The IPM Practitioner

Monitoring the Field of Pest Management

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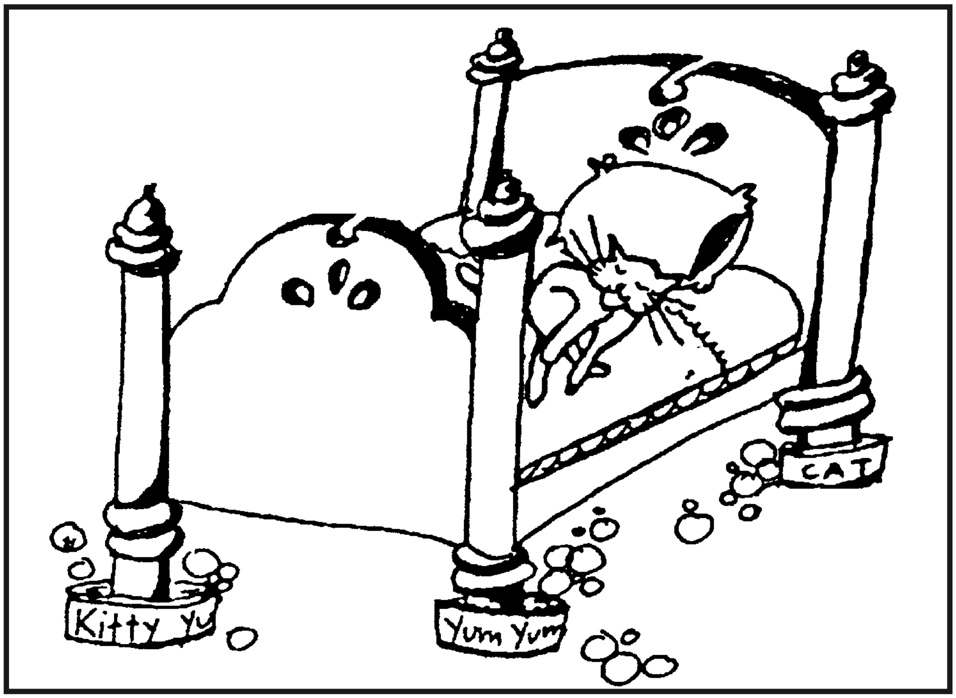
Special Pheromone Report

Don't Let the Bed Bugs Bite

By William Quarles



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.

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 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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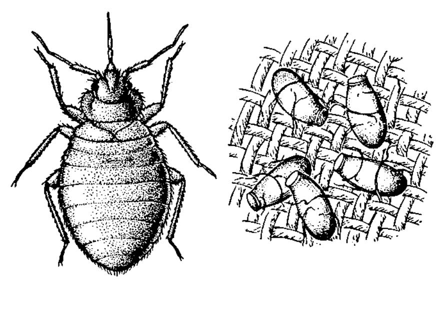
Update



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,

Photo from Usinger 1966

An aggregation of bed bugs

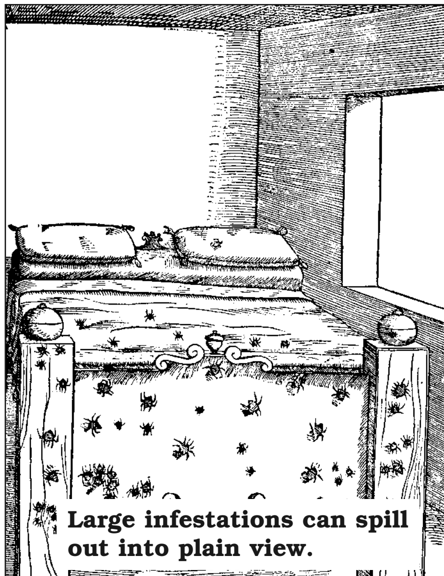
school dormitories, hotels, motels, and other places where people sleep are incubation centers. But as more and more homes are infested, bed bug hitchhikers are going to be taking rides with their hosts. The media has reported bed bug sightings in school buses, department stores, libraries, and office 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®) that can disinfest suitcases might be worth it (see Resources).



From Usinger 1966

Large infestations can spill out into plain view.

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 survey 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-

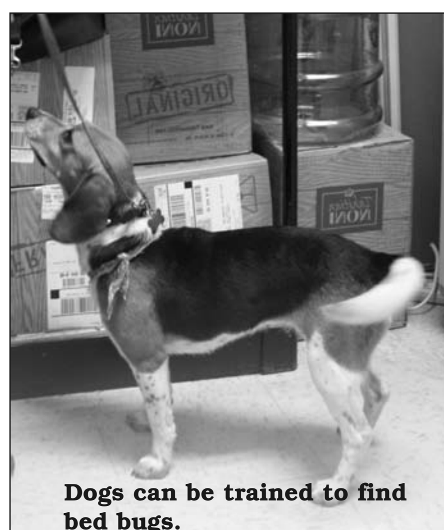


Photo courtesy of Pestec

Dogs can be trained to find bed bugs.

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

Interceptor traps (Climbup®) can protect beds from bed bugs.

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°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).

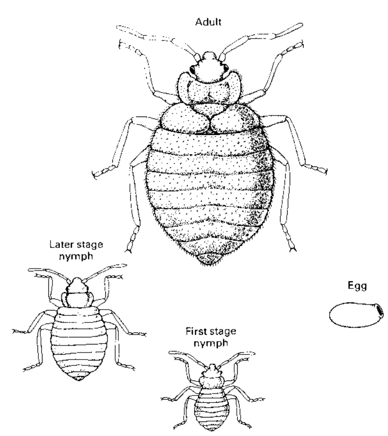
Another sign of drift toward pesticide solutions is the registration of

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 noctural 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. lectularius* 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 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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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/TPE 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.mattresssafe.com

References

Anderson, J.F., F.J. Ferrandino, S. McKnight, J. Nolen and J. Miller. 2009. A carbon dioxide, heat and chemical lure trap for the bedbug, *Cimex lectularius. Med. Vet. Entomol.* 23:99-105.

Berg, R. 2010. Bed bugs: the pesticide dilemma. *J. Environ. Health* 72(10):32-35.

Black, J. 2008. Hotel bed bugs. ESA Notes, *IPM Practitioner* 30(9/10):13.

