

The IPM Practitioner

Monitoring the Field of Pest Management

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Special
Pheromone Report

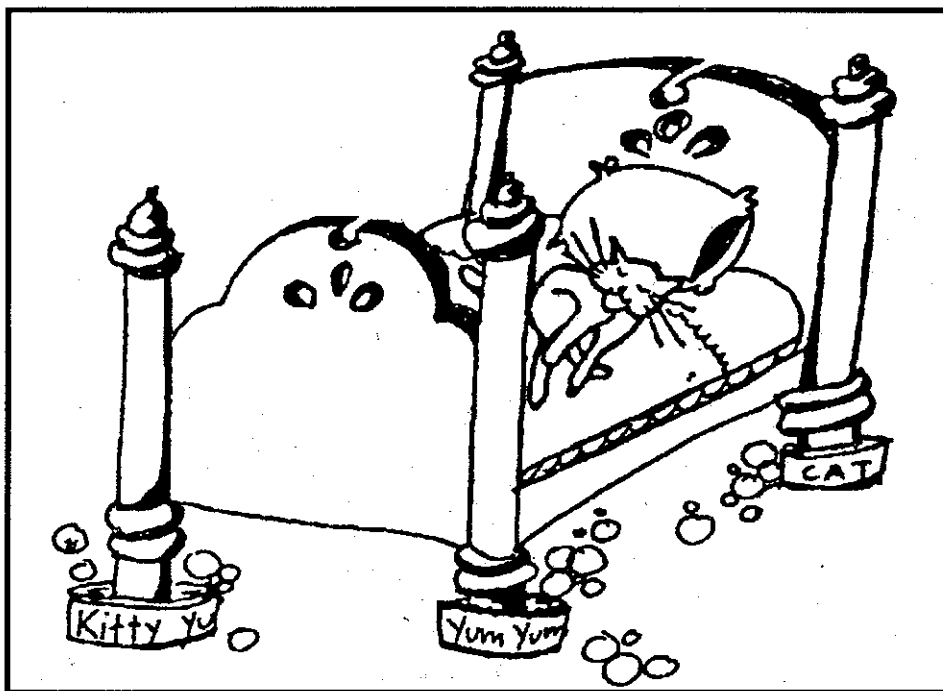
Don't Let the Bed Bugs Bite

By William Quarles

Bed bugs, *Cimex lectularius*, are a nuisance, and the discomfort and psychological problems they cause can be profound. Any reasonable attempt at prevention seems justified, but encounters with them must be viewed in perspective. Unlike ticks or mosquitoes, they do not cause death or disease. Yet much more media attention is given to them than to other more serious public health pests. The social and legal problems associated with bed bugs, and the hysteria and overreaction upon their discovery may be more of a problem than the bed bugs themselves (Gangloff-Kaufmann et al. 2006; Reinhardt and Siva-Jothy 2007).

A lot of attention is being given to bed bugs because they are difficult to eradicate, and infestations can lead to expensive treatments, inconvenience, and social stigma. No one wants to visit someone who has them, and that includes infested hotels and motels. Infestations can lead personally to loss of friendships, and for corporations, loss of income. Lawyers become involved when landlords and tenants fight over who pays for treatments (Miller 2009; Rajecki 2009, CDC 2010).

Bed bugs have now been found in schools, offices, department stores, movie theaters, and on public transportation. Though the public is rightly concerned about their spread, media reports are mostly of bed bug sightings, not infestations. School environments are especially sensitive to overreaction because officials are not sure of the proper approach. Should they use the lice confrontation model and send children home when bed bugs are found on them? Should children



Drawing by Deborah Green

Once beds are disinfested, they can be protected with bed leg traps and encasements for mattresses and box springs. If bed bugs, *Cimex lectularius*, cannot bite, they cannot reproduce.

stay away from school until their home is free of the pests? Is the school responsible if a student picks up a bed bug at school and takes it home?

In one example of overreaction, two bed bugs were found on a student book bag at John Bailey School in Bayonne, NJ. As a result, school officials called the Board of Health, a medical inspector, and a pest management company. They "fumigated" the school bus, sealed off the classroom and treated it with pesticides, and brought in bed bug sniffing dogs to insure there were no bed bugs in the school (Hudson 2010).

