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Special Pheromone Report

IPM for the Brown Marmorated Stink Bug

By William Quarles

Courtesy B. Butler, Northeastern IPM Center, StopBMSB.org

The black pyramid trap, shown here, can be used to monitor brown marmorated stink bug populations. Bugs are attracted by aggregation pheromones at the top of the pyramid.

The brown marmorated stink bug (BMSB), *Halyomorpha halys*, is an invasive species native to China, Japan, and Korea. It was first noticed in Pennsylvania in the late 1990s and was established in Pennsylvania by 2001. Genetic analysis shows the initial U.S. introduction likely came from Beijing, China, possibly from shipping containers. Populations are growing exponentially, and it spreads by hitchhiking on shipping containers and vehicles. Adults can fly, which aids local dispersal (Hoebeke and Carter 2003; Nielsen et al. 2013; Lee et al. 2013; Xu et al. 2014).

From the original introduction, the pest has now spread in 13 years to 41 states and Canada (Lee et al. 2013; BMSB 2014). It appeared in Oregon in 2004, and has been in California since 2005. Large breeding populations have established near Los Angeles and Sacramento (Hoddle 2013; BMSB 2014; Ingels and Varela 2014).

H. halys will eat almost anything. It attacks more than 170 different plant species, and prefers to eat many of the same foods as humans, especially beans, garden vegetables, and tree fruit. It is a threat to commercial agriculture, landscape ornamentals, and backyard gardens. It is also a structural pest, as large populations invade houses, trying to overwinter (BMSB 2014; Lee et al. 2013; Inkley 2012).

More than $37 million damage was done to apples in the mid-Atlantic states in 2010. Growers reacted by a four fold increase in pesticide applications. Pesticides disrupted IPM programs and led to secondary outbreaks of mites, aphids, and scales in orchards (Leskey et al. 2012a).

Most pyrethroids had limited effectiveness, as about one-third of the bugs recovered after knockdown. As a result, growers turned to endosulfan, methomyl, and neonicotinoids. Though more effective, these pesticides have environmental problems, including toxicity to bees (Leskey et al. 2012b; Funayama 2012; Quarles 2014a).

This article outlines an IPM program that will help control the brown marmorated stink bug (BMSB), while sparing beneficial insects and bees.

Why More Successful than Native Stink Bugs

We have many species of native stink bugs in the U.S. These have

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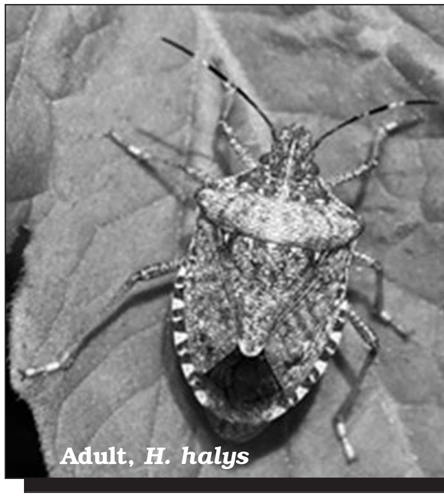
Adult, *H. halys*

Northeastern IPM Center, StopBMSB.org

always been rather low level pests. The invasive *H. halys* is more successful due to lack of specific natural enemies, reproduction in large numbers, wide host range, resistance to cold weather, effective overwintering strategies, and increased survival due to global warming (Lee et al. 2013). At crop sites throughout the mid-Atlantic states, *H. halys* is now the predominant stink bug pest (Nielsen and Hamilton 2009ab).

Though there is some predation, our native parasitoids have not yet adapted to the pest. Reproduction is prolific, as one female can lay an average of 240 eggs per generation. *H. halys* overwinters as adults, emerging in spring to start feeding when temperatures exceed 17°C (63°F). Long daylight hours, warm temperatures, and food lead to sexual maturation within about two weeks. In the Northeast there is one breeding generation a year, but two generations have been seen in West Virginia, and five generations a year are possible in tropical climates (Leskey et al. 2012a; Lee et al. 2013).

Survive Cold Weather

H. halys is more cold resistant than most stink bug species now living in the U.S. For example, mean winter temperatures of 4°C (39.2°F) will kill 81% of the southern green stink bug, *Nezara viridula*, but only 31% of *H. halys* (Kiritani 2006). U.S. spring populations of *H. halys* in 2014 were not reduced by the unusually cold winter of 2013 (BMSB 2014).

H. halys has effective overwintering strategies. Most U.S. stink bugs overwinter in weeds and crop debris. So crop sanitation and weed removal can discourage overwintering populations. But *H. halys* overwinters with a forest theme. It chooses leaf litter, crawls underneath tree bark, and can hide in wooded areas that make it more difficult to intercept. And hordes of *H. halys* invade structures to spend the winter in comfort (Lee et al. 2013).

Increased Survival from Global Warming

Global warming is contributing to the increase and spread of many pests. Pest ranges are spreading, and early springs increase the number of generations a year (Quarles 2007; IPCC 2013). Global warming may have contributed to increase and spread of *H. halys*. Temperatures in Japan and the U.S. have increased by nearly 1°C (1.8°F) over the last 100 years. When mean winter temperatures are averaging about 4°C (39.2°F), every 1°C (1.8°F) increase can increase winter survival rates of *H. halys* by about 16.5% (Kiritani 2006; 2007).

Stink Bug Damage

Adult bugs are about the size of a dime (see Box A), but they are way more than ten cents worth of trouble. *H. halys* sucks plant juices through a feeding stylet. Injection of saliva can cause enzymatic damage, brown spots, surface depression, and mealy consistency in apples. Individual kernels of sweet corn are destroyed. Bean pods are scarred and deformed. Grape berries are destroyed, and wine may be tainted. Though most damage is to fruit trees, greater than 20% damage has been seen in pepper, tomato, eggplant and okra (Leskey et al. 2012a). Damage to soybean includes deformed seeds, delayed maturity and reduced yields (Nielsen et al. 2011). *H. halys* can

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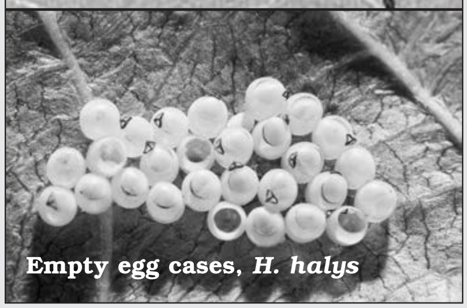
Box A. Biology of BMSB

Life stages are eggs, 5 nymphal instars, and adults. Females lay clusters of barrel shaped, white to light green eggs (1.6 mm) every 5-7 days on the underside of leaves. About 9-16 batches of eggs are laid over a 2-3 month period. Batch size averages about 28, and lifetime egg production ranges from 100-500, averaging about 240 (Lee et al. 2013; Medal et al. 2012; 2013; Hoebeke and Carter 2003).

Adult *H. halys* are about the size of a dime, approximately 17 mm (5/8 in) long. They have typical stink bug "shield" shape, and are almost as wide as they are long. Adults are marbled brown in color, antennae have white bands, and edges of the abdomen have alternating light and dark markings. Nymphs range from 2.5 to 12 mm (1/10 to 1/2 in), according to age of instar. Later instars have marbled brown bodies with red, black and white abdomen markings and white banded legs and antennae. Only adults have functional wings, so nymphs must walk everywhere they go (Ingels and Varela 2014; Jacobs 2014).

