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Orange Oil for Drywood Termites: Magic or Marketing Madness?

By Bill Mashek and William Quarles

There is a thriving market for reduced-risk pesticides. Many pesticides containing conventional active ingredients such as chlorpyrifos and diazinon have been phased out of urban markets. Their widespread use in both agriculture and urban areas had led to increased exposures and unacceptable risks (FQPA 1996; NRC 1993; Wright et al. 1994). They were also a threat to water quality in many areas (Johnson 2004).

A rich source of new pesticides is plant essential oils. Some of these occur in food and are even exempted from pesticide registration by the EPA. Active ingredients in the new products include oils of clove, rosemary, mint, and oranges. Large corporations such as EcoSmart, Woodstream, and Whitmire have made these pesticides readily available (Quarles 1999a; Isman 2006) (see Resources).

Orange oil has attracted a lot of media interest because it is a natural product and has low toxicity to mammals. It is a by-product of orange juice processing, and is extracted from orange peels. Orange oil is currently available as an insecticide (Orange Guard™; ProCitra®) and as an herbicide (Green Match™) (see Resources). It has been registered in California under the brandname XT-2000™ for control of drywood termites. If all the claims are true, it is the holy grail of pest control—an effective natural product with low toxicity and no toxic residuals; a green product obtained by utilization of waste. The purpose of this article is to present what is currently known about orange oil for termite control so that possible customers will have better information to evaluate the treatment. For comparison, we will summarize some of the other methods used in California for drywood termite control.

Photo courtesy USDA

Termites like these are vulnerable to desiccation. Contact with orange oil kills termites by damaging their exoskeleton, causing loss of water and protein.

What is Orange Oil?

Orange oil should not be confused with orange juice. Orange juice is basically a water extract; orange oil is insoluble in water. Though orange oil has low toxicity, it is irritating to eyes and skin, and drinking it would cause vomiting. Repeated exposure could cause allergic sensitivity in some individuals (MSDS 2006).

Orange oil is an oily mixture extracted from orange peels, and the major components are chemicals called terpenes or terpenoids. It is a volatile liquid and has a strong odor of oranges. A chemical relative of orange oil is turpentine. Both food grade and technical grade orange oil are available. According to Jeff Chang of Florida Chemical, a major supplier of orange oil, there

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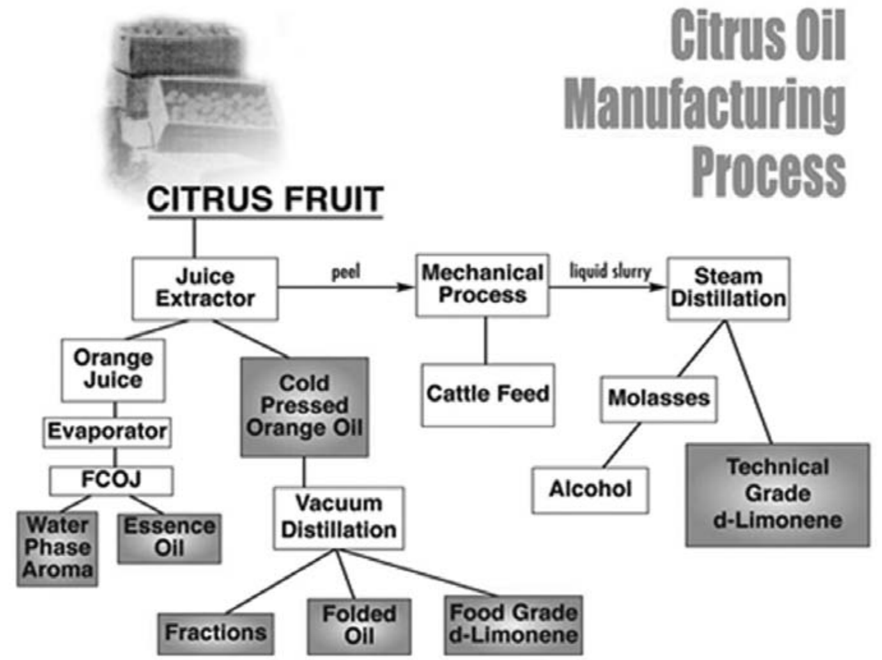
Update



Orange oil is extracted from orange peels. It contains terpenes and terpenoids, and the major component is d-limonene.

Schematic courtesy Florida Chemical Company

is very little chemical difference between the two. Food grade is obtained by cold pressing the peels to remove the oil, technical grade is mostly obtained by steam distillation.

There is a lot of misinformation on the internet about termites and orange oil. Some companies say that termites are killed by the citric acid in the oil. According to Chang, this is unlikely, because the orange oil they supply has less than 0.1% citric acid. Although their orange oil contains 5% of other terpenes, alcohols, ketones, and aldehydes that may have some activity, the major active ingredient is about 95% d-limonene. D-limonene (92%) is the registered active ingredient of the termiticide XT-2000, and d-limonene termiticidal activity is consistent with its known insecticidal properties against a variety of flies, mosquitoes, ants, weevils, fleas, wasps, crickets, mealybugs, scales, ticks, mites, and wood beetles (Taylor and Vickery 1974; Styer and Greany 1983; Sheppard 1984; Hink and Fee 1986; Coyne and Lott 1976; Karr and Coats 1988; Karr et al. 1990; Vogt et al. 2002; Hollingsworth 2005; Quarles 2006a).

Chang believes that d-limonene kills termites through its solvent activity. It actually "melts" or dissolves their chitinaceous exoskeleton. This is consistent with the known exoskeleton damage produced in the Formosan subterranean termite by a related chemical, *cis*-nerol. Damage to the exoskeleton and cell membranes causes lethal loss of proteins and water (Zhu et al. 2003).

Orange oil is sold as a cleaning agent, and it is a good solvent. Because it is a good solvent, it can cause paint damage if used on painted surfaces. It is flammable, but relatively small amounts of orange oil are used in a termite treatment (MSDS 2006).

