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Light Brown Apple Moth—Crisis of Trust

By William Quarles

The light brown apple moth (LBAM), *Epiphyas postvittana*, is a small moth that is presenting the U.S. with big problems. It is native to Australia but has invaded New Zealand, the UK and Hawaii. It flies at night, mates, and lays eggs on the top surface of a leaf. Eggs hatch into green caterpillars (larvae) that feed on the underside of leaves, secreting silk to secure their position on a plant. Larvae also use their silk to roll leaves into a cylinder, forming a shelter for feeding. This behavior makes them part of a class of pest moths called leafrollers (Tortricidae). LBAM mostly attacks leaves, but also may damage fruit (Varela et al. 2008). (See Box A for the Biology.)

The larvae feed on more than 250 different plant species, and they are an economic threat to a number of crops such as apples, pears, oranges, and grapes. The light brown apple moth has been in Hawaii for 80 years, and in New Zealand for about 100 years. Since the U.S. regularly trades agricultural commodities with New Zealand, and there are many tourist flights from the U.S. mainland to Hawaii every day, an accidental introduction of this pest was probably just a matter of time. In 2007, Jerry Powell, a retired USDA entomologist, found a couple of LBAM in his backyard in Berkeley, California. The California Department of Food and Agriculture (CDFA) began installation of pheromone monitoring traps in March of 2007, and by December nearly 16,000 moths had been found in 14 counties in California (Varela et al. 2008; Johnson et al. 2007).

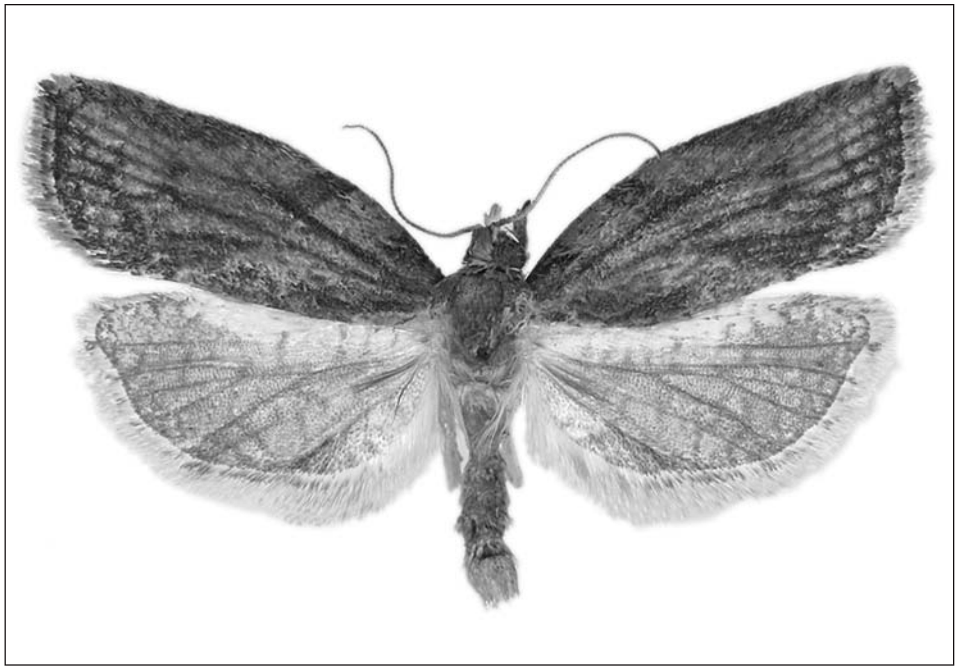

Photo courtesy of Todd Gilligan tortricid.net

Shown here is a male light brown apple moth, *Epiphyas postvittana*. Color variation in the forewing may vary widely between individuals. Females are more uniformly light brown.

No one really knows how long LBAM has been here. Initial introductions of invasives tend to be spotty, populations are small, and unless monitoring agencies know where to look, they do not find anything. According to University of California, Davis entomologist Jim Carey, LBAM was "probably here a very long time prior to its discovery and it's probably far more widespread than currently delineated" (Garvey 2007).

If the moths spread just by flying, the average flight distance is about the length of a football field (100 m; 328 ft). Moths also "seldom leave a high quality host" (Varela et al. 2008). Dispersal over 14 counties would have taken years if dispersal was by flying. If dispersal was from distribution of contaminated plant material, it would have still taken some time for the moths to appear in so many locations, and to appear so readily in monitoring traps.

In This Issue

The IPM Practitioner
Monitoring the Field of Pest Management

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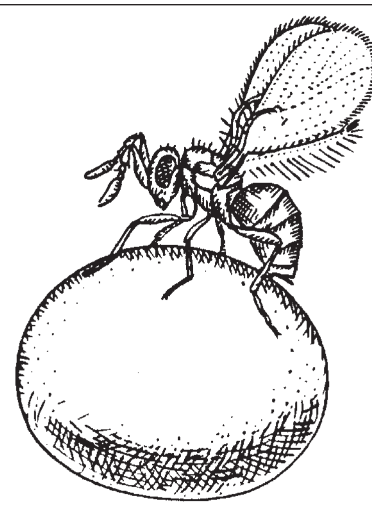
Update

Quarantine a Problem

Confirmation of LBAM presence in the U.S. has brought big trouble. Despite the fact that LBAM may have been here for some time, and has not caused noticeable plant damage, the California Department of Food and Agriculture (CDFA) slapped a quarantine on the most heavily infested counties. Though LBAM has been found in 14 counties, only nine counties are currently quarantined. These include Alameda, Contra Costa, Marin, Monterey, San Francisco, San Mateo, Santa Clara, Santa Cruz, and Solano Counties (CDFA 2007). If the offending counties had not been quarantined, then the USDA was ready to quarantine plant shipments from the entire state.



A *Trichogramma* egg parasitoid may be a good biocontrol for LBAM.

Quarantine would have put at risk California's $32 billion dollar a year agricultural industry (Johnson et al. 2007; Varela et al. 2008).

The USDA is concerned because LBAM could easily adapt to climate and crops throughout the U.S. Especially at risk are crops on the West Coast, the Southwest and the Southeast. This area includes major apple, pear, grape, and orange production regions of the country. USDA entomologists have estimated yearly damage of between $77 and $134 million for these crops if the pest becomes established (Fowler et al. 2007).

At the moment, the major economic hardship is on production nurseries in the nine quarantined California counties. Because of the quarantine, all shipments out of these areas must be inspected and certified free of the pest. Special monitoring techniques are needed. Pheromone traps must be installed at each nursery. Even more disturbing, infested plant material must be treated with the organophosphate chlorpyrifos. Chlorpyrifos is a neurotoxin that puts nursery workers at greater risk for toxic pesticide exposures (Johnson et al. 2007).

Eradication or Management?

Once a problem like this is identified, how should it be handled? One way is to remove it from the USDA list of quarantine pests, acknowledge that eradication will probably be impossible, and manage it like any other leafroller. But other countries that trade with the U.S. may continue with a zero tolerance policy. This stance might put U.S. commodity trade at risk (Johnson et al. 2008).

Because of possible trade impacts, a decision was made to contain and eradicate the infestation. The CDFA established a Technical Working Group (TWG) that proposed a number of recommendations at a meeting in San Diego in December 2007. The overall recommendations included: quarantine, intensive monitoring both nationally and in California, and implementation of an eradication program, of which "aerial application of mating disruption formulations remains the tool of choice for application across broad areas."

According to the TWG, "eradication of the LBAM population will not be a simple endeavor, and will likely take several years to accomplish. In addition to mating disruption, the program should consider using a "multi-pronged" integrated approach (insecticide, attract and kill, biological control and SIT (Sterile Insect Techniques)."

Continued research and nationwide monitoring seems reasonable. If the moth is already widespread throughout the U.S., quarantine and intensive eradication efforts might have to be reevaluated. Biological control is a reasonable and effective technique for suppressing invasives. A *Trichogramma* egg parasitoid would be a likely choice. Reduced-risk pesticides such as *Bacillus thuringiensis* (BT) and spinosad should be effective for the larval stages (Olkowski et al. 1991; Quarles 2005).

