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Improved strategies necessary to combat bed bug resurgence

Understanding a population's genetic structure and dispersal patterns may aid in control strategies.

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Within the past decade, the common bed bug — *Cimex lectularius* — has become an increasingly important domestic pest in the United States and abroad.

"Although bed bugs are not vectors of any pathogens, their bites and exuviae do provoke allergic reactions, and their socially perceived threat has economically affected hotels, department stores and other public places," **Rajeev Vaidyanathan, PhD,** associate director of vector biology and zoonotic disease at SRI International in Harrisonburg, Va., said during a symposium at the American Society of Tropical Medicine and Hygiene 60th Annual Meeting.

During the symposium, researchers discussed public health problems associated with bed bugs, as they cause physical and psychological discomfort, allergies, secondary infections and have a significant financial effect on businesses and the homes of many. "In 2010, for the first time, almost every pest control agency has reported that bed bugs are their No. 1 concern — superseding cockroaches and termites," Vaidyanathan said.

Increased international transport and travel, exchange of secondhand furniture, insecticide resistance and changes in insecticide use are being blamed for the bed bug resurgence.

"Understanding and more widely sharing these data will enable others to advance the field of bed bug research and provide more opportunities for collaboration among entomologists," Vaidyanathan told *Infectious Disease News*. "Underlying these points, however, is the important, yet muted issue of funding for bed bug research. Everyone agrees on the need for improved detection and control strategies, but these topics are poorly funded."

Coby Schal, PhD, said the reasons for the recent global resurgence of *Cimex lextularius* — the common bed bug — remain poorly understood.
Photo courtesy of Schal C

Population genetics

Bed bugs reappeared worldwide, and infestations within the United States are increasing at alarming rates, **Coby Schal, PhD,** of North Carolina State University, said during the symposium.

Schal said the reasons for the recent global resurgence remain poorly understood. "Bed bugs are now found extensively across all residential settings, with widespread infestations established in multi-apartment buildings. Within such buildings, understanding the population

genetic structure and patterns of dispersal may prove critical to the development of effective control strategies."

He and colleagues at Rutgers University conducted two studies to have a better understanding of dispersal patterns and to identify possible sources of infestation. For the first study, infestation dynamics were compared between three apartment buildings in Raleigh, N.C., and Jersey City, N.J.

Overall, infestations within apartments were characterized by high levels of relatedness and low levels of genetic diversity. "Regardless of the number of unique introductions, genetic data indicate that spread within buildings is extensive, supporting both active dispersal within and between adjacent rooms or apartments and passive human-mediated movement across apartments spanning multiple floors," Schal said.

Bed bugs (*Cimex lectularius*) in a colony maintained in Coby Schal's lab. The brigh red bugs have recently fed on rabbit bloo whereas the pale bug (bottom left) is an unfed nymph.

For the second study, the researchers sampled 21 bed bug infestations from homes in nine states across the eastern coast of the United States. For all infestations, they recorded a high genetic diversity with a mean of 10.3 alleles/locus. Conversely, within infestations, they observed low genetic diversity with one alleles/locus to four alleles/locus, indicating that nearly all of the studied infestations began with a small propagule.

"Infestations located in closer proximity to each other were nearly as genetically differentiated as those located hundreds of kilometers away," Schal said. "The high level of genetic diversity across infestations from the eastern US, together with the lack of geographically organized structure, are consistent with multiple introductions into the United States from foreign sources."

Insecticide-resistance likely to blame

During another presentation at the meeting, **Ken Haynes, PhD,** of the University of Kentucky, said the worldwide resurgence of the bed bug may in part be explained by the evolution and spread of resistance to pyrethroid insecticides — a mainstay for controlling bed bugs and other indoor pests after DDT was banned in the 1970s.

Haynes and colleagues conducted genetic tests and investigated mutations in one gene implicated with resistance to DDT and pyrethroids in many species of insects. Of 108 field collected strains, 88% had a specific type of resistance known as "target site insensitivity."

"There are more than 42 P450 enzymes in bed bugs, and any one or a combination of these could contribute to resistance," Haynes said. "Insecticide-resistance in bed bugs requires a management strategy, in which we rotate insecticides with different modes of action, use non-insecticidal approaches like heat treatments, dispose of infested items to prevent their reintroduction and use quick assays to make informed decisions for pest control." This could help preserve the few effective insecticides that are available, he added.

Ken Haynes, PhD

In a 2011 study published in *Morbidity and Mortality Weekly Report,* CDC officials found that between 2003 and 2010, more than 100 acute illnesses across seven states were associated with insecticides used to control bed bugs.

