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Special Pheromone Report

Giant Knotweed, Plant Disease Protection, and Immortality

By William Quarles

Plants can be rich sources of drugs and pesticides. Botanical pesticides such as neem extracts are made from renewable resources and can be used in organic agriculture (see *IPMP* 27(5/6):1-11; *IPMP* 28(3/4):1-12). They biodegrade quickly and often have multiple modes of action that make pest resistance less likely (Quarles 2006; Schmitt and Seddon 2005).

Starting about 20 years ago, research activity focused on the giant knotweed, *Polygonum sachalinense*. This is a wildly successful plant that produces many defensive chemicals. These help protect it against insects, diseases, and even other plants. Knotweed defensive chemicals also can have profound effects on other plants and animals, causing beneficial changes in metabolism. Extracts from the giant knotweed, for instance, can protect plants against pathogens that cause powdery mildew, gray mold, and many other diseases. Substantial yield increases are often seen because the treated plants remain free of disease, and their lifetime is extended. Knotweed extracts have low toxicity to mammals and provide protection by boosting the immune system of the plant (Pommer et al. 1989; Herger and Klingauf 1990; Quarles 2002; Schmitt and Seddon 2005; Vrchotova and Sera 2008).

Animal tests have also shown that extracts and pharmaceuticals isolated from giant knotweed or its relative, Japanese knotweed, *Polygonum cuspidatum*, protect against cancer, are antiflammatory, lower blood cholesterol, protect against diabetes, and improve cardiovascular health. Though giant knotweed may not be the key to immortality, one of the extract components, resveratrol, has extended average lifetimes of mice, yeast, nematodes, and fish up to 58%. Resveratrol is a plant phytoalexin (see below) that also occurs in grape skins, and may be responsible for the "French paradox" that moderate wine consumption has beneficial effects on health (Wikipedia 2009; Higdon et al. 2009; Howitz et al. 2003; Wood et al. 2004) (see Box A).

Photo courtesy California Department of Food and Agriculture

Giant knotweed, *Polygonum sachalinense,* contains many biologically active molecules. Extracts applied to plants can protect them against disease. Giant knotweed pharmaceuticals can extend the lifetime of animals.

Biology of Giant Knotweed

Giant knotweed is called *Polygonum sachalinense* by American botanists (Zika and Jacobson 2003). Europeans prefer *Reynoutria* or *Fallopia sachalinensis*. Giant

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Update

knotweed and its close relative, Japanese knotweed, *P. cuspidatum* (also called *Reynoutria* or *Fallopia japonica*) are natives of Japan. They were introduced into Europe as animal fodder, and were imported into the U.S. in the 1800s as garden ornamentals. These knotweeds can become invasive along river banks, roadsides, railroads, in wet meadows, vacant lots and disturbed areas. They are noxious weeds in several states. Where both occur together, a hybrid, *P. bohemicum* or *Reynoutria bohemica* is formed (Zika and Jacobson 2003).

Giant knotweed is a member of the buckwheat family and is an herbaceous perennial that can grow more than twelve feet (3.7 m) tall. Erect hollow stems give it the appearance of bamboo. It can grow more than four inches (10 cm) a day. It has large, heart-shaped leaves, and numerous small greenish-white flowers. It reproduces mainly by sprouting from rhizomes and cloning from vegetative parts (Rhoads and Block 2002; USDA 2006; Zika and Jacobson 2003).

The holy grail of ecological pest management is turning a pest into a beneficial. In the case of giant knotweed, organic farmers and gardeners can harvest wild plants and easily produce aqueous extracts to protect crops. Most producers, however, will probably buy commercially available extracts that have been registered with the EPA (see Resources).

Plant Disease Protection

Powdery mildew and a number of other common diseases cause billions of dollars of damage to crops every year. Chemical fungicides are often applied, but diseases are becoming resistant. Synthetic chemical fungicides can cause environmental problems, and these fungicides are not allowed on crops raised by organic production methods (Schmitt and Seddon 2005; Petsikos et al. 1992)

Plant protectants based on giant knotweed were developed in Europe, and many of the early experiments were conducted there. BASF screened hundreds of plants for efficacy, but an extract of giant knotweed gave the best results. “Highly effective disease control was achieved against powdery mildew in cucumber, tomato, pepper, apple, begonia, and cereals.” Gray mold caused by *Botrytis* sp. was controlled in begonia, cucumbers, ornamentals, pepper and tomato. Extracts had moderate efficacy on bean and carnation rust. The ethanolic extract was commercialized under the brandname Milsana® (Schmitt and Seddon 2005).

A similar formulation called Regalia® has now been registered in the U.S. by Marrone Bio Innovations (see Resources). Regalia meets the standards of the National Organic Program and can be used in organic production. Regalia suppresses a number of pathogens, including those that cause bacterial spot and speck, powdery mildew, gray mold, late blight, and early blight. It is registered for use on tomatoes, peppers, grapes, cucurbits, strawberries, walnuts, and citrus (Marrone 2009).

Field Tests of Milsana

Much of the early published work used the commercial formulation Milsana. Similar results should be expected from the registered U.S. product Regalia. Milsana was extremely effective for powdery mildew of cucumbers, especially for greenhouse crops grown under high disease pressure. Efficacy reached 90% and was comparable to chemical fungicides. The number of cucumbers per plant showed increases of 18-49%, and weight of each cucumber increased by an average 30% (Konstantinidou and Schmitt 1998). In Germany and Greece, efficacy was 86-98%, and yield increases were 22-25%. Yield increases in the Netherlands were 30% (Dik and van der Staay 1995; Schmitt and Sedon 2005).

Tomatoes

A number of induced resistance treatments including Serenade®, Elexa®, Messenger®, Milsana® and others were tested for effectiveness against powdery mildew of tomato caused by *Leveillula taurica*. Milsana was the most effective formulation tested (Laethauwer et al. 2006). In another test, efficacy of 42-64% was seen for powdery mildew of tomato. Milsana directly inhibited spore germination, and effectiveness was similar to sulfur (Konstantinidou et al. 2006). Experiments in France showed that effectiveness of Milsana was equal to chemical fungicides for powdery mildew of tomato caused by *Oidium* sp. (Trottin et al. 2003).

In young tomato plants, efficacy against gray mold caused by *Botrytis cinerea* was 90-100%. Large scale trials with more mature plants showed only a 23% reduction of gray mold (Schmitt and Seddon 2005). In another greenhouse experiment Milsana increased marketable yields of tomatoes in one of three years (Ingram et al. 2006).

Grapes

Effectiveness was similar to sulfur for powdery mildew of grapes caused by *Uncinula necator*. Powdery mildew reductions of about 80-97% were seen in Germany. In Greece, yield increases of about 40% were seen (Konstantinidou et al. 2007; Schmitt and Seddon 2005). In Michigan, Milsana gave moderate protection against powdery mildew, gray mold, and downy mildew caused by *Plasmopara* sp. (Schilder et al. 2002).

Other Plants

Milsana was extremely effective against powdery mildew of wheat caused by *Blumeria graminis*, reducing disease by 85-100% (Randoux et al. 2006; Vechet et al. 2009). Milsana gave protection similar to standard fungicides for powdery mildew caused by *Sphaerotheca* sp. and gray mold caused by *Botrytis* sp. in strawberries (Carlen et al. 2004). It showed moderate suppression of powdery mildew on roses (Pasini et al. 1997). Milsana reduced effects of marigold powdery mildew caused by *Podosphaera xanthii* (Heibertshausen et al. 2004).

The Regalia label suggests protection against powdery mildew, gray mold, and rust on ornamentals such as begonias, lisianthus, salvias, crape myrtle, petunias, snapdragons, freesias, poinsettias, zinnias, gerbera and roses. Regalia is labelled for powdery mildew and gray mold on grapes, powdery mildew on strawberries, lettuce, and cucurbits such as zucchini, cucumber, cantaloupe, pumpkin and watermelon. It may effectively prevent bacterial diseases of tomato, pepper, walnuts and citrus (Marrone 2009).

Regalia protects against plant disease.

Photo courtesy Marrone Bio Innovations

Regalia is also labelled for prevention of tomato late blight, a disease that has recently ravaged tomato growers in the Northeastern U.S. The source of the infection was traced to big box retailers. Perhaps treatment of tomato seedlings in these garden supply centers could have prevented the outbreak (Moskin 2009).

How Does It Work?

Giant knotweed extract acts by boosting a plant's immune system and inducing resistance to pathogens. It works through a combination of enzyme induction, production of antibiotics called phytoalexins (see below), and direct suppression of spore germination. Sprays of giant knotweed extract cause increased production of hydrolytic enzymes, such as chitinase and *beta*-1,3-glucanase, and oxidative enzymes such as peroxidase and polyphenoloxidase.

