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Inbreeding in Bed Bugs One Key to Massive Increases in Infestations

As bed bug populations spread throughout the United States, scientists at ASTMH meeting release new research on their biology and behavior

(Philadelphia, Pa., USA – December 6, 2011) New research on the bed bug's ability to withstand the genetic bottleneck of inbreeding, announced today at the American Society of Tropical Medicine and Hygiene (ASTMH) annual meeting, provides new clues to explain the rapidly growing problem of bed bugs across the United States and globally. After mostly disappearing in the US in the 1950s, the common bed bug (*Cimex lectularius*) has reappeared with a vengeance over the past decade. These stubborn pests have developed a resistance to the insecticides, known as pyrethroids, commonly used against them.

Scientists at ASTMH also offered new insights into infestations in apartment buildings and homes; a novel approach for preventing insecticide resistance; and new information about chemical compounds involved in attracting and repelling bed bugs.

While these blood-sucking parasites don't transmit disease, their bites provoke allergic reactions—including inflamed welts and severe itching—and they pose both a social and economic threat to owners and residents of apartment buildings, hotels and public buildings. The financial impact has been substantial.

“New York City alone spends between \$10 million and \$40 million per year on bed bug control, and these numbers are repeated in other major cities across the US,” noted Rajeev Vaidyanathan, PhD, associate director of Vector Biology and Zoonotic Disease at SRI International. “Over 95 percent of pest control agencies reported bed bugs as a priority in 2010, thus superseding termites as the number one urban pest.” The number of reported bed bug infestations in single family homes, hotel rooms and multi-unit housing has increased 10- to 100-fold since those recorded in 1990. Many reasons behind the increases are poorly understood.

One of the newly discovered factors that appears to be contributing to the bed bugs' effective infestation is their ability to establish new infestations through inbreeding. Coby Schal, PhD, and Ed Vargo, PhD, both entomologists at North Carolina State University (NCSU), and colleagues carried out two studies now under peer-review examining the genetics of bed bugs from three multi-story apartment buildings in North Carolina and New Jersey, and determined that there were high levels

of relatedness within each apartment and very low genetic diversity within each building, indicating that infestations start from just one or two introductions of the insect. Being able to withstand a very high level of inbreeding—i.e., still produce healthy offspring—allows the bed bug infestation to expand to other apartments within the building.

Another study by this team confirmed this same conclusion based on a study of 21 bed bug infestations from Maine to Florida in the US, nearly all of which came from single rooms within homes. “Inbreeding gives bed bugs an advantage in being able to colonize,” said Schal. “A single female that has been mated is able to colonize and start a new infestation. Her progeny and brothers and sisters can then mate with each other, exponentially expanding the population. With many organisms, extensive inbreeding would cause serious mutations that would eventually bring about an end to the population.” He also noted that cockroach populations are also able to survive inbreeding.

Overcoming Insecticide Resistance

Further evidence of such resilience has been observed in the bed bugs’ resistance to previously successful insecticide strategies. However, new research has revealed that it is possible to “shut down” the mechanism that is linked to breaking down the insecticide and making the bed bug resistant to pyrethroid insecticides.

For the last five years, entomologist Ken Haynes, PhD, and colleagues at the University of Kentucky have been focused on insecticide resistance in bed bugs. He and his colleagues, Subba Reddy Palli and Fang Zhu, looked at a way to eliminate this resistance by targeting specific enzymes inside bed bugs associated with the P450 detoxification system that destroy the insecticides before they reach their molecular target. Rather than attempting to knock out all of the enzymes in the system, the scientists used RNA interference against an enzymatic partner of the P450 family to selectively turn off the system inside bed bugs and preserve the utility of the insecticide—in this case deltamethrin.

Building Better Detectors and Traps

Other potential options for controlling bed bug populations may lie in identifying and understanding the function of chemical compounds secreted by the pests. The researchers revealed that they are still finding new compounds that influence bed bug behavior. Vaidyanathan’s group recently isolated seven new compounds that had never been identified from bed bugs that might serve as bed bug attractants. The researchers noted that it might be possible to develop a trap with a “cocktail” of these bed bug compounds to attract the pests.

Mark Feldlaufer, PhD, an entomologist with the US Department of Agriculture's Agricultural Research Service, is working to better understand the underlying mechanisms of the chemical factors, or pheromones that affect bed bug behavior. He has examined the chemical blueprint of “alarm compounds,” which warn animals of the same species that there is danger present. These alarm compounds could be used as “dispersants” during a chemical treatment, thereby exposing more bugs to the treatment.

Feldlaufer's research has also recently identified the chemicals associated with the bed bugs’ outer skeleton. His focus is now on the role, if any, of these chemicals in the ability of dogs to sniff out

bed bugs. When properly trained and handled, canines are used by pest management professionals to find bed bugs just as canines are used to find explosives, drugs or lost people.

Bed Bugs and Human Society

According to Vaidyanathan, “Bed bugs are our oldest roommates. There is even evidence of bed bugs in Pharaonic Egypt.”

Researchers say the most recent US resurgence of bed bugs has been caused by a number of factors. “The problems we are seeing with bed bugs in North America did not happen overnight,” said Vaidyanathan. “They are the consequence of multiple repeated introductions from all over the world. We have the highest concentration in the history of our species of humans living in cities. For as long as we’ve been standing on two legs, we’ve lived in rural areas. Over the last ten years, the majority of humans have moved to urban areas. This is the perfect setting for creating a high density of mammal nests for bed bugs. Bed bugs do not have wings; they are nest parasites, so our own population density has helped them to thrive.”

While there is limited genetic diversity within individual infestations, the NCSU team found that there is high genetic diversity across infestations along the East Coast; the bed bugs are coming from many different places, either from within the US or, more likely, from abroad. Previous studies confirm that turnover of residents is one of the biggest indicators for the presence of bed bugs and that increased domestic and international travel is one of the main factors driving bed bug infestations. Bed bugs also feed on chickens, and industrial production of poultry is providing the perfect breeding grounds for bed bug populations, according to Vaidyanathan. But researchers also attribute the spread to the increased introduction of used furniture and household items into homes.

Right now, either insecticides or heat treatment is used to deal with these infestations. The researchers noted that insecticides readily available to the consumer have generally not been tested against bed bugs. Applying heat treatment involves heating the whole home, or packing all furniture and belongings in a box and heating the objects at a high temperature for one hour, but both are expensive options and not ideal for chronic infestations. The researchers called for better education about bed bugs, improving existing detection methods, and safe and more effective control methods.

“Just as with other global diseases once thought under control and then neglected, bed bugs have shown the ability to resurge in great numbers once our vigilance wanes,” said Peter J. Hotez, MD, PhD, president of ASTMH. “To stay one step ahead of bed bugs and other parasitic organisms, we need to sustain investment in research for new tools.”

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About ASTMH

[American Society of Tropical Medicine and Hygiene](#), founded in 1903, is a worldwide organization of scientists, clinicians and program professionals whose mission is to promote global health through the prevention and control of infectious and other diseases that disproportionately afflict the global poor.