Drywood Termite Treatments

Drywood termites are found along the southern border of the U.S., and they are major pests in California and Florida.With global warming,their range is likely to extend northward (Quarles 2007). Treatment costs may exceed $500 million each year (Su and Scheffrahn 1990; Su and Scheffrahn 2000). Drywood termites are either built into new structures, or they invade by flying in from outside. Unlike subterranean termites that live in the ground, drywood termites spend most of their life cycle inside a piece of wood. They live in hollowed out spaces called galleries (see Box A).

In California, drywood termite treatments are either whole house treatments or local treatments. Local treatments include non-chemical methods such as heat, electro-gun or microwaves or injections of chemicals directly into termite galleries. Whole house treatments may be either a heat treatment or a chemical fumigation, usually with sulfuryl fluoride (Vikane®). Local treatments are done with minimal disruption. Whole house treatments require that occupants move out of the house for about 3 days in the case of a fumigant, or leave for 4-8 hours during a heat treatment (Quarles 2006b).

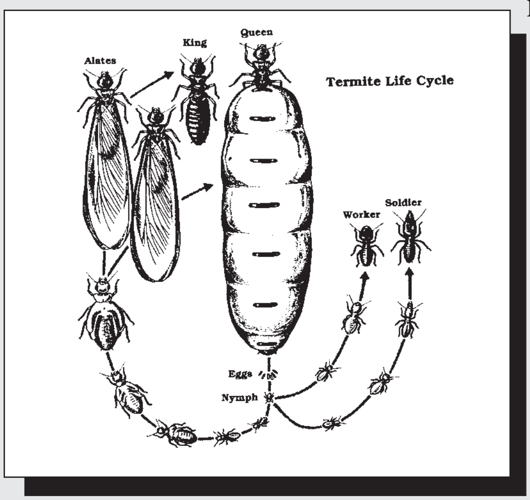
If there are a limited number of accessible colonies of known location, a local treatment is often used. In California, about 70% of the time, customers choose chemical injections, about 10% of the time, they choose non-chemical methods, and about 20% of the time a structural fumigant is used (Lewis 2003; Potter 1997).

Key to success with local treatments is detection. Termite inspection involves a trained and experienced inspector. Inspectors are limited to accessible areas and rely mostly on their eyes to find termite signs such as damaged wood, flying termites (swarmers), discarded wings, and fecal pellets. Tools of the trade include a flashlight and wood probe such as an icepick, knife, or screwdriver (see Box A).

Over the years additional tools have been developed. Since termites are encouraged by moisture, finding moist areas can help with the ter-

Box A. Biology of Drywood Termites

Pest termites can be roughly divided into two kinds, subterranean and drywood. Subterranean termites live in the ground and forage in wood beneath and above the ground. The most economically important species are the eastern and western subterranean termite, *Reticulitermes flavipes* and *R. hesperus*, and the Formosan subterranean termite, *Coptotermes formosanus*. Subterranean colonies usually maintain ground contact and commute back and forth between soil and structure through mud tubes. When there is a source of water such as a leaking pipe inside a building, a complete colony may reside inside a structure. Subterranean colonies are large, ranging in size from 50,000 to a few million, and a Formosan colony can do significant damage within 6 months (Su and Schefferahn 1990; Potter 1997).



Colonies of drywood termites, such as *Incisitermes* spp. or *Cryptotermes* spp., tend to be small, often containing fewer than 1,000 individuals. They live their entire life cycle inside of wood, except for time spent in reproductive swarming. Swarming drywood termites generally leave the colony between August and November. Reproductive swarms mate, fly around structures looking for cracks or holes, then lose their wings. King and queen crawl into cracks and small holes, excavate further, and start laying eggs that eventually turn into workers, soldiers or reproductives. Termites continue eating, producing hollow spaces called galleries. After 2-3 years annual swarming begins, and the termites infest other wood throughout the structure. A typical colony of drywood termites takes about four years to mature, and a colony of 1000 might take 7 years to develop. To eradicate, colonies might have to be reduced to less than 20 termites (Lewis 2003; Lewis 2002; Ebeling 1975; Smith 1995; Kofoid et al. 1946).

Signs of Drywood Termites

Current IPM programs for termites are based on regular inspections and early detection. If they can be detected early enough, infested wood can be physically removed, repaired, or treated without great cost. Wings, flying termites, kick-out holes in wood, and especially piles of hexagonal shaped, small BB sized fecal pellets sometimes resembling piles of sawdust are signs of drywood termites. Blisters on paint could hide a colony just underneath. Inspection is a laborious process because all exposed wood on the inside and the outside of the building should be inspected. Frames of doors and windows, eaves, soffits, fascia boards and dormers should receive attention. An infested board has a hollow sound when tapped with a screwdriver or probe (Potter 1997).

Inside, horizontal surfaces should be checked for pellets, window and door frames, doors, baseboards, moldings, paneling, flooring, shelves, bookcases, ceiling beams and even wooden furniture should be inspected. Drywood colonies have even been found in woody plants. In attics, "infestations are commonly found around vents, in rafters, ridgepoles, plates, ceiling joists, roof sheathing, and in general, around the perimeter" (Potter 1997).

Dogs can be used to locate drywood termites.

Photo courtesy TADD Dogs

mite search. Moisture can be sensed by moisture meters, and these are readily available (see Resources). Another useful tool is the borescope. By drilling holes and inserting a flexible, lighted probe, inspectors can see signs of termites in wall voids without removing the drywall (see Resources).

Other tools include termite-sniffing dogs, and "sniffers"—devices that detect characteristic gases emitted by a termite colony (Brooks et al. 2003; Quarles 2004; Lewis et al. 1997). Acoustic detectors have been developed that can "hear" termites feeding (Quarles 2004; Lemaster et al. 1997; Scheffrahn et al. 1993; Thoms 2000; Dunegan 2001; Lewis et al. 2004). In the last few years, there has been a surge in new detection methods. Detectors using microwave, infrared, lasers, and even X-rays have been commercially developed. Most termite companies do not invest in this technology because of excessive costs and lack of proven efficacy. Most use conventional visual inspection, sometimes augmented with a borescope, an acoustic detector, or a dog (Quarles 2004).