Another example was the closure of one whole floor of a New York University hospital after a mistaken

bed bug sighting. Much of the hysteria is because the public is unfamiliar with the pests and their biology, and cannot easily evaluate the threat (Hudson 2010; Reinhardt et al. 2008).

Bed Bugs in the U.S.

There are a lot of media reports, but exactly how widespread is the

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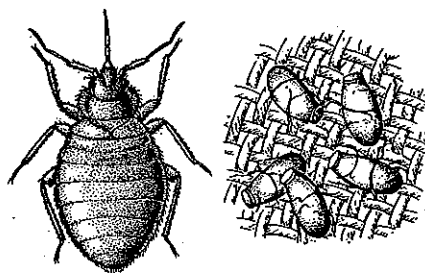
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A bed bug, *Cimex lectularius*, and its eggs

problem? Bed bug resurgence led the EPA to convene a National Bed Bug Summit in April 2009, and another one is scheduled for February 1-2, 2011 in Washington, DC. One conclusion of the 2009 Summit was that better tracking of infestations is needed. Most of the information available is either anecdotal or hearsay based on news reports, surveys, or from self-reporting websites. Infestations tend to be spotty. There were 1,400 bed bug complaints to the Cincinnati Health Department in 2008, but only 125 in the rest of Central Ohio (Ohio 2011).

Big cities have the largest number of infestations. New York City maintains a bed bug hotline and a self-reporting website. About 13,000 bed bug complaints were reported to the Department of Housing Preservation and Development in New York City in 2010. About 5,000 of these complaints were confirmed by City Inspectors and violations were issued.

One estimate is the self-reporting website, Bed Bug Registry, which shows the number and distribution of bed bug infestations in the U.S. This website reports 20,000 infestations at 12,000 locations since 2006. Most of the reports are in big cities on the East Coast. Some of these reports are probably entered in error through misidentification. However, overall trends are probably accurate. If so, bed bug problems are dwarfed by the number of encounters with termites, cockroaches, and ants (Quarles 2009c).

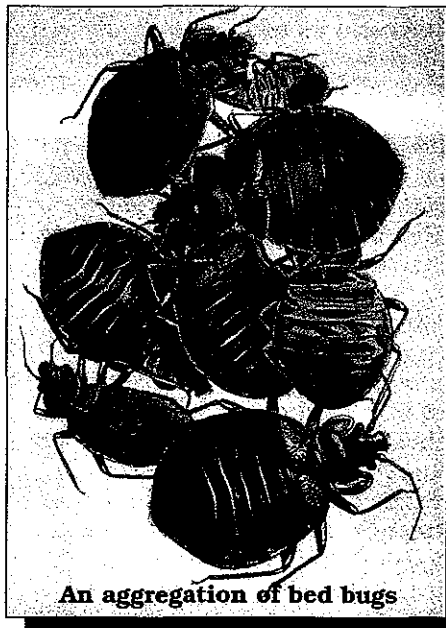
Dispersal a Consequence of Bed Bug Biology

Bed bugs are spreading because dispersal is a direct consequence of their biology. They practice traumatic insemination, and males slice through an intact female abdomen to deposit sperm directly into the body cavity. The effect is so traumatic that males and nymphs secrete pheromones clearly labeling themselves as sexually unsuitable to prevent injury (Harraca et al. 2010; Ryne 2009; Feldlaufer et al. 2010).

But traumatic insemination may be a key factor in bed bug survival and dispersal. Bed bugs usually aggregate near feeding sites. Fertilized females avoid these aggregations, possibly to avoid further injury. They are not attracted to, and do not secrete aggregation pheromones (Pfiester et al. 2009). For whatever reason, a dispersing bed bug is more than likely a fertilized female ready to lay eggs. In an infested high rise, they often just walk out the front door, down the hall and through the door into the next apartment (Wang et al. 2010; Usinger 1966; Pfiester et al. 2009).

