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[Bed Bug Supplement] Trouble Brewing for Insecticides?

Supplement - Bed Bug Supplement

Bed bugs are adept at becoming resistant to insecticides. While the new combo products are performing well in the field, University of Kentucky researchers say they foresee problems down the road.

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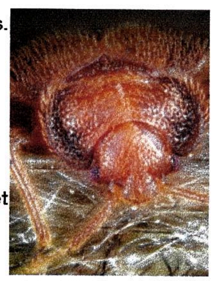

Cimex lectularius photo by Gilles San Martin

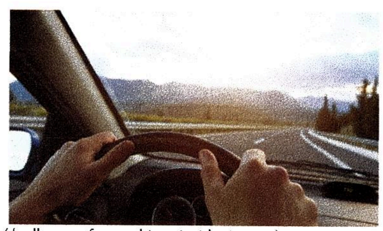
Insecticides have long been instrumental in managing bed bugs. Although non-chemical measures such as heating, encasing, vacuuming and vigilance are important, most companies also rely on insecticides to affordably and efficiently control infestations. The insecticides used for bed bugs in recent times have been mainly pyrethroids. However, results have been inconsistent and resistance seems to be widespread (Romero et al. 2007ab; Zhu et al. 2010). To achieve better control of resistant populations, manufacturers recently introduced formulations containing two distinct active ingredients — a pyrethroid and a neonicotinoid. At least four such combo products are being marketed for bed bugs (Bayer Environmental Science's Temprid, FMC Professional Solutions' Transport, Syngenta Professional Pest Management's Tandem and MGK's Bedlam Plus), with more expected in the future. Laboratory and field reports indicate the products are more efficacious than pyrethroids alone and are now the most utilized category for bed bug treatment (Potter et al. 2012, 2013).

While the combination products are currently performing well in the field, we are concerned about their longevity given the adaptability of this insect. The present study offers clues to what the future may hold for these compounds.

The Study.

Three laboratory experiments were conducted to assess the likelihood of bed bugs developing resistance to two popular combination insecticides: Temprid and Transport. Methods and results for each experiment are presented below.

THE PULSE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VIDEOS & PODCASTS

1. Population susceptibility. No two bed bug populations are identical in their susceptibility to insecticides. Consequently, the best way to forecast performance of products in the field is to evaluate them against multiple strains. In this experiment, 10 different populations of bed bugs were exposed to either Temprid SC (ß-cyfluthrin + imidacloprid) or Transport GHP (bifenthrin + acetamiprid). Four of the populations had been maintained in the lab for long periods (6, 6, 8 and 39 years), while the other six strains were collected from the field more recently, during the past one to two years (Table 1). All bugs were fed weekly on warmed rabbit blood using an artificial feeding system. Adult bed bugs (in most cases, 60 or 120 per population), were placed onto filter paper discs previously treated with label rate solutions of Temprid SC (0.075 percent), Transport GHP (0.11 percent) or water alone. Treated discs were allowed to dry completely before bugs were placed on the surface. Mortality was recorded after 1, 2, 3, 7 and 14 days of continuous exposure to each treatment.

Table 1. Origins and collection dates of bed bug populations utilized and their previously determined resistance level to pyrethroids.

Name	City	Collection Date	Pyrethroid Resistance[a]
FD	Fort Dix, NJ	<1974	Susceptible
CIN1	Cincinnati, OH	2005	Initially highly resistant, now moderately resistant
NY1	New York, NY	2007	Initially highly resistant, now moderately resistant
LA1	Los Angeles, CA	2007	Susceptible
LEX5	Lexington, KY	2011	Unknown
FF1	Frankfort, KY	2012	Unknown
RO1	Royal Oaks, MI	2012	Unknown
LEX7	Lexington, KY	2012	Highly resistant
LEX8	Lexington, KY	2012	Unknown
CIN10	Cincinnati, OH	2012	Highly resistant

[a] *Resistance level based on exposing bugs to an elevated dose of deltamethrin (0.6%) as a dry deposit for 24 hours. Populations were considered susceptible if mortality was >95%, moderately resistant if mortality was <50% and highly resistant if mortality was <5%.*

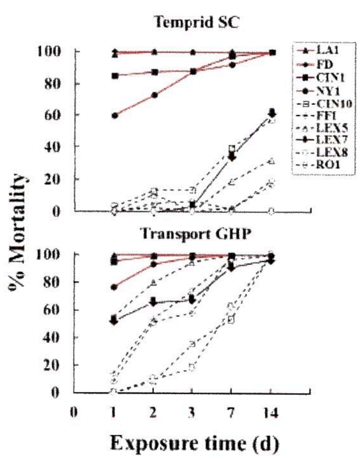

Figure 1. Cumulative effect on 10 different bed bug strains exposed to Temprid SC or Transport GHP. Populations indicated in red were maintained in the laboratory for several years.