The most controversial recommendation was the use of widespread aerial pheromone applications as part of the eradication strategy. Pheromones are generally a benign and effective way to control pests. However, pheromone applications are usually limited to crop production areas. Formulations used are often twist ties that

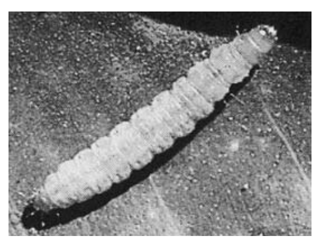
Box A. Biology of LBAM

Adult LBAM, as the name suggests, are generally light brown in color. They are small moths, less than half an inch long. They have protruding mouthparts that resemble a snout. Forewings of males may be lightbrown near the head, but the rear portion of the wings may be reddish-brown to black. Forewings of females have less color variation and are more uniformly light brown. Forewings of males range from 0.23 to 0.4 in (6-10 mm); females have forewings ranging from 0.27 to 0.5 in (7-13 mm). Adults at rest hold their wings over their abdomen forming a bell shape, which is characteristic of other members of the Tortricidae (Varela et al. 2008).

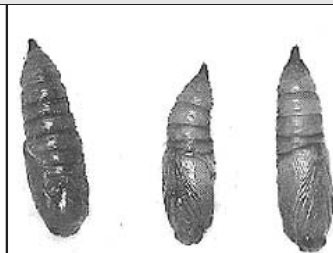
Backwings of both sexes are pale brown to gray. The moths are nocturnal. They rest on the underside of leaves during daylight, and they fly 2-3 hours after sunset and near daybreak. Identification can be made only of the adult stage. Moths that appear in LBAM pheromone traps should be sent to qualified USDA entomologists for confirmation of identity (Varela et al. 2008).

Male LBAM

Female LBAM



Green LBAM larva



Brown LBAM pupae

Photos courtesy D. Williams State of Victoria Dept. Primary Industries

White to lightgreen eggs are laid in masses averaging 20-50 on the upper surfaces of leaves. Females normally lay about 120-500 eggs, but lay a maximum of 1500. Eggs are flat, with pebbled surfaces and are covered by a greenish transparent coating. Eggs are occasionally laid on fruit and stems (Johnson et al. 2007).

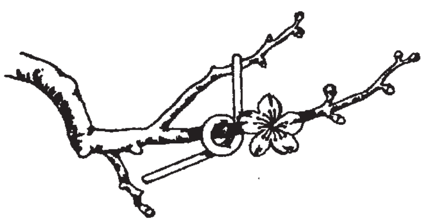
Newly hatched larvae are pale yellow-green, about 0.06 to 0.08 in (1.5 to 2 mm) long. The larvae molt through 5 or 6 instars, and mature larvae are about 0.4 to 0.7 in (10-18 mm). Larvae have a yellow brown head; the body is medium green with a darker green stripe. Hairs on the body are whitish. "In the anal region there is a greenish anal comb—a comb-shaped structure at the tail end of the larva" (Varela et al. 2008). The larvae web two leaves together with their silk in order to pupate. Maturing pupae are dark reddish brown, about 0.4 to 0.6 in (10-15 mm) long (Johnson et al. 2007).

Eggs take 5-30 days to hatch, according to temperature. Development is stalled below 45°F (7.2°C) and above 88°F (31.1°C). Larvae normally hatch in about 1-2 weeks. The pupal stage lasts 1-3 weeks. Adults live 2-3 weeks. In California the pest may go through 2-4 generations according to temperature; higher temperatures mean more generations. Larvae eat their way through the winter on many different food sources, including weeds, shrubs, trees, fruit or other plant material. Light brown apple moth is a more serious pest in cool areas with mild summers and moderate rainfall. Hot, dry conditions reduce populations (Varela et al. 2008).

Generations overlap, and larvae are present for most of the year. Eggs are found on top of leaves. Larvae are found underneath leaves, or they fold a leaf over or web two leaves together to form a feeding structure. Foliar feeding is usually minor damage. Larvae will also attack the surface of fruit, causing cosmetic damage. Sometimes larvae enter pome fruit through the calyx. They can also enter stone fruit. Grape damage includes loss of flowers and berries, or feeding allows mold damage to fruit (Johnson et al. 2007; Varela et al. 2008).

do not expose workers to anything but very small air concentrations of the active ingredient (Quarles 2000).

It is very difficult to eradicate any insect. That is why we still have the gypsy moth, fire ant, and the boll weevil. That is why LBAM is still in Hawaii and New Zealand. Not just one population, but many in different ecological niches must be destroyed (Garvey 2007). As the TWG admits, pheromones alone will probably not eradicate the population, but to reduce population levels, repeated applications over densely populated urban areas would be necessary. These exposures to the formulation might go on for years.



A twist tie pheromone formulation

Effectiveness of Mating Disruption

How effective will mating disruption be as part of an eradication strategy? Best results are obtained when population densities are low, when the moth is not reproductively prolific, when it is primarily a pest of one crop species, and does not migrate very far. If it attacks only one crop, only that crop needs treatment. If females do not fly very far, danger is less that already mated females will fly into a treated area. It is also best if mating moths find each other entirely by olfactory clues (Cardé 1990). Apple moth densities are currently low, it does not migrate very far, and mates are found mostly by odor. However, it is reproductively prolific and has a wide host range (see Box A). This means that even limited successful mating can perpetuate it, and large numbers of crop species or wide areas have to be treated (Varela et al. 2008).

Mating disruption is also more effective when pheromones can reach all the target moths. Difficult terrain, such as valleys, riparian areas, trees that block pheromone penetration, uneven tree canopies, all of these make mating disruption less effective (Harder and Rosendale 2007; Cardé 1990).

Pheromones are rarely used as a stand alone eradication strategy, especially when an infestation is widespread. Annual organophosphate sprays combined with mating disruption were able to reduce codling moth trap catches in 760 acres (308 ha) of pears on Randall Island in California from 1000/trap to 12/trap over six years. That is good management, but that is not eradication (Alway 1998; Quarles 2000). Mating disruption dispensers were able to reduce light brown apple moth infestations in Australian citrus by more than 50% over the course of one year. Again, mating disruption is a benign and effective management technique, but it does not usually eradicate insect populations (Mo et al. 2006).

Crisis of Trust

When aerial sprays were suggested, there was an intense negative public reaction. Part of this reaction was due to an erosion of trust in government and public officials. Recently, we have seen newspaper headlines almost on a daily basis that reflect failures in U.S. food quality inspections, recall of contaminated beef, deaths from contaminated drugs and pet food. Over the last 8 years, confidence in government veracity and competence has plummeted, as science has been deliberately manipulated to support political positions (PBS 2007; CIR 2007). Meanwhile, the internet has made possible grassroots organizing and widespread sharing of technical information independent of government.

Aerial spraying of an urban population is a drastic measure that should be used as a last resort, even if there is reason to believe the formulation is benign. Just the stress of being sprayed might trigger illness in weakened individuals. When millions of people are exposed through inhalation, chances of adverse reactions are increased, especially among children, the elderly, and those chronically ill.

Aerial sprays are a hard sell even if the pest is threatening human health. The CDFA bypassed the normal discussions that should have taken place by declaring the LBAM discovery an emergency. The pest emergency allowed the Department to apply aerial sprays without conducting an environmental impact study, and without producing chronic toxicity studies.

The formulation chosen was a microencapsulated pheromone spray. The public was concerned at the idea of inhaling small plastic capsules, especially since the pheromone microcapsule formulation had never been used on an urban population, and inhalation toxicity tests on the formulation had not been conducted. Despite the initial resistance, microencapsulated pheromones were applied by airplane in September 2007 in the Santa Cruz area. After the spraying, 600 people reported adverse reactions ranging from skin

Photo courtesy CDFA

A male LBAM. An expert is needed for rigorous LBAM identification.

irritation to respiratory distress (Warmerdam and Denton 2007).

After the experience with the first aerial sprays, more than 25 local governments and 70 organizations have passed resolutions against the spraying. Legislation was introduced in the California legislature aimed at limiting CDFAs ability to declare a pest emergency. Because of the controversy, Governor Arnold Schwarzenegger temporarily suspended the aerial spraying program until toxicology studies are completed (Scherr 2008ab).