Nymph, *H. halys*

Photo courtesy EPA



Empty egg cases, *H. halys*

Photo courtesy Wil Hershberger

Eggs hatch in 4-5 days, and each nymphal instar lasts about a week, except the 5th instar continues for two weeks. Development from egg to adult is about 1.5 to 2 months. Adults live an average of about one year, and overwintering spring adults usually die after egg laying is completed (Lee et al. 2013).

Adults emerge in the spring, spend about two weeks feeding, then mate and start laying eggs at about the end of May. Eggs hatch in June and July, and fall adults have developed by August. Fall adults usually go into reproductive diapause and start looking for overwintering sites in September. These fall adults overwinter, emerge next spring, lay eggs and die in the summer. Life cycle of *H. halys* is determined by day length and temperature. In warmer areas, there can be two or more breeding generations each year (Lee et al. 2013; Medal et al. 2012; 2013).

also vector diseases such as *Paulownia* witches' broom (Lee et al. 2013).

In the Northeast, adults of *H. halys* feed on apples both early and late in the season. Eggs are laid on apple, nymphs hatch, then walk away from apples to another host. After nymphs develop into winter adults in July and August, they fly back to feed on apples. Damage to apples at harvest can exceed 25% in New Jersey and more than 70% in Pennsylvania. Pears and peaches are also damaged (Nielsen and Hamilton 2009b; Leskey et al. 2012b).

In the Northeast, adults are first found in late April on ornamentals such as princess tree, *Paulownia tomentosa*, and crop hosts such as apple and pear. Egg laying starts at the end of May, and this coincides with the first appearance of adults in blacklight traps (see Monitoring below). Egg masses are seen by mid-June. Preferred hosts in July are viburnum and ash. Peak appearance in blacklight traps is in August, showing late season movement of fall adults to feeding sources (Nielsen and Hamilton 2009a). Pheromone traps also show peak populations in August (Weber et al. 2014).

H. halys feeds through bark on trees and ornamentals, leaving weeping holes of exudates. Martinson et al. (2013) found two-thirds of trees surveyed in Maryland had *H. halys* present, and about 15% of trees had exudates from feeding injuries. Native hymenoptera such as paper wasps, yellowjackets and ants feed on the injuries. This feeding can be viewed as good for native species, or if there are a lot of problems with yellowjackets, ants, and wasps as structural pests, a bad thing.

What Makes a Stink Bug Stink?

H. halys invades structures, and one of the problems is the odor produced. Stink bugs produce odorous secretions, probably to deter predators (Aldrich 1988; Millar 2005). The defensive secretions vary with each species, but often contain unsaturated aldehydes (Borges and Aldrich 1992; Noge et al. 2012). The major stink chemical of *H. halys* is (*E*)-2-decenal. It can be detected in concentrations of 0.3 micrograms per liter (Baldwin et al. 2014).

Stink bug defensive secretions can actually attract enemies such as spiders and parasitoids (Aldrich and Barros 1995; Mattiacci et al. 1993). As well as defensive secretions, stink bugs produce aggregation pheromones, and these may or may not have a noticeable odor (Weber et al. 2014). Aggregation pheromones are commercially available (see Resources), and are especially useful for monitoring and for attract and kill formulations (see Box B).

Monitoring

Monitoring can be done with pheromone traps or light traps,

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visual estimation, beat samples and sweep net samples (Leskey et al. 2012b; Lee et al. 2013; Nielsen et al. 2013; Nielsen and Hamilton 2009b).

Blacklight traps are useful to monitor for adult activity and mobility (see Resources). *H. halys* is more active at night, and males and females are equally attracted to light. White light attracts more *H. halys* than blue light. Blacklight populations can provide timing for taking beat samples (Nielsen et al. 2013; Leskey et al. 2012c).

Black pyramid traps baited with pheromones are useful monitoring tools, and they are commercially available (see AgBio Resources). [See photo on the front page.] Larger traps give better results than small ones, and placement on the ground is more effective than in a tree canopy (Leskey et al. 2012c).

Pyramids are about 1.22 m (4 ft) high, and on top is a 1.9 liter (2 qt) jar containing a lure (see Box B) and a killing strip of pesticide. In apples, traps were spaced 5 m (16.4 ft) from orchard edges, 20-25 m (65.6-82 ft) apart. The black pyramid shape is attractive probably because bugs mistake it for the trunk of a tree. Initial tests were done with MDT aggregation lures (see Box B). Attraction increased with the amount of MDT in the lures (Leskey et al. 2012c).

Beat samples are used for trees or woody shrubs. Limbs are tapped three times with a rubber bat at height of 1.5 to 3 m (5 to 9.8 ft). Startled insects drop into a canvas beat sheet 71 cm by 71 cm (28 in by 28 in) (see BioQuip Resources). One early season adult per 10 trees could result in economic damage. If first instar nymphs are found in beat samples, the tree should be visually inspected for egg masses (Nielsen and Hamilton 2009b).

Sweep nets are better than beat samples for monitoring soybeans (see Resources BioQuip). But large pyramid traps baited with aggregation pheromones can detect bugs earlier in the season than sweep net samples. Bugs move into soybean during critical bean development times. The full pod (R4) stage is most vulnerable, and 4 bugs per 0.3 m-row (4 per 1.0 ft-row) could cause economic damage (Nielsen et al. 2011; Owens et al. 2013).

Physical Barriers

Row covers could be effective in a garden situation. Sticky barriers around tree trunks could stop nymphs and many adults. Bags have been used to protect fruit, but this would be impractical for large orchards (Lee et al. 2013; Jacobs 2013). Netting has been used to protect houses (see below) (Watanabe et al. 1994).

Traps

Successful traps include light traps and pyramid traps. Light traps outside are mostly used for monitoring. Properly placed light traps inside may help with reduction of overwintering populations (see Sterling Resources). Pyramid traps are mostly used for monitoring, but the pheromone lures can be used to cause *H. halys* aggregations that can be destroyed by biopesticides (Leskey et al. 2012c).

Trissolcus halyomorphae

Photo courtesy S. Valley, OR Dept. Ag.

Trap crops may be successful. Early maturing soybeans have been used as a trap crop to protect late season varieties (Lee et al. 2013). Fall planted triticale, crimson clover and vetch, and spring planted sunflower and buckwheat have been recommended as trap crops in the Southeast. Bugs can be removed with vacuums or sweep nets (Mizell 2014).

Boxes packed with straw, paper, or straw mats have been used as overwintering traps. Slit traps made of layered wood have also been used in this way (see below) (Watanabe et al. 1994; Lee et al. 2013).

Repellents

H. halys is repelled by essential oils. Clove, lemongrass, spearmint, and ylang-ylang oils are nearly 100% repellent. Wintergreen, geranium, and rosemary are 60-85% repellent. The aggregation pheromone of the spined soldier bug, *Podisus maculiventris*, is also repellent. The pheromone is a mixture of *alpha*-terpineol and *(E)*-2-hexenal (Aldrich et al. 2007; Zhang et al. 2013).

Though essential oils are repellent, they volatilize quickly and do not provide ongoing protection. Effectiveness might be improved with encapsulated, slow release formulations. Repellents might also used in combination with *H. halys* aggregation pheromones in a “push pull” strategy to augment mass trapping or increase effectiveness of attract and kill formulations.

Biological Control

Biological control is an important component of brown marmorated stink bug IPM. Since they are not mobile, eggs are the most vulnerable stage of *H. halys*. Though eggs hatch within 4-5 days, females lay clusters about every 5-7 days, providing a continuous supply of eggs vulnerable to parasitoids and predators for at least 10-12 weeks (Medal et al. 2013).