The hydrolytic enzymes attack chitin in the cell walls of fungi. The oxidative enzymes protect plant cells through increased lignification, forming barriers against pathogen penetration. The antimicrobial hydrogen peroxide also accumulates in tissues near where pathogens are attacking. Induced changes are not systemic, but occur only on treated leaves, although there is some translaminar action, so treatment of only one side of a leaf can protect both sides (Herger and Klingauf 1990; Schneider and Ullrich 1994; Nicholson and Hammerschmidt 1992; Randoux et al. 2006). Induced enzyme levels reach a maximum 1-2 days after treatment, then levels drop back to normal over the course of 1-3 weeks (Fofana et al. 2002; Schneider and Ullrich 1994).

Phytoalexins and Physiological Changes

Induced increases in enzymes such as phenylalanine ammonium lyase (PAL) and others lead to buildup of phenolic phytoalexins (Daayf et al. 1997ab; Daayf 2000; Fofana et al. 2002). Phytoalexins are "low molecular weight antimicrobial compounds produced by plants in response to infection or stress" (Kuc 1995). The name is derived from the Greek roots phyton, meaning plant, and alexin, a warding off compound (Cruickshank 1963). More than 350 phytoalexins from 30 plant families have been identified. The phytoalexins directly attack the pathogen, suppressing spore germination. They are present in the plant before treatment, but treatment quickly boosts concentrations to effective levels (Kuc 1995; Cruickshank 1963).

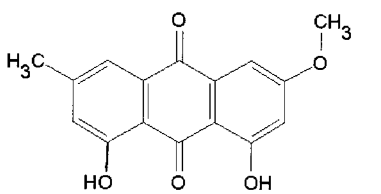
Knotweed extract activates more than 100 genes, causing physiological changes in the treated plant, including greener leaves due to increased concentration of chlorophyll, increased photosynthesis, increased flowering, changes in fatty acid concentrations, and a slowing of plant senescense (Herger and Klingauf 1990; Karavaev et al.

2005; Renard et al. 2009; Daayf et al. 1995).

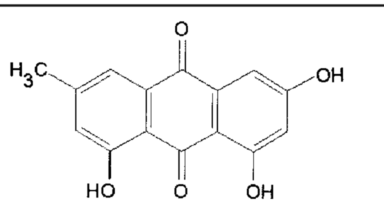
What is the Active Elicitor?

The compound that triggers induced resistance is called an elicitor, and a large number of elicitors have been found (Agrawal et al. 1999; Quarles 2000; Quarles 2002; Quarles 2004; Walters 2009). Much of the research on plant protection with giant knotweed has been of a practical nature, and identification of the active elictor of the extract has progressed slowly. Anthraquinones, stilbenes, flavonoids and other phenolics have been isolated from *Reynoutria* spp. (Zhang et al. 2005).

At first thought, one might suspect the involvement of resveratrol, since it has so many profound physiological effects (see Box A). It does protect plants against



The anthraquinone physcion



The anthraquinone emodin

pathogens (Kuc 1995; Hahn et al. 1993), but the commercially developed plant protectant from giant knotweed is a leaf extract. Concentrations of resveratrol in giant knotweed leaves are low; highest concentrations are in roots and sprouts (Vrchotova et al. 2007; Vrchotova et al. 2005).

The most effective component of the leaf extract isolated so far is the anthraquinone physcion. Induction is fairly specific, as the closely related anthraquinone, emodin, is not effective. There are other active components of the extract that have not yet been identified (Schmitt et al. 2005; Kowalewski and Herger 1992).

Effects on Insects

When sulfur is used to treat powdery mildew, it kills beneficial predatory mites, leading to significant increases of pest spider mite populations (Gent et al. 2009). Some tests show that Milsana sprays may reduce populations of predatory mites (Jackel and Schmidt 1999). But field tests in vineyards show actual increases of predatory mite populations after Milsana treatment (Schuld et al. 2002). In any event, induced plant physiological changes, at least in cucumber, make the plants less attractive to pest mites such as *Tetranychus urticae* (Tomczyk 2006).

Sprays of Milsana in vineyards have no effects on the parasitoid *Aphidius* sp. (Schuld et al. 2002). Extracts of giant knotweed are not harmful to the parasitoid *Trichogramma* sp., but conventional fungicides kill the beneficial (Hafez et al. 1999).

Combinations

Giant knotweed extract can be combined with other treatments. For instance, it is compatible with other biopesticides when used in an IPM program, especially tomato management programs in greenhouses (Bardin et al. 2008). Combinations with microbials in most cases are more effective than standalone applications of either (Schmitt and Seddon 2005).

Safety

Giant knotweed extract has the advantage of very low toxicity. It has been consumed in the human diet in Japan for generations without any known adverse effects. Milsana and Regalia have low acute toxicity with oral LD50>5000 mg/kg in rats. According to the EPA, there is "reasonable certainty that no harm to infants, children, or adults will result from aggregate exposure to *R. sachalinensis.*" It is already found in foods, animal feed, and medicines. No adverse health issues for man, animals, or plants have been associated with giant knotweed. Residues from treatment with the extract are lower than those found for *R. sachalinense* consumed as food (EPA 2004).

Conclusion

Giant knotweed extract can help prevent many plant diseases. It has low toxicity and works by boosting the immune system of a plant. It is a natural product that can be used in organic production. It is especially effective for powdery mildew, although good results have been seen with gray mold and rust. The registered formulation Regalia can be used to treat a large number of plant species, including ornamentals, curcurbits, citrus, grapes, strawberries and other high value crops.

Phenolic compounds produced by knotweed not only boost the immune system of plants, they activate animal enzymes called sirtuins. Sirtuins alter metabolism to improve health and extend lifetimes of yeast, nematodes, flies, fish and mice. Although giant knotweed may not hold the key to immortality, drugs based on knotweed plant phenolics may eventually improve human health and extend human lifetimes.

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Update

Box A. Resveratrol—Key to Longevity

Resveratrol is a phytoalexin produced by many plants. It has been found in 72 plant species, including grapes, peanuts, blueberries, and of course Japanese and giant knotweeds. It is a polyphenolic stilbene, basically two phenolic rings attached to an ethylene molecule. Resveratrol and other phenolic compounds in red wine may contribute to the "French Paradox" where moderate wine drinkers have a 20-30% reduction in risk of coronary heart disease (Wikipedia 2009; Jang et al. 1997; Corder et al. 2006).

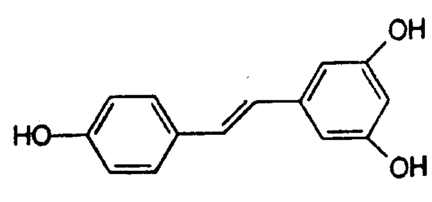
In experiments with rats and mice, resveratrol is anti-inflammatory, anticancer, has beneficial cardiovascular effects, and lowers blood sugar. Oral administration of resveratrol inhibited development of esophageal, intestinal, and mammary breast cancer (Higdon et al. 2009). Resveratrol inhibits tumor initiation, promotion, and progression. In mice, a dose dependent reduction in skin cancer was seen (Jang et al. 1997).

Sirtuins

Much of the research interest in resveratrol comes from its ability to extend lifetimes. It is well known that caloric restriction can extend average lifetimes in a number of organisms. Further research identified genes that are triggered by caloric restriction to produce enzymes called sirtuins. Genes for sirtuins are present in a large number of species. In mammals, 7 sirtuin genes have been identified. SIRT-1 enzyme regulates glucose and insulin production, fat metabolism, and cell survival. The human enzyme SIRT-1 is activated by a number of polyphenols, and resveratrol is the strongest activator identified (Howitz et al. 2003).

In yeast, *Saccharomyces cerevisiae*, the polyphenols butein, fisetin and resveratrol stimulated SIR2, mimicing the effects of caloric restriction and extending average lifetimes 31, 55, and 70% (Howitz et al. 2003). Resveratrol activated sirtuins in the nematode *Caenorhabditis elegans* and the fruit fly, *Drosophila melanogaster*. Average lifetimes were extended by about 20 and 25% respectively (Wood et al. 2004).

In one impressive experiment mice were fed either a standard diet or a high calorie (HC) diet rich in fats. Some of the HC rodents were treated with about 22 mg/kg a day of resveratrol. The resveratrol reversed the bad effects of the high calorie diet, correlating with a life extension of about 20%. Resveratrol reduced the risk of death from the HC diet by 31%. Treated mice had higher insulin sensitivity, larger numbers of mitochondria in their livers, better physical coordination, and resveratrol "opposed the effects of high caloric intake in 144 out of 153 significantly altered [genetic] pathways." Treated mice lived longer despite being fatter and having high cholesterol levels (Baur et al. 2006).



Resveratrol

Humans

The 22 mg/kg day is a feasible dose for humans. This would be about 1-2 grams a day. Preliminary experiments show no observed toxic effects in humans from 5 g doses. Oral doses of 300 mg/kg in rats for four weeks produced no adverse effects. And, of course, knotweed extract has been consumed in Asia for some time. One troubling thing about resveratrol is that it has a structure similar to the synthetic estrogen diethyl stilbestrol. Some experiments have shown it is estrogenic, others not estrogenic. Paradoxically, it may even increase testosterone levels (Wikipedia 2009).