Incubation Versus Casual Dispersal Centers

Bed bugs depend on a readily available sleeping host. So homes,



An aggregation of bed bugs

Photo from Usinger 1966

Update

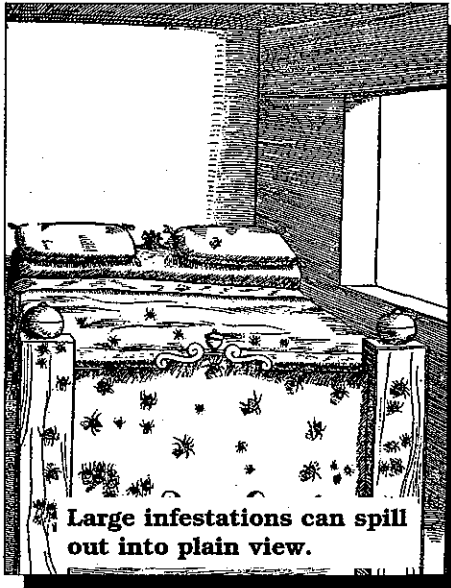
school dormitories, hotels, motels, and other places where people sleep are incubation centers. But as more and more homes are infested, bed bug hitchhikers are going to be taking rides with their hosts. The media has reported bed bug sightings in school buses, department stores, libraries, and office buildings. The risk of picking up a bed bug in one of these casual dispersal sites is low. Statistics are on your side. Large numbers of potential hosts lower the odds they will hitch a ride with any particular person (Usinger 1966).

Treatment should be focused on incubation centers. Treatment of a casual dispersal site such as a department store is not likely to be effective in the long run. Constant traffic will lead to constant reintroductions, and bed bugs are mostly resistant to currently registered pesticides. If you are concerned, inspect your clothing and possessions after returning from your daily commute (Moore and Miller 2006; Moore and Miller 2008; Romero et al. 2007).

Bed Bug Risks

Greatest risk comes from sleeping in an infested motel or hotel, or at a friend's infested apartment. Pesticide resistant strains are showing up at hotels throughout the U.S. For instance, about 700 rooms in 293 hotels in the U.S. were treated for bed bugs in 2007. This number represents an infestation rate of about one room in 100 (Black 2008).

When you check into a motel or hotel, check the mattress and bedding for signs of bed bugs. Look for live bed bugs, skins, and spots on the mattress especially along the seams. If possible, check both sides of the mattress. Bed bugs also will hide behind the headboard. If the headboard is easily removable, it might be worth the effort to remove it and inspect for bed bugs. Luggage should be kept off the floor and the bed. When you return from your trip, wash or dry clean your clothing. Check the suitcase for bed bugs and eggs. If you travel a lot, investment in a heater (PackTite®)



Large infestations can spill out into plain view.

that can disinfect suitcases might be worth it (see Resources).

There is also a risk associated with bringing infested items such as thrift store treasures or curbside furniture into your home. Used books should be scrutinized for bed bug nymphs and eggs (Quarles 2007; Potter 2010).

Detecting Bed Bugs

Bed bugs are usually detected through bites, or by visual sightings of bugs, blood spots, eggs, or castoff skins. Bed bugs tend to bite on the face, neck, and arms (Quarles 2005; Ebeling 1975). They do not bite right away, but wander about looking for just the right place. If you are awake, a slight tickling sensation may be initially the only clue (Usinger 1966; Schaefer 2000).

Low level infestations are hard to detect. There is a range of host sensitivity from an extreme allergic response to no reaction at all. Only about half of the population notices the first bite, and even then bite reactions may be delayed for 10 days. With repeated encounters, an immune response develops, and itchy bites are sensed faster. But even after repeated bites, about 20% of the population may show no response (Reinhardt et al. 2009). There is some evidence that individuals over 65 may react less, or they are less likely to be bitten. One sur-

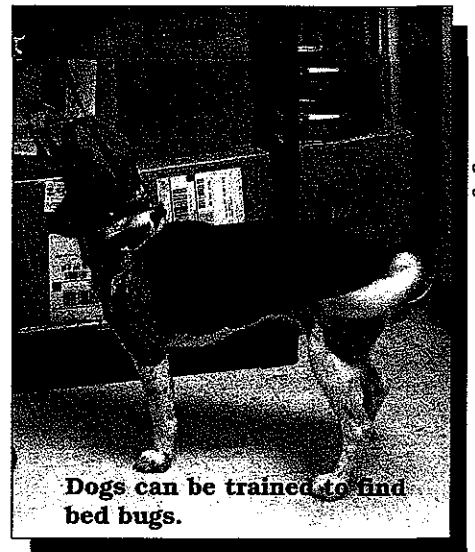
vey found 42% of those over 65 reported no bites or no bite reactions, despite the confirmed presence of bed bugs (Potter et al. 2010a).