Our native parasitoids have not yet adapted to *H. halys*, and parasitism rates are less than 5% (Aldrich et al. 2007). Classical biological control may provide a solution. The *H. halys* U.S. introduction likely came from Beijing (Xu et al. 2014). *Trissolcus halyomorphae* is an effective *H. halys* egg parasitoid from that area. Parasitism rates of 20-70%, averaging 50%, are common. The parasitoid overwinters as an adult, and its populations are synchronized with *H. halys*. The parasitoid produces 10 generations a year. Female to male ratios are about 5:1, and one female parasitizes all the eggs in a typical 28 egg BMSB cluster before moving on.

T. halyomorphae is identical with *T. mitsukurii*, which is found in Japan (Yang et al. 2009).

Stink bugs produce stinky defensive secretions to deter predators. But birds eat nymphs and adults anyway (Ingels and Varela 2014). General predators such as lacewings, ladybugs, and pirate bugs, *Orius* sp. feed on *H. halys* eggs. Predation of *H. halys* eggs by spiders and bigeyed bugs, *Geocoris* sp. in Maryland soybeans can approach 50% (Leskey et al. 2012a). Many of the same predators attack our native stink bugs, following them from crop to crop (Tillman 2010; 2011).

Tachinid flies such as *Euclytia flava* are attracted by MDT aggregation pheromones. So pheromone monitoring can increase biocontrol when both tachinids and pests are drawn to the same areas (Aldrich et al. 2007).

Box B. Aggregation Pheromones

A late season attractant for *H. halys* is the aggregation pheromone of the related stink bug, *Plautia stali*. This pheromone, methyl (*E,E,Z*)-2,4,6 decatrienoate (MDT), is useful for late season monitoring and mass trapping of *H. halys*. The pheromone also attracts other stink bugs, and acts as a kairomone, attracting stink bug natural enemies, such as tachinids and wasps (Cottrell et al. 2014; Aldrich et al. 2009; Aldrich et al. 2007; Khrimian et al. 2008). The *P. stali* pheromone (MDT) is used in the commercial pyramid trap sold by AgBio (see Resources).

Addition of murgantiol (10,11-epoxy-1-bisabolen-3-ol), the aggregation pheromone of the harlequin bug, *Murgantia histrionica*, makes the *P. stali* pheromone more attractive to BMSB earlier in the season. Sterling Intl. (see Resources) uses this combination for a commercial monitoring trap (Zhang et al. 2013; Zhang et al. 2014ab).

Natural Pheromone

The USDA has recently isolated the true aggregation pheromone secreted by *H. halys* adult males. A major component is (3*S*,6*S*,7*R*,10*S*)-10-11-epoxy-1-bisabolen-3-ol (SSRS). This is related to 1,10-bisaboladien-3-ol (zingiberenol) which occurs in ginger, *Zingiber officinale* (Weber et al. 2014).

A minor component is (3*R*,6*S*,7*R*,10*S*)-10,11-epoxy-1-bisabolen-3-ol (RSRS). The SSRS to RSRS ratio in the natural pheromone is 3.5 to 1. Donald Weber of the USDA tested the *H. halys* pheromone and found mixtures of these two components attract and capture both *H. halys* adults and nymphs (Weber et al. 2014).

Addition of the *H. halys* pheromone to MDT is synergistic, and the combined mixture (COMB) is attractive throughout the year. The combined lure catches 3-4 times more adults and 2-4 times more nymphs than MDT alone. COMB is attractive to spring adults, fall adults, and nymphs. Field tests showed the first *H. halys* adults appeared in April, and largest numbers of adults and nymphs were found in August (Weber et al. 2014).

COMB makes it possible to monitor early season populations, establish economic thresholds for IPM, implement mass trapping, and produce attract and kill formulations. The all-season attractant is a giant step toward effective, reduced risk IPM management of BMSB.

Biopesticides

Conventional management of BMSB is multiple applications of pesticides. However, of 37 pesticides tested, residues of about one-third killed less than 50% of the bugs. Pyrethroids tend to knock them down, but many bugs recover within 7 days (Leskey et al. 2012e).

Biopesticides may be just as effective as more toxic or environmentally destructive materials. As well as mortality, they can have valuable sublethal effects. Neem (azadirachtin) formulations act as antifeedants and may decrease fecundity. Pyrethrins are repellent and can be lethal (Lee et al. 2013). The combination of neem and pyrethrins (Azera™) can be used in organic agriculture (Jacobs 2014).

Chitin synthesis inhibitors such as novaluron and diflubenzuron are not effective against eggs or adults, but will kill nymphal stages. Sprays applied during June and July will target developing nymphs (Kamminga et al. 2012).

Some microbial biopesticides show promise (Quarles 2013). *Chromobacterium* sp. (Grandevo®) (see Marrone Resources) is more effective than the pyrethroid esfenvalerate and many other conventional pesticides (Leskey et al. 2012d). Laboratory tests of *Chromobacterium* showed 100% mortality against the southern green stink bug, *Nezara viridula* (Martin et al. 2007).

The Japanese fungus, *Ophiocordyceps nutans*, specifically attacks stink bugs (Sasaki et al. 2012). Fungi such as *Beauveria bassiana* or *Metarhizium anisopliae* are effective *against H. halys* (see Resources). Lab tests showed several isolates of *B. bassiana*, including a commercial formulation (Botanigard™) gave 100% mortality to *H. halys*. Isolates of *M. anisopliae* produced about 85% mortality. MET52™ is a commercial formulation of *M. anisopliae* (see Resources) (Gouli et al. 2012).

Pesticide Reductions

In soybeans *H. halys* accumulates on field edges. Spraying only the periphery reduces pesticide use by 85%, while retaining effectiveness. Most of the damage done in apples and sweet corn is also done in outer rows (Leskey et al. 2012ac)

Spray reductions may result from a knowledge of *H. halys* behavior. Adults fly up to the trunk of a tree, then walk up the trunk into the canopy. Since nymphs have no wings, they also walk into the canopy. Banding tree trunks with pesticides or sticky barriers could reduce the amount of pesticides applied. Pyramid traps baited with aggregation pheromones may also be used to lure the pest to discreet locations, reducing applied pesticides (Leskey et al. 2012ac).

Leskey et al. (2012c) baited trees with aggregation pheromones to reduce pesticide applications. Nine trees in a border row were baited with pheromones, then pesticides were used to destroy the bugs.

At temperatures of 21°C (70°F) or less, Li et al. (2007) achieved an 88% reduction in pesticides applied to trees by beating trees with sticks, causing BMSB to drop to the ground. Pesticides were then applied to bugs on the soil.

Organic Home Gardens

H. halys will eat tomatoes, corn, beans and other garden vegetables. It will also feast on apples, peaches and pears. Shade trees and roses are part of the menu. A list of 170 host plants can be found at the website StopBMSB.org. If there are large populations overwintering in your neighborhood, you may have to use row covers. Row covers of lightweight polyester or polypropylene will protect crops, but you will have to remove them to allow pollination (Nielsen and Hamilton 2009a; Ingels and Varela 2014).

***H. halys* damages apples.**

Courtesy J. Oberg, MD Dept. Ag.

Fruit tree protection is difficult, but BMSB prefers to fly up to the trunk of a tree, then walk up the trunk into the canopy (Leskey et al. 2012c). Sticky barriers around the trunk might stop nymphs and adults from climbing. Applying a 1 ft wide (30 cm) band of natural pyrethrins around the trunk might also prevent colonization. Ultimately, this approach may fail if adults adapt their behavior and fly directly into the canopy.