Giant knotweed extracts can be purchased in health foods stores. Though resveratrol shows promise, longterm human toxicity studies have not been done, so there is some element of risk. Higdon et al. (2009) advise that resveratrol supplements should not be taken by pregnant women until more research is done.

Giant knotweed extract has been used in Chinese medicine for many years. Recent Chinese clinical trials of an herbal concoction containing knotweed showed anti-inflammatory action and improved liver function (Gu et al. 2007). An oral formulation of resveratrol has been tested by the U.S. corporation Sirtris Pharmaceuticals (see Resources). About 5 g oral doses lowered blood sugar in diabetics (Wikipedia 2009; Wade 2008).

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Resources

Plant Protection (Regalia®)—Marrone Bio Innovations, 2121 Second St., Suite B-107, Davis, CA 95618; 530/750-2800; www.marronebioinnovations.com

Clinical Products—Sirtris Pharmaceuticals, 200 Technology Square, Cambridge, MA 02139; 617/252-6920; Fax 617/252-6924; www.sirtrispharma.com

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IPM News

Antibiotics, CAFOs and MRSA

Antibiotics are given to animals on feedlots primarily to increase their growth rate. About 24 million pounds are used each year, representing 70% of the total antibiotic use in the U.S. Constant exposure of microbes to antibiotics causes them to mutate into pathogenic forms, and the pathogen *E. coli* O157 likely had a feedlot origin. This organism alone causes 73,000 illnesses a year in the U.S. (see *Common Sense Pest Control Quarterly* Spring/Summer 2006).

Antibiotic use in feedlots can also produce resistant strains of dangerous pathogens, such as Methicillin Resistant *Staphyloccus aureus* (MRSA). MRSA is now causing about 19,000 deaths a year in the U.S. while AIDS kills about 17,000. Research on feedlot antibiotics and MRSA has been published in scientific journals, but it is now receiving attention from the mass media. In June 2009, *Prevention* reported that the University of Iowa found MRSA strain ST398 in 45% of the farmers and 49% of the pigs at two midwestern farms. MRSA is in the farmers, the pigs, and the food supply. Researchers at Louisiana State University LSU found MRSA in 4% of the pork and 1% of the beef purchased at the local supermarket. A Canadian study found MRSA in 9% of 212 pork samples. MRSA contamination of food is not monitored by any government agency. These facts mean that you could potentially become infected with MRSA while cooking your dinner.

The Obama administration on March 17, 2009 introduced legislation to restrict antibiotic use in feedlot operations. The legislation is HR 1549, Preservation of Antibiotics for Medical Treatment Act of 2009. The relationship between MRSA and feedlot antibiotics will also be discussed at the upcoming meeting of the American Public Health Association, November 7-11, 2009 in Philadelphia, PA.

Pesticide Residues Linger

A study of 1131 randomly selected homes in the U.S. found that at least 90% had measurable pesticide residues on floors, walls, kitchen counters, and other surfaces. Permethrin was found most often, in about 89% of the homes. Chlorpyrifos was found in 78%, and chlordane in about 74% of the homes. Natural pyrethrins was found in only 2% of the samples. Frequency of discovery relates both to popularity and persistence of the pesticide. Chlorpyrifos has not been applied in homes for about 7 years, and chlordane has been banned for about 30 years. They are likely still there because of persistence. Pyrethroids such as permethrin are both popular and persistent. Pyrethrins are found less often because they are less popular and degrade faster. The study shows that pesticides applied indoors persist longer than is commonly thought.


Feedlot antibiotics produce pathogens.

Stout, D.M., K.D. Bradham, P.A. Jones et al. 2009. American healthy homes survey: a national study of residential pesticides measured from floor wipes. *Environ. Sci. Technol.* 43:4294-4300; email stout.dan@epa.gov

Moist Soil Attracts Termites to Bait Stations

One of the problems with termite bait stations is that termites typically find only about 10% of them over the course of treatment. In practice, 10% is usually enough to suppress or eliminate a colony. But researchers in New Orleans are finding ways to make baits more attractive. They tried rotted wood, the sports drink Gatorade®, and the feeding stimulant Summon® as attractants for Formosan subterranean termites, *Coptotermes formosanus*. The experiment showed the importance of water in attracting termites to bait stations. Dry Summons bait disks attracted no more termites than controls after 21 days. Addition of 100 mls of water extract to the bait station caused a significantly increased rate of discovery after 14 days. About 29% of the stations were discovered over 84 days. Gatorade was a better attractant than water, but the effect lasted only 42 days. Although the researchers do not suggest this, since termites are attracted to moisture, they might be more likely to find a bait if the area is occasionally watered with a garden hose, so that the moist bait station stands out above a dry background.

Cornelius, M.L., M. Lyn, K.S. Williams et al. 2009. Efficacy of bait supplements for improving the rate of discovery of bait stations in the field for Formosan subterranean termites. *J. Econ. Entomol.* 102(3):1175-1181; email mary.cornelius@ars.usda.gov

Hot Air Versus Plant Pests

California State University, Fresno researchers have reported success using hot air to control lettuce pests. The hot air source is mounted on a tractor. Low aphid population densities and a low incidence of downy mildew resulted. Further studies will be needed to see the effect on beneficial insects and to research cost versus benefits.

Farrar, J.J. and A.B. Lawson. 2009. Evaluation of thermal pest control technology for insect and disease control and harvest quality parameters in romaine lettuce. Presentation at American Phytopathological Society Meeting, Portland, OR. August 2009. [From *HortIdeas* 26(4):81]

Essential Oils and the Argentine Ant

Because of the movement toward green pest management, researchers have been looking for least-toxic pesticides. Six plant oils were tested as repellents and for mortality to the Argentine ant, *Lithepithema humile*. The least effective repellent was eucalyptus oil. Lemon, basil, citronella, and tea tree oils were better than 70% repellent. Residues were tested as barriers between the ants and a food source. Mortality experiments were conducted by confining the ants on filter paper treated with 20 microliters of each oil. Only citronella oil gave 100% 24 hr mortality for Argentine ants, although peppermint and tea tree oil mortality was greater than 85%.

Wiltz, B.A., D.R. Suiter and W.A. Gardner. 2007. Essential oil deterrency and toxicity to the Argentine ant and the imported fire ant. *J. Entomol. Sci.* 42(2): 239-249; email dsuiter@griffin.uga.edu

Interaction of Baits and Exclusion

North Carolina researchers excluded foraging Argentine ants from maple trees containing terrapin scale, *Mesolecanium* sp., a source of honeydew. Ants were excluded with a Tanglefoot™ barrier. As a result, ants moved their nests away from the trees into areas closer to food supplies. Nests remained near untreated trees. Boric acid baits near trees where foraging was excluded had fewer foragers than baits near untreated trees.

This fact suggests that excluding ants from a majority of their food sources will force them to nest closer to a fewer untreated sources. Baits applied near the untreated areas should then exert better population control. Baits should have food sources large enough to trigger ants to move their nests close to the bait.

Brightwell, R.J. and J. Silverman. 2009. Effects of honeydew producing hemipteran denial on local Argentine ant distribution and boric acid bait performance. *J. Econ. Entomol.* 102(3):1170-1174. email jules_silverman@ncsu.edu

Chenopodium Oil and Pests

An essential oil product derived from *Chenopodium ambrosioides* was tested under greenhouse conditions. It was effective as a soil drench for control of both 2nd and 3rd instars of fungus gnats, *Bradysia* sp. When applied to foliage, the oil was the most effective of the products tested for the longtailed mealybug, *Pseudococcus longispinus*. But it had little effect on citrus mealybug, *Planococcus citri*, probably because of the protective wax secreted by the pest. It was moderately effective for western flower thrips, *Frankliniella occidentalis*, but the spinosad product Conserve® was at least three times more effective. A new formulation of *Chenopodium* oil called Requiem® is now available from AgraQuest of Davis, CA.

Cloyd, R.A. and H. Chiasson. 2007. Activity of an essential oil derived from *Chenopodium ambrosioides* on greenhouse insect pests. *J. Econ. Entomol.* 100(2):459-466; email rcloyd@ksu.edu

Pesticides and Water Pollution

A researcher at the University of California, Davis has found high levels of water pollution coming from household use of pesticides. Rainfall and irrigation washes pesticides and fertilizers into storm drains, eventually contaminating surface waters. Current models may underestimate water pollution coming from homes by 50%.

Oki, L. and D. Haver. 2009. Homes pollute: linked to 50% more water pollution than previously thought. Presentation August 19, 2009 at the 238th National Meeting of the American Chemical Society, Washington, DC. email lroki@ucdavis.edu

Birth Defects, Premature Babies, and Water Pollution

Researchers at Indiana University have found that babies conceived in the spring during the months of April, May, June or July have a higher risk of birth defects. During these same months, according to the U.S. Geological Survey, there are higher concentrations of pesticides and fertilizers such as atrazine and nitrates in U.S. surface waters. Although the correlation does not prove causation, it suggests that further research is needed into the seasonal nature of reproductive problems.