As previously reported in *Infectious Disease News*, 111 cases were reported in California, Florida, Michigan, North Carolina, New York, Texas and Washington between 2003 and 2010. Of these, 81% were of low severity, and one fatality occurred. Pyrethroids and pyrethrins were identified in 89% of cases, including one fatality. Excessive application of insecticides, failure to wash or change pesticide-treated bedding and inadequate notification of pesticide application were the most common reasons for illness, according to the report.

"Although the number of acute illnesses from insecticides used to control bed bugs does not suggest a large public health burden, increases in bed bug populations that are resistant to commonly available insecticides might result in increased misuse of pesticides," CDC officials wrote.

Detection and control methods

"The resurgence of bed bug populations has led to a renewed interest in the chemical ecology of bed bugs," **Mark Feldlaufer, PhD,** of the US Department of Agriculture, said during the symposium. "The goals of this renewed research include gaining a better understanding of bed

bug behavior and, ultimately, how pheromones may be used to manage these pests."

Early detection is key in bed bug management and also is difficult because bed bugs are "cryptic" and hide in cracks and crevices. "Because their bites may cause no reaction, or a reaction is not recognized as resulting from a bed bug bite, infestations can reach relatively large sizes before being noticed," Feldlaufer said. He suggested detection methods to employ, including visual inspection, monitoring devices such as a lure or trap, canines trained to find bed bugs or a combination of these methods.

Results from a recent study conducted by Feldlaufer and colleagues indicated that a bed bug-detecting canine trained to locate live bed bugs and viable bed bug eggs could detect the alarm pheromones of the common bed bug and the Neotropical brown stink bug, which produces the same chemicals.

"Using dogs trained to detect bed bug infestations has become an emerging industry, and a better understanding of the chemical basis of canine detection will hopefully contribute to a harmonization of training and detection methods," Feldlaufer said.

Further research, funding needed

Because bed bugs communicate by pheromones, this behavior can be exploited to engineer superior detection and control strategies, Vaidyanathan said.

He and colleagues recently identified at least seven new molecules from the shed exoskeletons of bed bugs (exuviae) and from bed bug fecal droplets. They are currently examining whether these molecules influence bed bug aggregation or dispersal.


Rajeev Vaidyanathan, PhD

"Our goal is to deliver a cocktail of aggregation pheromones that can be used to enhance monitoring devices or to improve the efficacy of control measures," he said. "Our challenge will be to formulate a simple, effective and stable pheromone cocktail that is not objectionable to the hotel manager or homeowner.

"There is still a lot we don't know about bed bug biology, and fundamental research like this cannot continue without industry and federal funding," Vaidyanathan said. – *by Ashley DeNyse*

For more information:

Feldlaufer M. Symposium #82.

Haynes K. Symposium #82.

Jacobson JB. *MMWR*. 2011;60:1269-1274.

Schal C. Symposium #82.

Vaidyanathan R. Symposium #82. All presented at: the American Society of Tropical Medicine and Hygiene 60th Annual Meeting; Dec. 4-8, 2011; Philadelphia.

Disclosures: Drs. Feldlaufer, Haynes and Vaidyanathan report no relevant financial disclosures. Dr. Schal reports his work was funded by a grant from the USDA and the National Science Foundation.

Do you anticipate bed bug infestation to get worse before it gets better in the United States? Which control measures do you recommend?

POINT

The current bed bug problem is expected to become worse in the coming years.


Philip G. Koehler, PhD

The current bed bug epidemic began about a dozen years ago with infestations found in high-end hotels in major cities and resort destinations. These hotels were favorite places for international visitors who unknowingly transported bed bugs to the United States. Since the turn of the century, bed bugs have spread from hotels to many locations, including houses, hospitals, doctor waiting rooms, movie theaters, retail stores, offices and public transportation. Every year, the problem has intensified, expanding to areas of the country with less population and has impacted virtually every segment of society. The problem is expected to become worse in the coming years due to difficulty of detecting early infestations, ineffectiveness of residual insecticides and the extraordinary cost of effective control measures (more than $1,000 per household).

Most of the current products for control are pyrethroids, but bed bugs have evolved resistance to pyrethroid chemistries. In fact, the highest levels of resistance to any insecticide (more than

300,000-fold) have been recently reported for bed bugs collected from field sites throughout the United States. The evolution of resistance may be partially due to the use of pyrethroid-treated bed nets for mosquito control in Asia and Africa. These bed nets have sufficient insecticide to kill mosquitoes, but not all bed bugs. The ideal bed bug control strategy would be to spray a residual chemical that would kill bed bugs as they crawl across the treated surface.

Currently, there are no satisfactory residual controls for bed bugs despite a large number of products that are available. The Environmental Protection Agency's search engine for bed bugs lists 343 crack and crevice, 270 mattress, 22 whole-home and three whole-room products for bed bug control. However, most of these are pyrethroids or products that only kill if they are sprayed directly onto bed bugs. Most effective insecticides that controlled bed bugs between the 1940's and 1990's are no longer permitted to be used in the United States. Of course, nobody wants to sleep in a bed or sit on a couch drenched with insecticide, so appropriate products are limited. Currently effective methods of bed bug detection and control are very expensive.