Destroy egg masses on the underside of leaves starting in June. Hand pick bugs and drop into soapy water or use a hand held vacuum cleaner to remove them from plants (Ingels and Varela 2014).

As usual, providing floral resources for natural enemies such as lacewings, parasitoids and ladybugs to encourage biocontrol is worthwhile (Quarles 2014a).

Pheromone Traps in Gardens

Pheromone traps (see Resources) may give early warning, but if populations are large, trap spillover may lead to plant damage. Sargent et al. (2014) found that pheromone traps led to increased bug colonization and increased damage in Maryland tomatoes. Traps were placed near tomato plants. About 300 bugs were caught in each trap, but bugs aggregated near the trap, damaging plants nearby and up to 6 m (18 ft) away.

If you use pheromone traps in your garden, you should space them away from desirable plants. The traps will give you early warning, but you must be prepared to vacuum up the trap spillover, or kill the bugs with least-toxic pesticides such as (Azera®).

House Invasions

Brown marmorated stink bugs are rude guests, as they eat your garden and then move in with you. Some houses have seen more than 25,000 bugs invade. These bugs fly toward lights, colliding with people. Fortunately, the bugs do not reproduce or feed while overwintering. They do not bite or carry diseases, but they produce unpleasant smells when crushed, and fill a house with excrement. Proteins associated with the bugs can cause allergies (Inkley 2012; Mertz et al. 2012).

Reproduction is prolific. If your house is invaded by 25,000 *H. halys*, this group of bugs could produce a summer population of almost three million in the immediate vicinity of your home (Lee et al. 2013; Kawada and Kitamura 1983).

Overwintering bugs like to hide in dark, tight places. Attics are favorite hideaways. Inkley (2012) found about 60% of the invading population was in the attic. The rest were captured in the living space. Bugs may hide in cracks and crevices along baseboards, door and window trim, and in light fixtures (Toyama et al. 2011; Ingels and Varela 2014).

Exclusion is Best

The best approach is exclusion. Pay especial attention to the side of the house facing the sunset. Caulk up all holes, make sure that window screens fit tightly. Pay attention to sealing around window air conditioners. Cover attic and foundation vents with screens. Make sure the chimney is protected with a screen. Weatherstrip doors, and make sure each one has functional door sweep (Ingels and Varela 2014).

In Japan, boxes filled with straw, paper, or straw mats are used as traps outside to attract overwintering bugs. They also use special "slit" traps of layered pieces of plywood. Bugs crawl into the slits cut between the boards and are trapped. One 90 x 90 cm (36 by 36 in) slit trap placed on the ground trapped 2693 bugs (Watanabe et al. 1994).

Near complete exclusion was achieved by covering exterior walls with 1 cm (0.4 in) mesh netting treated with pyrethroids. Deet repellent around windows also helped exclude bugs (Watanabe et al. 1994). Deet also repels the ladybug, *Harmonia axyridis*, another structural invader (Riddick et al. 2004). In the U.S., pheromone traps are available for use outside that attract overwintering bugs, reducing the number of invaders (see Sterling Resources).

Do Not Use Pesticides Inside

If they get inside your living space, do not use foggers. Any that you kill will just be replaced by others crawling from wall voids. If pesticides are applied to kill populations in wall voids, large numbers of dead bugs may attract flies and carpet beetles (Jacobs 2014).

The best approach is to use a vacuum cleaner to remove them from your living space. Bugs can give a vacuum cleaner an odor, so having an old one just for this purpose is the best idea. Bugs can be killed by dropping them into soapy water. Live bugs should not be dropped into garbage. Bugs inside are attracted to a light trap. These are commercially available (see Sterling Resources). Or you can use a desk lamp over a pan of soapy water as a trap (BMSB 2014).

Conclusion

The BMSB invasion will likely increase and spread. The invasive pest is favored by prolific reproduction, wide host range, lack of specific natural enemies, cold tolerance, global warming, and overwintering skills. There can be a short lag time between initial invasion and population explosions. Monitoring is extremely important, and pheromone monitoring can now give an early warning.

Biological control of eggs is a promising approach. Predators in the U.S. are effective, but parasitoids have not adapted. Importation of a more effective egg parasitoid may be necessary. Biopesticides are available that can help manage populations without killing bees. Special techniques such as banding trees, using aggregation pheromones in attract and kill formulations, and spraying perimeters of row crops and orchards can reduce amount of pesticide applied. Overwintering traps and efficient exclusion can reduce the impact of BMSB inside houses. The brown marmorated stink bug is not going to go away, but IPM techniques can limit the damage.

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Resources

Beauveria (Botanigard®)—Laverlam International, 117 South Parkmont, PO Box 4109, Butte, MT 59702; 406/782-2386. Fax 406/782-9912; www.laverlamint.com. BioWorks Inc., 100 Rawson Road, Suite 205, Victor, NY 14564; 800/877-9443, 585/924-4362, Fax 800/903-2377; www.bioworksinc.com

Chromobacterium (Grandevo®)—Marrone Bio Innovations, 2121 Second St., Suite B-107, Davis, CA 95618; 877/664-4476, 530/750-2800; www.marronebioinnovations.com

Indoor Light Trap—Sterling International, Inc., 3808 N. Sullivan Rd., Bldg 16, Spokane, WA 99216; 800/666-6766, 509/926-6766, Fax 509/928-7313; www.rescue.com

Metarhizium (MET52®)—Novozymes Biologicals, 77 Perry Chapel Church Rd., Franklinton, NC 27525; 919/494-3000, Fax 919/494-3450; www.novozymes.com

Neem plus pyrethrins (Azera®)—MGK Company, 8810 10th Avenue North, Minneapolis, MN 55427; 800/645-6466, 763/544-0341, Fax 763/544-6437; www.pyganic.com; www.mgk.com

Pheromone Baited Black Pyramid Trap (Dead Inn™)—AgBio Inc., 9915 Raleigh St., Westminister, CO 80031; 877/268-2020, 303/469-9221, Fax 303/469-9598; agbio-inc.com

Pheromone Lures—Trécé Inc., PO Box 129, Adair, OK 74330; 866/785-1313, 918/785-3061, Fax 918/785-3063; www.trece.com

Pheromone Trap—Sterling, see above

Sweep Nets, Beat Sheets, Black Lights—BioQuip Products, 2321 Gladwick Street, Rancho Dominguez, CA 90220; 310/667-8800, Fax 310/667-8808; www.bioquip.com

Sticky Barriers (Tanglefoot®)—Contech Enterprises, 7572 Progress Way, Delta, BC, CANADA V4G 1E4; 604/940-9944, Fax 604/940-9433; www.contech-inc.com

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Conference Notes

2013 ESA Conference Special Pheromone Report

By Joel Grossman

These Conference Highlights are from the Nov. 10-13, 2013, Entomological Society of America (ESA) annual meeting in Austin, Texas. ESA's next annual meeting is November 16-19, 2014, in Portland, Oregon. For more information contact the ESA (3 Park Place, Suite 307, Annapolis, MD 21401; 301/731-4535; http://www.entsoc.org).

Monitoring and Mass Trapping NOW

"Almonds, pistachios and walnut production in California was valued at approximately $5 billion on over a million combined acres (404,686 ha) in 2012," said Justin Nay (Integral Ag Inc, PO Box 537, Durham, CA 95938; njay01@student.ucr.edu). Direct and indirect costs associated with navel orangeworm (NOW), *Amyelois transitella*, and its management are likely to exceed 2% annually and in severe infestation years may reach as high as 5%.