Orange Oil Treatment Method

Orange oil is a local treatment method. When a drywood colony is found, holes are drilled into the infested wood, and orange oil is injected. According to one company's website, "drill in a staggered pattern from the point of the infestation out 30 inches (76 cm) in all directions." The schematic on the website shows drill holes about every 5 inches (12.7 cm). If the holes and injections coincide with an active gallery, laboratory efficacy studies suggest (see below) termites in the gallery will be killed by contact. The problem with this method is finding the galleries, one cannot drill and inject into solid wood. Orange oil must be pumped into the hollow spaces where termites are feeding.

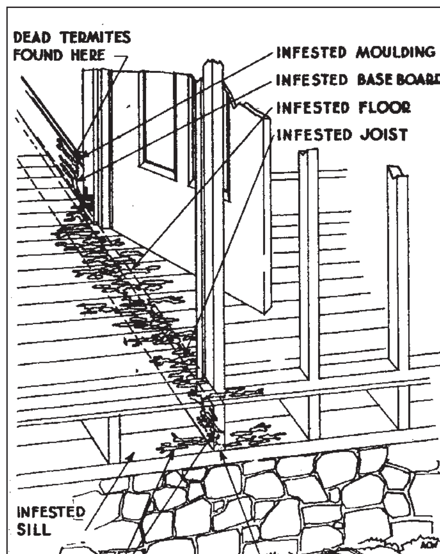
There are anecdotal claims that orange oil "wicks through wood," and it may do so. However, there are no published studies that show termites can be killed in this way. Orange oil vapor moves by diffusion out of the injected gallery, through the wood and off-gasses into the air. This movement accounts for the odor of oranges in the air that lingers after a treatment. But there is no published evidence that shows this movement produces concentrations large enough to kill termites by fumigant action in a gallery at an appreciable distance from an injection site. From laboratory studies with the Formosan subterranean termite, *Coptotermes formosanus*, orange oil fumigant concentrations of about 5 ppm would have to be maintained for about 5 days (Raina et al. 2007). Professor Rudolf Scheffrahn, who did some of the laboratory efficacy studies believes, "any fumigant action is over a short distance" (Scheffrahn 2008). Further research may be needed to clarify this point. Orange oil research is currently being conducted by Prof. Michael Rust at the University of California (UC) Riverside.

Like a structural fumigation, orange oil does not leave a residual, so once the material has diffused and evaporated, it is no longer effective. One study showed that it dissipates within a week, the orange oil companies say the smell of oranges lingers from three days to two weeks (Raina et al. 2007).

Efficacy of Orange Oil

Despite widespread publicity and promotion, very little has been published in peer reviewed journals on the efficacy of orange oil for termite control. Orange oil will kill termites by contact in laboratory situations. Dr. Rudolph Scheffrahn was hired by XT-2000 to test the efficacy of orange oil injections into infested trunks and branches of Brazilian pepper trees with active galleries of the drywood termite, *Incisitermes synderi*. Infested pieces were 82-144 cm long (32.8-57.6 in) and ranged from about 1-5 liters (approx. 1-5 quarts) in volume. Injections were made about every 5 inches (12.7 cm). Termite mortality ranged from about 48 to 100%. Lowest percent mortalities were in larger pieces that had lower termite densities. Injection volumes of XT-2000 were about 3% of the total wood volume. Termites in pieces injected with water showed no mortality (XT-2000).

Though published experiments with drywood termites are sparse, USDA researchers have recently published experiments with orange oil and the Formosan subterranean termite, *Coptotermes formosanus*. They found that 96% of termites



Orange oil must be injected into active termite galleries. If the injection misses a gallery, termites will not be killed.

Drawing from Kofoid 1946

sealed in a 1.9 liter (0.5 gal) plastic container containing 5 parts-per-million (ppm) of orange oil died within 5 days. Lower concentrations tested showed reduced mortality, but caused termites to reduce feeding. Orange oil vapors came from a filter paper saturated with orange oil suspended from the top of the container. Termites were not in contact with the source, and thus they were killed by fumigant action (Raina et al. 2007).

However, when a wooden mockup of a wall void was used as a test platform, twice as much, or 10 ppm of orange oil, caused only 15% mortality. The researchers believe that the wet wood used in this test absorbed orange oil, making it less effective as a fumigant. Thus, ability of wood to soak up orange oil, may actually work against its action as a fumigant. For fumigant action, enough orange oil must be used to overcome wood absorption and dissipation into ambient air.

Finally, termites were added to glass tubes filled with treated sand containing 0.2% and 0.4% orange oil by weight. All termites were killed by contact with the orange oil within 72 hours. The orange oil was not persistent, and about half of the oil from the 0.4% treatment was gone within a week, and most of it had volatilized within 3 weeks (Raina et al. 2007).

So laboratory experiments show that orange oil is a fumigant, kills by contact, and acts as an antifeedant. Other essential oils have similar properties. Clove oil can kill termites by fumigant action (Park and Shen 2005). Basil and citronella oils kill by contact, act as antifeedants, and are repellent to termites (Sbeghan et al. 2002). Though no tests are available, orange oil may also be repellent.

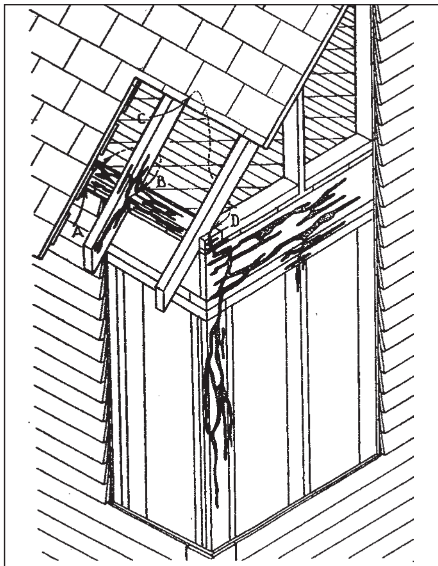
Field Efficacy of Drywood Termite Treatments

It is not easy to completely rid a structure of drywood termites. Most treatments properly applied lead to a significant reduction of colony numbers, but complete eradication in all cases just does not happen (Lewis 2003). Even with structural fumigation, some termites may be left alive (Lewis and Haverty 1996), especially if termites are in areas where the wood has high moisture content, because water acts as a barrier to sulfuryl fluoride (Vikane) penetration (Su and Scheffrahn 1986). It may not be necessary to kill all the termites to destroy a drywood colony. If the queen and most of them are killed that may be enough. However, supplementary reproductives can be produced from a queenless colony as small as 20 termites (Smith 1995).