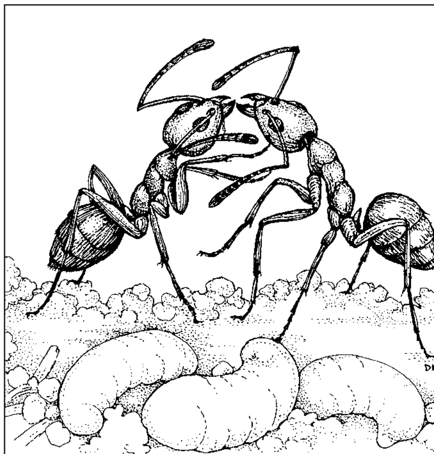
Earlier studies have shown that there is a similar seasonal fluctuation in the birth of premature babies. About 12.03% of live births are premature in June, about 10.44% in September. The seasonal variation in premature births is independent of age, race, education, marital status, alcohol or cigarette use, or area of residence.

Winchester, P., J. Hoskins and J. Ying. 2009. Agrochemicals in surface water and birth defects in the U.S. *Acta Paediatrica* 98(4):664-669. email paul.winchester@ssfhs.org

Mercury in Fish

The U.S. Geological Survey went fishing over a 7-year period in 291 streams throughout the U.S. They focused on catching predator fish and analyzing them for mercury content. All the fish contained some level of mercury. At 27% of the locations, mercury tissue levels exceeded the limit of 0.3 µg/gram set by the EPA as the maximum safe level for the average fish eater. Bass were more polluted than trout and catfish. Streams and streambeds were also contaminated with mercury. Highest levels were in the eastern and southeastern states, and also in areas where mining occurred. Much of the mercury comes from coal-fired power plants, concrete plants, and burning of trash.

Scudder, B.C., L.C. Chasar, D.A. Wentz et al. 2009. Mercury in fish, bed sediment, and water from streams across the United States, 1998-2005. U.S. Geological Survey Scientific Investigations Report 2009-5109. 74 pp. http://pubs.usgs.gov/sir/2009/5109



Drawing by Diane Kuhn

Argentine ant, *Lithepithema humile*

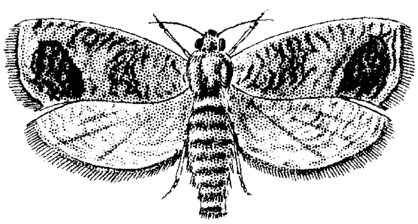
Special Pheromone Report—ESA 2008

By Joel Grossman

These Conference Highlights are from the November 16-19, 2008, Entomological Society of America (ESA) annual meeting in Reno, Nevada. ESA's next annual meeting is December 13-16, 2009, in Indianapolis, Indiana. For more information contact the ESA (10001 Derekwood Lane, Suite 100, Lanham, MD 20706; 301/731-4535; http://www.entsoc.org

Carob Moth Mating Disruption

"We have been working with the date industry on a mating-disruption strategy to replace malathion dust" for management of carob moth, *Ectomyelois ceratoniae*, said Jung-Joon Park (Univ of California, Riverside, CA 92521; jjpark@ucr.edu). Carob moth ruins 10-40% of the U.S. harvestable crop, causing $4-16 million in annual damage, excluding control costs. Field experiments were conducted at two date gardens to evaluate the female moth pheromone mimic (Z7,E9,11-dodecatrienyl formate), which was mixed with a biodegradable wax carrier (SPLAT® ISCA Tech) and applied directly to the trunks of date palms. Pheromone releases were large enough that there was pheromone monitoring trap shutdown in the center of the 4-acre (1.6-ha) blocks. [Trap shutdown means moths are too confused to find the traps—a sign of mating disruption efficacy.] Trap shutdown was maintained from the treatment date (early Sept. 2007 and early August 2008) through harvest in late October.



Codling moth, *Cydia pomonella*

Male moth counts were high in the standard malathion (dust every two weeks from mid-August to harvest) and untreated control plots. In contrast, male moth counts were low in the pheromone mating disruption plots. "Based on the trap results, male confusion was nearly complete from the one-time pheromone mimic application until harvest," said Park. "At harvest, infestation rates were similar or lower in the mimic-treated plots than in either malathion plots or untreated control plots. These results indicate that "a single treatment with carob moth pheromone mimic, which is economically comparable to malathion treatments, is a viable alternative to malathion dust for carob moth management in date gardens."

New Jersey Mating Disruption

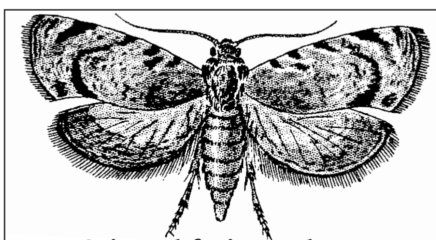
In New Jersey, apples and peaches are commonly grown on the same farms and are attacked by both codling moth (CM), *Cydia pomonella*, and oriental fruit moth (OFM), *Grapholita molesta*. "As part of a reduced-risk pest management program, mating disruption (MD) is an effective tool," said Kris Tollerup (Rutgers Univ, 121 Northville Rd. Bridgeton, NJ 08302; tollerup@aesop.rutgers.edu). "We hypothesized that MD applied against OFM provides better control when applied across adjacent apple and peach blocks than if applied to either crop alone."

Commercial orchards with adjacent apple and peach plantings were treated with 370 mating disruption dispensers per ha (148/acre). CheckMate CM/OFM Dual® was used before the first CM flight in apples and CheckMate OFM® before the second OFM flight in peaches. Pheromone traps monitored moths from mid April to early Oct. Reduced risk insecticides were also applied.

Mating disruption significantly reduced the infestations. "MD had a negative impact on OFM capture in all plots," said Tollerup. MD applied in apple plots appears to have reduced OFM populations in adjacent peach plots. Mating disruption reduced the number of OFM trapped in apple plots by 90% and in peaches by 92%. In 2009, the researchers will eliminate OFM mating disruption to measure the extent of any carry-over effect. The cost of MD can be reduced if populations of OFM can be controlled over three seasons with two consecutive season applications of MD.

NOW Areawide Mating Disruption

"The navel orangeworm (NOW), *Amyelois transitella*, causes economic damage in California almonds, pistachios, walnuts and figs," said Bradley Higbee (Paramount Farming Co, 33141 E. Lerdo Hwy, Bakersfield, CA 93308; bradh@paramountfarming.com). "These crops are worth over $2 billion/year, and losses from NOW have been estimated to be as high as $100 million in almonds and pistachios alone." In the first year of a demonstration project, a single-component mating disruption pheromone was as effective as



Oriental fruit moth, *Grapholita molesta*

insecticides, reducing NOW up to 60%.

Year two of the Santa Fe Areawide Mating Disruption Project combined mating disruption (Suttera Puffers®) on 800 ha (2,000+ acres) with "intense sanitation." Males were monitored with wing-type sticky traps baited with females producing pheromones. Females were monitored with egg-laying attractants in delta sticky traps. Insecticides were applied to about 16% of the acreage on a "where and when needed" basis, as indicated by monitoring.

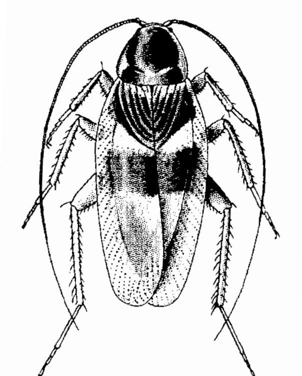
"Nearly complete shutdown of males in pheromone traps was achieved in all areas monitored, suggesting that pheromone drift impacted male orientation to traps over 600 meters (2,000 ft) away," said Higbee. "Since the conventional and control areas were nearly surrounded by mating disruption plots, it is likely that pheromone emission contributed to control of NOW in those areas. Sanitation, mating disruption and targeted insecticide applications successfully maintained low NOW populations and damage."

Cockroach Pheromones

L.M. Roth spent 10 years in the 1950s trying to identify a cockroach pheromone. In the 1960s, success was mostly elusive despite papers by researchers in prestigious journals claiming cockroach pheromone identification, said Coby Schal (North Carolina State Univ, Box 7647, Raleigh, NC 27695; coby_schal@ncsu.edu). In 1976, Persoons et al. working with 58,000 female midguts and feces finally identified the cockroach pheromone periplanone-B, whose isomers were synthesized in 1979.

Cockroach pheromone research moved forward in 1995, when stereoisomers of supellapyrone, a female sex pheromone of the brownbanded cockroach, *Supella longipalpa*, were identified. Dose-response ratios were also established; and it was discovered that virgin females, but not mated females, attract males.

Supellapyrone has moved out of the research lab and is proving useful in IPM programs to reduce brownbanded cockroach populations. For example, the North Carolina Museum of Natural Science uses traps baited with supellapyrone in its IPM program. Prior to IPM, potential donors at evening fund-raising dinners were distracted by foraging nocturnal brownbanded cockroaches. With IPM and pheromone traps, brownbanded cockroach populations dropped from 2,700 males/trap/night to 40/night and then an undetectable 5/night, which makes evenings at the museum much more pleasant.