CDC (Centers for Disease Control). 2010. Joint statement on bed bug control in the United States from the U.S. Centers for Disease Control and Prevention (CDC) and the U.S. Environmental Protection Agency (EPA). August 8, 2010. http://www.cdc.gov/nceh/ehs/publications/bed_bugs_CDC-EPA_statement.htm

Ebeling, W. 1975. *Urban Entomology.* University of California, Berkeley and Los Angeles. 695 pp.

Feldlaufer, M.F. M.J. Domingue, K.R. Chauhan, and J.R. Aldrich. 2010. 4-oxo-aldehydes from the dorsal abdominal glands of the bed bug (Hemiptera: Cimicidae). *J. Med. Entomol.* 47(2):140-143.

Feroz, M. 1968. Toxicological and genetical studies of organophosphorous-resistance in *Cimex lectularius. Bull. Ent. Res.* 59:377-382.

Gangloff-Kaufmann, J., C. Hollingsworth, J. Hahn, L. Hansen, B. Kard and M. Waldvogel.

Update

2006. Bed bugs in America: a pest management survey. *Pest Control Technol.* 34(11):46, 48-49, 52.

Harlan, H. 2006. Bed bugs 101: the basics of *Cimex lectularius*. *Amer. Entomol.* 52(2):99-101.

Harned, R.W. and H.W. Allen. 1925. Controlling bed bugs in steam heated rooms. *J. Econ. Entomol.* 18(2):320-329.

Harraca, V., C. Ryne and R. Ignell. 2010. Nymphs of the common bed bug (*Cimex lectularius*) produce anti-aphrodisiac defence against conspecific males. *BMC Biology* 8:121.

Hudson. 2010. Bedbugs on school bus near Bailey School. November 17, 2010. Hudson Reporter.com

Miller, D. 2009. Living with bed bugs. *Pest Manag. Professional* July:37-43.

Moore, D.J. and D.M. Miller. 2006. Laboratory evaluations of insecticide product efficacy for control of *Cimex lectularius. J. Econ. Entomol.* 99(6):2080-2086.

Moore, D.J. and D.M. Miller. 2008. Field evaluations of insecticide treatment regimens for control of the common bed bug, *Cimex lectularius. Pest Manag. Sci.* 65:332-338.

Naylor, R.A. and C.J. Boase. 2010. Practical solutions for treating laundry infested with *Cimex lectularius* (Hemiptera: Cimicidae). *J. Econ. Entomol.* 103(1):136-139.

Ohio. 2011. Final Report, Ohio Bed Bug Workgroup. Ohio Department of Health, 34 pp.

Olkowski, W., S. Daar and H. Olkowski. 1991. *Common Sense Pest Control*. Taunton Press, Newtown, CT. 715 pp.

Pereira, R.M., P.G. Koehler and M.E. Pfiester, 2009. A new option, localized heat treatments. *Pest Control Technol.* March:34-39.

Pfiester, M., P.G. Koehler and R.M. Pereira. 2008. Ability of bed bug detecting canines to locate live bed bugs and viable bed bug eggs. *J. Econ. Entomol.* 101(4):1389-1396.

Pfiester, M., P.G. Koehler and R.M.Pereira. 2009. Effect of population structure and size of aggregation behavior of *Cimex lectularius* (Hemiptera: Cimicidae). *J. Med. Entomol.* 46(5):1015-1020.

Pinto, L.J., R. Cooper and S.K. Kraft. 2007. *Bed Bug Handbook: The Complete Guide to Bed Bugs and their Control.* Pinto and Associates, Mechanicsville, MD. 266 pp.

Pinto, L. 2009. Greening your bed bug service. *Pest Control Technol.* March:31-32.

Potter, M. 2010. Bed Bugs. University of Kentucky. http://www.ca.uky.edu/entomology/entfacts/ef636.asp

Potter, M.F., K.F. Haynes, K. Connelly et al. 2010a. The sensitivity spectrum: human reactions to bed bug bites. *Pest Control Technol.* 38(2):70-74, 100.

Potter, M.F., K.F. Haynes, M. Goodman et al. 2010b. Blast from the past. *Pest Manag. Prof.* March:46-52.

Quarles, W. 2005. What's biting me? *Common Sense Pest Control Quarterly* 21(1):3-10.

Quarles, W. 2007. Bed bugs bounce back. *IPM Practitioner* 29(3/4):1-8.

Quarles, W. 2009a. Mainstream pest management and IPM (Green) certification. *IPM Practitioner* 31(1/2)1-6.

Quarles, W. 2009b. Bed bug pheromones and traps. *IPM Practitioner* 31(5/6):1-8.

Quarles, W. 2009c. IPM reduces pesticides, cockroaches, and asthma. *IPM Practitioner* 31(9/10):1-8.

Rajecki, R. 2009. Avoid bed bugs' legal bite. *Pest Manag. Prof.* Aug:31-38.

Reinhardt, K. and M.T. Siva-Jothy. 2007. Biology of the bed bugs (Cimicidae). *Annu. Rev. Entomol.* 52:351-374.

Reinhardt, K., A. Harder, S. Holland, J. Hooper and C. Leake-Lyall. 2008. Who knows the bed bug? Knowledge of adult bed bug appearance increases with people's age in three counties of Great Britain. *J. Med. Entomol.* 45)5):956-958.

Reinhardt, K., D. Kempke, R.A. Naylor and M.T. Siva-Jothy. 2009. Sensitivity to bites by the bedbug, *Cimex lectularius. Med. Vet. Entomol.* 23:163-166.

Romero, A., M.F. Potter and K.F. Haynes. 2007. Insecticide resistance in the bed bug: a factor in the pest's sudden resurgence? *J. Med. Entomol.* 44(2):175-178.

Ross, W.A. 1916. Popular and practical entomology. Eradication of the bed bug by superheating. *Can. Entomol.* 48(3):74-76.

Ryne, C. 2009. Homosexual interactions in bed bugs: alarm pheromones as male recognition signals. *Animal Behavior* 78(6):1471-1475. [CAB Abstracts]

Schaefer, C.W. 2000. Bed bugs (Cimicidae). In: Schaefer and Panizzi, pp. 519-538.

Schaefer, C.W. and A.R. Panizzi, eds. 2000. *Heteroptera of Economic Importance*. CRC Press, Boca Raton, FL. 828 pp.

