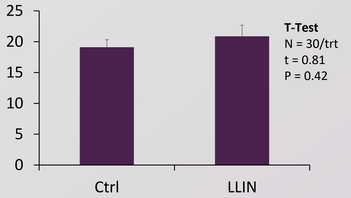
Repellency

Time to Decision

Confused Flour Beetle (CFB)

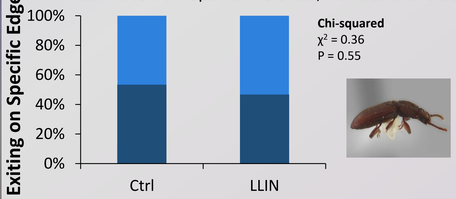
- LLIN was not repellent to CFB, nor was there a significant difference in the time to decision.

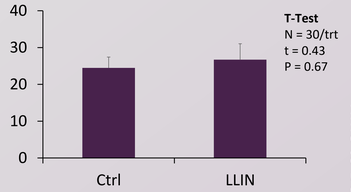




Saw-Toothed Grain Beetle (STGB)

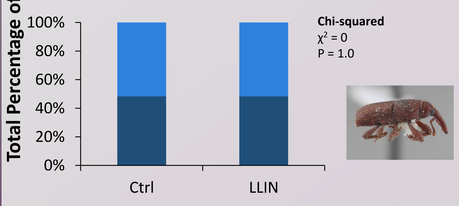
- LLIN was not repellent to STGB, nor was there a significant difference in the time to decision.

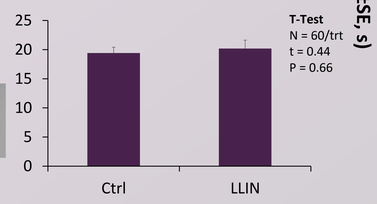




Maize Weevil (MW)

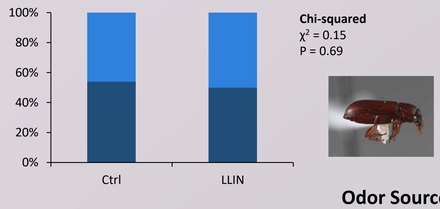
- LLIN was not repellent to MW, nor was there a significant difference in the time to decision.

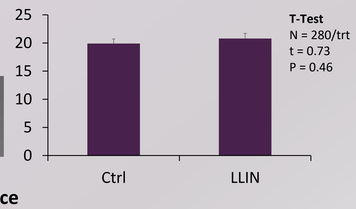




Red Flour Beetle (RFB)

- LLIN was not repellent to RFB, nor was there a significant difference in the time to decision.





Odor Source

Conclusions & Future Work

The long-lasting insecticide netting was not repellent to any of the tested species, suggesting that as individuals are foraging in the wild, they will contact the netting and be exposed to the insecticide. Taken together with the significant impacts on the movement and dispersal capacity of LLIN, this is a promising tool to diversify IPM programs for stored product insects.

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Acknowledgements

I would like to thank Dr. Jeremy Marshall for this research opportunity. I would also like to thank both Rachel Wilkins and Dr. Rob Morrison for helping and guiding me throughout my research project. The mention of any trade names is for the purposes of providing scientific information only, and does not constitute endorsement by the United States Department of Agriculture. The USDA is an equal opportunity employer. This work was funded by a USDA NIFA Crop Protection and Pest Management Grant # 2017-70006-27262.