Another problem is that many people do not know what bed bugs look like. Their cryptic and secretive behavior, and long periods of hiding in refuges make detection even harder. By the time signs of them are spotted, an infestation may be well established (Reinhardt et al. 2008; Reinhardt et al. 2009; Thomas et al. 2004).

Low level infestations can be detected by bed bug dogs or traps. Dogs represent a costly investment for a pest control company. Bed bug traps can be less expensive and may be a reasonable alternative (see Resources). A styrofoam cup full of dry ice placed in a pet food bowl dusted with talcum powder can be an effective homemade trap (Pfiester et al. 2008; Pinto et al. 2007; Wang et al. 2009a; Quarles 2009b; Anderson et al. 2009).

Bed Bugs at Home

Rather than paranoia about incidental encounters on the bus or subway, more attention should be given to prevention and monitoring in the home. If you feel you are at risk, mattress encasements (see Resources), elimination of clutter, and regular cleaning are your best protection. If you have had an infestation, installation of monitor-



Dogs can be trained to find bed bugs.

Photo courtesy of Pestic

ing traps such as Climbup™ seems prudent (see Resources).

It may be harder to stop them if you have pets, which are also hosts for bed bugs. You may be able to give pets some protection with flea and tick spot-on treatments containing fipronil (Frontline®) and imidacloprid (Advantage®). Tests of chicken house bed bugs show imidacloprid and fipronil are more potent than permethrin, diazinon, chlorfenapyr, dichlorvos, and DDT.

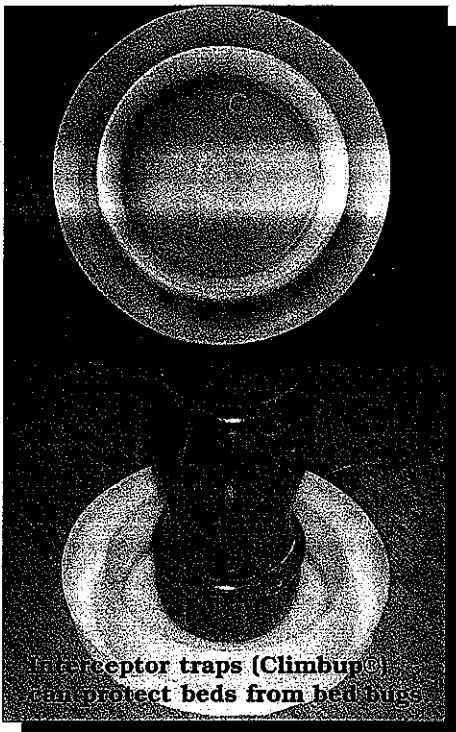


Photo Changlu Wang

Photo Susan McKnight

However, the bugs may not remain on pets long enough to be killed (Steelman et al. 2008).

Stopping them Without Pesticides

Leaving the light on will not stop bed bugs from feeding. Taking a vacation from the premises is unlikely to starve them. Turning off the heat in a cold climate will not kill them unless room temperatures reach -17°C (1.4°F) for at least two hours (Usinger 1966; Naylor and Boase 2010). But if you are able to protect your bed with mattress encasements and traps, bed bugs will not be able to eat and will not be able to reproduce. Females stop

laying eggs after 11 days without eating. Remaining bugs will slowly be removed by the traps (Usinger 1966).

Single Family Dwellings Versus High Rises

Those living in single family dwellings probably do not need to be too concerned about bed bugs. Current IPM techniques such as monitoring, exclusion, removal of clutter, heat treatments, dry ice generators, and traps can disinfest a dwelling (Quarles 2007; Quarles 2009b; Pinto et al. 2007).