"Current industry standards for NOW management are to treat 2-4 times per year with organophosphates, carbamates, pyrethroids, and various new chemistries," said Nay. Sanitation and removal of overwintering host material (mummies) is also used. "Very little, if any, of these management tactics utilize treatment thresholds or actual measurements of pest densities."

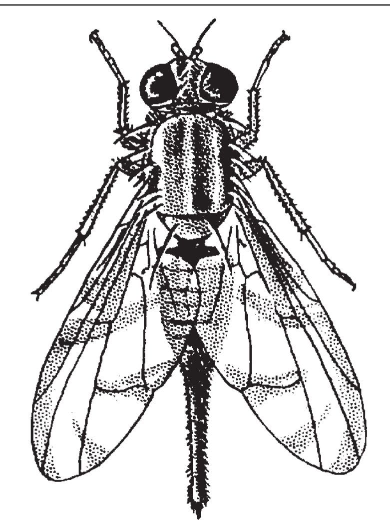
A new monitoring and mass trap has been developed by Peterson Trap Co. in Visalia CA. GPS/GIS 'heat' maps of moths per trap allow for tracking of moth movement between blocks. Traps also uncover flight patterns such as "hill topping, individual field emergence, and down row versus across row movement."

Traps allow evaluation of tactics such as "mummy sanitation, chemical sprays, and mating disruption," said Nay. In 10 paired almond fields, mass trapping was just as effective as one hullsplit pyrethroid spray. Mating disruption blocks had two traps per acre (0.4 ha); and at some levels of infestation, sprays were neither necessary nor economical.

"In order to eliminate 'insurance' sprays, thresholds are being tested to remove the fear farmers might have with not making an application," said Nay.

NOW Pheromone and Egg Traps

"Navel orangeworm (NOW), *Amyelois transitella*, is the principal insect pest of California's multi-million dollar almond crop," said Charles Burks (USDA-ARS, 9611 S. Riverbend Ave, Parlier, CA 93648; charles.burks@ars.usda.gov). In NOW IPM programs, sanitation and early harvest date are considered key cultural practices. Moths are monitored with pheromone traps and egg traps to determine when to apply hullsplit sprays.



Mexican fruit fly, *Anastrepha ludens*

NOW was "previously monitored using egg traps," said Burks. But "egg traps are more labor-intensive and provide poorer detection" than pheromone traps. The problem is that 2-6 weeks can elapse between the capture of male NOW moths in pheromone traps and female egg-laying, the event used to time hullsplit sprays. Another complication is that Kern County has four generations of NOW flights; overwintering moths plus three generations. Hence, timing IPM treatments based on pheromone trap catches is problematic at best.

"We used a 4-year data set, collected from 32 1 ha (2.47 a) plots spread over 220,000 ha (543,632 acres) of Kern County, CA to compare the phenology of pheromone and egg traps, and to examine the relationship between counts in pheromone and egg traps and subsequent damage."

"These observations suggest that monitoring with egg traps in almonds for the first flight only would provide useful information about risk of navel orangeworm infestation relative to previous year," said Burks. "Pheromone traps are probably sufficient for timing hullsplit insecticide applications."

Mexican Fruit Fly 2-Component Lure

"The Mexican fruit fly (MFF), *Anastrepha ludens*, is a pest species of economic importance with the potential to cause millions of dollars in damage to citrus and other fruit," said David Bartels (USDA-APHIS, 22675 N. Moorefield Rd, Edinburg, TX 78541; david.w.bartels@aphis.usda.gov). "A ten week field study was conducted to evaluate the effectiveness of bait stations with GF-120 fruit fly bait (with spinosad) imbedded in a wax matrix to control MFF."

"Lures attract flies which then feed on the wax matrix, and the spinosad kills the flies as a stomach poison," said Bartels. "Spinosad is produced by a naturally occurring bacterium, *Saccharopolyspora spinosa*, and is considered an organic insecticide that can be used by organic growers. Laboratory bioassays indicated that at least 24 to 48 hours are required for the stomach poison to immobilize or kill adult flies."

"Bait stations contain a two-component lure consisting of putresine and ammonium acetate to attract adult MFF," said Bartels. Bait trap MFF mortality was over 90% after a week; versus under 10% for controls.

Bait stations may be especially useful in residential yards where fruit often remains on the trees year around. They may also be useful as a tool for organic growers.

SPLAT Repellents

When citrus and guava are interplanted there is very little Asian citrus psyllid (ACP), *Diaphorina citri*, or huanglongbing disease, said Agenor Mafra-Neto (ISCA Tech, 1230 Spring St, Riverside, CA 92507; president@iscatech.com). Dimethyl disulfide (DMDS), a crushed guava sulfur compound that is cheap and easily obtained, was formulated into the amorphous, flowable SPLAT® (Specialized Pheromone and Lure Application Technology) matrix. SPLAT sprays dry into long-lasting, slow-release dollops. In 35-tree test blocks in Florida, as well as in Brazil, SPLAT® DMDS repelled Asian citrus psyllid (see *IPMP 34(1/2)* IPM for Asian Citrus Psyllid).

Verbenone, antiaggregation pheromone of the mountain pine beetle, *Dendroctonus ponderosae*, was formulated as SPLAT® Verb to protect pine forests from this bark beetle. EPA has given unconditional organic registration for the Western States, except California which has its own separate regulatory system, said Mafra-Neto.

Plants "Smell" Pest Pheromones

Insects provide a variety of clues to their presence on plants, such as footsteps, broken trichomes and chemical emissions; plants may perceive these cues and prime their defensive systems against insect attack, said Anjel Helms (Pennsylvania State Univ, 541 ASI bldg, University Park, PA 16802; amh468@psu.edu). For example, plants of tall goldenrod, *Solidago altissima*, exposed to the sex pheromone of the male gall fly, *Eurosta solidaginis*, have stronger insect defenses [enhanced jasmonic acid pathway induction] and suffer less damage from beetle feeding. Other plants do not "smell" the gall fly, and volatile emissions from *E. solidaginis* do not prime the defenses of unrelated plants such as squash or asters.

H. halys **adult**

N. Eastern IPM Center, StopBMSB.org

"This phenomenon appears to occur between coevolved plant and insect species" such as goldenrod and the specialist gall fly. Helms emphasized that the gall fly emissions are not HIPVs (Herbivore-Induced Plant Volatiles) for goldenrod plants. Rather, as a result of coevolution, goldenrod plants "perceive" the chemicals emitted by the fly. Each of the gall fly pheromone compounds should be researched separately for deterrence of herbivore feeding.

Stink Bug Aggregation Pheromones

The Pentatomidae, known as stink bugs for their volatile scent, has about 5,000 described species, both pests and beneficials such as the spined soldier bug, *Podisus maculiventris*, said Donald Weber (USDA-ARS, 10300 Baltimore Ave, BARC-W, Beltsville, MD 20705; don.weber@ars.usda.gov). Male-produced stink bug aggregation pheromones usually attract both females and nymphs. They can also attract stink bug natural enemies such as hymenopterous parasitoids, tachinid flies, specialist predators and sphecid wasps. (See the lead article in this issue.)

In Japan, aggregation pheromones of the brown-winged green bug, *Plautia stali,* are used for monitoring, mass trapping, and auto-dissemination of the entomopathogenic fungus, *Beauveria bassiana. Plautia stali* moves from pines to persimmons. The aggregation pheromone, MDT (methyl (2E,4E,6Z)-decatrienoate), attracts both males and females to potted eggplant trap plants. But there is a spillover effect, and persimmons are damaged by hundreds of thousands of stink bugs overwhelming the trap plants. But tachinid fly natural enemies are also attracted by the MDT. Hence, the ecology is complex and spatial considerations and pest density need to be considered when using aggregation pheromones and trap plants.