Pheromone Formulation

LBAM pheromone is a mixture of two chemicals, (E)-11-tetradecen-1-yl acetate and (E,E)-9,11-tetradecadien-1-yl acetate (Suterra 2008). Basically, these are two esters that have very low toxicity to mammals. Just nanogram quantities in the air are sufficient to cause mating disruption. Although most people have little concern about the toxicity of the pheromones, there is considerable concern about the formulation and widespread aerial application. Laboratory tests with a related microencapsulated product showed that it was irritating to eyes and skin, and “could reasonably be expected to cause some respiratory irritation if a sufficient amount were inhaled” (Warmerdam and Denton 2007).

The active pheromones and inerts are encapsulated in small plastic capsules, ranging in size from 10-190 micrometers (μm). [One μm is one-millionth of a meter.]. A key controversy is the actual size of the particles. According to a review by the California Department of Pesticide Regulation (CADPR) and the Office of Environmental Health Hazard Assessment (OEHHA), “The microcapsules are very large by inhalation standards (25 micrometers in diameter or larger) and unable to reach the deep lung. As a result, an inhalation toxicity study, which is designed to examine systemic effects resulting from inhalation into the lung, would not be useful and was not conducted” (Warmerdam and Denton 2007).

The size of the particles is very important. Chronic exposure to small 10 μm airborne particles has been shown to cause human health effects, including increased mortality when the exposure is on a longterm basis (Zanobetti et al. 2000). Suterra, manufacturer of the microencapsulated pheromone, has published a size distribution curve of the formulation. Only about 1% of the formulation **by volume** is small, 10 μm particles that are likely to be a health hazard on inhalation. However, since the size of these particles are small, there are actually a large number of them in any given volume. An analogy is that in a 5 gallon bucket of tennis balls and marbles, though 90% of the volume may be occupied by tennis balls, the 10% occupied by marbles will actually contain a large number of marbles (Knepp and Haferman 2008).

Independent analysis of actual size distribution data showed that the average particle size was 16.9 μm, median size was 10 μm. This means that half the particles in the formulation are in a size range that might have a negative impact on human health. When the formulation is mixed with water prior to spraying, water adheres, making initial airborne particle sizes larger. There is no information on how the particles might redistribute and reaccumulate after aerial release. This redistribution has some importance since the formulation is expect to persist for at least 30-90 days (Knepp and Haferman 2008).

Mitigating the problem somewhat is the low application rate, which is 88.23 ml (86.4 g) of product or 15 g active ingredient/acre (37 g/ha) (Suterra 2008). However, according to modeling studies done by Knepp and Haferman (2008), if the formulation is evenly applied, this amount could represent up to 300,000 10μm particles/ft^2.

Management of LBAM

If LBAM cannot be eradicated, no one knows exactly how bad the consequences will be. Severity of the problem will vary with each affected crop. The pest is basically a leafroller that is similar to many of our native pests, such as the omnivorous leafroller (OLR), *Platynota stultana*. According to entomologist Cliff Ohmart, Research Director of the Lodi Woodbridge Winegrape Commission, “if LBAM cannot be eradicated, I do not think it will in the longrun be any more or less of a problem than OLR...the damage caused by LBAM to winegrapes is exactly the same as that caused by OLR, and the insect behaves in exactly the same way” (Omart 2007).

Wing coloration of LBAM varies widely.

Photo courtesy Natasha Wright, FL Dept. Agric., Bugwood.org

Native leafrollers in California have parasitoids such as *Trichogramma*, *Cotesia*, *Exochus*, *Macrocentrus* and *Nemorilla*; and predators such as spiders, minute pirate bugs, *Orius* spp.; and lacewings, *Chrysoperla* spp. It is likely that these natural enemies will attack the invading leafroller. Biocontrol can be combined with mating disruption, and reduced risk insecticides such as spinosad, insect growth regulators (IGRs), and *Bacillus thuringiensis* to manage LBAM populations (Varela et al. 2008).

Frank Zalom, a University of California entomologist and IPM Specialist believes that California growers can “learn to manage this new pest much as they successfully manage other endemic leafrollers at present. Potential methods would probably include pheromone mating disruption monitoring and use of a degree-day model to target young larvae with less-toxic materials, and biological control” (Garvey 2007).

In the 1990s LBAM was managed in New Zealand with organophosphates. These applications led to population resistance and loss of control. Since then, monitoring has

Update

been combined with biocontrol and applications of IGRs. This approach has been successful. Of 3000 shipments of pome fruits to the U.S. in 2006, only six were rejected due to LBAM contamination (Harder and Rosendale 2008).

Conclusion

In these days of worldwide trade, travel, and increased global warming, increased numbers of invasive pests are going to occur on a regular basis. No one knew the apple moth was here, and there are probably other new invasive pests waiting to be discovered in someone's backyard. Eradication might be possible in some instances, but experience has shown this may be impossible with some pests.

Though pests are a force to be reckoned with, we have learned from the LBAM invasion that the reaction has a potential to be more disruptive than the pest. When new invasives are encountered, government agencies should work to reestablish the trust that has been lost. Bypassing due process through declaration of an emergency increases public suspicion and makes it difficult to obtain public cooperation. The public should be fully informed and involved in the decision-making steps. When aerial sprays are absolutely needed, there should be no shortcuts on safety evaluations.

If LBAM cannot be eradicated, IPM provides some sophisticated methods of managing it in cropping situations. Ultimately, LBAM should be no worse than the native leafrollers we already have. Biocontrol combined with mating disruption and least-toxic materials such as spinosad, IGRs, and BT should keep LBAM below damage thresholds.

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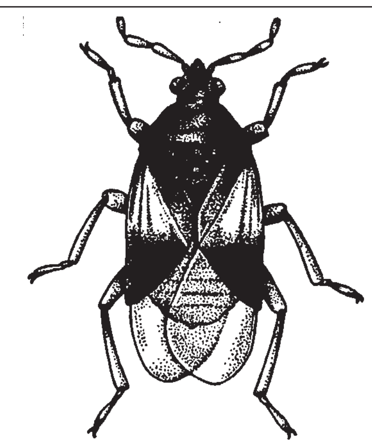
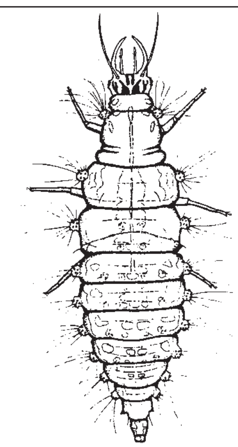


***Orius insidiosus* is a predator of LBAM.**



Lacewing larvae, *Chrysoperla* spp. prey on LBAM.

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IPM News

Rodenticides and Bait Stations

On May 29, 2008 the EPA acted to reduce exposures of children and wildlife to rat poisons. Rodenticides sold in the consumer market must be sold in bait stations. The most toxic rodenticides will only be available to Pest Control Operators (PCOs) and ranchers.

The ten rodenticide active ingredients covered by this action can be divided into three categories:

•First-generation anticoagulants: warfarin, chlorophacinone, and diphacinone;

•Second-generation anticoagulants: brodifacoum, bromadiolone, difenacoum, and difethialone; and

•Non-anticoagulants: bromethalin, cholecalciferol and zinc phosphide.

The anticoagulants interfere with blood clotting, and death can result from excessive bleeding. Bromethalin is a nerve toxicant that causes respiratory distress. Cholecalciferol is vitamin D3, which in small dosages is needed for good health in most mammals, but in massive doses is toxic, especially to rodents. Zinc phosphide causes liberation of toxic phosphine gas in the stomach.

The second-generation anticoagulants are especially hazardous for several reasons. They are highly toxic, and they persist a long time in body tissues. The second-generation anticoagulants are designed to be toxic in a single feeding, but since time-to-death is several days, rodents can feed multiple times before death, leading to carcasses containing residues that may be many times the lethal dose. Predators or scavengers that feed on those poisoned rodents may consume enough to suffer harm.

To reduce wildlife exposures and ecological risks, EPA will require sales and distribution and packaging restrictions for products containing four of the ten rodenticides that pose the greatest risk to wildlife (the second-generation anticoagulants – brodifacoum, bromadiolone, difenacoum, and difethialone) to prevent purchase on the consumer market.