The problem comes with infestations in high rises. In one 253-unit apartment house, bed bugs spread from one unit to 101 apartments within 41 months. Pest control operators currently have difficulty controlling cockroaches in high rises, and bed bug eradication efforts also promise difficulties. In these situations, community involvement may be needed. Ongoing monitoring for bed bugs may be necessary (Wang et al. 2010; Quarles 2009c).

Bed Bugs at Hotels

Hotels and motels have to be proactive. It is hard to hide the problem. Self-reporting websites such as bedbugreports.com make infestation information readily available to customers. Mattress encasements provide a good investment in prevention (see Resources). Regular monitoring for bed bugs seems like good insurance. Sticky traps, pitfall traps, and bed bug dogs are available for detection (see Resources). Housekeeping staff and customers are the first line of defense, and reports of bed bugs should be taken seriously. Laundry in infested rooms should be bagged separately from that in other rooms.

The good news is that washing clothes at 60°C (140°F) is effective against all life stages. Tumble drying in a hot ($>40^{\circ}\text{C}$; 104°F) dryer for 30 minutes or freezing at -17°C (1.4°F) for 2 hours will kill all bed bugs. Adults and nymphs can be drowned by soaking laundry, but this will not kill the eggs. It takes

about 8 hours to disinfest 5 lbs of laundry by putting it in a freezer at -18°C (0.4°F) (Naylor and Boase 2010).

Monitor Before Treating

Bed bug dogs can be trained to find bed bugs with high accuracy. The training standard is better than 90% accuracy for live bed bug detection with a false positive rate less than 10%. Eggs are harder to detect than bugs, and false positives sometimes occur with bed bug feces.

As a consequence of their biology, bed bugs are predisposed to dispersal. A bed bug might hitch a ride to an office, find that the space is not to its liking, then hitch a ride out. A dog at the office might alert to bed bug feces and give a false positive response (Pfiester et al. 2008).

It makes sense to treat for bed bugs if they have been seen in an area where they are likely to thrive. But a dog alert should be handled with caution. Dog monitoring can be backed up with monitoring traps. If an infestation is active, sooner or later bed bugs will show up in a monitoring trap (Wang et al. 2009abc).

“Stronger” Pesticides not the Answer

Despite the lesson that should be learned from pesticide resistant bed bugs, some pest management professionals harbor the fantasy that if they were only allowed to use a pesticide that is “strong” enough, the bed bug resurgence would be over. As a consequence, the State of Ohio petitioned the EPA for a Section 18 exemption to use the organophosphate propoxur in structural pest control. Propoxur poses health risks to children, and the EPA denied the petition. Bed bugs are resistant to DDT and pyrethroids, and were showing resistance to organophosphates in the 1960s. So even if propoxur had been approved, resistance would have developed, eventually making it useless (Feroz 1968; Berg 2010).

Another sign of drift toward pesticide solutions is the registration of

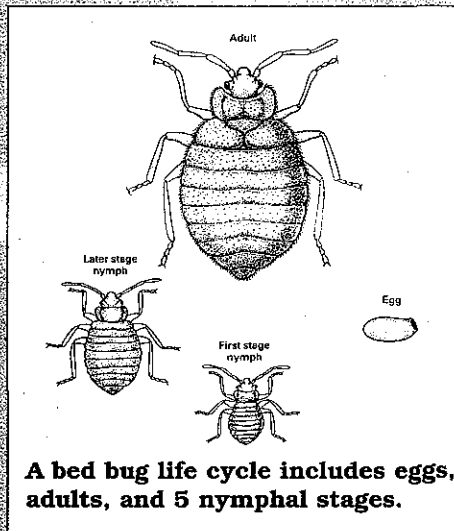
Box A. Biology of the Bed Bug

Bed bugs are a worldwide pest, and are members of the family Cimicidae. There are over 100 species in this family of blood sucking bugs. They include bed bugs, bat bugs, chicken bugs, swallow bugs, pigeon bugs and others. Two species live almost exclusively on human hosts. *Cimex lectularius* is the major pest in temperate areas, and probably originated in caves of the Middle East. Genetic analysis of current U.S. populations shows genetic diversity consistent with many independent breeding populations. Resurgence is probably due both to reintroduction from native reservoirs as well as dispersal from foreign sources through international travel. *C. hemipterus* is found mostly in tropical areas, although ranges overlap and hybridization can occur. In the laboratory and sometimes in the field these species will also feed on a wide variety of other mammals and birds. In addition, human dwellings are sometimes invaded by bat bugs and swallow bugs (Szalanski et al 2008; Usinger 1966; Schaefer 2000; Harlan 2006).