But how can we rate the field efficacy of any particular treatment? There are four possible methods: the termite company can visually reinspect some time after treatment, some kind of instrument can be used to measure termite activity before and after treatment; the treated wood can be removed and destructively sampled; or the customer can act as a quality control agent by calling the termite company back when fresh signs of termites are seen.

The first method is rarely used. Companies usually treat on a one-time basis and do not return unless called back. Acoustic detectors have been used to evaluate field efficacy. Termites make sounds when they feed, and the number of feeding sounds per minute is a measure of activity. Activity is measured before and after treatment to get a measure of field efficacy (Thoms 2000). Because of cost and the technical expertise needed to operate the detector, this method is rarely used (see below).

Destructive sampling is also rarely used. Although infested wood is sometimes removed and replaced, seldom is the wood treated before replacement. So most of the time, field efficacy assessments rely on the customer. Customers see fresh evidence of termite excretions or swarming, and the company is called back for further work. These "callbacks" can be a practical measure of treatment effectiveness, and are often the only measure. A survey of pest control operators (PCOs) by the Bio-Integral Resource Center



Drawing from Kofoid 1946

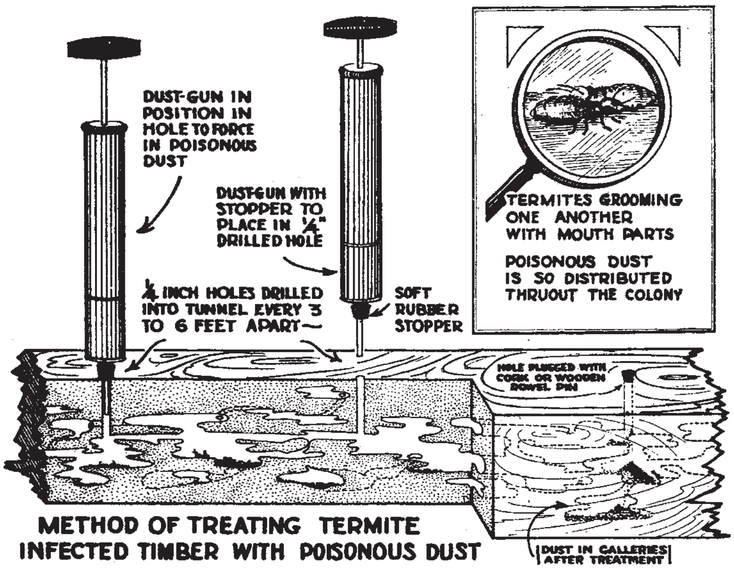
Local treatments require that galleries be accessible. Each active gallery must be injected with orange oil to kill termites.

(BIRC) found callbacks on structural fumigations to be 5-15% (Quarles and Bucks 1995). Consistent with this callback estimate of efficacy, Ebeling and Wagner (1964) found that 26 to 37% of all structures fumigated for drywood termites in Los Angeles showed evidence of active infestations within 3 to 5 years. Some of these were reinfestations, but some of this activity undoubtedly reflected a fumigation failure (Ebeling 1975).

Callback rates for treatments other than fumigation are more heavily dependent on the skill of the operator. John Lemm of Cal Western Pest Control in Los Angeles treated over 1200 structures with heat in the 1990s, and had a callback rate of less than 1%. Other heat treatment operators have higher callback rates. According to Phil Holt, former president of Etex, Ltd., the manufacturer of the Electrogun, "the callback rate for Electrogun treatments done properly is probably about 5%. However, companies that do not adhere to treatment guidelines may have a failure rate of up to 25% (Quarles 1999b). This estimation is consistent with a study by Ebeling (1983), who found an Electrogun callback rate of 3 out of 35 or 9%.

Efficacy of Local Injections

The local treatment method of injecting chemicals to kill drywood termites was developed by University of California researchers in the 1930s (Light et al. 1930; Ebeling 1975). Dusts containing arsenic salts or other chemicals were injected into active galleries. Any termites that did not encounter the material initially were exposed to toxic residues as they blundered through the treatment area. There was also transfer of active residues between termites (Randall and Doody 1946; Kofoid and Williams 1946). Many current researchers believe that local treatments work better if termites are presented with lingering toxic residuals. In case an active gallery is missed, surviving termites may encounter lethal residues later (Ferster et al. 2001; Scheffrhan et al. 1997; 1998).



Local treatment with chemicals involves drilling holes into wood and injecting either dusts or liquid termiticides. Those that leave a residual provide ongoing protection.

Drawing from Kofoid 1946

As mentioned earlier, 70% of the time customers choose chemical injections for treatment of drywood termites. Colonies must be accessible, and field efficacy of local chemical treatments depend on the skill of the operator, skill of the termite inspector, and to some degree on the specific treatment chemical (Lewis 2003; Thoms 2000; Scheffrahn et al. 1997, 1998). A number of materials have been tested in the past (Lewis 2003), some of these were very toxic and only a few are currently registered. There are very few published studies covering the field efficacy of chemical injection for drywood termite control that directly compares currently registered materials.

Scheffrahn et al. (1997) found field efficacy measured with an acoustic detector at 1 month after treatment ranged from 22-90% for a number of materials they tested. Thoms (2000) and cooperating PCOs used an acoustic detector to monitor efficacy of spinosad injections for drywood termite control. All colonies tested were totally accessible. Infestations were monitored, then treated. Then effects were checked 1-2 months later with the acoustic detector. Colonies were completely eliminated at 61% of the treated sites, and 90% or better reduction of activity was seen at 89% of the sites. At 11% of the sites, mortality was less than 90%, and these sites required further treatment. These results are probably as good as it gets with local injections.

Woodrow et al. (2006) did a field efficacy simulation by injecting various products into infested loading pallets. Some of the active galleries were part of several interlocking boards. Each board received only one injection of either spinosad, chlorpyrifos, disodium octaborate tetrahydrate (DOT), or resmethrin. Spinosad showed the largest mortality with rates of 53-59%. Because of the limited number of injection sites, some galleries were missed. Thoms (2000) probably obtained better results with spinosad because a larger number of injection sites were used near signs of infestation.