Dogs can be effectively trained to detect active bed bug infestations, but many bed bug dogs are not maintained correctly and give false alerts or miss infestations. One of the best controls for bed bugs is heat. Either the whole structure or rooms can be heated to more than 120 degrees Fahrenheit to kill bed bugs, or infested items, even beds, can be placed in heated, insulated boxes. Heat treatment is usually very expensive and does not provide residual protection. As a result, bed bugs can be reintroduced as soon as the residents return with their infested luggage. Because of the lack of affordable control, the bed bug epidemic will continue to spread. Bed bugs are now well-established in low-income apartments where the cost of control is out of reach for residents. As a result, the bed bug epidemic will continue and will expand until affordable control methods can be developed.

Philip G. Koehler, PhD, is professor of entomology at the University of Florida. Disclosure: Dr. Koehler reports no relevant financial disclosures.

COUNTER

The initial 'freak-out' will have to be experienced and overcome.


Dini Miller, PhD

No doubt the bed bug situation will become worse before it gets better, but I should qualify what is meant by these terms in the case of bed bugs. The bed bugs are continuing their spread throughout the nation (and the world for that matter).Therefore, they are getting 'worse'. New locations (more rural states like North Dakota, Iowa, Idaho, Nevada, Arizona, etc.) that have had relatively few bed bug incidences so far are starting to see an increase and that increase will continue. Combine this with the fact that the learning curve for a pest management industry that is new to bed bug control has been steep and continues to be so. This is because the only way a pest control company comes to truly appreciate the long tedious process bed bug control is with firsthand experience.

Finally, as more and more people experience bed bug infestations for the first time, the initial 'freak out' will have to be experienced and overcome. All of the above being said, we are already seeing communities adjust to the 'bed bug experience'. In this sense, the bed bug situation is getting better. A friend of mine (not an entomologist) living in NYC, a place known for its bed bug infestation, recently posted on Facebook that having bed bugs is now regarded as a "rite of passage for those who live in the city." Because of this, several pest management companies in New Jersey and New York City have become nationally known bed bug experts. These companies have mastered the art of bed bug control and are busy teaching companies in other states how to deal with this pest. No question we can now eradicate a bed bug infestation. Finally, the 'freak out' factor for finding a single bed bug in Victoria's Secret is old news. People are discovering that although bed bugs are a pain (causing itchy ugly bites that last a long time) and expensive to treat ($1,200 or more), they are certainly not the worst thing that can happen to the average middle-class person (no, they really are not), and they do not transmit disease (thank goodness).

Dini Miller, PhD, is an associate professor at Virginia Tech University, and the Urban Pest Management Specialist for the state of Virginia. Disclosure: Dr. Miller reports no relevant financial disclosures.

The geographic spread of bed bug infestations have not yet peaked in the United States.

From my own observations, I think that numbers and geographic spread of


Harold Harlan, PhD, BCE

bed bug infestations have not yet peaked in the United States. This past year, I gave presentations at five different meetings to pest management professionals (PMPs), public health workers, business or housing managers and the public. In every case, at least 15% of attendees had never seen an infestation nor a live bed bug. No single control technique or product can be effective against all bed bug infestations. Each site may require a different strategy or technique than a very similar site, to eliminate most of a given bed bug population. You must survey to detect, correctly identify the pest and locate infested spots in the room, apartment or building. Concurrently provide information to victims, owners or managers and to adjacent tenants, managers and others impacted by the pests or by intended treatment actions. Take some action to control the bed bugs. Control techniques or products must be considered carefully. Choices may be affected by details of the site, associated costs, personal preferences and possibly other factors. Physical techniques (heat, cold, vacuuming, steam, etc.) may cause some quick population reduction, but they have no residual effects. Immediately after such a control action, any newly introduced bugs would not be affected at all by that completed effort. Chemicals must include only properly EPA-registered products, used exactly according to their own label directions, but many of them provide some residual effects. A properly certified, licensed, trained and experienced PMP should be involved in such actions to control bed bugs. Monitor results of the control effort and take appropriate follow-up actions, as needed, maybe repeating certain prior steps.

Please note: All the above information is specifically in reference to the common bed bug, Cimex lectularius L.; and not to any of the more than 84 named species currently included in the insect family: Cimicidae, which are all called 'bed bugs' (in the broad sense).

Harold Harlan, PhD, BCE, of the Information Services Division of the Armed Forces Pest Management Board. Disclosures: Dr. Harlan reports no relevant financial disclosures.