The only food of the bed bug is blood. Blood is needed to live, to produce eggs and sperm, and to moult. The behavior of the bed bug can be described as feed and hide. They feed quickly, usually in about 10 minutes, then hide close to the host for a week or two before feeding again. They aggregate in tight spaces, such as cracks, crevices, underneath wall paper, and other out of the way places. Feeding is usually nocturnal and takes place after midnight, and especially near 3 AM. Relatively large amounts of blood are taken. According to life stage, bugs can ingest 3-6 times their body weight. A female can ingest about 8 mls of

blood in a single feeding. Human DNA from blood can be detected up to 60 days after a feeding, and bed bugs may eventually become a forensics tool (Usinger 1966; Szalanski et al 2006).

Reproduction is sexual and insemination is traumatic. Males pierce the body walls of females and inject sperm directly into the body cavity.



A bed bug life cycle includes eggs, adults, and 5 nymphal stages.

Both males and females feed before reproduction. After she feeds, a female will typically mate about 5 times. The damage done by mating causes about a 30% decrease in her lifespan. Due to female selection, paternity is usually determined by the last male to mate. Females store sperm and are able to fertilize eggs from 5-7 weeks after mating. They lay about 3 eggs a day, but stop after 11 days unless they feed (Schaefer 2000).

Bed bugs practice incomplete metamorphosis, and there are eggs, 5 nymphal stages, and adults. Every stage except the egg bites. *C. lectu-*

larius and *C. hemipterus* lay eggs mostly in and about their harborage. Eggs are laid individually and glued to the substrate. Eggs are yellowish-white capsules about 1 mm long (1/25th in) and 0.44 mm (1/50th in) wide. Rate of development increases with temperature. *C. lectularius* takes about 128 days to develop from egg to adult at 18°C (64.4°F) and about 24 days at 30°C (86°F). At 22°C (71.6°F), eggs take about two weeks to hatch, and bugs spend about one week in each of the 5 instars. Instars grow from about 1.5 mm (1/25th in) long (1st instar) to 4.5 mm (1/5th in) (last instar). Unfed nymphs have a yellowish color, adults are reddish-brown, oval or elliptical in shape and about 1/5 of an inch (5 mm) long.

It is easier to kill them with heat than with cold. Freezing temperatures do not kill them. All stages can survive for at least 5 days at -10°C (14°F), but all stages are killed by 15 minutes exposure to -32°C (-25.6°F). The thermal death point is 45°C (113°F), and all stages are killed by 7 minutes of exposure to 46°C (114.8°F). Longevity after feeding is greatest at low temperatures: at 10°C (50°F) the average for *C. lectularius* adults is about 413 days at 27°C (80.6°F), it is 65 days (Usinger 1966; Sokolova 1956).

A bed bug cannot detect a host at greater distances than 5 ft (1.5 m). Bed bugs can run at 126 cm/min (4 ft/min; 1 in/sec). They can climb walls and cling to ceilings, but they cannot fly and cannot jump like a flea. Activity ceases at low temperature (12°C; 53.6°F). They are attracted to their hosts by heat, CO₂, pheromones, and perhaps other cues. Rodents will eat bed bugs, but bats will not (Schaefer 2000).

fumigation strips containing the organophosphate dichlorvos (Nuvan®). The fumigation strips must be used at least two weeks to kill bed bug eggs. But some bed bugs survived after 14 days of continuous exposure. There is no evidence that this fumigant is any more effective than a heat treatment in destroying the pests (Potter

et al. 2010b; Harned and Allen 1925; Pereira et al. 2009; White 2010; Ross 1916).

The manufacturer may also be in the process of registering dichlorvos sprays. Dichlorvos is a very volatile organophosphate, and spray formulations could lead to ongoing neurotoxin exposure. Tests in dichlorvos treated chicken houses show that

bed bugs develop resistance to the pesticide (Potter et al. 2010b; Steelman et al. 2008).