Results. Susceptibility to both Temprid SC and Transport GHP varied widely among populations (Figure 1). Both products were very effective against the four bed bug strains maintained in the laboratory for several years (FD, LA1, CIN1 and NY1). FD and LA1 are highly susceptible to pyrethroids and also succumbed quickly to Temprid SC and Transport GHP. NY1 and CIN1 were highly resistant to pyrethroids when first collected from the field in 2005 and 2007, but have since reverted to being moderately resistant (Romero et al. 2008, Zhu et al. 2013). Temprid SC and Transport GHP also were effective against these populations, although longer exposure times were needed to achieve 100 percent mortality.

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Neither product performed as well against the six populations collected from the field more recently. After a full day of exposure to Temprid SC, no bugs had died in strains RO1, LEX5, LEX7 or LEX8 and fewer than 5 percent succumbed in CIN10 and FF1. Better results were observed with Transport GHP, although after one full day of exposure all six populations still had less than 60 percent mortality and no mortality had occurred in the CIN10 or LEX8 strains. Mortality generally increased with longer exposure to treated surfaces, especially with Transport GHP. A two-week exposure to the formulation resulted in nearly 100 percent mortality of all populations (LEX7 mortality was 97 percent). Mortality at two weeks of continuous exposure to Temprid SC ranged from a high of 61 percent (LEX7) to a low of zero percent (LEX8).

Bed bugs were continuously exposed to dry insecticide deposits.

2. Influence of formulation. Formulation can have a big influence on the efficacy of insecticides. For dilution in water, Temprid SC is formulated as a suspension concentrate while Transport is available as either a micro-emulsion (Mikron) or wettable powder (GHP). For indoor pests including bed bugs, Transport Mikron is used most often since spotting or staining of some surfaces can occur with wettable powders. We wanted to determine if both formulations of Transport were similarly efficacious. For this experiment, adult bed bugs from three populations (CIN1, NY1 and FF1) were confined on filter paper discs treated with Transport Mikron, Transport GHP, Temprid SC or water alone. Treatments were allowed to dry completely before adult bed bugs were placed on surfaces and mortality was recorded after 1, 2, 3, 7 and 14 days of continuous exposure.

Results. The difference between formulations was pronounced, with Transport GHP providing higher mortality in all three populations (Figure 2). The difference between Transport GHP and Mikron was especially apparent with the more resistant FF1 and NY1 strains. While all individuals in both populations succumbed to Transport GHP – only 27 percent and 2 percent of NY1 and FF1 strains died after 14 days of confinement on deposits of Transport Mikron. Temprid SC provided 100 percent mortality in CIN1 and NY1, but killed only 17 percent of FF1 bugs during the same period.

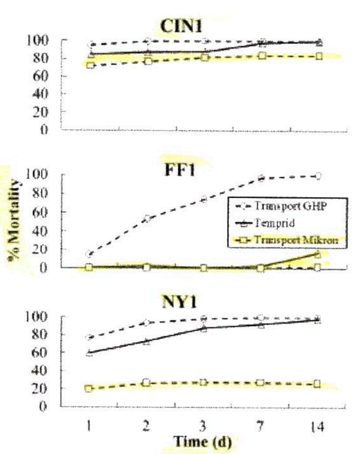

Figure 2. Cumulative effect on three strains of bed bug exposed to two formulations of Transport (GHP and Mikron) and Temprid SC. Bugs were continuously exposed to labeled rate (dry) deposits on filter paper.

3. Selection for resistance. In a final experiment, we wanted to see if populations became more resistant when successive generations were exposed to these materials. Adult bed bugs (males and females) from three different populations were confined on filter paper discs treated with label rate deposits of Temprid SC (0.075 percent). By adjusting the duration of exposure, we were able to produce a level of mortality in each population of 80 percent. (Author's note: We called this value an ET_{80} – the "exposure time" necessary to cause approximately 80 percent mortality of a population.)

Bed bugs that survived treatment were transferred to untreated rearing containers and allowed to feed, mate and lay eggs. The offspring of surviving individuals were then reared to adulthood and subjected to the same Temprid SC treatment as their parents. To serve as an "unselected" control, other groups of bed bugs from each population were exposed to filter papers treated only with water.

Results. Surprisingly, decreased susceptibility to Temprid occurred after only one generation of selection. In all three populations, mortality was significantly lower in the "selected" group of offspring from bugs that survived previous exposure to the insecticide. In a follow up experiment, groups of bed bugs from two populations previously selected for resistance to Temprid SC also had decreased susceptibility to Transport (Figure 3).

Although Temprid and Transport have different active ingredients, both contain a pyrethroid and neonicotinoid and thus employ similar modes of action. Cross resistance (decreased susceptibility) between such products is expected since collectively the constituents target the same sites on insect nerves (i.e., pyrethroids disrupt the flow of sodium ions through tiny channels along nerve cells, while neonicotinoids bind to post-synaptic acetylcholine receptors and disrupt transmission of signals between nerve cells). Cross resistance is also likely to extend to other bed bug products containing pyrethroid and neonicotinoid dual ingredients.

