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THE **SECRET** LIFE OF BED BUGS

Sublethal Effects of Insecticides on Bed Bug Behavior:
A Pest Management Foundation Funded Research Project

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THE **SECRET** LIFE

By now everyone in the pest management industry is aware that bed bugs are back, and barring some unforeseen breakthrough, we will be battling them for decades. Their reemergence after more than 40 years in the background is one of the great pest control mysteries of the first decade of this new century. The fact that some populations of these flightless, blood-thirsty bugs are resistant to many of our insecticides makes our need for a deeper understanding of how they interact with pesticide residues critical. The answer to that question depends first on knowing their life habits.

Bed Bug Habits

The survival of bed bugs depends on their stealthy habits. Their primary harborages are usually close to the bed, but are hidden from view.

They venture out mainly under the cover of night, and unlike a mosquito, there is no buzzing to give them away. They can cover a surprising amount



Bed bugs, eggs and waste products in a mattress seam (photograph by Michael Potter).

of ground even in the absence of cues signaling the presence of their hosts (heat and carbon dioxide).

We found that an adult bed bug can cover over 16 feet in five minutes. Given that their nighttime foray may last hours, it is clear that seemingly distant locations — like a suitcase in the corner of a hotel room — are not immune from wandering bugs. Their bites are often unnoticed by their victims, at least until the immune system reacts, often producing an itchy welt. By that time the bed bug has returned to its hiding place. Their return “home” depends at least in part on a particular chemical signature that is almost always undetectable to us. If their foray out was successful they imbibed the nutritious blood meal that will allow the nymphs to molt and grow and allow the adults to mate and produce eggs. If it was not successful they can survive for months without feeding. It is in their hidden harborages where mating, egg-laying, hatching, molting, digestion and defecation occur. These places are where they would be most susceptible to direct sprays with insecticides, but finding these harborages takes experience and time. Most often populations go unnoticed for a generation or two. By then mixed stages (eggs, nymphs, and adults) have established residence behind headboards, along seams and edges of the mattress and box spring, within upholstered furniture, and beneath carpet edges, to name just a few of the more common places.

Forgotten Pests

Very few scientists maintained an interest in bed bugs through decades when they were in the background. The few hardy souls, like Dr. Harold Harlan formerly of the National Pest Management Association (NPMA), who maintained colonies did

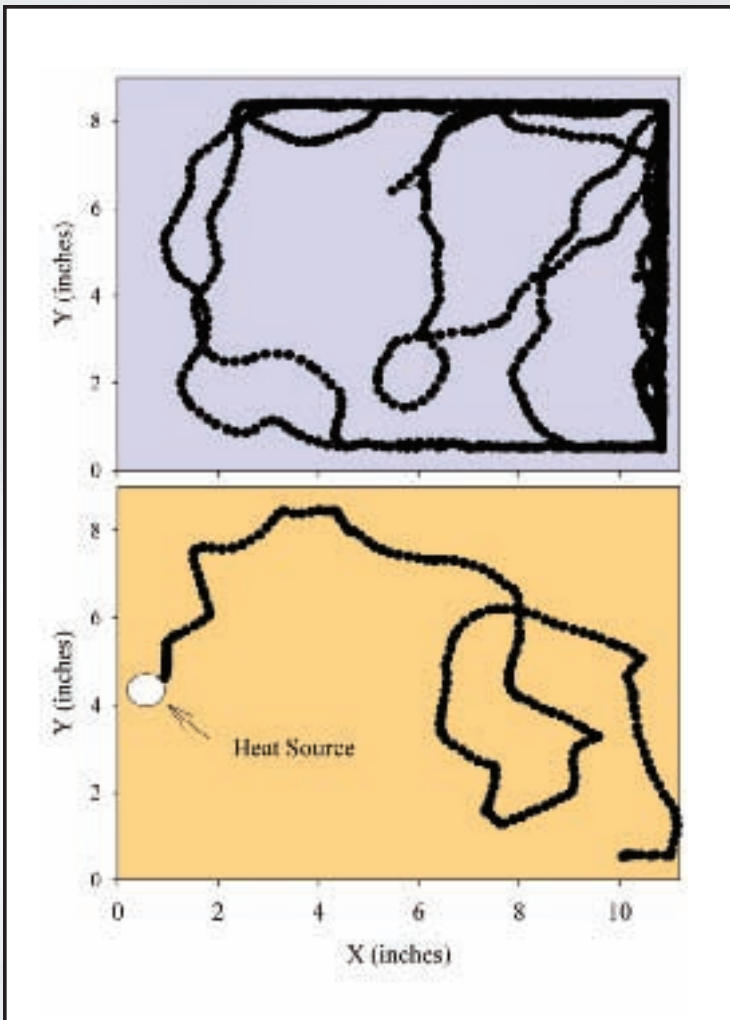
OF BED BUGS

Sublethal Effects of Insecticides on Bed Bug Behavior:
A Pest Management Foundation Funded Research Project