Sokolova, N.Y. 1956. The lowest and highest temperature for mortality of the bed bug (*Cimex lectularius*). *Ektoparasity* 3:113-125. [CAB Abstracts]

Steelman, C.D., A.L. Szalanski, R. Trout, J.A. McKern, C. Solorzano and J.W. Austin. 2008. Susceptibility of the bed bug *Cimex lectularius* (Heteroptera: Cimicidae) collected in poultry production facilities to selected insecticides. *J. Agric. Urban Entomol.* 25(1):41-51.

Szalanski, A.L., J.W. Austin, J.A. McKern et al. 2006. Time course analysis of bed bug, *Cimex lectularius*, (Hemiptera: Cimicidae) blood meals with the use of polymerase chain reaction. *J. Agric. Urban Entomol.* 23(4):237-241.

Szalanski, A.L., J.W. Austin, J.A. Mckern, C.D. Steelman and R.E. Gold. 2008. Mitochondrial and ribosomal internal transcribed spacer 1 diversity of *Cimex lectularius* (Hemiptera: Cimicidae). *J. Med. Entomol.* 45(2):229-236.

Thomas, I., G.G. Khiczak and R.A. Schwartz. 2004. Bedbug bites: a review. *Intl. J. Dermatol.* 43:430-433.

Usinger, R.L. 1966. *Monograph of Cimicidae*. Volume 7, Thomas Say Foundation Series, Entomological Society of America, College Park, MD. 585 pp.

Wang, C., T. Gibb, G.W. Bennett and S. McKnight. 2009a. Bed bug (Heteroptera: Cimicidae) attraction to pitfall traps baited with carbon dioxide, heat, and chemical lure. *J. Econ. Entomol.* 102(4):1580-1585.

Wang, C., T. Gibb and G.W. Bennett. 2009b. Evaluation of two least-toxic integrated pest management programs for managing bed bugs (Heteroptera: Cimicidae) with discussion of a bed bug interception device. *J. Med. Entomol.* 46(3):566-571.

Wang, C., T. Gibb and G.W. Bennett. 2009c. Interceptors assist in bed bug monitoring. *Pest Control Technol.* April:112, 114,

Wang, C., K. Saltzmann, E. Chin, G.W. Bennett and T. Gibb. 2010. Characteristics of *Cimex lectularius* (Hemiptera: Cimicidae), infestation and dispersal in a high-rise apartment building. *J. Econ. Entomol.* 103(1):172-177.

White, J. 2010. Crank up the heat. *Pest Manag. Prof.* Sept:64-66.

IPM News

Proposed Ban of Sulfuryl Fluoride on Food

The U.S. Environmental Protection Agency is beginning a three year phaseout of the pesticide sulfuryl fluoride on food. Sulfuryl fluoride breaks down into fluoride and is commonly used in food storage and processing facilities.

Sulfuryl fluoride is currently registered for the control of insect pests in stored grains, dried fruits, tree nuts, coffee and cocoa beans, and for use in food handling and processing facilities. Although sulfuryl fluoride residues in food contribute only a very small portion of total exposure to fluoride, when combined with other fluoride exposure pathways, including drinking water and toothpaste, the tolerance (legal residue limits on food) no longer meets the safety standard under the Federal Food, Drug, and Cosmetic Act (FFDCA), and the tolerances for sulfuryl fluoride will be withdrawn.

Sulfuryl fluoride is an important postharvest replacement for the pesticide methyl bromide, which depletes stratospheric ozone. Methyl bromide has been phased-out in developed countries under the Montreal Protocol, and many industries that previously relied on methyl bromide to control insect pests in stored and processed food commodities and in food processing and handling facilities now depend on sulfuryl fluoride. Since sulfuryl fluoride is an important alternative to methyl bromide, EPA is proposing to phase out uses of sulfuryl fluoride over a period of three years.

EPA will work with users of sulfuryl fluoride to identify potential alternatives. EPA will also continue to work collaboratively with other government agencies to address fluoride in a way that ensures the public's health while minimizing the risk of overexposure. EPA will be accepting comments on the proposed decision, assessment and benefits assessment for 90 days. For more information, please visit http://www.epa.gov/pesticides/sulfuryl-fluoride/.—*EPA Pesticide Program Updates from EPA's Office of Pesticide Programs January 10, 2011*

Phosphonates Stop Sudden Oak Death

Sudden oak death is killing oaks in 14 California counties. The disease is caused by the pathogen, *Phytophthora ramorum*. Phosphonates (Agrifos®) are registered to control the pathogen in oaks and tanoaks. Phosphonates are salts of phosphorous acid that are either injected into trees or applied directly to the bark along with a surfactant.

Formulation concentrations of 217 mg/ml were injected into trees, or bark was sprayed with a concentration of 310 mg/ml. Both methods were effective. Sprays may be easier to use, but care must be taken with the sprays, as they can cause phytotoxicity to foliage and moss. According to the researchers, phosphonates can protect oaks from sudden oak death for up to two years. Protection is likely due to induced resistance. Applicators should refer to the reference below for a description of the proper application technique.

Garbelotto, M. and D.J. Schmidt. 2009. Phosphonate controls sudden oak death for up to two years. *Calif. Agric.* 63(1):10-17.

Salicylic Acid Increases Pepper Yields

Researchers in Egypt have shown that very dilute sprays of salicylic acid (10^{-6} millimolar) can increase pepper yields by up to 80%. A larger concentration (10^{-4} millimolar) increased yields by a smaller amount (46%). The sprays also increased the amount of vitamin C found in the peppers. The salicylic acid sprays likely stimulate induced resistance through the salicylic acid signaling pathway. Increasing the concentration may cause phytotoxicity.

Elwan, M.W.M. and M.A.M. El-Hamahmy. 2009. Improved productivity and quality associated with salicylic acid application in greenhouse peppers. *Scientia Horticulturae* 122(4):521-526.—from *HortIdeas* Nov/Dec 2009

Red Light Stops Powdery Mildew

Researchers at Cornell have found that greenhouse roses exposed to powdery mildew, *Podosphaera pannosa*, can be protected by exposing them to red light. As little as one hour exposure to red light emitting diodes each night reduces powdery mildew spore formation. Infrared or blue light increases spore formation. It is not clear exactly how light exposure works, but further research may show that other greenhouse crops can be protected by this kind of light therapy.