Brownbanded cockroach, *Supella longipalpa*

Nursing homes, zoos and schools also use supellapyrone-baited traps in their IPM programs. At several university campuses, supellapyrone traps are first used in monitoring to identify where brownbanded cockroaches are located. Then the pheromone-baited traps are placed in locations to reduce pest populations to undetectable levels.

Males of the outdoor broad wood cockroach, *Parcoblatta lata*, use pheromones to locate and fly to the wingless females. *P. lata* is 50% of the diet of the endangered red-cockaded woodpecker, *Picoides borealis*. Thus, traps baited with the pheromone parcoblattalide monitor *P. lata* as part of the program to conserve the endangered woodpecker's food supply and habitat.

Thrips Monitoring Pheromones

Western flower thrips, *Frankliniella occidentalis*, is a weak flyer that disperses in the wind and forms patchy infestations. Multiple generations, high reproductive potential, a lack of biological control, and quick development of insecticide resistance make it a formidable pest, causing damage to leaves and flowers and transmitting plant viruses, said David Cox (Syngenta, 14446 Huntington Rd, Madera, CA 93636; david.cox@syngenta.com). Monitoring is difficult. Thus, this cryptic pest often goes undetected until after damage occurs.

Immature western flower thrips produce decyl acetate and dodecyl acetate, which act as alarm pheromones and egg-laying deterrents. Alarm pheromones cause thrips to move around more and come into contact with insecticides. However, these compounds combined with insecticides such as fipronil have not provided adequate control in commercial ornamental greenhouses.

Another strategy is to use attractants to catch thrips in sticky monitoring traps. Kairomones and plant volatiles attractive to thrips include *p*-anisaldehyde and (E)-*beta*-farnesene from chrysanthemums. Thrips sticky card catches can also be increased with the pyridines methyl or ethyl isonicotinate (Davidson et al, 2007). In 2007 Koppert introduced Lurem-TR, which combines sticky cards with large (1-gram) lures.

Aggregation pheromones patented by Kirk and Hamilton (2004) can also help with monitoring. They found neryl (S)-2-methylbutanoate alone or combined with lavandulyl acetate increased blue sticky card catches of adult male and female thrips; but lavandulyl acetate alone was not effective. Syngenta Bioline's Advanced Monitoring System (AMS) uses this technology. A Thripline AMS rubber lure with 30µg of neryl (S)-2-methylbutanoate is used to increase thrips attraction to sticky cards spaced at 1 per 100 m^2 (1,076 ft^2).

Flower Tapping Boosts Thrips Pheromones

In Davis, CA, zinnia greenhouses, both Lurem-TR and Thripline AMS increased numbers of thrips and thrips females caught by sticky cards, though not at statistically significant levels. However, in UK tests where chrysanthemum flowers were tapped to get flower thrips moving, blue sticky cards with pheromone lures caught 400% more adult thrips compared to traps without pheromone.

A pheromone lure plus a sticky card costs $3, versus 10-20 cents for a sticky card alone. So the best pheromone use might be monitoring for early detection of thrips vectoring tospovirus diseases in sensitive crops. Greenhouse conditions such as air circulation and vapor deficits, which may affect pheromone efficacy, and host plant effects still need exploration. Other research possibilities include adding alarm pheromones to the system or attracting thrips out of refugia for chemical or biological control.

Citrus Leafminer IPM

Citrus leafminer (CLM), *Phyllocnistis citrella*, is a major Alabama Satsuma citrus pest that infests the first flushes, beginning in April. Yingfang Xiao (Auburn Univ, 301 Funchess hall, Auburn, AL 36830; xiaoyin@auburn.edu) monitored the pest in citrus orchards with wing (Pherocon® 1C) and delta (Pherocon® VI) traps baited with CLM sex pheromone lures (APTIV; Portland, OR). "At least three distinct flight peaks of CLM were recorded, indicating multiple generations," with highest flight populations in August and October.

Predators, the major CLM mortality factor in Alabama, account for almost 90% of biological control. Alabama's key CLM predators include: spiders, *Hibana* spp; green lacewings, *Chrysoperla* spp; several ant species. The parasitoids *Ageniaspis citricola* (Encyrtidae) and *Cirrospilus* sp. (Eulophidae) account for under 5% of biological control.

Oils Mixed with Pheromones

Obliquebanded leafroller (OBLR), *Choristoneura rosaceana*, a major secondary apple pest widely sprayed and increasingly resistant to broadspectrum insecticides, can be controlled with pheromone mating disruption, said Maya Evenden (Univ of Alberta, CW-405 Bio Sci Cent, Edmonton, AB T6G 2E9, Canada; mevenden@ualberta.ca). Though hand labor is expensive, apple orchards often attach twist-tie pheromone mating disruption dispensers to trees.

Alternatively, microencapsulated (MEC) sprayable pheromone formulations can be sprayed onto trees; and can even be tank mixed with fertilizers and IPM compounds such as horticultural oils. However, MEC pheromone sprays tend to give off a large burst of pheromone initially and thereby lack longevity, necessitating multiple applications.

Horticultural oils control pests such as mites and scales, are easy to apply and can act as carriers while synergizing pheromones. The availability of newer more highly refined horticultural oils means leaf toxicity during the apple growing season is less of a concern. Oils can enhance MEC pheromones by increasing rainfastness on the leaf and stabilizing pheromone release rates (reduced evaporation). Oils also add a second mode of action against OBLR and can target other pests.

Pheromone Saturation

Evenden and A.H. Wins-Purdy tested oil-pheromone mixes for apple orchard mating disruption. Mating disruption can work via competitive mechanisms, as in the case of hand-applied ties, when male moths follow a false plume with no female at the end. Mating disruption can also work via non-competitive mechanisms such as camouflage, antennal adaptation, and central nervous system habituation, as in the case of MEC sprays.

A 100 gal (380 l) per ha (2.5 a) 3M MEC formulation of Z11-14:AC mixed with a highly refined, organic certified horticultural oil, Purespray Green® (2% v/v in water), was used. Electroantennogram (EAG) assays were conducted in the field and lab on OBLR from British Columbia. Close male moth contact with sprayed surfaces was important for efficacy. MEC pheromone alone and MEC plus oil worked much better than oil or water alone. There was a slight but significant oil synergism of MEC pheromone. EAG tests showed that the mechanism was not lack of antennal detection; in other words, central nervous system blockage of signal processing was likely.

Field studies in apple orchards looked at MEC pheromone efficacy and longevity alone (in water) versus mixed with 2% horticultural oil. The oil application rate via air-blast sprayer was 1,000 liter/ha (107 gal/acre). There was a water control, but no available acreage for an oil alone plot (lab tests indicated oil alone had little mating disruption effect). Marked males were released and captures in female-baited traps were recorded weekly to measure mating disruption efficacy.

Surprisingly, MEC pheromone longevity was not an issue. Both MEC and MEC plus oil disrupted mating almost equally for at least 42 days, and were much better than the water control. Thus, although oil did not boost pheromone mating disruption efficacy in field tests, oils and MEC pheromones are compatible IPM technologies.

Pepper Weevil Pheromone Push-Pull

"The pepper weevil, *Anthonomus eugenii*, is the most serious pest of sweet and pungent peppers in the southern United States and the Caribbean region," said Heather McAuslane (Univ Of Florida, PO Box 110620, Gainesville, FL 32611; hjmca@ufl.edu). Current control relies on insecticides applied when weevils leaving wild nightshade,

Conference Notes

Solanum spp., are trapped in peripherally located traps baited with a commercial male aggregation pheromone. Spray timing is critical, as once in the fruit, pepper weevil eggs and larvae are safe from insecticides and can cause considerable yield loss. Entire infested shipments are rejected after harvest.

"To develop a semiochemical-based push-pull strategy to manage pepper weevil, we have isolated and characterized a oviposition-deterring host-marking pheromone produced by the female weevil (the 'push' component of our strategy)," said McAuslane. Females excavate a hole in flower buds and immature fruit, lay an egg, then seal the hole with a quick-drying liquid containing the pheromone. This secretion hardens into a 'plug' which reduces subsequent oviposition (egg-laying) by more than half.

The 'pull' component of the strategy uses a trap baited with aggregation pheromones and host plant volatiles. "Pepper plants with active feeding by females are more attractive than undamaged plants or those with old damage. Fruiting plants with active feeding are more attractive than flowering plants. Feeding induces increased levels of constitutively produced volatiles" which are being captured and identified.

Pear Psylla Pheromones

"Synthetic forms of sex attractants could be used in IPM programs as monitoring tools or as a means to disrupt mating" of pear psylla, *Cacopsylla pyricola*, a seasonally dimorphic pear pest with a dark overwintering adult winterform and a smaller lighter colored summerform, said Peter Landolt et al. (USDA-ARS, 5230 Konnowac Pass Rd, Wapato, WA 98951; peter.landolt@ars.usda.gov). Winterform males are attracted by volatiles produced by live females and are repelled by male-produced volatiles.