**By Kenneth F. Haynes, Alvaro Romero,
Rebekah Hassell, and Michael F. Potter**

photograph by Michael Potter



Tracks of individual bed bugs in a laboratory test arena. Clearly bed bugs cover a lot of ground at night even when not stimulated by a host (top). Note how they tend to follow the edges of our test arena. Movement is more directed when a heat source warmed to human body temperature is provided (bottom).

so because they were curious about these stealthy creatures and used their own blood to nurture the colonies for years. Before 2000 few pest management firms dealt with them. The public, if they knew about them at all, were glad that they had been confined to nursery rhymes. Funding agencies at all levels had their hands full with so many serious health issues, that it would have been futile for curious scientists to write grants. This all started to change when the “perfect storm” of bed bugs started to sweep the country (Potter, 2006). Amongst many other objectives, we became interested in how bed bugs interact with insecticide residues and the importance that these interactions might have to the broader issues of bed bug control. The NPMA through their Pest Management Foundation gave us funding to get started.

Research Findings

We found that bed bugs tend to avoid residues of a pyrethroid insecticide, deltamethrin. If given a choice between a deltamethrin-treated harborage and clean harborage, bed bugs from several populations will choose to rest on the untreated harborage. (See Chart A).

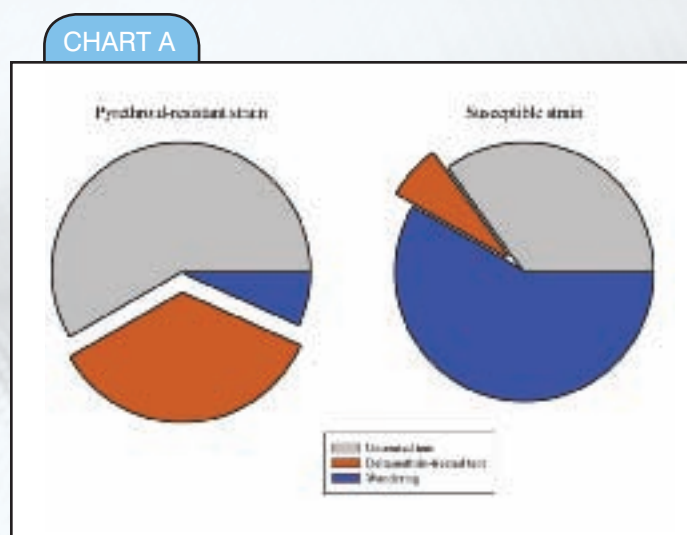
Video-recordings over the course of a night and day let us know that each harborage was explored by the bed bugs, but they would not stay put on the pyrethroid-treated surface. The result was that susceptible populations, even while avoiding the deltamethrin-treated tents were exposed to enough residue to affect their behavior. Thus many were found wandering outside of harborages during the day, while more resistant individuals, survived, moved away from treated surfaces and eventually colonized the untreated harborage. While the facts of this experiment are straightforward, there is more to the story. It turns out that the avoidance of insecticide treated surfaces can be overcome by the odor stimuli that are part of established or occupied harborages, i.e., the odors that come from feces, other bed bugs, etc. Thus, when these stimuli were present bed bugs would *not* avoid the pyrethroid at all. In addition, we found that bugs will cross pyrethroid-treated barriers to get to a blood meal. If you think about this as counteracting stimuli, it is apparent that the harborage odor or host stimuli can overwhelm the “irritancy” from the insecticide. (See Chart B).



A bed bug explores a test arena and ultimately rests on a paper tent-like harborage that was not treated with a pyrethroid insecticide (photograph by Kenneth F. Haynes).