To protect Georgia cotton fields from the brown stink bug, *Euschistus servus*, which migrates in from peanut fields, pheromone traps can be combined with trap crop strips of sorghum.

An important soybean pest in southern Japan is redbanded shield bug, *Piezodorus hybneri*. Males emit a pheromone whose major components include *beta*-sesquiphellandrene, (*R*)-15-hexadecanolide, and methyl (*Z*)-8-hexadecenoate. Male emissions vary with age and life stage. Diapausing males produce no pheromone, indicating the pheromone is also involved in sexual communication. To further complicate matters, *P. hybneri* also responds to pheromones of other stink bug species.

The harlequin bug, *Murgantia histrionica*, produces an aggregation pheromone that also attracts the brown marmorated stink bug (BMSB), *Halyomorpha halys*. Thus, aggregation of harlequin bugs in border rows of a mustard trap crop will protect cole crops, and BSMB will be attracted to harlequin bug aggregation pheromone. MDT synergizes the attraction (see the lead article in this issue).

The spined soldier bug, a beneficial predator, has an aggregation pheromone that attracts males, females, adults and nymphs. In potatoes, the aggregation pheromone keeps the predator in fields to eat Colorado potato beetles. Similarly, the aggregation pheromone keeps soldier beetles in tomato fields to eat cabbage loopers.

Red Palm Weevil Pheromones and Areawide IPM

"The red palm weevil (RPW), *Rhynchophorus ferrugineus*, is an internal tissue borer reported to infest 40 palm species worldwide," including date palms in the Middle East, said Lyndsie Stoltman (ISCA Tech, 1230 Spring St, Riverside, CA 92507; lyndsie.stoltman@iscatech.com). Pheromone traps have been used to monitor and mass trap RPW in areawide management programs. However, these conventional food-baited pheromone traps (FBPTs) must be installed and routinely serviced. Frequent servicing of FBPTs becomes cumbersome and costly, especially at a higher trap density.

Hook™ RPW is an attract and kill formulation containing RPW pheromone and a contact insecticide in an amorphous and flowable paste. The paste can be applied via disposable plastic syringes, caulking guns and various spray technologies. "When applied as discrete dollops (2-4 g), red palm weevils of both sexes are highly attracted to Hook RPW point sources. Weevils contacting Hook RPW point sources receive a lethal dose of insecticide." Red palm weevils that contact the Hook RPW dollop become sedentary, and die within a few hours.

"It is preferred that Hook RPW be applied to a non-host surface such as wooden stakes placed between palm trees," said Stoltman. "We recommend applying a higher density of Hook RPW point sources around the periphery of the plantation to intercept beetles that might invade the area."

In Al-Hassa, Saudi Arabia, Hook RPW was applied under hot, arid conditions in a 14 ha (35 acre) date plantation at 250 points/ha (100 points/acre). Hook RPW point sources were individually placed at the bottom of standard bucket traps to better measure (weekly) weevil numbers attracted and killed.

Weevil captures were not significantly different between the Hook RPW and plots treated with FBPT. Hook RPW could substantially reduce the cost of an areawide IPM program.

European Corn Borer Pheromone Races

"European corn borer (ECB), *Ostrinia nubilalis*, was introduced from Europe to New England in broom corn near a broom factory in Everett, MA some time from 1909-1913, most likely in 1910...and was causing serious damage to corn by 1914," said Thomas Sappington (USDA-ARS, Iowa State Univ, Genetics Bldg, Ames, IA, 50011; tom.sappington@ars.usda.gov). After its introduction, it then spread westward, into and across the Corn Belt, reaching Iowa in the 1940s and the foot of the Rocky Mountains by the late 1970s.

There are ECB races that are "partially reproductively isolated," said Sappington. "The Z and E pheromone races are characterized by different dominant racemic isomers in their sex pheromone blends. The Z-race is widespread east of the Rockies, while the E-race is restricted to the eastern U.S., with only low proportions of E moths as far west as Ohio."

There are also ECB races based on voltism (number of generations per year). "There is B for bivoltine (=multivoltine) or U for univoltine (one brood per season)," said Sappington. The B race can exhibit 1-5 generations per year depending on latitude and environmental conditions. The U race produces only one generation per year regardless

Calendar

June 19-21, 2014. 71st Annual Convention, Pest Control Operators of CA. Harrah's, Las Vegas, NV. Contact: www.pcoc.org

June 19, 2014. Sustainable/Organic Practices. Pala Mesa Resort, Fallbrook, CA. Contact: Steve Beckley, sbeckley@aol.ocm

July 24-26, 2014. Mid-Atlantic Conference, NPMA. Wrightsville Beach, NC. Contact: NPMA, www.npmapestworld.org

August 8-10, 2014. NOFA Summer Conference. UMass, Amherst, MA. Contact: Christine Rainville, 508/572-0816; www.nofasummerconference.org

August 10-15, 2014. 99th Annual Conference Ecological Society of America. Sacramento, CA. Contact: www.esa.org

August 9-13, 2014. Annual Conference American Phytopathological Society (APS). Minneapolis, MN. Contact: APS, 3340 Pilot Knob Rd., St. Paul, MN 55121; 651-454-7250; aps@scisoc.org

September 21, 2014. Bird Conservation Alliance Meeting. St. Louis, MO. Contact: Steve Holmer, Bird Conservation Alliance, 202-88-7490; sholmer@abcbirds.org

September 30, 2014. Deadline Application Ecological Horticulture, Center for Agroecology, Santa Cruz, CA. Contact: CASFS, UC Santa Cruz, 831-459-3240; casfs@icsc.edu

October 21-24, 2014. PestWorld, NPMA Annual Meeting. Orlando, FL. Contact: NPMA, 10460 North St., Fairfax, VA 22030; 800-678-6722; www.npmapestworld.org

November 16-19, 2014. Annual ESA Meeting. Portland, OR. Contact: ESA, 10001 Derekwood Lane, Suite 100, Lanham, MD 20706; 301/731-4535; http://www.entsoc.org

January 21-24, 2015. 34th Annual EcoFarm Conference. Asilomar, Pacific Grove, CA. Contact: Ecological Farming Association, 831/763-2111; info@eco-farm.org

February, 2015. Annual Conference, Association Applied Insect Ecologists, Monterey, CA. Contact: www.aaie.net

February, 2015. Annual Meeting Weed Science Society of America. Lexington, KY. Contact: www.wssa.net

February, 2015. 26th Annual Moses Organic Farm Conference. La Crosse, WI. Contact: Moses, PO Box 339, Spring Valley, WI 54767; 715/778-5775; www.mosesorganic.org

March 2015. California Small Farm Conference. Contact: www.californiafarmconference.com

March 24-26, 2015. 8th Intl. IPM Symposium. Salt Lake City, UT. Contact: Elaine Wolff, Wolff1@illinois.edu of photoperiod or temperature. The B race is now widespread in North America except perhaps in the northernmost part of the ECB range.

Multiple Generations and Colonization

"Geographic spread of ECB was relatively slow for several decades," said Sappington. An unpublished USDA report from 1955 noted: "For almost twenty years the area of infestation increased at a very slow rate....*During the late thirties some change took place* which resulted in a second generation...Shortly after the establishment of two generations per year, the borer began to spread rapidly westward and northward."