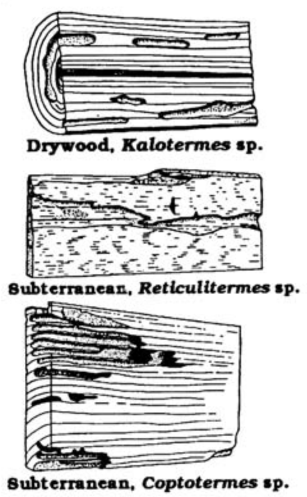
Another experiment by Woodrow and Grace (2005) with imidacloprid, DOT, and spinosad, showed best results with DOT, about 63% mortality. Again, only one injection site per board was used, and some galleries missed treatment. Orange oil practitioners saturate galleries near signs of infestation with injection holes every 5 inches (12.7 cm).

Sometimes laboratory efficacy studies show good results, but field efficacy is poor. Scheffrahn et al. (1997) found that injections of DOT dust in the laboratory killed more than 80% of termites. Injections in the field killed very few, because "dust applications, which are difficult to inject into wood, yielded sparse coverage in natural gallery systems." Conversely, surface applications of DOT liquid did not kill any termites in the laboratory, because galleries were deeper in the wood than the penetration distance of the borate. Termites were killed in the field with surface applications because colonies were near the surface. The great value of DOT comes as a treatment to prevent termite infestations (Scheffrahn et al. 2001).

Field Efficacy of Orange Oil

Since there are no published studies of orange oil field efficacy, we have to rely on callback estimates given by the practitioners. One of the major orange oil companies is X-Termite, which is owned by Mike Folkins. According to Mike, X-Termite has treated 15,000 structures with orange oil in the last 9 years. He believes that a fair estimate of the callback rate on orange oil treatments is 5-15%. He believes that success with orange oil depends on intensive structural inspections and extensive treatment of areas adjacent to active infestations. He agrees that there is a lot of misinformation about orange oil, including the claims that termites are killed by citric acid. The registered active ingredient in XT-2000, which is technical grade orange oil, is d-limonene.

According to Nathan Vogel of Orange-X Termite, his company has about a 5% callback rate from orange oil treatments. Most important on keeping callbacks low is treatment of a large enough area so that all active galleries are saturated with orange oil. Vogel believes termites are killed by contact, by fumigation action from orange oil vapors, and by eating the treated wood. Typically, about a gallon of orange oil is used in a local treatment. Orange oil does not leave a residue, and according to Vogel, the smell lingers from 3 to 10 days, depending on temperature. When the smell has disappeared, it is likely that any insecticidal action also disappears. So termites that are not killed immediately will likely persist.



Damage caused by drywood termites has a different appearance than that caused by subterraneans.

According to Joseph Grande of Pacific Coast Termite, his company has about a 15% callback rate from orange oil treatments. Inspections rely on standard visual techniques. When a colony is found, orange oil is injected into the active gallery. Since orange oil is not persistent, Pacific Coast uses Boracare® foam as a supplemental treatment in areas near the active infestation. After treatment, any infestations found by the customer anywhere in the structure within a two-year period are treated without charge.

Marketing Claims

Controversies surrounding orange oil treatments are centered on possibly misleading marketing claims. Termite treatments in California are either local treatments such as chemical injections into active termite galleries, or whole structure treatments such as heat or chemical fumigation where all elements of the structure are actually in contact with the lethal agent. According to one company's website, orange oil is a "full structure treatment."

Actually, an entire structure is not treated with orange oil. Standard inspection techniques and an optical instrument called the borescope are used in an intensive visual inspection of all areas that are accessible by these techniques. Any accessible colonies detected receive a local treatment with orange oil. The borescope can increase the efficacy of an inspection by viewing some inaccessible areas, such as wall voids, but whole house termite-free guarantees with a borescope seem optimistic. Accessing some areas, such as behind tile walls or stucco may involve substantial renovation and might be expensive.

In fact, companies usually do not warranty a whole house to be free of termites from a local orange oil treatment. Instead, they offer to come back and locally treat any accessible infestation found upon inspection anywhere in the structure within a one or two year guarantee period (Vogel 2008).

Conclusion

Orange oil is not magic, but it may represent a reasonable local treatment method that can compete with other chemical injection techniques. However, there is some uncertainty, because field, or even laboratory studies directly comparing orange oil efficacy with other products for drywood termite control have not been published. The only field efficacy estimations available are the callback rates given by the termite companies. Based on our limited sampling, orange oil callbacks compare favorably with other options.

Advantages of orange oil are that it has low toxicity and is perceived as a green product. Disadvantages of orange oil are that, like structural fumigation, electrogun, microwave, or heat treatments, it does not leave a residue, and provides no ongoing protection. Other disadvantages are that some people may react to the strong smell of oranges; it is flammable; and care must be used not to damage paint jobs.

The good news is that Californians now have a number of options for treating drywood termites. None of them are magic, none of them are perfect. Nonchemical options, botanicals, and conventional methods are all available. The larger number of choices make it more likely customers can find one that fits their special needs and personal preferences.

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Update

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Resources

Acoustic Detectors— Dunegan Engineering Consultants, PO Box 61808, Midland, TX 79711; 432/561-5901, Fax 432/563-0178; www.deci.com; Acoustic Emission Consulting, 5000 San Juan Avenue, Suite D, Fair Oaks, CA 95628; 916/965-4827, Fax 916/965-4350; www.aeconsulting.com

Borescopes—Univar USA, 2256 Junction Ave., San Jose, CA 95131; 800/888-4897, 408/953-1612, Fax 408/434-6489. Professional Equipment (see below)

Electrogun—ETEX Ltd., 5200 West Oakley Blvd., Ste. D24, Las Vegas, NV 89146; 800/543-5651, 702/364-5911, Fax 702/364-8894; www.etex-Ltd.com

GreenMatch™ (herbicide)—Marrone Organic Innovations, 2121 Second St., Suite B-107, Davis, CA 95618; 530/750-2800; www.marroneorganicinnovations.com. Monterey Chemical, 3654 S Willow Avenue, PO Box 35000, Fresno, CA 93745; 559/499-2100, Fax 559/499-1015; www.montereychemical.com