Similarly, winterform males are attracted to female (pentane) extracts and repelled by male extracts. The biologically active compounds attracting and repelling male psyllids are currently being identified.

Flour Beetle Pheromone IPM

The red flour beetle, *Tribolium castaneum*, a major flour mill pest infesting food processing facilities, warehouses and retail stores, is monitored with traps baited with aggregation pheromone and food lures. Both endogenous factors such as sex, age, mating status, and exogenous ones such as the environment around the trap affect pheromone trap responses. Landscape variables such as the pattern of flour "spillage abundance might impact beetle probability of encountering pheromone traps, with implications for implementation and interpretation of pheromone based monitoring programs," said James Campbell (USDA-ARS, 1515 College Av, Manhattan, KS 66502; james.campbell@ars.usda.gov).

Indeed, flour beetles spend triple the amount of time in landscapes composed of fine-grained flour particles versus landscapes with coarse-grained particles. In a "fragmented" environment with fine-grained flour particles, *T. castaneum* responded more to pheromone/food oil traps than to unbaited traps. In the "clumped" large-grain particle landscape, the presence or absence of attractant did not affect trap catches.

Dual-Lure Japanese Beetle Traps

Since their 2005 detection near Denver, Colorado, Japanese beetles, *Popillia japonica*, have spread from Arapahoe to Denver, Douglas and Jefferson counties, prompting the 2007 formation of the Front Range Japanese Beetle Task Force and placement of 330 Trécé traps (yellow, four-fin funnel top; green plastic jar bottom) utilizing dual floral and sex lures. "There is no insecticide used, which is a selling point to homeowners," said Thaddeus Gourd (Colorado State Univ, 9755 Henderson Rd, Brighton, CO 80601; tgourd@co.adams.co.us).

Conference Notes

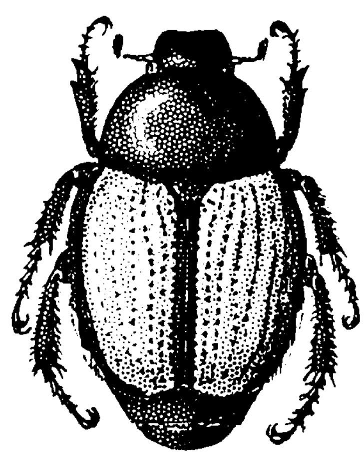
The lures last 6 weeks; the sex pheromone attracts males and the floral component ensnares both sexes.

"Each trap was GIS mapped using Google Earth or handheld remote units," said Gourd. Combining "precise trap location" with "an online reporting system enabled the monitoring of recently trapped beetles, promoting a rapid response to 'hot spots.'"

"An important finding was that the majority of beetles in the Front Range of Colorado were trapped from July 1 to September 22," said Gourd. "Trapping results also indicated that the greatest adult beetle migration to traps occurred during the last two weeks in July. These findings suggest that if resources are limited, an organization could trap only during the July 1 to August 15 time period, saving money on monitoring costs and by not replacing lures at mid-summer."

Japanese Beetle Trap Spillover

"Adult Japanese beetles, *Popillia japonica*, are significant pests of over 300 species of plants, including many important horticultural and agricultural species," said Paul Switzer (Eastern Illinois Univ, 600 Lincoln Ave, Charleston, IL 61920; pvswitzer@eiu.edu). Trap lures combine a floral component that is a 3:7:3 mixture of phenethyl propionate, eugenol, and geraniol with a synthetic version of female sex pheromone (Japonilure). Traps "capture thousands of beetles during the peak of beetle flight season." But trap effectiveness is limited by a "trap-spillover" effect. That is "many beetles that are attracted to the trap are not captured, so host plants surrounding the trap incur greater damage than if the trap had not been present."



Japanese beetle, *Popillia japonica*

About half the Japanese beetles attracted to the trap land on adjacent plants rather than entering the trap; about 1/3 remain on plants for more than 1 minute. Ultimately, about 69% are trapped. The first beetles landing on plants near the traps tend to be females, and they start pairing up with males, forming damaging aggregations on plants around the traps. Traps tend to capture the smallest females. Males guarding the larger more egg-laden females may keep them out of the traps. [One IPM approach is to deploy traps near expendable plants or to treat foliage near the trap with a reduced risk insecticide.]

Mass Trapping June Beetles

When late June/July rains loosen up soils, scarab green June beetles (GJB), *Cotinis nitida*, emerge to lay eggs and then search out fermenting or damaged fruit to feed on, said Donn Johnson (Univ of Arkansas, AGRI 319, Fayetteville, AR 72701; dtjohnso@uark.edu). Adult GJBs can be very damaging, forming feeding aggregations on fruit ripening in July and early August. Grapes, peaches, blackberries, apples, pears, ears of corn, and tomatoes are all attacked; in one case, a corn crop adjacent to a ripening vineyard was completely destroyed.

GJB may move off ripening fruit and feed on decomposing manure in adjacent fields, leaving behind what look like small mouse droppings. GJB larvae are nocturnal, emerging from the soil at night,

Calendar

October 2, 2009. 15th Annual Ladybug Bash. Safer Pest Control Project, Chicago, IL. Contact: Safer, 4611 N. Ravenswood Ave., Suite 107, Chicago, IL 60640; 773/878-7378; www.spcpweb.org

October 3, 2009. Hoes Down Festival, Full Belly Farm, Capay Valley, CA. Contact: www.hoes-down.org

October 7-9, 2009. 33rd Annual Provender Alliance Conference. Bellingham, WA. Contact: www.provender.org

October 15, 2009. Deadline for Application to the Ecological Horticulture Program. UC Santa Cruz, CA. Contact: Center for Agroecology, 831/459-3240; apprenticeship@ucsc.edu

October 16-18, 2009. 20th Annual Bioneers Conference. San Rafael, CA. Contact: www.bioneers.org

October 19-20, 2009. 4th Annual Biocontrol Industry Meeting. Lucerne, Switzerland. Contact: www.abim-lucerene.ch

October 26-29, 2009. Annual Meeting National Pest Management Association (NPMA). Las Vegas, NV. Contact: NPMA, 10460 North St., Fairfax, VA 22031; 800/678-6722, 703/352-6762, Fax 703/352-3031; www.npmapestworld.org

October 28-29, 2009. WSU IPM Plant Workshop. Chehalis, WA. Contact: http://pep.wsu.edu

November 18-19, 2009. IPM Coordinator Conference. San Marcos, TX. Contact: Janet Hurley, 972-952-9213; http://agrilifeevents.tamu.edu/index.cfm

December 13-17, 2009. Entomological Society of America Annual Meeting. Indianapolis, IN. Contact: ESA, 9301 Annapolis Road, Lanham, MD 20706; Fax 301/731-4538; www.entsoc.org

January 20-23, 2010. 30th Annual Ecofarm Conference. Asilomar, CA. Contact: Ecological Farming Association, 406 Main St., Suite 313, Watsonville, CA 95076; 831/763-2111; www.eco-farm.org

January 31-February 3, 2010. Annual Meeting Association Applied IPM Ecologists. Napa, CA. Contact: www.aaie.net

February 7-11, 2010. Annual Meeting Weed Science Society of America. Denver, CO. Contact: www.wssa.net

February 25-27, 2010. 21st Annual Moses Organic Farm Conference. La Crosse, WI. Contact: Moses, PO Box 339, Spring Valley, WI 54767; 715/778-5775; www.mosesorganic.org

February 28-March 2, 2010. California Small Farm Conference. San Diego, CA. Contact: www.californiafarmconference.com

July 1-3, 2010. 67th Annual Convention, Pest Control Operators of CA. Monterey, CA. Contact: www.pcoc.org wiggling on their backs and pupating in the soil; as they tunnel and feed, GJB larvae uproot pasture grasses. "It's pretty simple to manipulate the grubs" by switching from organic to synthetic fertilizers for grasslands adjacent to vineyards and fruit orchards ripening in July/August (high GJB egg-laying risk), said Johnson.

After two days of GJB fruit feeding, there are strong fermentation odors from yeast species that act as GJB feeding aggregation kairomones. These odor molecules include: fruit skin chemicals (hexadecane, farnesene), ethanol, acetic acid, butane compounds, 1-hexyl actetate, and ethyl acetate. A compound unique to GJB and not seen in other scarabs, cyclohexanecarboxylic acid, is a precursor for natural yeast fungicides that manipulate bacteria and fungal competitors, allowing yeast dominance.