"Taken together, evidence from the early ECB literature on voltinism and range expansion suggests that the BZ race of ECB, currently the most widespread and destructive race in North America, was introduced independently from Europe sometime in the mid to late 1930s."

Bean Bug Aggregation Pheromone

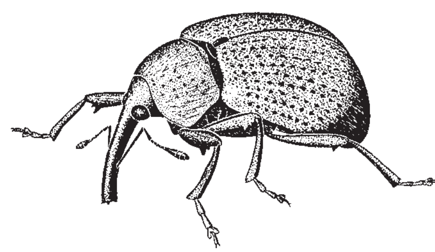
Bean bugs, *Riptortus pedestris*, are pests of beans, peas, lentils, chickpeas, and other crops, said Hyo-Seob Shin (Chungnam National Univ, 99 Daehakro, Yuseung Gu, Daejeon 305-764, South Korea; sbh1382@naver.com). Bean bugs also visit hairy vetch, *Vicia villosa*, green manure crops, but cannot develop to maturity on that plant alone.

Adult male bean bugs produce an aggregation pheromone attracting male and female adults and nymphs. The bean bug aggregation pheromone lure (Greenagrotech, Korea) includes: (*E*)-2-hexenyl (*Z*)-3-hexenoate; (*E*)-2-hexenyl (*E*)-2-hexenoate; and tetradecyl isobutyrate.

Aggregation pheromone production was assayed for bean bugs feeding on mung bean, hairy vetch, yellow soybean, black soybean and cranberry bean. Aggregation pheromone secretion is affected by season, physiological status, nutritive conditions, and bean cultivar. More is produced when bean bugs feed on soybean seeds and plant parts together, versus feeding only on seeds or only on plant parts.

Boll Weevil Extended Release Pheromone

"With the exception of South Texas, the boll weevil, *Anthonomus grandis*, has been eradicated from



Boll weevil,
Anthonomus grandis

all cotton production areas in the U.S.," said Charles Suh (USDA-ARS, 2771 F&B Rd, College Station, TX, 77845; charles.suh@ars.usda.gov). "However, programs continue to operate pheromone traps in these eradicated areas to detect potential re-infestation of weevils." In order to reduce trapping costs, the trap servicing interval was extended from a weekly schedule to a three-week interval. The extended interval was made possible by the development of an extended release pheromone lure.

Standard lures contain ~10 mg of grandlure (synthesized pheromone), and can last two weeks. Extended release lures contain ~25 mg of grandlure plus ~30 mg of eugenol, and last three weeks. To further reduce trapping costs, a 4-week trap servicing interval is being sought. Monthly servicing requires a new, longer-lasting lure.

Grandlure has increased 50% in price the past two years, making increased lure doses uneconomical. "Development of a dispenser that releases pheromone in a controlled manner may be a more efficient and economical approach," said Suh. "In collaboration with Scentry Biologicals Inc., efforts were initiated in 2012 to develop such a dispenser."

"Our ultimate goal is to develop a dispenser loaded with 25 mg of grandlure that releases at least 4 mg of grandlure per week during the first three weeks and at least 2 mg during the fourth week of aging under a broad range of environmental conditions," said Suh.

Leafroller 4-Component Sex Pheromone

Chilean fruit leafroller, *Proeulia auraria* (Tortricidae), is an economically important pest of vineyards and varied crops "due to its quarantine status and increasing severity of infestations," said Tomislav Curkovic (Univ de Chile, Casilla 1004, Santiago, Chile; tcurkovi@uchile.cl). "Two compounds produced by females in abdominal tissue were identified in the late 1970s as (*E*)-11-tetradecen-l-yl acetate (E11-14OAc) and (*E*)-11-tetradecen-1-ol (E11-14OH), and a mixture of these compounds was proven to be attractive to males in the field. Based on these results, the bait for monitoring of *P. auraria* in Chile is a lure developed for *Platynota idaeusalis* (TBAM; tufted apple bud moth), a species not present in Chile, which contains 10 mg of a 1:1 mixture of those compounds."

To produce a better pheromone, pheromone glands of *P. auraria* females were extracted, producing three active compounds; and in some cases a fourth. Field experiments with varying ratios of the four active compounds showed that a 4-component mixture containing 1% Z11-14OAc was the most attractive treatment, whereas the blend with 4% Z11-14OAc did not differ from the control. All 3-component blends were less attractive than the 4-component mixture with 1% of Z11-14OAc.

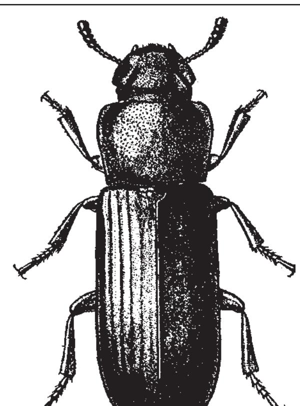
Identification of these "biologically active minor compounds" is a step towards formulation of an optimized pheromone blend more specific for the Chilean fruit leafroller. This "paves the way for formulation of monitoring lures with increased specificity and efficiency and, eventually, development of the mating disruption technique," said Curkovic.

Pheromones Monitor Grain Beetle Chill Kill

"The confused flour beetle, *Tribolium confusum*, is notorious for infesting stored foods including grains and flours," said Christopher Vitek (Univ of Texas Pan American, 1201 West University Dr, Edinburg, TX 78539; vitekc@utpa.edu). "A serious infestation of *T. confusum* was found within a Moore Air Base warehouse." Infested were bags of diet ingredients used in production of Mexican fruit fly, *Anastrepha ludens*, and fruit fly trapping supplies.

Pallets with 50 bags of wheat germ, data-loggers, Jackson traps, and bags of flour beetles were placed inside refrigerated truck semi-trailers and subjected to cold temperatures prior to shipping. "Pallets (50 bags) of wheat germ were placed inside a 0° F (-17.8 °C) freezer for a week," said Vitek. "After 5 days in the freezer, the interior bags reached 10°F (-12.2°C) killing the beetles."

"Monitoring is ongoing using Dome traps with insect pheromones Bullet Lure™ (Insects Limited, Westfield, IN)," said Vitek. "Surveillance for new insects has been completed, with no new insects found."



Confused flour beetle, *Tribolium confusum*

Second Generation Anticoagulants Pulled from Consumer Market

On May 30, 2014 the EPA announced that 12 d-CON rodenticide products will be voluntarily withdrawn from the consumer market. These rodenticides were not sold in bait stations, and eight of these products contained 2nd generation anticoagulants such as brodifacoum. These anticoagulants persist in the environment and kill dogs, raptors, and other wildlife through secondary poisoning when they eat a poisoned rat. (See "Raptors and Rodenticides," *Common Sense Pest Control Quarterly* 28(1-4). These were the last 2nd generation anticoagulants remaining on the consumer market.

Summer Bees Poisoned, Winter Bees Die

Harvard researchers showed in 2012 that when summer bees were fed sublethal doses of imidacloprid, no obvious effects of poisoning immediately appeared. About six months later, the poisoned colonies died. This kind of delayed effect mimics symptoms of colony collapse disorder. (See "Pesticides and Honey Bee Death and Decline," *IPMP* 33(1/2):1-8.)

The experiment has been repeated with the neonicotinoids imidacloprid and clothianidin. Pesticides at a concentration of 135 ppb were administered for 13 weeks. Each bee received about 0.74 ng/day. [An ng is one-billionth of a gram.] This is well below the minimum lethal dose of 3.4 ng/bee.