The terms and conditions of registration for products containing brodifacoum, bromadiolone, difenacoum, and difethialone must be amended to specify that the registrants will control distribution of the products so that they shall only be distributed to or sold in agricultural, farm and tractor stores or directly to PCOs and other professional applicators, and that registrants will not sell or distribute products containing brodifacoum, bromadiolone, difenacoum, and difethialone in channels of trade likely to result in retail sale in hardware and home improvement stores, grocery stores, convenience stores, drug stores, club stores, big box stores, and other general retailers.—From http://www.epa.gov/pesticides/reregistration/rodenticides/finalriskdecision.htm

Bee-Killing Pesticides Banned

Massive deaths of honey bees have been reported in Germany in the state of Baden-Wurttemberg. Up to 50% of the bees have died and some beekeepers have lost all their hives. Because of the deaths, Germany's Office of Consumer Protection and Food Safety (BVL) suspended use of eight seed-treatment pesticides. These pesticides contain either clothianidin or imidacloprid as active ingredients. From: http://www.guardian.co.uk/environment/2008/may/23/wildlife.endangeredspecies

IPM and Cockroaches

According to Professor Patricia Hynes of Boston University School of Public Health, up to 30% of children in public housing have asthma. The likely source of the problem is allergens produced by cockroaches. To mitigate the problem, Hynes established the Healthy Pest-Free Housing Initiative, which has implemented an IPM program. A key innovation is that "a core group of peer educators" live in public housing and "help maintain the antipest efforts from within the public housing communities." From: http://www.bu.edu/today/2008/05/23/cockroaches-may-unlock-asthma-answers

Flying Exotics

A major route for invasive exotics may be in airplane baggage of world travelers. For instance, the Mediterranean fruit fly, *Ceratitis capitata*, is constantly being intercepted at U.S. airports. Thousands of interceptions are made, but only a small percentage of baggage is checked carefully for insects. From: Liebhold, A.M., T.T. Work, D.G. McCullough, and J.F. Carvey. 2006. Airline baggage as a pathway for alien insect species invading the United States. *American Entomologist* 52(1):48-54.

Pesticides and Childhood Cancer

French researchers have discovered a link between pesticide use and cancer. When pesticides are used in households with pregnant women, their children have twice the risk of getting acute leukemia or non-Hodgkin lymphoma. The study included 1060 children with cancer and 1681 controls. From: Beyond Pesticides, *Technical Rpt.* 22(12) and *Environmental Health Perspectives* 115(12).

Hot Water In the Nursery

Stanton Gill of the University of Maryland Cooperative Extension has developed a hot water treatment system for nursery plant pests, especially scales, mealybugs, mites and aphids. The device "heats large amounts of water quickly and maintains the specified temperatures while it circulates water around large numbers of plant cuttings." From *IPM Insights*, Northeastern IPM Center, Feb 2008. For more information contact Stanton Gill at sgill@umd.edu.

Pesticides and Autism

Researchers in California report that mothers who lived within a few hundred feet of sites where high rates of the pesticides dicofol and endosulfan were applied are six times more likely to give birth to children with autism disorders than mothers who did not not live near such sites. *Hortideas* 25(2):35 and *Environmental Health Perspectives* 115(10) or www.ehponline.org/docs/2007/10168/abstract.html

ESA 2007 Annual Meeting Highlights—Part 2

By Joel Grossman

These Conference Highlights are from the Dec. 9-12, 2007, Entomological Society of America (ESA) annual meeting in San Diego, California. ESA's next annual meeting is November 16-19, 2008, in Reno, Nevada. For more information contact the ESA (10001 Derekwood Lane, Suite 100, Lanham, MD 20706; 301/731-4535; http://www.entsoc.org).

Pheromone-Enhanced Fire Ant Baits

Toxic baits are effective for fire ant control and have low concentrations of active ingredients. "However, their low specificity presents a threat to many non-target species, particularly other ants," said Yasmin Cardoza (North Carolina State Univ, PO Box 7613, Raleigh, NC 27695; yasmin_cardoza@ncsu.edu). Amending baits with a specific attractant, such as a pheromone, could greatly increase the efficacy. Natural enemies such as phorid flies, *Pseudacteon tricuspis* could also use volatile chemical cues such as pheromones to hunt fire ants.

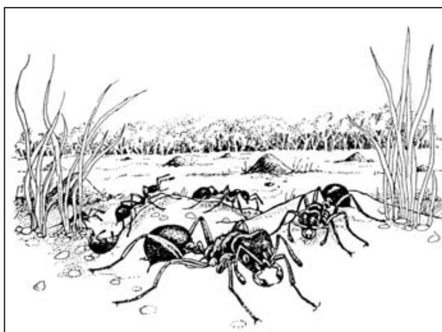
All castes of red imported fire ant, *Solenopsis invicta*, have mandibular glands that produce highly volatile alarm pheromone chemicals. Synthetic versions of two mandibular chemicals were tested for ant behavioral responses and as bait attractants for both fire ants and phorid flies. In dual-choice Y-tube olfactometer tests, a 2-ethyl 3,6-dimethyl pyrazine isomer was biologically active and attractive to fire ant workers; the aldehyde nonanal was not.

In dual-choice assays, racemic synthetic pyrazine was mixed with a typical fire ant corn cob grit bait that included corn oil to stimulate feeding. In 30 second trials, pyrazine significantly increased ant bait discovery from 17% to 60%; 24-hour particle retrieval was significantly increased from 85% to 100%; there were no adverse effects on corn oil ingestion or distribution. "Pyrazine in combination with nonanal may be key to phorid host attraction in the field," said Cardoza. These compounds may prove useful for monitoring phorid population establishment and expansion range.

Jasmine Foils Fire Ants

"Aromatic plants have a distinctive and pleasant odor and contain high concentrations of aromatic volatile organic substances collectively known as essential oils," which due to low vapor pressures easily evaporate at room temperature, said Marla Eva (Auburn Univ, 301 Funchess Hall, Auburn, AL 36849; tanlemj@auburn.edu).

"Several studies have evaluated the efficacy of essential oil-containing formulations against red imported fire ants, *Solenopsis invicta*," said Eva. Citrus oil formulations containing d-limonene were as effective as a conventional insecticide when used as a mound drench. Mounds opened and treated with 2% mint granules caused ants to abandon nests, then form satellite colonies. These studies show that essential oils are both repellent and toxic to red imported fire ants.



Fire ant, *Solenopsis invicta*

Drawing by Diane Kuhn

Extracts of plant materials containing essential oils were obtained from commercial sources, namely NOW Foods (Bloomington, IN) and Sigma-Aldrich (St Louis, MO), and included allspice, *Pimenta dioica*; cinnamon, *Cinnamomum zeylanicum*; clove, *Eugenia caryophyllata*; ginger, *Zingiber officinale;* and jasmine, *Jasminum officinale*. Toxicity and repellency were evaluated with a treated sand digging bioassay and a fumigation assay using red imported fire ants in plastic cups.

In continuous exposure experiments on treated sand, jasmine oil extract was the most toxic essential oil with an LC50 value of 120 ppm. Similarly in the fumigation bioassay, jasmine was the most toxic with an LT50 value of 2.6 hours. All extracts were toxic in the fumigation assay, but there was a two-fold range of toxicity among the extracts.

All extracts were repellent in the digging assay. However, cinnamon was the least repellent at 100 ppm, whereas jasmine and ginger extracts were most repellent. Jasmine extract and its essential oil components including benzyl acetate, linalool, benzyl alcohol, indole, benzyl benzoate, cis-jasmone, geraniol, and methyl anthranilate were singled out for further development as fast-acting fire ant remedies.

Surfactant Fights Fire Ants

Quarantine treatments of red imported fire ant, *Solenopsis invicta*, include contact insecticide dips and soil saturation around tree roots, said Jian Chen (USDA-ARS, PO Box 67, 59 Lee Rd, Leland, MS 38756). A less toxic alternative is potassium oleate, a common surfactant that can immobilize and slowly kill fire ants when used alone as a quarantine treatment.

Small amounts of potassium oleate immobilize fire ants in 38-46 seconds. An 0.03% potassium oleate concentration immobilizes individual fire ants in 32 to 356 seconds. In paper disk bioassays, worker ants were killed in anywhere from 10 to 640 minutes. Though fire ant mortality is slow, fire ant digging in treated sand is suppressed. Additional data is needed on soil effects, length of efficacy, and phytotoxicity before potassium oleate dips can be more widely used for quarantine treatments.