Suthaparan, A., S. Torre, A. Stensvand et al. 2010. Specific light emitting diodes can suppress sporulation of *Podosphaera pannosa* on greenhouse roses. *Plant Dis.* 94(9):1105-1110.

Sugar Kills Termites

Researchers at Louisiana State University have found that feeding a sugar derivative to Formosan subterranean termites, *Coptotermes formosanus*, led to significant termite mortality over a two week period. The compound is 2-deoxy-D-galactose. Consumption of filter paper soaked in the sugar also led to a decrease in hindgut protozoan populations. Since mortality starts one week after feeding, the sugar has promise as the active ingredient of a termite bait. Slow action would allow time for the chemical to affect an entire colony by trophallaxis.

Veillon, L., S. Muniruzzaman, G. Henderson and R.A. Laine. 2010. Toxic effects of 2-deoxy-D-galactose on *Coptotermes formosanus* (Isoptera: Rhinotermitidae) and symbionts. *J. Econ. Entomol.* 103(50:1647-1656.

Conference Notes

Special Pheromone Report from the ESA 2009 Annual Meeting

By Joel Grossman

This Special Pheromone Report is from the December 13-16, 2009 Entomological Society of America (ESA) annual meeting in Indianapolis, Indiana. Later this year, we will do a Special Pheromone Report from the December 12-16, 2010 meeting in San Diego, California. For more information contact the ESA (10001 Derekwood Lane, Suite 100, Lanham, MD 20706; 301/731-4535; http://www.entsoc.org

Each year, navel orangeworm (NOW), *Amyelois transitella*, causes as much as $100 million in damage to California almonds and pistachios, and it also damages figs and walnuts. Pheromones are a possible treatment. According to Bradley Higbee (Paramount Farming, Bakersfield, CA 93308; bradh@paramountfarming.com), "we have previously demonstrated NOW damage reductions up to 60% in 16 ha (40 acre) plots relative to untreated controls, using a single component sex pheromone. This is equivalent to reductions seen with insecticide programs."

The Santa Fe NOW Areawide Management Project, now in its third year, combines "intense sanitation" and mating disruption. Metered and timed pheromone puffers (Suttera LLC, Bend, OR) dispense the pheromone Z,Z-11,13-hexadecadienal. Insecticides are used only when and where monitoring indicates a need.

"Egg, female, and male trap counts on some exterior edges were elevated relative to the interior," said Higbee. "This coincided with relatively high levels of infestation determined from preharvest sampling in July. Based on this monitoring data, bifenthrin (Brigade® WSP) was applied to the perimeter of each mating disruption treatment area." About 10 acres (4 ha) out of a total of about 2500 acres (1000 ha), or about 0.5% of the total area were treated with the pesticide.

Monitoring NOW

"The navel orangeworm moth is the primary insect pest of almonds and pistachios in California," said Charles Burks (USDA-ARS, 9611 S. Riverbend Ave, Parlier, CA 93648; charles.burks@ars.usda.gov). A viable pheromone lure for monitoring this pest is not currently available, although a component of the pheromone is used for mating disruption. So Burks examined phenyl propionate (PP) as a candidate lure for monitoring NOW populations.

An 0.1% aqueous solution of phenyl propionate dispensed from glass vials as an attractant captured more female navel orangeworm moths than glass dispensers filled with almond meal bait, but less than glass dispensers baited with virgin females. Glass vial PP lures were equally effective in sticky traps or Unitraps. According to Burks, "phenyl propionate released from glass vials captured NOW adults more effectively than other available options, and will be useful in research projects where capturing adults and comparing mating status of females are important."

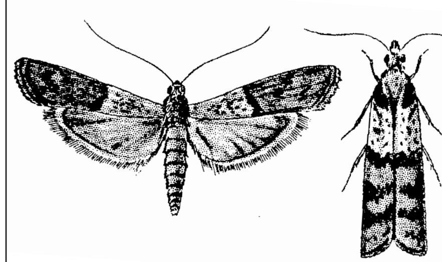
"Almond and pistachio production in California was valued at approximately $2.8 billion on over a million combined acres (400,000 ha) in 2008," said Justin Nay (Integral Ag Inc, 1635 Almendia Dr, Chico, CA 95926; justin.nay@email.ucr.edu). "Direct and indirect costs associated with navel orangeworm and its management are likely to exceed 2% [of that value] annually and in severe years may be as high as 5%."

Navel orangeworm moths are usually monitored with egg-laying traps baited with ground almond meal and almond oil; but recent studies show a preference for pistachio. This observation prompted studies comparing traps baited with almond or pistachio mummies in California almond and pistachio orchards.

Standard sticky bottom winged traps baited with mesh bags containing either ground almond or pistachio mummies can be used to monitor gravid NOW females. A "benefit of this new trap system is the reduction in time to count a few gravid females, versus hundreds of eggs," said Nay. "Traps baited with pistachios caught more gravid females in both almond orchards and pistachio orchards." However, 85% of gravid female NOW moths were caught in pistachio orchards, perhaps indicative of a greater odor plume in this crop.

Indian Meal Moth Mating Disruption

Female Indian meal moths (IMM), *Plodia interpunctella*, use (Z,E)-9,12-tetradecadienyl-1-ol acetate (ZETA) to attract males, and a ZETA mating disruption product is registered with the U.S. EPA, said Rizana Mahroof (South Carolina State Univ, 300 College St NE, Campus PO Box 7365, Orangeburg, SC 29117; rmahroof@scsu). ZETA is also useful for monitoring Indian meal moth. However, even inside a ZETA mating disruption fog, males may still find a pheromone trail



Indian meal moth, *Plodia interpunctella*

released by females. Thus, although male Indian meal moths waste time following false trails, they still may find some females. Other IPM methods such as heat fumigation are necessary against large populations.

Male moths are attracted to Exosex™ tablets (Exosect LTD, Winchester, UK), which are food grade wax powder containing ZETA and pheromone of the Mediterranean flour moth, *Ephestia kuehniella*. Male moths contaminated with ZETA from the tablets attract other male moths, and further transfer the ZETA. Thus, male moths become "mobile pheromone dispensers." With ZETA on their bodies, male moths habituate to ZETA and are unable to locate females.