Heat Treatment— Thermapure/TPE Associates, 180 Canada Largo Road, Ventura, CA 03001; 800/873-2912, Fax 805/648-6999; www.thermapure.com

Moisture Meters—Professional Equipment, 30 Oser Avenue, Suite 500, Hauppauge, NY 11788; 800/334-9291; www.professionalequipment.com

Non-Chemical Treatment Methods—Northwest Termite, 112 Commercial Court No. 4, Santa Rosa, CA 95407; 800/281-2710; www.northwesttermite.com

Orange Guard™ (insecticide)— Orange Guard, 20 Village Square, Suite 7, Carmel Valley, CA 93924; 888/659-3217, Fax 831/659-5128; www.orangeguard.com

Orange Oil Treatment—Orange-X, San Leandro, CA,877/444-6726; www.orangextermite.com

Orange Oil Treatment—Pacific Coast Termite, 1175 Chess Drive, Foster City, CA 94404; 800/672-6436, 650/212-0801; www.pacificcoast-termite.com

Orange Oil—Florida Chemical Company, 351 Winter Haven Blvd. NE, Winter Haven, FL 33881; 863/294-8483; Fax 863/294-7783; www.floridachemical.com

Orange Oil—XT-2000, 6328 Riverdale St. Suite A, San Diego, CA 92120; 866/870-8485, 619/276-7640, Fax 619/542-8471; www.xt2000.com

ProCitra™ (insecticide) —Whitmire Microgen Inc., 3568 Tree Court Industrial Blvd., St. Louis, MO 63122; 800/777-8570, 636/225-5371, Fax 636/225-3739; www.wmmg.com

Conference Notes

ESA 2007 Annual Meeting Highlights—Part 1

By Joel Grossman

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

Pesticides and Bee Colony Collapse

According to Elina Niño (North Carolina State Univ, 2315 Gardner Hall, Campus Box 7613, Raleigh, NC 27695; elastro@ncsu.edu), pesticide exposure could be a contributing factor in honey bee decline and colony collapse disorder. "Our data suggest that oxalic acid and imidacloprid significantly reduce queen survival, weight, and lipid storage. Since the queen is the only reproductive female, this could have negative effects on colony productivity and health."

Imidacloprid, which affects the insect nervous system and may cause disorientation, is accumulated from treated plants when bees forage. Oxalic acid is effective against varroa mites and may be used to treat hives, though it has some negative impacts on bees. "Our results show that oxalic acid and imidacloprid significantly reduced the number of successfully reared queen cells," said Niño. This reduction could have a negative effect on the natural requeening process that occurs in the hive, thus weakening the colony.

Shipping Hungry *Orius*

If the insidious flower bug, *Orius insidiosus*, is fed for 72 hours on sucrose or water instead of moth eggs before insectary shipment, predation on western flower thrips, *Frankliniella occidentalis*, is about 400% greater, said Jeffrey Shapiro (USDA-ARS, 1700 SW 23rd Dr, Gainesville, FL 32608; jeff.shapiro@ars.usda.gov). Eliminating moth eggs as a food source for 72 hours also reduces predator production costs with no impact on reproduction rate or survival.

Fungal Biofumigant for Potatoes

"Recent reintroduction of potato tuber moth, *Phthorimaea operculella*, into the potato growing areas of the Pacific Northwest resulted in large economic losses to some growers," said Lawrence Lacey (USDA-ARS, 5230 Konnowac Pass Rd, Wapato, WA, 98951; llacey @yarl.ars.usda.gov). The principal economic damage occurs towards the end of the growing season when tubers become exposed and are infested prior to or during harvest.

A good IPM tool is biofumigation with an endophytic fungus, *Muscodor albus*, which was isolated from cinnamon tree bark. This fungus produces volatile compounds such as alcohols, ketones, esters, acids and lipids that are toxic to insects, nematodes and plant pathogens, and it is being commercialized by AgraQuest.

Fungal biofumigation at 24°C (75°F) for 3 days is effective against the pest. But potato storage temperatures can be much lower, depending on whether the end use market is seed, fresh market or processing. At lower temperatures, *M. albus* is less effective against pest larvae. Though "fumigation with *M. albus* during the initial few days of storage may be adequate to control neonates and young larvae," said Lacey. "Older larvae would produce detectable frass and these tubers should be culled before storage."

Chenopodium Extracts in 2008

"Keynote™ (=QRD 400, QRD 400416, Facin™) is a biopesticide product based on an essential oil extract of *Chenopodium ambrosioides* var. *ambrosioides*, said Paul Walgenbach (AgraQuest, 1530 Drew Ave, Davis, CA 95616; pwalgenbach@agraquest.com). *Chenopodium* extracts (1% spray solutions) are contact insecticides/miticides with limited residual that can be sprayed right up to harvest (see *IPMP* 28(3/4):1-12). Extracts are effective against soft-bodied arthropods such as thrips, aphids, whiteflies and web-spinning spider mites on greenhouse crops such as onions, peppers, cucurbits, tomatoes, leafy vegetables, bedding plants and potted flowers. Besides being comparable to synthetic pesticides against pests, the *Chenopodium* extract is "safe to adult forms of beneficial insects and mites."

EPA registration for Facin, which is compatible in tank mixes with a wide range of pesticides, is expected in the third quarter of 2008, said Walgenbach, noting that "with continued improvement in isolation and identification techniques, the opportunity for discovery of novel plant compounds has increased." In the case of Facin, the extract is a mixture of compounds with varied modes of action, which is expected to slow resistance.

Nematodes Conquer Curculio and Borers

Soil treatments of *Steinernema* spp. nematodes, if properly formulated, can provide 78-100% biological control of plum curculio, *Conotrachelus nenuphar*, said David Shapiro-Ilan (USDA-ARS, 21 Dunbar Rd, Byron, GA 31008; dshapiro@saa.ars.usda.gov). Nematodes can also control peachtree borer, *Synanthedon exitiosa*, and lesser peachtree borer, *Synanthedon pictipes,* in peach orchards.