Odorous House Ant Baits

The second most common U.S. ant pest, and the most common ant invading Tennessee and Mid-South structures is the odorous house ant (OHA), *Tapinoma sessile*. Karen Vail (Univ of Tennessee, 205 Plant Sci Bldg, 2431 Joe Johnson Dr, Knoxville, TN 37916; kvail@utk.edu) has studied ant baits for OHA management. The Advion® Ant Bait Arena applied indoors, Advion Ant Bait Arena applied indoors plus an exterior perimeter application of Advion Mole Cricket Bait, and Advion Mole Cricket Bait applied to the outside perimeter of a structure were tested.

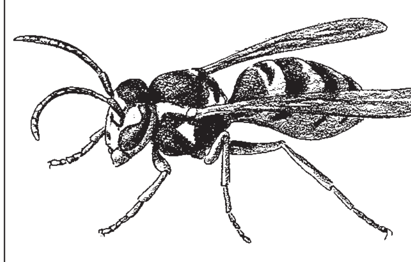
Placing indoor ant bait stations near the entry points and ant trails was the easiest way of reducing ant sightings. "The Advion Mole Cricket Bait rapidly and significantly reduced the number of OHA around homes," said Vail. The effect was prolonged and increased when the Advion Ant Bait Arenas were used indoors in combination with the mole cricket bait. OHA reductions of over 85% lasted for six weeks with indoor and outdoor baiting, versus two weeks with outdoor baiting only. But concentrations of the active ingredient indoxacarb are 300 times higher in the mole cricket bait than indoor bait stations.

European Fire Ant Baits

"The invasive European fire ant, *Myrmica rubra*, has become a serious problem in many Maine communities, including Acadia National Park on Mount Desert Island," said Carrie Graham (Univ of Maine, Deering Hall, Orono, ME 04469;carrie.graham@umit.maine.edu). Of the five fire ant bait insecticides and two bait stations tested, "the most effective treatment was the Advion® fire ant bait (indoxacarb), which resulted in significantly lower numbers of foragers after both the first and second broadcast applications. Pre-Empt® (imidacloprid) liquid in AntPro® bait stations also lowered the number of foragers after the first application, but not after the second. Our feeding preference study suggests that this difference could relate to seasonal changes in relative food preferences of the ants away from sugars."

Trapping Western Yellowjackets

Several sympatric yellowjacket species, particularly the western yellowjacket, *Vespula pensylvanica*, are seasonal predators in California, said Donald Reierson (Univ of California, Riverside, CA 92507; donald.reierson@ucr.edu). However, as insect prey decreases during the summer, yellowjackets can become pests as they compete for human foods at zoos, picnic areas, water parks, schools, campgrounds and other venues.



Yellowjacket, *Vespula* sp.

Alcohol repels yellowjackets, so ethylene glycol was used as a collecting agent in two-part plastic traps. None of 32 pet foods evaluated were attractive in the bait matrix. But Swanson® minced mixed chicken and ground chicken tested in 2 oz (14.8 ml) plastic fast-food salsa cups were effective western yellowjacket baits. Effectiveness was evaluated from landing rates and amount eaten at 2, 6 and 24 hours.

When traps were hung in trees 2-3 m (6.6-10 ft) off the ground in parks or zoos, low doses of fipronil, chlorfenapyr and indoxacarb were 99.7% effective within 4 weeks in 2006, but not with the reduced yellowjacket populations in 2007. A minimum of 10 days was needed for the transfer of toxicants such as fipronil, which easily eliminated yellowjacket nests. But the chicken baits were not effective before July 4th.

To capture more aggressive foragers and reduce the number of stings, Reierson recommends baiting with heptyl butyrate lure. In "virtual baiting," when there is no collecting jar at the bottom of the trap and heptyl butyrate is used as a lure without chicken bait, yellowjackets alight on the treated surface and then emerge out the bottom of the trap and contaminate their nest with toxicants like fipronil.

DEET Alternatives

"More than 700 million cases of mosquito-transmitted disease have been reported annually," and "over 3 billion people live under the threat of malaria, which kills millions annually," said Aijun Zhang (USDA-ARS, 10300 Baltimore Ave, BARC-West, Beltsville, MD 20705). DEET is the most widely used repellent worldwide, but "our laboratory bioassays demonstrate that isolongifolenone, as a sustainable natural product, is more effective than DEET as deterrents and repellents against mosquitoes and ticks." Since isolongifolenone derivatives have been widely used as ingredients in the cosmetic industry, there is "great potential" for "further development and eventual safe clinical usage" of isolongifolenone against disease vectors.

Biteblocker BioUD™, "a plant-based repellent whose active ingredient, 2-undecanone, is derived from wild tomato plants," was approved by EPA in 2007, and is now commercially available in retail stores as a mosquito and tick repellent with no restrictions on use by children, said Brooke Witting (North Carolina State Univ, Box 7613, Raleigh NC 27695; brooke_witting@ncsu.edu). Lab bioassays, field studies and arm-in-cage studies against wild mosquitoes such as *Aedes aegypti* and *Ae. albopictus*, and American dog tick, *Dermacentor variabilis*, indicate that BioUD™ is "a viable alternative to DEET." However, under certain circumstances, where the yellow fever mosquito, *Ae. aegypti* is the major threat, 15% DEET is still the top choice.

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Bed Bug Traps

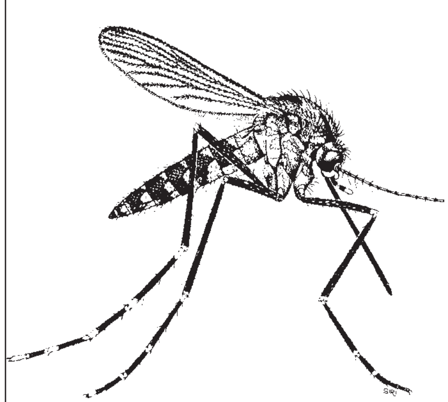
Changlu Wang (Purdue Univ, 901 W. State St, West Lafayette, IN 47907; wang85@purdue.edu) talked about bed bug traps. Bed bugs, *Cimex lectularius*, are very difficult to find because of their small size and nocturnal behavior, especially when the numbers are very low. An effective trap could detect a bed bug infestation in an early stage, reducing insecticide use and increasing the effectiveness of IPM.

Bed bugs are attracted to rough surfaces, and can detect humans from 1.5 m (5 ft). Heat or temperature differentials of 1-2 degrees are detectable from 3 cm (1.2 in), and nest odors are detected from 75 cm (30 in). Blood-sucking insects in general are attracted to host odors and carbon dioxide (CO_2). Octenol, which is exhaled by cattle, plus CO_2, attracts mosquitoes and tsetse flies. L-lactic acid, a major component of human body odor, and CO_2 synergistically attract the yellow fever mosquito, *Aedes aegypti* or conenose bug, *Triatoma infestans*. L-lactic acid plus CO_2 and propionic, butyric and valeric acids is equal to a live mouse in attracting *T. infestans*. Bed bug lures using perspiration odors need more research. Though no trapping efficacy data were provided, patent 20070044372 conceptually outlines a sticky-surface bed bug trap using heat and bait.

A pitfall trap with a fabric outer surface, a bottom trench that releases heat (44-47°C; 111-117°F), and a slow-release chemical lure of octenol plus L-lactic acid was tested in one-bedroom, low-income senior citizen apartments containing 1,000 bed bugs.

A major trap component is a heat-generating cylinder that also releases CO_2 and heats the chemical lure to speed up release of attractant. Three traps operating from 12-6 AM were placed around beds to attract and monitor bed bugs. All the traps caught many bed bugs, and the combination of heat and a chemical lure was more effective than heat alone.

In a second experiment, a lower profile trap design with the cylinder placed horizontally rather than vertically reaffirmed the value of heat plus a 5-component mixed lure for monitoring bed bug populations. The traps caught 200% to 800% more bed bugs than traps without heat and lures. "Pitfall traps with heat and chemical lure have the potential to become a very useful tool for small bed bug infestations," said Wang. "The synergistic effect among CO_2, heat, and chemical lures need to be investigated."



Mosquito, *Aedes* sp.