In feed and flour mill trials, moths were monitored with diamond-shaped sticky traps and food cups for moth egg laying. One Exosex™ tablet per 5 m2 (54 ft2) was used where ceilings were 4 m (13 ft) high. The "control" mills used heat treatments to combat the moths. Mating disruption worked well on a commercial scale for about 10 weeks before the moth population bounced back, indicating the need for an IPM approach combining mating disruption and other control methods.

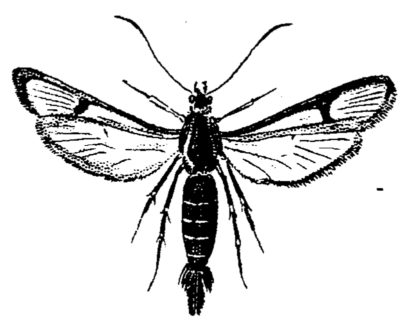
Pink Bollworm Mating Disruption

"Since its arrival in the Southwestern United States, the pink bollworm, *Pectinophora gossypiella*, has proved to be a devastating pest," said Michelle Walters (USDA-APHIS-PPQ, Phoenix, AZ 85040; michelle.l.walters@aphis.usda.gov). "Through the areawide and programmatic use of sterile insect release, genetically modified cotton, good cultural practices of growers, and mating disruption via the dispersal of sex pheromones, pink bollworm populations have been suppressed and eradicated."

"The current standard mating disruption product, PB-Rope®L, is effective and long-lived (90-120 days) but requires hand application. The eradication program needed a mating disruptant that could be mechanically applied by air or ground, is economically priced and would be effective for at least 30 days."

Mating disruption was deemed effective when pheromone baited delta sticky traps (4 per field; 30 rows from edges, 30 paces into field) caught less than one pink bollworm moth per trap per night. PBW-GEL (Pacific Biocontrol), a sprayable acrylic formulation (9.2% active ingredient), was applied by ground tractor rig and Cessna aircraft. In 3 years of Arizona and New Mexico cotton field tests, sterile moth releases over the entire area were combined with three PBW-GEL applications per test field.

When cotton plants are small, 90% of the aerial spray ends up on the ground. Early season sprays were effective less than 30 days, due to a variety of factors including rainfall. Aerial application is more efficient mid-season, when the crop canopy is almost closed. Later season ground and aerial applications provided over 40 days mating disruption. "Pacific Biocontrol and Shin-Etsu are pursuing registration for GEL" in 2010, and it is expected to become a standard part of pink bollworm eradication efforts, said Walters.



Male peachtree borer, *Synanthedon exitiosa*

Pheromones Protect Peaches

"Effective mating disruption by competitive attraction requires that pheromone dispensers outcompete female moths for male approaches, and that male moths become inactivated as a consequence of approaching a dispenser," said Luis Teixeira (Michigan State Univ, East Lansing, MI 48824; teixei10@msu.edu). "The interaction of wild male peachtree borer (PTB), *Synanthedon exitiosa*, and lesser peachtree borer (LPTB), *S. pictipes*, with commercial pheromone dispensers was recorded during four days in mid-August using field-deployed cameras and DVRs. Moth behavior was observed in a pheromone treated peach orchard and in a clean air orchard. Pheromone treatment was part of a mating disruption trial, and dispensers were deployed at the rate of 150 dispensers per acre (0.4 ha).

Moth flight events varied from day to day, probably as a result of changing weather conditions such as cloud cover and wind speed. But male moth events started, peaked and ended at about the same time whether or not the orchard was protected with pheromones.

In 2008 and 2009, mating disruption and mass trapping experiments were conducted in 3-8 acre (1-3 ha) peach plots with PTB, LPTB and American plum borer, *Euzophera semifuneralis*; 150 Isomate dispensers with PTB and LPTB pheromone were used per acre (0.4 ha). Mass trapping results with large orange plastic delta traps were excellent, and reduced moth populations carried over to the second year.

SPLAT Pheromone Technology

SPLAT is an acronym meaning Specialized Pheromone and Lure Application Technology. SPLAT uses a patented, biologically inert waxy matrix to release compounds (primarily pheromones) for IPM monitoring, mating disruption and attract-and-kill techniques, said Lyndsie Stoltman (ISCA, 1230 Spring St, Riverside, CA 92507; isca@iscatech.com). SPLAT dollops are divisible into varying sizes, and are formulated with water to adhere to surfaces and allow for slow pheromone release. As the water carrier evaporates, dollop size decreases and pheromone molecules migrate from the center to the surface.

SPLAT formulations are flowable, and have been applied with grease and caulk guns purchased from hardware stores, paintballs, metered backpack sprayers, tractors, and aircraft. Reloadable grease guns dispense 1 g (0.035 oz) SPLAT dollops from 350 g (12 oz) tubes.

The Splat-O-Gator, a makeshift tractor-like flatbed vehicle for driving field rows, has a drum containing SPLAT, a pneumatic grease pump, a gasoline driven air compressor, and adjustable frame arms for directing SPLAT applications. In USDA ground applications to hoop-trellis caneberries to disrupt brown apple moth (LBAM), *Epiphyas postvittana*, mating in Watsonville, CA, 2.4 kg (85 oz) of product was applied to 10 acre (4 ha) plots in 3 hours. Aerial applications are faster. As of 2009, 5,500 kg (12,125 lbs) was sprayed aerially for gypsy moth mating disruption on over 100,000 acres (40,468 ha) in Wisconsin, Illinois, Virginia and Minnesota.

Human safety, natural enemy preservation, and reduced chemical use are among the advantages cited for pheromone mating disruption, said Agenor Mafra-Neto (ISCA, 1230 Spring St, Riverside, CA 92507; isca@iscatech.com). At its most simplistic, the traditional theory of mating disruption is that a synthetic pheromone cloud hides pheromone plumes emitted by females from males. Though, of course, other mechanisms are also recognized, such as competitive attraction—males use up their time and energy fruitlessly following numerous false trails, and find fewer plumes from real pheromone emitting females.

Whatever the mechanisms, pheromone mating disruption involves flooding a wide area with synthetic pheromones. Hand application of pheromone ropes, tapes and sachets is expensive, but dispensers can last months or even an entire season. Spray technologies such as microencapsulates are cheaper and can rely on conventional equipment, but tend to dissipate more rapidly, with efficacy per application measured in days or weeks. SPLAT attempts to maximize field life with UV light and rain protection inside a reservoir holding a large amount of active ingredient for gradual release.