Permethrin treated mattress protectors (Active Guard®) are another sign of the mistaken search for an easy pesticide solution. Since the whole point of a mattress encasement is physical exclusion, it is not clear what added effect can be

expected by coating the encasements with permethrin. Laboratory tests show that it does not repel bed bugs, and that they are resistant to it (Moore and Miller 2006).

Bed Bug Technology

Rather than drift toward ever more toxic pesticides, we should consider the resurgence of bed bugs as an opportunity to prove the effectiveness of IPM methods, and to develop new chemical free pest control technologies. What has evolved for bed bugs through necessity, such as heat, steam, and dry ice treatments might be adapted for other pest situations. There are several competing heat treatment systems, using both electric and propane heaters. Light weight, portable heaters have been designed (see Resources). As the new technologies are more widely adapted, their costs will be reduced (Pinto 2009; White 2010).

Pest Control Industry

The pest control industry was taken by surprise when the resurgence started in 2007. Companies unfamiliar with the problem underpriced jobs, and in some cases provided ineffective treatments (Miller 2009). One recommendation of the 2009 EPA Bed Bug Summit was that companies should be certified in IPM techniques for bed bugs. Presumably, these certifications would be part of the EcoWise, Greenshield, or GreenPro IPM Certification programs. But an extra bed bug certification seems unnecessary if a company has already been certified in IPM methods (Quarles 2009a).

Conclusion

Bed bugs are currently showing a resurgence. They are formidable pests because they are hard to eradicate, and they carry a social stigma. But they are just pests, not supernatural vampires. Unlike ticks and mosquitoes, they do not cause diseases. There may be too much media hysteria about sightings in potential dispersal centers such as schools, offices, and department

Resources

Bed Bug Traps

BDS Catchmaster Sticky Trap—www.catchmasterpro.com
CDC 3000™—Cimex Science—www.cimexscience.com
Climbup™ Insect Interceptor—Susan McKnight, Inc., 2924 Walnut Grove Road, Memphis, TN 38111; 860/922-1561; www.insect-interceptor.com
Nightwatch™—BioSensory, 107 Providence St., Putnam, CT 06260; 860/928-1113, Fax 860/928-2720; www.biosensory.com

Detection and Treatment

Bed Bug Dogs—American K-9 Team, PO Box 425, Tarpon, FL 34688; 866/615-2662; 727/781-7879; Fax 727/781-1537; www.k9teams.com
Florida Canine Academy, www.termitedogs.com; www.allprok9training.com
Cold Treatment (Cryonite™)—Rest Assured, 877/411-0053; www.restassuredmc.com
Diatomaceous Earth—Perma-Guard, 2430 Alamo SE, Suite 102, Albuquerque, NM 87106

505/243-1460, Fax 505/243-8878; www.perma-guard.com
Woodstream, 69 N. Locust St. Lititz, PA 17543-0327, 800/800-1819, 717/626-2125, Fax 717/626-1912; www.woodstreampro.com
Heat Treatment—Thermapure/TPB Associates (propane), 180 Canada Largo Road, Ventura, CA 03001; 800/873-2912, Fax 805/648-6999; www.thermapure.com
Pest-Heat (propane)—900C Tryens Rd., Aston, PA 19014; 610/558-0837; 877/234-5630; www.pestheat.com
Temp-Air (electric)—3700 West Preserve Blvd., Burnsville, MN 55337; 800/836-7432; www.thermalremediation.com; PackTite Heater—www.amazon.com
Mattress, Bedspring Covers—Protect A Bed, Chicago, IL 866/297-8836; www.protectabed.com; Residex, 800/998-2847; www.cooperpest.com; Mattress Safe, 888/405-5335, www.mattress-safe.com

stores. More attention should be paid to realistic prevention measures—measures such as diligent inspection of thrift store treasures, and avoidance of the curbside mattress or sofa. Travelers should use care when sleeping in hotels and motels. At home, monitoring traps are a cost effective preventive measure. Mattress encasements are a worthwhile investment if you have an infestation. A comprehensive IPM program can successfully eliminate them, but community involvement may be necessary with infested multiunit dwellings.

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