Ambrosia Beetle Repellents

Woodboring ambrosia beetles such as the black stem borer, *Xylosandrus germanus*, are becoming increasingly problematic on deciduous trees in ornamental nurseries, said Christopher Ranger (USDA-ARS, Rm 206 Ag Eng Bldg, OARDC, Wooster OH 44691; Christopher.Ranger@ARS.USDA.GOV). "Host selection by ambrosia beetles is known to be influenced by attractive host-volatiles and repellent non-host volatiles." So, applying non-host coniferous volatiles such as *alpha*- and *beta*-pinene to deciduous nursery trees might repel ambrosia beetles.

"Repellents or non-host volatiles represent a more user- and environmentally-friendly alternative to traditional insecticides," said Ranger. Ultra-high release rates (UHR) of *alpha*-pinene reduced the attraction of three *Xylosandrus* species to ethanol-baited traps; ethanol alone, but not pinenes alone, attracted *X. germanus*.

Bark Beetle Early Warning

The redhaired pine bark beetle (RPBB), *Hylurgus ligniperda*, native to Europe, the Mediterranean and Asia, was first found overwintering in North America in New York in 2000, said Mary Louise Flint (Univ of California, 720 Olive Dr, Davis, CA 95616; mlflint@ucdavis.edu). In July 2003, it was detected in Los Angeles County, California. Typically a secondary pest attacking weakened trees, "RPBB has since been collected in flight traps in urban and more remote forest lands in Orange, Riverside, San Bernadino, San Diego and Ventura Counties."

Female beetles are attracted to pine volatiles, establish "nuptial chambers" in the phloem, and may release an aggregation pheromone. *Alpha*-pinene attracts them, but ethanol does not. However, ethanol synergizes pinene and increases attraction. Trap data reveals year-round beetle flight, with peaks in March/early May and late July. Traps baited with *alpha*-pinene and ethanol also caught three dozen other tree beetle species including *Scobicia declivis, S. suturalis, Amphicerus cornutus, Arhopalus syriacus, and Hylastes tenuis* and are thus suited for an early detection system.

Luring and Trapping Emerald Ash Borer

Since being discovered in 2002, emerald ash borer (EAB), *Agrilus planipennis*, has killed 25 million ash trees in lower Michigan. "Development of traps and lures for EAB is a high priority," said Deborah McCullough (Michigan State Univ, 243 Nat Sci Bldg, East Lansing, MI 48824; mccullo6@msu.edu).

Adult borers feed on foliage in summer. Larval galleries girdle trees and branches, disrupting water and nutrient transport. Visual monitoring cannot detect low EAB populations and new infestations. Chopping down and debarking "detection trees" to look for EAB larval galleries is effective, but expensive and difficult to implement over large areas.

"Because adult EAB do not produce long-range pheromones, lures must be based on ash volatiles and must effectively out-compete ash trees in the vicinity," said McCullough. Both olfactory and visual factors were incorporated into EAB trap designs. Double-decker (DD) traps with leaf blend (*cis*-3-hexanol + *trans*-2-hexanol + *trans*-2-hexanal + hexanal) and Manuka oil lures caught significantly more EAB than other trap-lure combinations. DD lure traps can detect new infestations, attract EAB 300 m (984 ft) away, and might "replace or supplement girdled detection trees."

Tree Injection Alternatives

"Trunk injection requires repeated wounding, with risk of long-term damage to trunk tissues; soil injection is often unreliable and dependent on site conditions," said David Cappaert (Michigan State Univ, 243 Nat Sci Bldg, East Lansing, MI 48824; cappaert@comcast.net). "In 2005, we began investigating a non-invasive alternative to trunk and soil injection. The technique involves spraying neo-nicotinoids on the trunk from ground level to 1.5 m (4.9 ft) high with a simple garden sprayer. The materials are combined with PentraBark, a bark-penetrating surfactant."

Unfortunately, PentraBark "had no strong effect" on emerald ash borer (EAB) mortality from either imidacloprid or dinotefuron. Possibly, higher concentrations of the PentraBark surfactant are needed to make the technique work.

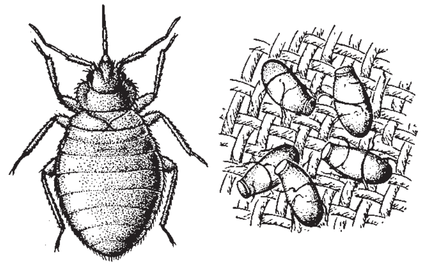
However, Cappaert found that trunk injections of emamectin benzoate were very effective. "We observed 100% mortality of EAB in June, July and August bioassays." No other product has yielded similar results in 5 years of studies. A major question underlying every EAB insecticide trial is whether 'good' performance –e.g. 80% larval control—ultimately prevents the eventual decline or death of a treated tree. In this case, emamectin benzoate provided 99.8% control. Additional studies are planned. [*Note: The emamectin benzoate injections were mistakenly attributed to Blair Helson of Canadian Forest Service in the Jan/Feb issue of the IPM Practitioner. The Practitioner regrets the error.*]

Stink Bug Trap Crops

Reduced areawide spraying of broadspectrum organophosphate and pyrethroid pesticides on cotton and soybeans has encouraged stink bugs, said Russell Mizell (Univ of Florida, 155 Research Rd, Quincy, FL 32351; RFMizell@ufl.edu). Stink bug populations have increased dramatically across the Southeast, and they are now primary pests in every crop they infest. They are found in homeowner gardens, organic production and conventional crops of soybean, rice, corn, cotton, vegetables, and fruit.

Stink bugs prefer to feed on the seeds and succulent areas of plants that are present for a limited amount of time during the season. Trap cropping exploits this behavior by continuously providing food plants in the preferred stage. Sorghum, millet, sesbania, okra, buckwheat and sunflower "with attractive pod and seed formation" are potential trap crops to attract stink bugs "away from the main trap into smaller more manageable areas" for spot treatment or biological control.

Pheromone trap and GIS/GPS data support the potential of trap crops alone or in combination with other tactics to suppress stink bugs throughout the growing season. Mizell tested trap crops of buckwheat, sunflower, okra, pearl millet and grain sorghum. Buckwheat was chosen because it is easy to obtain and culture, grows quickly and is highly attractive to stink bugs when in seed. The flowers also provide pollen and nectar to bees and wasps as well as to tachinid fly parasitoids of stink bugs. Okra and sunflowers also provide nectar and pollen or alternate hosts (aphids, whiteflies, mites) for beneficial insects, as well as large seeds attractive to stink bugs.



Adult bed bug, *Cimex lectularius* and eggs

Though their seed heads are the most attractive to stink bugs, early season is too cool for sorghum and millet. However, spring-planted buckwheat and sunflower and fall-planted triticale, hairy vetch and crimson clover can be early season trap crops. "Buckwheat attracted all of the main pest species during the late flowering and seed formation stage 3-5 weeks after planting," said Mizell.

Organic Cole Crops

Adults and larvae of yellowmargined leaf beetle, *Microtheca ochroloma*, feed on foliage of crucifers such as turnip, mustard, radish, cauliflower, cabbage, collards and watercress in the southern U.S. from Florida west to Texas. Entomopathogenic fungi such as *Beauveria bassiana* strain GHA (Mycotrol O®; Laverlam Intl Corp) and *Metarhizium anisopliae* strain F52 (Tick Ex®; Novozymes Biologicals Inc, Salem, VA) are potential options for organic farmers, said Rammohan Rao Balusu (Auburn Univ, 301 Funchess Hall, Auburn, AL 36849; balusrr@auburn.edu). Eight days after application of recommended rates of fungal conidia in direct immersion assays, adult beetle mortality was 77-94%. Tick Ex worked significantly faster than Mycotrol O. Field efficacy is currently being evaluated.

Yellowmargined leaf beetle, *Microtheca ochroloma*, a native of South America introduced to the U.S. in the mid-1940s, and the harlequin bug, *Murgantia histrionica*, a Central America and Mexico native first found in the U.S. in the late 1800s, can have high populations on organic farms and in research plots that are not heavily sprayed, said Lisa Overall (Oklahoma State Univ, 127 Noble Res Cent, Stillwater, OK 74078; lisa.overall@okstate.edu). Cultural controls, natural enemies and physical barriers are not considered reliable controls for organic cole crops.