Light brown apple moth, *Epiphyas postvittana*

Multiple species can be targeted with pheromone mixes; water and oil soluble compounds and mixtures of inert and biologically active compounds can be accommodated. Attract-and-kill formulations add chemical or biological insecticides to the pheromone mix; males are killed after visiting a point on the surface. In lab tests, pheromone of pink bollworm, *Pectinophora gossypiella*, and insecticides were synergistic. The use of SPLAT attract-and-kill mixtures of pheromones and insecticides has expanded to include Oriental fruit moth, *Grapholita molesta*; codling moth, *Cydia pomonella*; the South American tomato leafminer moth, *Tuta absoluta*, and light brown apple moth (LBAM), *Epiphyas postvittana*. SPLAT pheromone and spinosad are combined to combat Oriental fruit fly, *Bactrocera dorsalis*; Asian fruit fly, *B. invadens*; and carambola fruit fly, *B. carambolae*.

Primones Protect Corn

"Priming occurs when an undamaged plant is exposed to a primone or primogen," said Elizabeth Bosak (Pennsylvania State Univ, 122 Chem Ecol Lab, University Park, PA 16802; ejb246@psu.edu). An example is when a corn plant damaged mechanically or by insects releases green leafy volatiles (GLVs) stimulating neighboring undamaged corn plants to increase their internal pest defenses.

The undamaged, primed corn "plant initiates a variety of unspecified biochemical, morphological, and perceptual changes," said Bosak. "When an herbivore begins to feed, the primed plant responds with greater speed and strength." Thus, beet armyworms (BAW), *Spodoptera exigua*, feeding on primed corn plants have higher neonate mortality (57% vs 40% on unprimed plants), are smaller in size, and develop more slowly. This fact likely means less plant damage and greater BAW susceptibility to natural enemies.

Bosak primed corn (maize) plants using Z-3-hexenyl acetate, a green leafy volatile that also happens to be a component of many insect pheromone blends and a flavoring and fragrance ingredient. "Primed maize did not produce a greater amount of volatiles after 24 hours of continuous feeding" by BAW, said Bosak. "During BAW feeding primed maize plants do not show an earlier and stronger induction of jasmonic acid, a phytohormone typically produced during feeding and linked to anti-herbivore defense." Hence, defensive metabolic pathways other than the jasmonic acid system are activated when corn plants are primed with Z-3-hexenyl acetate.

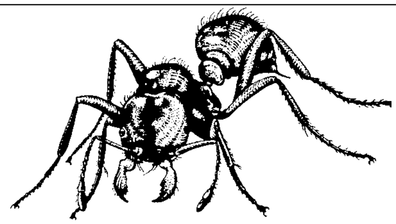
Termite Primer Pheromones

Termites have three main castes for division of labor: workers, soldiers and reproductives, said Matthew Tarver (Univ of Florida, 970 Natural Area Dr, PO Box 110620, Gainesville, FL 32611; tarverm@ufl.edu). Soldiers secrete defensive compounds to combat termite enemies. Soldiers also have large jaws to defend the termite colony, but cannot feed themselves. Thus, worker termites must feed the soldiers.

High levels of juvenile hormone (JH) induce workers to molt into soldiers, though moisture and temperature are also factors. In the termite *Reticulitermes flavipes*, *gamma*-cadinene and *gamma*-cadinenal may be primer pheromones involved in regulating the expression of the caste system that is essential to the termite colony.

Alarm Pheromones and Fire Ant Biocontrol

Semiochemicals such as alarm pheromones of imported fire ant, *Solenopsis* spp., help natural enemies such as the phorid fly, *Pseudacteon tricuspis,* locate hosts and provide fire ant biological control, said Kavita Sharma (Auburn Univ, Auburn, AL 36849; kavitasharma03@gmail.com). Phorid fly antennae, tarsi (leg segments), and ovipositors (tubular egg-laying structures) have sensilla for sensing chemicals (odors).



Fire ant, *Solenopsis* sp.

During courtship, male flies use their tarsal bristles both for mating with female flies and for hovering over and harassing fire ant workers. "Chemosensory bristles on male tarsi may play a role in the semiochemical mediated attraction of males to fire ants at close range," said Sharma. "In *P. tricuspis*, both sexes are attracted to fire ants and mating occurs while females are searching for ant workers to attack." Both male and female genitalia bristles also aid in mating and in identifying fire ant workers as hosts.

Yellowjacket Sex Pheromones

"Yellowjackets (Vespidae) are of economic significance as beneficial predators of pest insects, pestiferous scavengers and as stinging hazards," said Bonnie Ohler (Washington State Univ, 5230 Konnowac Pass Rd, Wapato, WA 98951; jantzerb@yahoo.com). Yellowjacket IPM programs could benefit from identification of volatile sex attractants released by aerial queens for male attraction and a better understanding of yellowjacket reproductive behavior.

In experiments, caged live queens of the common aerial yellowjacket, *Dolicovespula arenaria*, were used as "bait" to capture males. Traps baited with queens caught significant numbers of males, whereas control traps caught none. "These results suggest that *D. arenaria* queens produce a sex pheromone and call for mates," said Ohler.

Sugarcane Weevil Pheromones

The New Guinea sugarcane weevil, *Rhabdoscelus obscurus*, a pest introduced to Guam and neighboring Pacific Ocean islands, attacks sugarcane, betel nut and palms in ornamental nurseries. A 40x25 cm (16x10 in) russet-brown ground trap baited with pheromone lures captures both male and female New Guinea sugarcane weevils. According to Gadi Reddy (Univ of Guam, Mangilao, Guam 96923; reddy@uguam.uog.edu), "recent semiochemical based trapping studies indicate that the Guam population of *R. obscurus* is responding significantly more to pheromone lures of the Australian population than to pheromone lures of the Hawaiian population."

"We expect the new trap design to be useful for monitoring and mass trapping of this important pest in larger ornamental nurseries," said Reddy. A parasitoid found in Hawaii, Australia and Fiji, the tachinid fly *Lixophaga sphenophori*, is specific to *R. obscurus;* but since its introduction from Hawaii has yet to establish on Guam.