No morbidity or mortality was observed in either the 12 treated colonies or the six controls until winter. Then both neonicotinoid and control bees started to die due to the effects of winter. But in January, control colonies started to expand due to reproduction, but the neonicotinoid colonies continued to die. Six of the 12 treated colonies died with the symptoms of CCD. In treated colonies that survived, many bees abandoned the hive. The authors speculate that hive abandonment was due to the neurological effects of the neonicotinoids. Only one control colony died, and this was due to the pathogen *Nosema*.

In the 2012 study, the winter was colder, and about 94% of the treated colonies died. In this experiment, the winter was warmer and 50% of the colonies died. The results suggest that neonicotinoids ingested by summer bees can interfere with honey bee reproduction and survival during the winter.

Lu, C., K,M. Warchol and R.A. Callahan. 2014. Sublethal exposure to neonicotinoids impaired honey bees winterization before proceeding to colony collapse disorder. *Bull. Insectol.* 67(1):125-130.

Glyphosate Accumulates in Roundup Ready™ Soybeans

Continued use of glyphosate on GMOs has led to resistant superweeds, which in turn has led to increased glyphosate applications. (See "Systemic Pesticides and Genetically Engineered Crops," *IPMP* 33(3/4):1-9)

The authors of this study analyzed market samples of organic, conventional, and GMO soybeans. They found large concentrations of glyphosate in GMO soybeans. Average concentrations of glyphosate (3.26 mg/kg) plus the degradation product AMPA (5.74 mg/kg) totaled nearly 9 mg/kg, and maximum concentrations were near 20 mg/kg. High levels were not found in conventional or organic soybeans.

When Roundup Ready™ soybeans were first released, maximum residue levels (MRL) of 5.6 mg/kg were considered extreme. Since then, the MRL allowed in the EU and U.S. has been raised to 20 mg/kg. Residues are higher because of more frequent glyphosate applications and applications later in the season.

Nutritional analysis of organic, conventional, and GMO soybeans were compared. Organic soybeans had higher levels of protein, GMO had higher levels of fatty acids.

Herbicide residues have often been overlooked, but will become more important if GMO crops resistant to 2,4-D and other herbicides are approved.

Bohn, T., M. Cuhra, T. Traavik et al. 2014. Compositional differences in soybeans on the market: glyphosate accumulates in Roundup Ready GM soybeans. *Food Chemistry* 153:207-215.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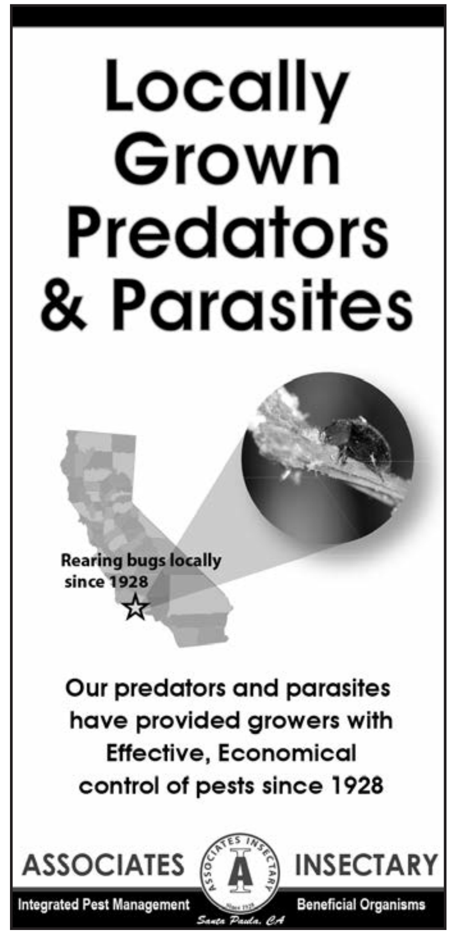
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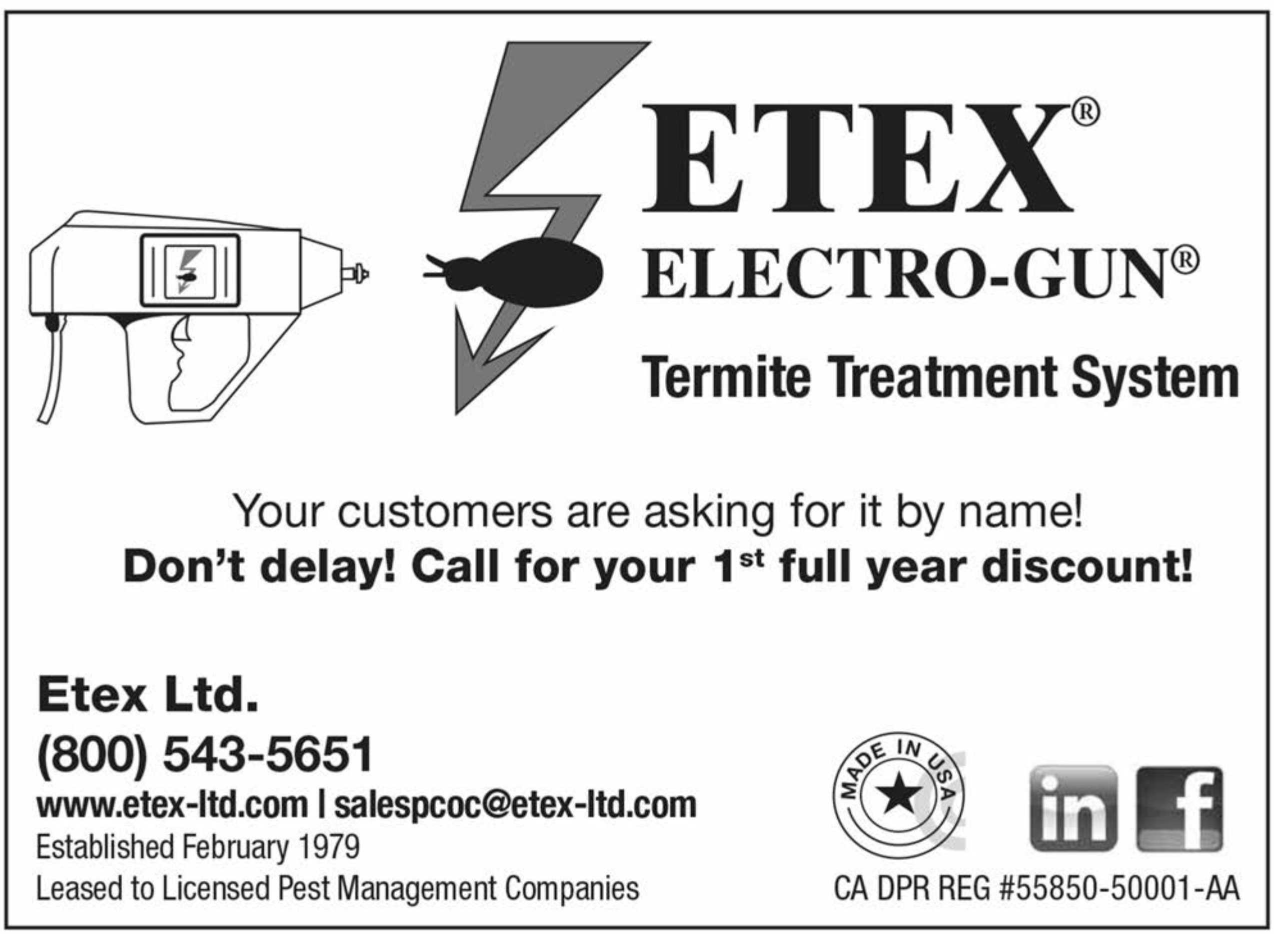
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