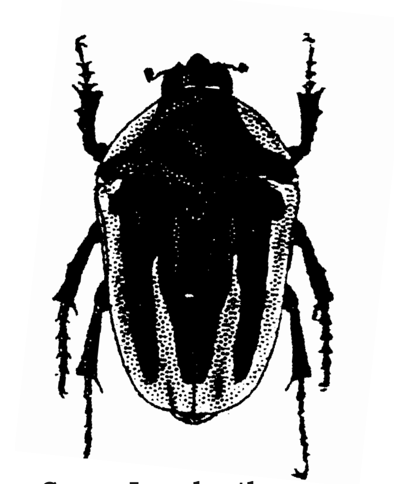
Five Component Blend

Mass trapping lures had 3.5 ml of TRE-8607 (Trécé), a 5-component blend that includes the fermentation compounds phenylacetaldehyde and phenethanol, plus methyl-2-methoxybenzoate, (R)(+)limonene, and methyl salicylate. Another lure, the scarab blend, which also attracts moths, had 100 ml of 91% isopropanol. TRE-8607 was placed in Trece Floral Cups. Xpando traps with wide-throated funnels were also used; with GJB catches sometimes totaling over 10 gallons (38 l) in one week, larger capture boxes were added. Wick isopropanol lures worked well inside the trap or outside on the rebar holding the trap.

Mass trap lines (lures recharged weekly) were established on pasture perimeters of vineyards in Altus, Arkansas, and Purdy, Missouri. Double lure traps with 3.5 ml TRE-8607 and 100 ml of 91% isopropanol were compared to single lure traps. At the two Purdy sites with a dozen traps, isopropanol traps caught 178,413 GJB, which was significantly more than the 138,166 caught by TRE-8607. In Altus with 6 traps, TRE-8607 lures caught 4,485 GJB and isopropanol 2,943. In all, the 36 Trécé traps caught 324,000 GJB.

Attract and Kill

Synthetic and organic pesticides were tested for potential use in an attract-and-kill system. Almost all the synthetic compounds gave 100% kill in 72 hours. Ecotrol EC (10% rosemary + 2% peppermint oil) was the best of the organic materials with 71% kill, followed by Aza-Direct (1.2% azadirachtin) (51% kill) and MOI 201 (a mix of Chinese medicinal plants; 41% kill).



Green June beetle, *Cotinis nitida*

Beauveria bassiana products need 6 days to be effective, and thus could not be properly evaluated with a 72-hour protocol.

Johnson considers the new systems an improvement on the messy old system where growers put out trays of fermenting fruit, sprinkled it with carbaryl, and hoped for the best. Research is continuing to identify the GJB sex pheromone, which could be added to an attract-and-kill dual lure system.

Homemade Banana Pheromone Traps

On small Costa Rican farms, mass trapping with homemade pitfall traps baited with aggregation pheromone (Triteca, Costa Rica) reduced banana weevil, *Cosmopolites sordidus*, corm damage by 33% and increased crop sale prices significantly, said Ruth Dahlquist (Fresno Pacific Univ, 1717 S. Chestnut Ave, Fresno, CA 93702; ruth.dahlquist@fresno.edu). Six small farms with pheromone traps were paired with control farms without pheromone traps. Detergent-laced water was used to remove weevils.

Small banana farmers are paid by the bunch rather than by weight. There was no significance difference in bunch weight, with or without pheromone traps. However, bunches protected by pheromone traps had less weevil damage and looked better, which yielded farmers significantly higher selling prices. Pheromone trap catches were highest on farms having the highest weevil populations at the start of treatments.

Weevil Pheromone IPM

Aggregation pheromones are not uncommon in weevils and often synergize with food plant materials, said Cam Oehlschlager (ChemTica Internacional, Apdo 159-2150, San Jose, Costa Rica; cam@pheroshop.com). Banana weevils infest the base of plants, crawling along the ground to find injury points to enter. Buried containers with water in the bottom and aggregation pheromone lures are effective. Indeed, the aggregation pheromones have a variety of creative IPM uses around the world.

The red palm weevil, *Rhynchophorus ferrugineus*, a major pest of date, coconut, oil and other palms in every continent except the Americas, are often trapped (monitoring, mass trapping) in bucket traps with fermented mashed dates and water; though ethyl acetate, plant sugars and pheromone can be combined as bait. In many related species, there is a synergism between the pheromone and palm plant tissues or sugar compounds. The synergism of pheromone and mashed dates can increase red palm weevil capture by a factor of 10.

In Costa Rica the West Indian sugarcane weevil, *Metamasius hemipterus*, is best mass trapped with pheromones (plus ethyl acetate and food plant material in the traps) early in the season to prevent invasion when the sugarcane is first planted. Early in the invasion, pheromones are important for the weevils to find each other. But after a few months, as the population matures, pheromones become less important.

Ambrosia Beetle Trap Trees

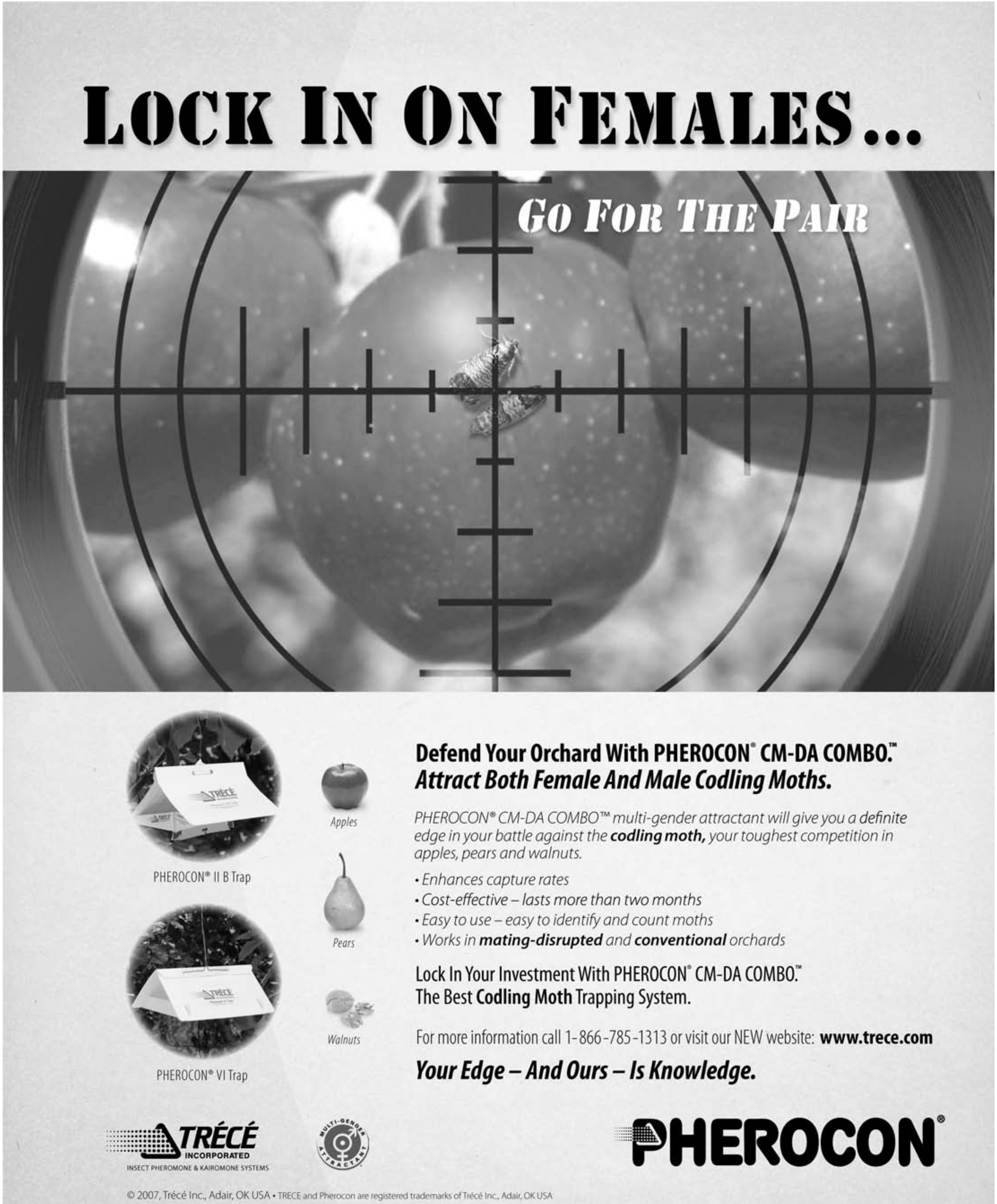
The black stem borer, *Xylosandrus germanus*, is among the most economically important exotic ambrosia beetles in U.S. nurseries," said Christopher Ranger (USDA-ARS, 1680 Madison Ave, Wooster, OH 44691; Christopher.ranger@ars.usda.gov). "Deciduous trees or tissue physiologically stressed by abiotic or biotic factors are preferred for colonization. A variety of volatile organic compounds are produced in greater concentrations by stressed (versus healthy) plants, including acetaldehyde, acetone, ethanol, ethyl acetate and methanol."

Ethanol baited traps used for ambrosia beetle monitoring in ornamental nurseries show a dose-response without inducing tree attacks. However, injecting ethanol, acetaldehyde or ethyl acetate into living trees rapidly promotes ambrosia beetle attack. "The absence of attacks by *X. germanus* on uninjected trees indicates the importance of stress-related volatiles for host selection," said Ranger. "Rapidly inducing attacks by *X. germanus* and other Scolytinae in trees injected with stress volatiles, but not in uninjected trees, shows considerable promise as a trap tree strategy. The viability of using trap trees as part of a push-pull approach for *X. germanus* and other nursery-infesting ambrosia beetles is being assessed."