In tests on collards and turnips in Oklahoma, pyrethrins (Pyganic® EC 1.4) and spinosad (Entrust®) significantly reduced harlequin bug on some, but not all, sampling dates. Pyganic®, Entrust® and neem

(Neemix® 4.5) significantly reduced yellowmargined leaf beetle on some, but not all sampling dates. Unfortunately, Pyganic also reduced numbers of lady beetle adults and larvae. Overall recommended Pyganic or Entrust for yellowmargined leaf beetle and Entrust for harlequin bug on organic cole crops. Neemix was adequate against yellowmargined leaf beetle, but not harlequin bugs.

Corn Earworm Zapping Oils

"Peruvian subsistence farmers use vegetable oil to kill corn earworm, *Helicoverpa zea*," but the technique also works in the U.S. for both corn earworm and sap beetles, *Carpophilus* spp. said Xinzhi Ni (USDA-ARS, Coastal Plain Exper Stn, Tifton, GA 31793; xinzhi.ni@ars.usda.gov). Xinzhi Ni is extending research by colleague Alton Sparks (Univ Georgia, Tifton). Sun-Spray® and neem (Neemix®) oils served as positive controls, and water was the negative control. The pure corn, canola, olive, peanut, sesame and soybean oils tested were purchased from local supermarkets.

The vegetable oils and controls were applied to 'Silver Queen' sweet corn ears pre-pollination (fresh silk stage) and post-pollination (silk starting to dry). Best results were obtained with pre-pollination treatment.

In 2006 and 2007, Neemix, Sun Spray, sesame and corn oils applied to corn silks were best overall at reducing corn earworm damage; and Sun Spray, sesame and corn oils were best against sap beetles. In 2006 against corn earworm, neem was best for pre-pollination application; and neem and Sun-Spray were best post-pollination. In 2007, there were fewer corn earworm and all the oils worked well as pre-pollination silk treatments; corn, sesame and Sun Spray oils were best post-pollination.

Silicon Slows Zinnia Aphids

Though not an essential element, silicon can increase plant growth and yields, promote tolerance for abiotic and biotic stresses, and wear down the mandibles of chewing insects such as fall armyworm and stalk borers, said Christopher Ranger (USDA-ARS, Rm 206 Ag Eng Bldg, OARDC, Wooster OH 44691; Christopher.Ranger@ARS.USDA.GOV).

As silicic acid, silicon is readily absorbed by plant roots, transported in the xylem, and polymerized and deposited in plant tissues. The greenbug, *Schizaphis graminum*; a wheat-infesting aphid, withdraws its stylets more and whiteflies, *Bemesia tabaci*; infesting cucumber have fewer offspring, in part because silicon leads to elevated levels of oxidative enzymes such as peroxidases.

In zinnias, *Zinnia elegans*, a dicot and specialty cut-flower crop with a high silicon accumulation potential, silicon accumulation reduces powdery mildew. With green peach aphid, *Myzus persicae*, on zinnias, silicon induces phenolic acids, flavonoids and peroxidase enzymes. In experiments with white zinnia (cv 'Oklahoma') irrigated every two days with or without potassium silicate, green peach aphids were confined to a single plant leaf.

No differences were noted in aphid survivorship or developmental time. But silicon significantly lengthened aphid pre-reproductive time and thereby reduced offspring production. Thus, for zinnias, silicon fertilization significantly reduces aphid population fitness and number of offspring; similar results are reported for cucumbers and wheat.

Analysis of dried leaves indicated that extra silicon from the fertilization experiment was incorporated into zinnia leaf tissues. Even plants not supplied extra silicon picked up some silicon from the soil. Silicon's action as an elicitor of defenses against aphids and powdery mildew will be investigated further, said Ranger.

Biocontrol Hedges

Along the central California coast, perennial shrubby hedgerows near 29 commercial organic vegetable fields were vacuum sampled biweekly, and captured Ichneumonidae wasps were sprayed with fluorescent dye for later identification in monitoring traps of organic fields. Deborah Letourneau and Sarah Bothwell (Univ of California, 1156 High St, Santa Cruz, CA 95064; sgb@ucsc.edu; dletour@ucsc.edu). tested vegetation effects on the "abundance, movement and richness of Ichneumonidae, a diverse family of parasitoids."

Ichneumonidae, present on all hedgerow shrubs, and most abundant on coyote bush, *Baccharis pilularis,* moved at least 100 m (328 ft) into annual crop fields. Ichneumonidae species richness, but not abundance, "was positively associated with perennial vegetation cover in the surrounding landscape, and negatively associated with annual crop cover."

The annual crops may lack resources for parasitoids or may be mortality sinks due to factors such as pesticides. Coyote bush provides resources for parasitoids, and parasitoids may prefer to remain there rather than leave for nearby annual crop fields. Riparian areas, identified by willows, *Salix* spp., are humid areas conducive to wasp foraging during dry hot summers, and have a positive association with Ichneumonidae.

Sweet Corn and *Trichogramma*

"Depending on the year and pest pressure, *Trichogramma ostriniae* were a viable alternative to insecticides, both biologically and economically" for controlling European corn borer, *Ostrinia nubilalis*, in northern U.S. sweet corn, said Michael Hoffmann (Cornell Univ, 241 Roberts Hall, Ithaca, NY 14853; mph3@cornell.edu).

When released alone or integrated with insecticide, *T. ostriniae* reduced ear damage and economic returns were favorable for the adoption of the techniques. In 2006, *T. ostriniae* (82,000/acre; 205,000/ha) was at least as good in reducing ear damage as was a single application of methomyl. In 2007 where ear damage was low, there were significant biological effects of *T. ostriniae*, but there was less economic benefit.

Imidacloprid Resistance Warning

Silverleaf whiteflies, *Bemisia tabaci* B-biotype, from a commercial greenhouse were fed imidacloprid (systemic uptake) via cotton seedlings. "The parental generation showed

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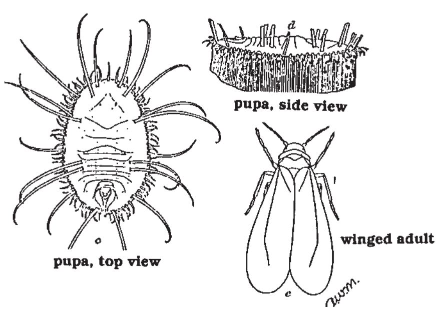
about 13-fold resistance to imidacloprid compared with the susceptible strain," said Mamy Rakotondravelo (Michigan State Univ, Nat Sci Bldg, East Lansing, MI 48824; rakotond@msu.edu). "The resistance ratio increases very fast, from 13-fold in the parental generation to 195-fold in the fifth generation. This suggests a resistance problem with the repeated use of imidacloprid in commercial greenhouses."

Eggplant Traps Whitefly

Eggplant works "quite successfully" as a whitefly trap crop in poinsettia greenhouses in Ontario, Canada, said



Whitefly, *Bemisia* sp.

Doo Hyung Lee (Cornell Univ, 135 Old Insectary Bldg, Ithaca, NY 14853; dl343@cornell.edu). In 24-hour free choice tests, 80% of released greenhouse whitefly, *Trialeurodes vaporariorum*, and silverleaf whitefly, *Bemisia argentifolii*, chose eggplant over poinsettia. In 24-hour "pull-off" experiments, with clean eggplants placed into greenhouses with whitefly-infested poinsettias, 90% of the whiteflies moved off poinsettias onto the eggplant trap crop; more silverleaf than greenhouse whiteflies remained behind on poinsettias.

In "concealment" experiments, with the eggplant trap crop hidden, greenhouse whiteflies first landed on the poinsettias and then moved onto eggplants. But silverleaf whiteflies landing first on poinsettias remained on poinsettias. When eggplant trap crops were placed in the middle of poinsettia greenhouses, at 6 hours whiteflies landed on poinsettias near the release point; at 24 hours whiteflies were moving towards the eggplants; at 48 hours to 10 days, whiteflies had moved onto eggplant.

"Eggplant changes whitefly spatial distribution by holding them," said Lee. However, silverleaf whitefly levels on eggplant are consistently low compared to greenhouse whitefly levels. Thus, in poinsettia greenhouses eggplant is a better trap for greenhouse whiteflies than for silverleaf whiteflies. Olfactory differences are suspected, but the reason for greenhouse whitefly attraction to eggplant is still unknown. In Ontario, Canada, where eggplant trap cropping was developed for greenhouses, greenhouse whitefly was the major pest, though in the last 2-3 years silverleaf whitefly has entered poinsettia greenhouses.