In two years of plum thicket field tests, *Steinernema riobrave* strain 355 provided 100% plum curculio control. Strain 3-8b provided 99% plum curculio control in the first year and 88% control in the second year. *S. riobrave* is highly effective at controlling *C. nenuphar* larvae in the soil, regardless of host plant. Since nematodes are less effective against adult plum curculio, managers may have to shift emphasis from adult insects to soil monitoring of larvae for timing nematode applications.

"High levels of peachtree borer control can be achieved using *Steinernema carpocapsae* in a preventive and curative approach," said Shapiro-Ilan. These tactics also appear to be promising from an economic perspective because application rates needed are less than 100 million IJs (infective juveniles) per ha (2.47 acres). Nematodes in this case are not applied to the soil, but to tree wounds produced by the borer.

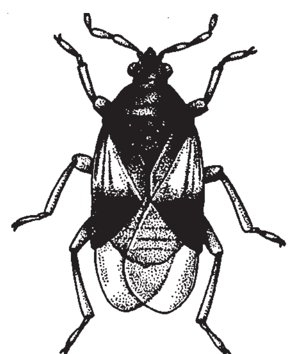
S. carpocapsae applications required a protective covering to be effective against lesser peachtree borer. "The bandage (diaper) treatment with nematodes caused 100% suppression whereas the gel wrapped in cheesecloth resulted in about 70% reduction in larval survival," said Shapiro-Ilan. "Thus, suppression of lesser peachtree borer appears promising as long as the nematodes are provided protection upon application."

Yellow Sticky Circles

Cylindrical and cup-shaped traps capture more thrips than flat shapes such as yellow sticky cards. But trap shape and background color are typically ignored in IPM programs trapping western flower thrips (WFT), *Frankliniella occidentalis*, said Bishwo Mainali (Andong National Univ, Gyungbook, Andong, South Korea; mainali.bishwo @gmail.com).

In commercial South Korean strawberry greenhouses and growth chambers, choice and no-choice trials were conducted using varied laminated trap shapes (square, triangle, inversed triangle, diamond, semi-circle, circle) and background colors (yellow, green, blue, black). Only a circular yellow surface was coated with sticky Tanglefoot™; the background color surrounding the circle was not sticky.

"As in the laboratory tests, circular yellow sticky cards with 5 cm (2 in) diameters and a black background (12 x 12 cm; 4.7 x 4.7 in) trapped 2.3 to 21 times more *F. occidentalis* than the commercial yellow sticky cards. "Vernon and Gillespie (1995) reported that high



Insidious flower bug, *Orious insidiosus*

contrast background colors to the yellow such as blue and violet trapped more thrips than low contrast background colors to yellow. We also found a similar result, that yellow color with black background attracted more thrips."

The best ratio of yellow sticky surface to black background was 1:7.5. The larger the ratio of the (black) background to the (yellow) sticky area, the higher the attractiveness of the trap to WFT. The attractiveness of the circle shape to WFT may be related to floral geometry; but thrips shape discrimination is still not completely understood.

Pheromone Trap Color

"Understanding factors that may affect interpretation of data is important in efforts to design better traps and optimize efficiency of monitoring efforts," said Clayton Myers (USDA-ARS, 2217 Wiltshire Rd, Kearneysville, WV 25430; cmyers@afrs.ars.usda.gov). Trap designs with low capture efficiency may underestimate pest pressure. Conversely, designs that are too attractive to insects can cause saturation by non-target insects or even the pest species being monitored.

Orange, red, green, blue, yellow and white delta-style pheromone traps deployed in commercial orchards in Wayne County, NY, and Adams County, PA, were compared for capturing obliquebanded leafroller, *Choristoneura rosaceana*; Oriental fruit moth, *Grapholita molesta*; and non-target muscoid flies and honeybees, *Apis mellifera*. "In contrast to prior observations conducted in the western U.S. (Knight & Miliczky, 2003) where high early season capture of flies in un-baited red and orange delta style traps was noted, we observed the highest seasonal fly captures (mid-June and mid-late July) in white, unpainted white, and blue traps," said Myers. White, unpainted white, and blue were also most attractive to honeybees.

"For monitoring of obliquebanded leafroller and Oriental fruit moth in the eastern U.S., we recommend choosing trap colors such as yellow, red or orange because they appear to be less attractive to non-target insects," said Myers. "While green traps were also less attractive to non-target insects, our experience indicated that this color can be problematic for finding the trap within the green tree canopy."

Pheromones and *Beauveria*

Increased regulation has left a need for alternatives to protect stored products. Ian Baxter (Univ of Southampton, Southampton SO17 1BJ, Hampshire, United Kingdom; ihb@soton.ac.uk), has examined an electrostatic powder (Entostat™) that carries the fungus, *Beauveria bassiana*, as an alternative pest control approach for the Indianmeal moth, *Plodia interpunctella*."

Indianmeal moths (IMM) are attracted to a synthetic pheromone lure in a dispensing station where they become inoculated with *B. bassiana* conidia. In one trial, 45 out of 50 male moths entered the dispensing station and were inoculated with conidia despite walking only briefly on the powder, which was repellent. During mating, male moths transferred 3.3% of the Entostat powder to females. Some of the powder even gets transferred to the egg via maternal scale shedding.

Blueberry Conservation Strips

"Flowering plants are being used increasingly around the world as a means to improve biological control in agricultural landscapes," said Nathaniel Walton (Michigan State Univ, 202 CIPS, East Lansing, MI 48824; waltonn2@msu.edu). "However, few studies have used flowering plants that are native to their particular region."

As part of a longer term study of conservation strips for biological insect control in blueberries, the following flowering plants native to Michigan were evaluated: penstemon, *Penstemon hirsutus*; bee balm, *Monarda fistulosa*; culver's root, *Veronicastrum virginicum*; early goldenrod, *Solidago juncea*; blue lobelia, *Lobelia siphilitica*; yellow giant hyssop, *Agastache nepetoides*; smooth aster, *Aster laevis*; and little bluestem, *Schizachyrium scoparius*.