Pine Bark Beetle Attractants

Southern California has been invaded by several pine beetles, including: 1) *Arhopalus syriacus* (Cerambycidae), native to the Mediterranean, Canary Islands and Middle East; 2) Asian ambrosia beetle, *Xyleborinus saxeseni* (Scolytidae), a pest of injured, recently cut and dying conifers and hardwoods that has been in the U.S. over 100 years; 3) redhaired pine bark beetle (RPBB), *Hylurgus ligniperda*, found overwintering in NY in 2000, in Los Angeles County in July 2003, and has since been trapped in urban forests in counties surrounding Los Angeles.

Alpha-pinene attracts RPBB and *A. syriacus* males and females, but ethanol does not, said Hamud. Yet ethanol and *alpha*-pinene work together synergistically to attract RPBB and *A. syriacus*. In contrast, Asian ambrosia beetles are attracted to ethanol, but not to *alpha*-pinene; and there is no significant synergism.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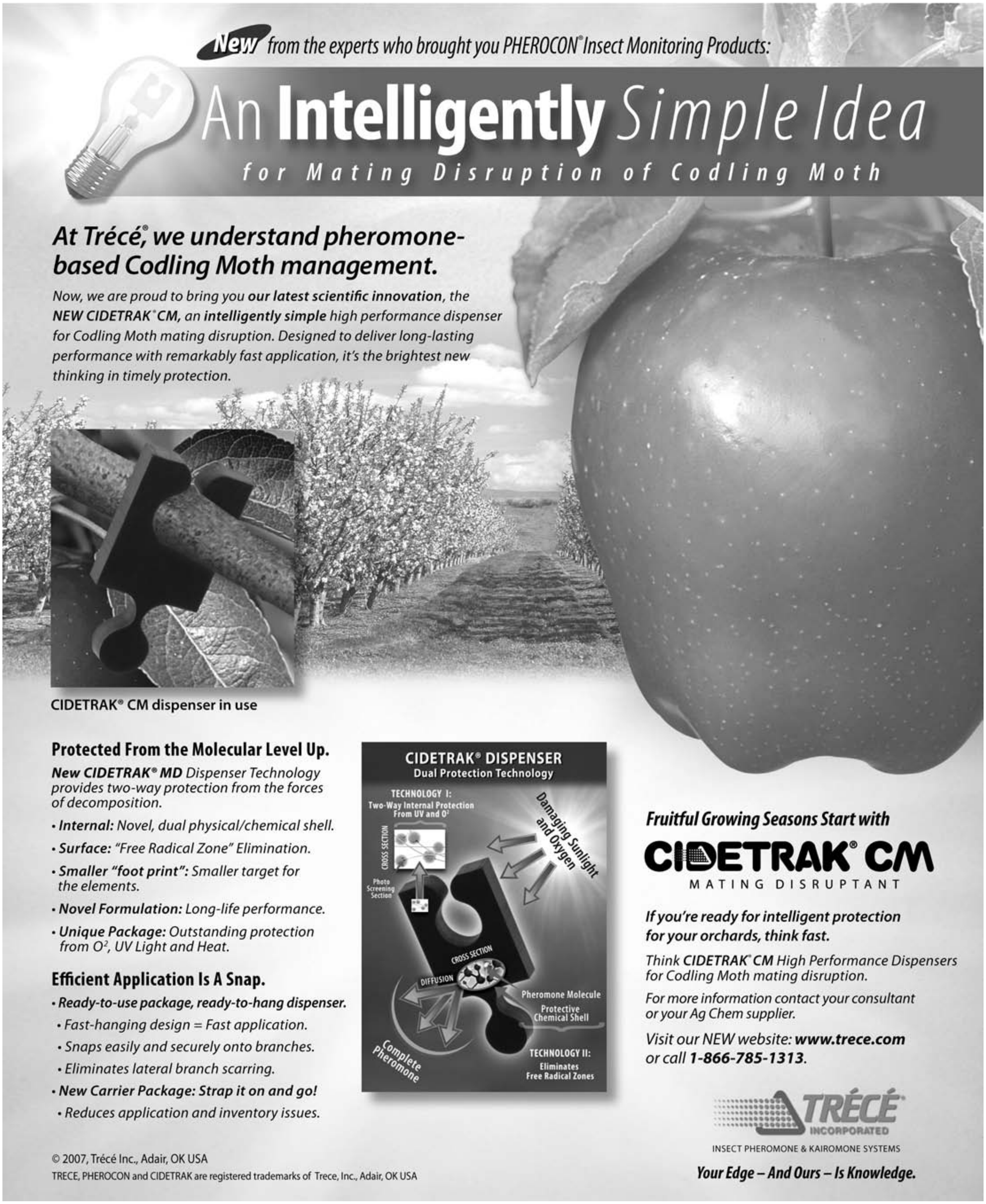
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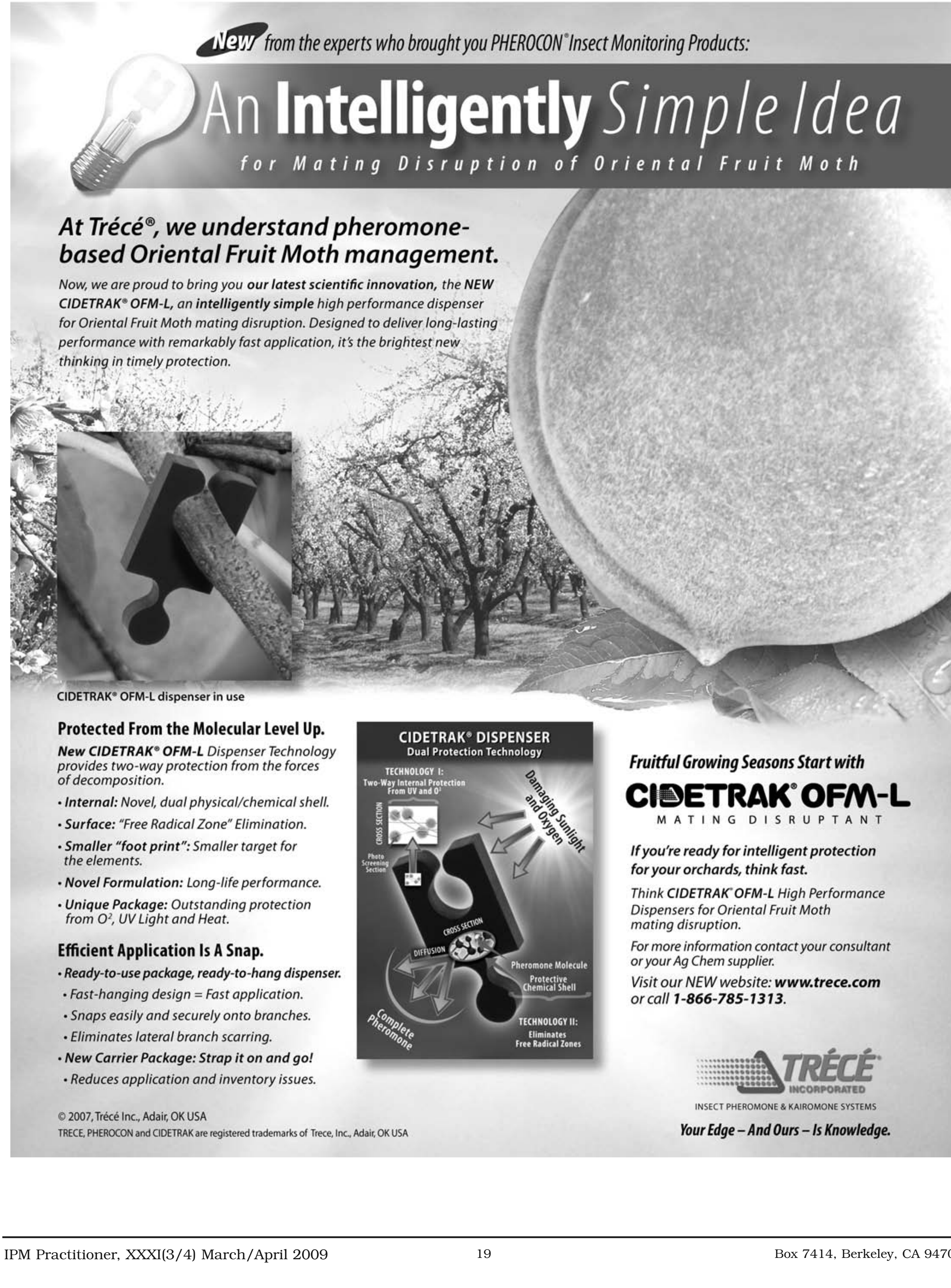
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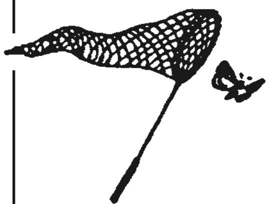

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