Stinkbug Pheromones and Better Biocontrol

"Aggregation pheromone traps have been used in Korea in soybean fields and apple orchards to reduce bean bug, *Riptortus clavatus,* populations," said Md. Abdul Alim (Andong National Univ, Songchun Andong, Gyeongbuk, South Korea 760-749; alimtasfi@gmail.com). "As a new method of pest management we are suggesting to use the aggregation pheromone trap and host eggs together for dual control actions."

In other words, trapping stink bug pests while simultaneously providing host eggs, reduces stink bug populations in the field and boosts parasitoid reproduction and biological control. Where *R. clavatus* eggs and aggregation pheromone traps were used together, parasitism was significantly higher on both natural (78-91%) and refrigerated bean bug eggs (36-59%). Soybean pod damage was reduced 47%, even without significantly reducing *R. clavatus* density.In contrast, when aggregation pheromone traps lacked host eggs, parasitism rates were only 0-62% on natural eggs and 16-34% on refrigerated eggs.

"*Ooencyrtus nezarae* (Encyrtidae) and *Gryon japonicum* (Scelionidae) are major egg parasitoids of *R. clavatus*," said Bishwo Prasad Mainali (Andong National Univ, Songchun Andong, Gyeongbuk, South Korea 760-749; mainali.bishwo@gmail.com). Parasitism in soybean and barley fields is increased by periodic release of refrigerated host eggs (to promote parasitoid reproduction) in traps baited with *R. clavatus* aggregation pheromone.

"Dispersal ability of the parasitoids should be understood in terms of minimizing the number of release points per unit area." Parasitoids disperse about 16 m (52 ft) from aggregation pheromone traps. Current research is aimed at defining the optimum number of pheromone traps per unit area for biocontrol of *R. clavatus*.

Pheromone for Decoy Trees in Japan

"The mass mortality of oak trees (Japanese oak wilt) has recently increased explosively in Honshu and southern Kyushu Island of Japan," said Masahiko Tokoro

Conference Notes

(Forestry Res Inst, PO Box 16, Tsukuba Norin Kenkyu Danchi-nai, Tsukuba Ibaraki, 305-8687, Japan; tokoro@affrc.go.jp). "Japanese oak wilt fungus, *Raffaelea quercivora*, is vectored by the ambrosia beetle, *Platypus quercivorus*, which bores into sapwood of oaks and other broad-leaved trees. The beetle releases an aggregation pheromone that together with host plant kairomones attracts mass attacks of ambrosia beetles leading to tree mortality."

"One component of the aggregation pheromone is (1S,4R)-p-menth-2-en-1-ol (quercivorol)," said Tokoro. "Several types of traps baited with synthetic quercivorol failed to capture large numbers of beetles, probably because of unsolved problems such as the effectiveness of the synthetic pheromone as an attractant, the release rate, method of release, or purity of the pheromone, or missing pheromone minor components or missing synergistic pheromone components."

"Thus, we developed a "decoy tree" method, which uses live oak trees inoculated with a fungicide in combination with the synthetic pheromone as a novel and effective method to attract and kill the beetle (patent pending)," said Tokoro. "The decoy trees were lethal to *P. quercivorus* because the symbiotic fungi that the beetles feed on was killed by the fungicide. Thus, further operational controls such as cutting and burning of the infested trees were not necessary." Indeed, the decoy trees not only attracted and killed many beetles, but also survived thanks to an absence of fungal development. Since *P. quercivorus* is also a pest in India, Indonesia, Taiwan and New Guinea, this IPM technique may have worldwide utility.

Spruce Bark Beetle Aggregation Pheromone

Rescue™, the trade name for a spruce bark beetle aggregation pheromone blend whose components include ipsdienol, ipsenol and verbenol, may soon show up in stores such as Home Depot, Costco and Walmart, said Qing-He Zhang (Sterling International, 3808 N. Sullivan Rd, Bldg 16, Spokane, WA 99216; qing-he@rescue.com). In 2000, high elevation outbreaks along the China-Tibet border of Qinghai spruce bark beetle, *Ips nitidus* spurred research. Infested logs were aerated to collect volatiles, and standard methods of chemical analysis such as gas chromatography-mass spectrometry led to identification of the pheromone.

Ash Borer Lures

Emerald ash borer (EAB) has a close range pheromone, 3-methyl tricosane, but it does not increase EAB trap catches. "This invasive insect produces no long range pheromone and newly infested trees exhibit no external symptoms," said Stephen Burr (Michigan State Univ, 243 Nat Sci Bldg, East Lansing, MI 48824; burrstep@msu.edu). "Currently, EAB traps are baited with lures comprised of compounds that are similar to volatiles emitted by ash, *Fraxinus* spp. trees." The most commonly used lures consist of either a 4-component ash leaf volatile blend or Manuka oil (similar to ash bark and wood volatiles). [Manuka oil is a distillate from the New Zealand tea tree, *Leptospermum scoparium*.]

"We hypothesized that increasing release rates of the compounds or incorporating a close range pheromone produced by EAB could enhance attraction of EAB to lures," said Burr. At standard and high release rates in purple DD traps: "Increasing release rates of the 4-component leaf blend or Manuka oil did not significantly increase EAB attraction to traps." Results were similar with the close range pheromone. Removing the sesquiterpene fraction reduced the attractiveness of Manuka oil.

"We conducted several trapping experiments to evaluate attraction of EAB to different combinations of green leaf volatiles, Manuka oil, and Phoebe oil (essential oil of *Phoebe porosa*)," said Therese Poland (USDA-FS, 1407 S. HarrisonRd, East Lansing, MI 48823; polandt@msu.edu). "Experiments

Calendar

January 3-6, 2011. 23rd Advanced Landscape IPM Short Course. College Park, MD. Contact: U. Maryland, 301/405-3913; Ex 3911.