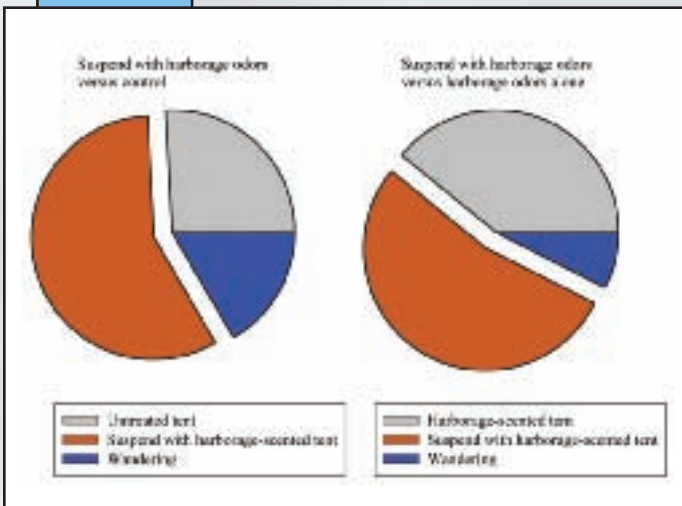
What do these complicated results mean for the pest control industry? First if you are fortunate to be dealing with a susceptible population of bed bugs pyrethroid residues in occupied or unoccupied harborages probably will do the job. For these populations there is less chance that the application itself will lead to bed bugs dispersing to other areas. While the number of wandering bed bugs was large, these bugs were sick and not likely to recover. For pyrethroid-resistant populations not only are the pyrethroid residues ineffective in killing individuals, but bugs that encounter treated, but unoccupied cracks and crevices will keep moving until they find an occupied harborage or an untreated area. This brings some risk that a pyrethroid treatment will help spread a resistant population, including to nearby rooms. These laboratory results would need to be verified under field conditions.

Another insecticide that we evaluated using the same behavioral assays was chlorfenapyr, the active ingredient in Phantom. Bed bugs faced with a choice between treated and untreated harborages would not avoid the treated surfaces. In our evaluations it was clear that chlorfenapyr was not a “repellent” by any definition, and that it would unlikely to be a contributing factor to population spread. These seem like ideal characteristics for a bed bug insecticide. Unfortunately, we and others have found that Phantom is comparatively slow to kill bed bugs. Over 50 percent of individuals in various populations we have tested from across the United States will survive for 4 to 8 days when confined for



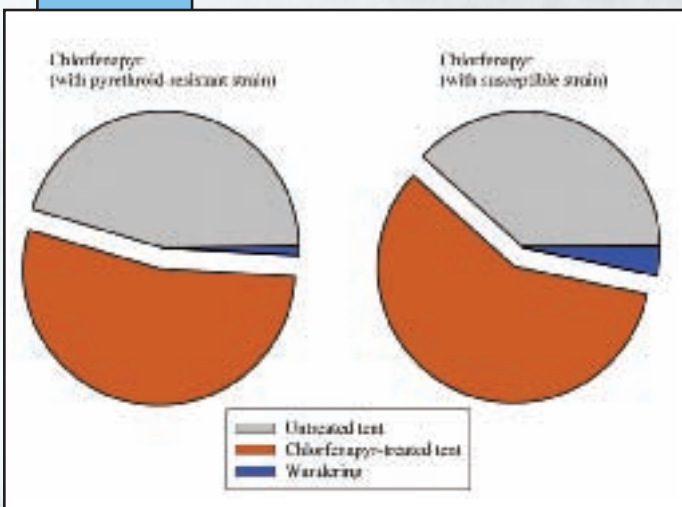
Where were bed bugs found after the testing period? The orange and gray sections of the pie chart indicate the proportion of bed bugs that chose to rest on deltamethrin-treated or untreated surfaces. More bed bugs preferred the untreated tents. The large proportion of bed bugs that were found wandering (blue) in the arena using the susceptible strain indicates that a sublethal exposure to the insecticide was adversely affecting them, and many appeared too sick to recover.

CHART B



When Suspend (deltamethrin) was combined with harborage odors, resistant bed bugs no longer avoided resting on treated surfaces (left pie chart). In fact, Suspend-treated harborages were just as effective as scented untreated harborages in retaining bed bugs (right pie chart).

CHART C



Bed bugs did not avoid chlorfenapyr-treated surfaces whether they were from a resistant or susceptible population (orange and grey slices about the same size).

the entire time to a treated surface. Clearly there is no perfect bed bug insecticide in the arsenal right now, and companies should take a multi-faceted approach to management. (See Chart C).

The Battle Continues

Bed bugs are here in a big way, and barring some unforeseen breakthrough they will be an increasing problem. We need to use the available tools for pest control wisely, which means knowing what works and why it works, and what doesn't work and why. While our investigations are still at an early stage, our results suggest that knowing the resistance level of particular populations to pyrethroids is important, and would affect the choice of control tactics. In addition, the evaluation of potential synergists for the pyrethroids that could improve toxicity without contributing to potential spread of populations is needed. Likewise, finding ways to improve the efficiency of slow-acting alternatives to pyrethroids, such as chlorfenapyr, is critical. The scientific hunt for effective strategies is on, but bed bugs temporarily have the upper hand. ➡

Citation

Potter, M.F. 2006. The perfect storm: an extension view on bed bugs. *Am. Entomol.* 52(2): 102-4.

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For more information about NPMA's Pest Management Foundation or to learn how to support this organization, visit npmapestworld.org/PMFoundation.