Virus Barriers

Aphid-transmitted non-persistent viruses (ATNPVs) are acquired after a few brief aphid feeding probes and just as easily lost after probing a healthy plant, but crop losses in Hawaii can reach 100%, said Roshan Manandhar (Univ of Hawaii, 3500 Maile Way, Honolulu, HI 96822; roshanm@hawaii.edu). Barrier plantings surrounding crop fields can suppress ATNPVs by acting as physical barriers or virus sinks. Barriers compared for zucchini fields included buckwheat, sunn hemp, okra, zucchini monoculture, cover crops of buckwheat and clover, and bare ground. Aphids were sampled via leaf turning and water pan traps. Virus symptoms were detected via visual inspection.

Monocultures (zucchini alone; bare ground) had significantly more aphids and virus symptoms than dicultures (zucchini crop with zucchini, sunn hemp, okra barriers; buckwheat & clover ground covers). To test the "virus sink" hypothesis of barrier plant protection, cotton aphid, *Aphis gossypii*; and green peach aphid, *Myzus persicae*; infected with a watermelon strain of Papaya ring spot virus were released into field plots.

Compared to zucchini monoculture control plots, cotton aphid virus transmission efficiency was significantly reduced by all zucchini dicultures except okra. Green peach aphid virus transmission was significantly reduced by zucchini, sunn hemp and okra dicultures, but not by buckwheat or clover ground covers.

Calendar

March 29, 2008. UC Master Gardeners Gardening Workshop. Napa, CA. Contact: UC Coop Extn, 1710 Soscol Ave. No. 4, Napa, CA 94559; 707/253-4221.

April 20-May 3, 2008. Permaculture Design Course, San Luis Obispo, CA. Contact: www.earthflow.com

May 20, 2008. 60th Intl. Symp. Crop Prot., Ghent, BelMay 29, 2008. Postharvest Methods, Farm to Buyer. Stratford, OK. Contact: Kerr Center, Sustainable Agric., www.kerrcenter.com

June 5-7, 2008. Understanding Biodynamic Agriculture, San Luis Obispo, CA. Contact: http://continuing-ed.calpoly.edu/

June 12-13, 2008. Environmental Horticulture IPM Conf., San Luis Obispo, CA. Contact: R. Rice, Hort and Crop Sci, Cal Poly, 805/756-2830; http://hcrs.calpoly.edu

June 13, 2008. Grant Application Deadline. Western SARE. Contact: Western SARE, Ag Science Bdlg, Rm 305, 4865 Old Main Hill, Logan, UT 84322; 435/797-3344, http://wsare.usu.edu

June 19 and 20, 2008. AHS Symposium Gardening with Native Plants. Denver, CA. Contact: American Horticultural Society, 7931 East Boulevard Drive, Alexandria, VA 22308.

July 24-26, 2008. AHS National Youth Garden Symposium. Philadelphia, PA. Contact: American Horticultural Society, 7931 East Boulevard Drive, Alexandria, VA 22308.

July 26-31, 2008. Annual Meeting, American Phytopathological Society. Minneapolis, MN. Contact: APS, 3340 Pilot Knob Rd., St. Paul, MN 55121; www.apsnet.org.

August 5-6, 2008. Sustainable Farming Conference, Oklahoma City, OK. Contact: Kerr Center Sustainable Agric., www.kerrcenter.com

October 4-8, 2008. 12th Annual Conf. Community Food Security Coalition. Philadelphia, PA. Contact: www,foodsecurity.org

October 15, 2008. Application Deadline, UC Santa Cruz Farm and Garden Apprenticeship Program. Contact: 831/459-3240; www.ucsc.edu/casfs

October 20-22, 2008. Farming with Grass, Oklahoma City, OK. Contact: Soil and Water Conservation Society, 945 SW Ankeny Rd, Ankeny, IA 50023; www.swcs.org

November 7-8, 2008. Annual Meeting, Assoc. Natural Biocontrol Producers. Stoneville, MS. Contact: M. Burt, ANBP, 714/544-8295; www.anbp.org

November 16-21, 2008. 10th Annual Meeting, Safety of GMOs. Wellington, New Zealand. Contact: 64-9-269-1240; email, isbgmo@tcc.co.nz; www.isbgmo.info

November 16-19, 2008. Annual Meeting Entomological Society of America. Reno, NV. Contact: ESA, 9301 Annapolis Rd., Lanham, MD 20706; Fax 301/731-4538; www.entsoc.org

December 8-11, 2008. Annual Meeting, North Central Weed Science Soc. Indianapolis, IN. Contact: 217/352-4212; www.ncwss.org

Conference Notes

There was no significant difference in numbers of winged aphids landing in monoculture or diculture plots. But diculture plots had fewer aphids and fewer virus symptoms than monoculture plots. Thus, the data supported the "virus sink" hypothesis of barrier plant protection from ATNPVs, not the physical barrier hypothesis. In other words, aphids lost the ATNPVs by feeding on the barrier plants. Sunn hemp barriers provided the highest marketable zucchini yields.

Soybean Aphid Biocontrol

"In the last five years, research has shown that the predator community in U.S. soybean is capable of suppressing soybean aphid, *Aphis glycines*, below economic levels," said Nick Schmidt (Iowa State Univ, 113 Insectary, Ames, IA 50011; schmidni@iastate.edu). In North America, the soybean aphid is attacked by more than 30 species of predators, eight species of parasitoid and several fungal pathogens. Two key generalist predators are the insidious flower bug, *Orius insidiosus,* and the Asian lady beetle, *Harmonia axyridis*. The generalist predator complex has been shown to respond favorably to heterogeneous landscapes, harkening back to the Iowa tallgrass prairie dominant before agriculture intensified in the mid-1800s.

"We observed higher predator-prey ratios in fields that showed low aphid levels, suggesting that predators contributed to aphid population suppression," but "it is unknown what levels of natural enemies are needed to suppress soybean aphid populations in the field," said Alejandro Costamagna (Univ of Minnesota, 219 Hodson Hall, 1980 Folwell Ave, St Paul, MN 55108; costa054@umn.edu). "Our preliminary analysis suggests that practical methods for sampling natural enemies such as transect & whole-plant sampling correlate significantly with more accurate, but tedious methods such as quadrats and sweep-nets, suggesting that these methods may be viable tools to estimate soybean aphid natural enemies for management purposes."

Transect sampling involved walking 30 steps and making visual counts of natural enemies. There were 25 sweeps per sweep-net sample, with 4 samples per field. In whole-plant soybean samples, *Orius insidiosus* (50%) was the dominant natural enemy, followed by lady beetles (39%). Lady beetles were dominant in sweep-net samples (57%), quadrat samples (63%), sticky cards (72%) and transects (97%). "Higher alate (winged aphid) activity earlier in the season was also associated with aphid outbreak populations," said Costamagna. "This suggests that the role of alate migration should be studied to fully understand the factors leading to injurious aphid populations."

CO_2 Traps

"Locating sources of dry ice and compressed gas often presents a logistical problem to staff, especially in remote areas or military settings," limiting the use of CO_2 mosquito traps, said Reginald Coler (ISCA Tech, 2060 Chicago Ave, Suite C2, Riverside, CA 92507; rcoler@iscatech.com). "ISCA's prototype generator produces pure CO_2 at a wide range of output rates using chemical reagents that are safe, easy-to-use, and most importantly, can be shipped to any address with a guarantee for extended shelf-life." Also, the CO_2 generator's circuitry can be programmed via a graphical user interface (GUI) for CO_2 release rate and time of operation.

Sampling mosquitoes and biting flies (midges; black flies) by vacuuming a live horse was compared with a CO_2 trap in southern California, where West Nile Virus (WNV) is a concern. "Host-seeking mosquitoes were generally most active for the first few hours after sunset, with the more abundant species captured in lower numbers throughout the night," said Alec Gerry (Univ of California, 3401 Watkins Dr, Riverside, CA 92507; alec.gerry@ucr.edu). "The significantly higher horse biting rate of *Culex erythrothorax* relative to the CO_2 trap capture rate suggests that our current mosquito surveillance system utilizing CO_2 traps is underestimating the potential threat of this species for WNV transmission to horses."

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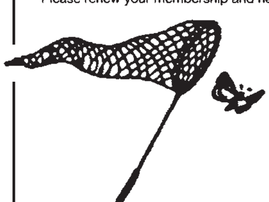

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