January 22, 2011. Annual Bay Area Environmental Education Fair (BAEER). Civic Center, San Rafael, Marin County, CA. Contact: 510/657-4847; kenpacx@yahoo.com

January 26-29, 2011. 31th Annual Ecofarm Conference. Asilomar, CA. Contact: Ecological Farming Association, 406 Main St., Suite 313, Watsonville, CA 95076; 831/763-2111; www.eco-farm.org

January 30-February 1, 2011. Annual Meeting Association Applied IPM Ecologists. Embassy Suites, Monterey, CA. Contact: www.aaie.net

February 1-2, 2011. National Bed Bug Summit. Washington, DC. Contact: www.epa.gov

February 7-10, 2011. Annual Meeting Weed Science Society of America. Portland, OR. Contact: www.wssa.net

February 24-26, 2011. 22st Annual Moses Organic Farm Conference. La Crosse, WI. Contact: Moses, PO Box 339, Spring Valley, WI 54767; 715/778-5775; www.mosesorganic.org

March 6-8, 2011. California Small Farm Conference. Doubletree, San Jose, CA. Contact: www.californiafarmconference.com

April 8-9, 2011. Beyond Pesticides Meeting. Protecting Health and the Environment. Colorado School of Public Health, Denver, CO. Contact: Beyond Pesticides, 701 E Street SE, No. 200, Washington, DC 20003; 202/543-5450; www.beyondpesticides.org

June 19-23, 2011. 13th Annual IOBC Working Group, Insect Pathogens and Entomoparasitic Nematodes. Innsbruck, Austria. Contact: hermann.strasser@uibk.ac.at

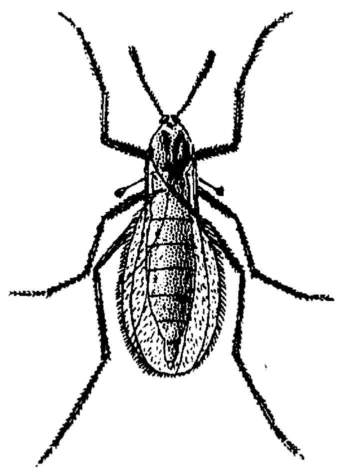
June 23-25, 2011. 68th Annual Convention, Pest Control Operators of CA. Disneyland, Anaheim, CA. Contact: www.pcoc.org

August 6-10, 2011. International Association for Plant Protection Sciences (IAPPS). Honolulu, HI. Contact: www.plantprotection.org

August 6-10, 2011. Annual Meeting American Phytopathological Society. Honolulu, HI. Contact: APS, 3340 Pilot Knob Rd., St. Paul, MN 55121; 651/454-7270; www.aps.net

August 7-12, 2011. 96th Annual Ecological Society of America Conference. Austin, TX. Contact: ESA, 1900 M St. NW, Suite 700, Washington, DC; 202/833-8773; esahq@esa.org

November 13-16, 2011. ESA Annual Meeting, Reno, NV. For more information contact the ESA (10001 Derekwood Lane, Suite 100, Lanham, MD 20706; 301/731-4535; http://www.entsoc.org



Hessian fly,
Mayetiola destructor

were conducted using purple or green prism traps, or double-decker traps." Purple prism traps were hung 1.5 m (4.9 ft) high on rebar poles, and green prism traps were hung at a height of 3m (9.8ft) in the lower canopy of ash trees.

"Phoebe oil alone captured the most EAB" in purple prism traps, said Poland. Male EAB showed more attraction to green prism traps baited with the leaf oil (*cis*)-3-hexenol. The 4-component leaf blend was equal to (*cis*)-3-hexenol alone, and not improved by adding Manuka oil or Phoebe oil. Results were somewhat similar with double-decker traps, except adding Phoebe oil improved catches.

Ash Borer Parasitoid Pheromone

Emerald ash borer, *Agrilus planipennis*, is now in at least 12 U.S. states and two Canadian provinces. So far three Asian parasitoid species, including the braconid *Spathius agrili*, have been released to try to slow the infestation. "Current methods of determining whether newly released populations of *S. agrili* are successfully established at the release sites involves the felling of EAB infested trees, peeling of the bark, searching for the eggs of *S. agrili* on EAB larvae, and the rearing out of possible parasitoid infested EAB larvae," said Allard Cossé (USDA-ARS, 1815 N. University St, Peoria, IL 61604; allard.cosse@ars.usda.gov). This is a very laborious, costly, inefficient, and destructive detection method.

"Long-range attractants for *Spathius agrili*, an important larval ectoparasitoid of the emerald ash borer (EAB), might be useful tools in the EAB biocontrol program" for monitoring parasitoid populations, said Cossé. "We compared the volatile emissions of virgin male and female *S. agrili* and detected at least 10 male and 2 female specific compounds." Female-specific compounds include tetradecyl acetate and (Z)-7-tetradecyl acetate. Male-specific compounds include dodecanal, tetradecane, tridecan-2-one, tetradecanal, hexadecane, 10-pentadecene-2-one, pentadecan-2-one, 11-tetradecen-4-olide, 10-heptadecene-2-one, and heptadecan-2-one.

"A tentative identification of the sex-specific compounds indicated that the compounds are relatively simple to obtain or to synthesize, making a practical tool more promising," said Cossé. Wind tunnel behavioral studies and "all preliminary results so far point to a male-produced aggregation pheromone system in *S. agrili* that might be adaptable to a monitoring system."

Hessian Fly Pheromone

"In recent years a five component pheromone blend has been developed that has had success in attracting male Hessian fly, *Mayetiola destructor*, in a small number of field tests," said Kirk Anderson (North Dakota State Univ, 202 Hultz Hall, Fargo, ND 58108; kirk.anderson@ndsu.edu). The polyethylene microtube sex pheromone lures (Pheronet, Alnarp, Sweden) were placed in the crop canopy "early in the spring and kept in the field until fall freeze" at several locations representing North Dakota's major climatic and cropping regions. The lures, which were changed every two weeks (sticky cards were monitored weekly), were "useful for monitoring" and "appears to be specific for Hessian fly."

"The pheromone is a convenient way to track Hessian fly," said Anderson. "Prior to this project it was believed that there were 1-2 broods per year in North Dakota. Our results show that there is as many as three broods each year. Peak emergence occurred in late-July-early August," which is too early to infest winter wheat and a bit late for infesting spring-sown wheat.

Volunteer wheat, native grasses and introduced forage and conservation grasses (e.g. *Bromus, Agropyron* spp.) may be acting as Hessian fly host plants. However, the pheromone traps indicated some fly emergence persisting from early May to early October, indicating the unreliability of calendar-based "fly-free" planting dates and some risk to spring and winter wheat. Monitoring with pheromone lures could establish actual biological "fly-free" periods for sowing wheat.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