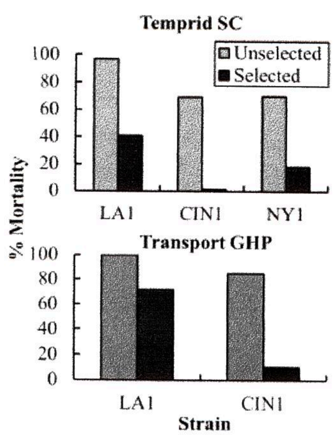

Figure 3. Decreased susceptibility to Temprid SC and Transport GHP in bed bugs after one generation of selection in the laboratory.

Study Implications.

Bed bugs have a history of developing resistance swiftly to insecticides. In the case of DDT, for example, some populations were already becoming resistant within the first years of commercial usage (Potter 2011). Recent studies have shown that bed bugs are teeming with genetic mechanisms to deter insecticides (Adelman et al. 2011, Zhu et al. 2013). Therefore it should not be too surprising that populations are already showing decreased susceptibility to these compounds – particularly since resistance to one of the two ingredients (pyrethroids) was already widespread.

Moderately resistant bed bugs are more likely to succumb when sprayed directly.

Previous studies by our group found that pyrethroid/neonicotinoid combination products are more lethal to bed bugs than either active ingredient alone (Potter et al. 2012). At that time only three strains were tested and each had been maintained in the laboratory for at least four years. In the current study, additional populations were evaluated that had been collected from the field more recently and displayed higher levels of resistance. The current study is also the first verification of decreased susceptibility to combination insecticides as a result of selection.

While selecting for resistance in the laboratory has been accomplished with other insects, it is unusual for a decline in susceptibility to evolve so quickly — elevating concerns for what might also be happening in the field.

Thus far, industry feedback regarding performance of combination products remains mainly positive. Of course service procedures often employ multiple tactics, which may "compensate" for reduced insecticide effectiveness. Encasing beds, for example, can purge many bed bugs from a dwelling, especially when augmented by laundering, vacuuming, steaming, etc. Most insecticides, including the products we examined in this study, also tend to perform better when the bed bugs (even moderately resistant ones) are sprayed directly. Such factors could help to explain the discrepancy between our laboratory findings and more favorable reports from the field.

Monitoring insecticide susceptibility and prescribing the most efficacious materials are core pest management principles. In the future, we hope to develop tools to help the industry better make such determinations. In the meantime, pest managers should be alert for possible signs of declining insecticide performance, such as continued presence of bed bugs on formerly treated surfaces. Employing additional tactics (education/vigilance/early detection, heat, cold, vacuuming, encasement, etc.) will further help to mitigate resistance and conserve our existing materials.

Jennifer R. Gordon, Mark H. Goodman, Michael F. Potter and Kenneth F. Haynes are Ph.D. students and professors, respectively, at the University of Kentucky. Funding for the study was provided by Rollins. Portions of this article were adapted from a recent research paper published in Scientific Reports(4:3836 DOI:10.1038/smp03836)

REFERENCES

Adelman, Z.N., K.A. Kilcullen, R. Koganemaru, R. Anderson, M.A.E. Anderson, T.D. and Miller, D.M. 2011. Deep sequencing of pyrethroid-resistant bed bugs reveals multiple mechanisms of resistance within a single population. PLoS ONE 6: e26228

Potter, M.F. 2011. The history of bed bug management — with lessons from the past. American Entomologist. 57(1):14-25.

Potter, M.F., K.F. Haynes, J.R. Gordon, E. Hardebeck and W. Wickemeyer. 2012. Dual action bed bug killers. Pest Control Technol. 40(2): 62-68, 75-76.

Potter, M.F., K.F. Haynes, J. Fredericks and M. Henriksen. 2013. Bed bug nation: are we making any progress? PestWorld. Sept./Oct. 4-11.

Romero, A., M.F. Potter, K.F. Haynes and E. Hardebeck. 2007a. Insecticide resistant bed bugs: implications for the industry. Pest Control Technol. 35(7): 42,44,46,48,50,143.

Romero, A., M.F. Potter, D.A. Potter and K.F. Haynes. 2007b. Insecticide resistance in the bed bug: a factor in the pest's sudden resurgence? J. Med. Entomol. 44: 175–178.

Zhu, F., H. Gujar, J.R. Gordon, K.F. Haynes, M.F. Potter and S.R. Palli. 2013. Bed bugs evolved unique adaptive strategy to resist pyrethroid insecticides. Sci. Report. 3:1456. (DOI:10.1038/srep01456)

Zhu, F., J. Wigginton, A. Romero, A. Moore, K. Ferguson, R. Palli, M.F. Potter, K.F. Haynes and S.R. Palli. 2010. Widespread distribution of knockdown resistance mutations in the bed bug, Cimex lectularius (Hemiptera: Cimicidae), populations in the United States. Arch. Insect Biochem. Phys. 73: 245-57.

COMMENTS