Native Michigan flowering plant species varied in their attraction of natural enemies, and only one had significantly greater abundance than mown field borders or native grass plots. This was the late-season blooming plant, *Solidago juncea*, which produces large floral displays. Recent research has shown that floral display area is a strong predictor of the abundance of natural enemies on flowers (Fiedler and Landis, 2007). Flowers improved survivorship of natural enemies regardless of whether the flower was native or not. Benefits varied with the insect species.

The insidious flower bug, *Orius insidiosus* was most sensitive to provision of flowers, living significantly longer in cages with flowers. The aphid parasitoid, *Aphidius colemani*, was intermediate, and only blue lobelia and non-native Queen Anne's Lace, *Daucus carota*, increased survival more than water controls. The convergent lady beetle, *Hippodamia convergens*, was "relatively insensitive" to flower availability, though it did better with bee balm and survived worst with culver's root.

Natural enemies caused a reduction in aphid colony growth, "emphasizing the importance of these insects for suppressing blueberry pest insects," such as blueberry aphid, *Illinoia pepperi*, said Walton. "During 2008, we will test additional native flowering plant species for their ability to increase survival of the natural enemy species tested here. Then, as the flowering plant strips become more established next year, we will continue to evaluate the response of different natural enemy groups to these insect conservation strips. Finally, aphid exclusion methods will be further explored for determining the effect of flowering plant strips on the level of natural aphid control in crop fields."

Cover Crops, Mulches, and Viruses

Despite frequent insecticide applications for aphid control, South Carolina muskmelon growers are plagued by aphid-transmitted watermelon mosaic virus, said Geoff Zehnder (Clemson Univ, Clemson, SC 29634 ; zehnder@clemson.edu). Over a two-year period, pesticide alternatives such rye cover crops drill-seeded between rows (in January), black plastic mulches, and reflective aluminum mulches were tested to reduce the visual attraction of the aphid virus vectors to muskmelons.

"Results indicated that the establishment of a rye cover crop between plant beds and the use of reflective mulch could effectively reduce the incidence of virus disease," said Zehnder. Interestingly, rye cover crops and reflective mulch worked better alone; combining the cover crop and reflective mulch did not confer an advantage.

Ground Beetles and Weeds

Ground beetles (Carabidae) are opportunistic feeders that feed on weed seeds in addition to slugs and other soft-bodied insects, said Jessica Green (Oregon State Univ, 4017 ALS Bldg, Corvallis, OR 97331; BugL8dy@msn.com). Annual weed seeds such as pigweed, *Retroflexus amaranthus*; wild-proso millet, *Panicum miliaceum*; and hairy nightshade, *Solanum sarrachoides* can reduce yields and quality in vegetable crops such as snap bean. But ground beetles eating weed seeds can be part of "an integrated weed management plan" to "reduce herbicide use."

In row-planted Oregon snap beans, the most abundant ground beetle species collected were *Pterostichus melanarius* and *Harpalus pennsylvanicus* with lesser numbers of *Agonum, Amara* and *Bradycellus* species. Weed seed predation averaged about 20%, despite ground beetle population reductions by pesticides.

Neem for Stinkbug IPM

The southern green stink bug, *Nezara viridula*, a worldwide pest of many crops, can be managed with neem extracts in India, where neem trees are common. "The present study indicated that the antifeedant effect of neem can be utilized to reduce the damage inflicted by *N. viridula* and may be a promising solution for the management of this pentatomid pest," said Paula Mitchell (Winthrop Univ, Rock Hill, SC 29733; mitchellp@winthrop.edu).

A 5% concentration of Neem Azal® "was significantly more effective" (reducing stinkbug damage to near zero) than crude aqueous extracts and neem oil in protecting bean pods. Neem "reduced the preliminary probing behavior that further resulted in reduced damage to the seed," said Mitchell. Neem Azal's advantage was likely due to its higher azadirachtin content; azadirachtin concentrations of 1.25% and higher significantly reduced seed damage.

Conference Notes

Injections for Landscape Trees

The emerald ash borer, *Agrilus planipennis*, is a Chinese wood-boring beetle that has killed millions of native ash trees in Canada and the U.S. It was discovered in Windsor, Ontario, Canada, in 2002. According to Blair Helson (Canadian Forest Service, 1219 Queen St E, Sault Ste Marie, ON P6A 2E5 Canada; bhelson @nrcan.gc.ca), trunk injection of TreeAzin™ (5% azadirachtin; neem) is an effective, highly targeted new tool. Low volumes of TreeAzin can be injected quickly and completely into trees with a new, high output, commercial tree delivery method, the EcoJect System (BioForest Technologies, Inc).

After injection of TreeAzin into large green ash trees, "azadirachtin is rapidly taken up and effectively translocated." Emerald ash borer (EAB) exit holes in branches were significantly reduced, over 80% compared to untreated trees. Trunk exit holes were reduced 96% at the high rate of TreeAzin, but not at the low rate.

"Early summer injection with TreeAzin at 250 mg azadirachtin/cm diameter at early stages of infestation should provide very effective control of EAB larvae and tree protection as prophylactic treatments," said Helson. Trunk injections with azadirachtin may also result in reductions in fertility and fecundity of adults feeding on leaves.

Helson also found that trunk injections of emamectin benzoate were very effective. "We observed 100% mortality of EAB in June, July and August bioassays." No other product has yielded similar results in 5 years of studies. A major question underlying every EAB insecticide trial is whether 'good' performance –e.g. 80% larval control—ultimately prevents the eventual decline or death of a treated tree. In this case, emamectin benzoate provided 99.8% control. Additional studies are planned.

Japanese Beetle Repellent Oils

Nadeer Youssef (Tennessee State Univ, 472 Cadillac Ln, McMinnville, TN 37110; nyoussef@blomand.net) has studied Japanese beetle repellents. Repellents were tested to see if they could drive Japanese beetles away from collection points. Of the 49 essential oils, 5 essential oil combinations, and 2 non-essential oils tested for adult Japanese beetle repellency in 2003-2007, 23 plant oil or oil combinations significantly reduced collected numbers of adult Japanese beetles, *Popillia japonica*.

Plant oils significantly reducing adult Japanese beetle collection include: "peppermint, wintergreen, ginger, juniper berry, *Juniperus communis*; cedar leaf, *Thuja occidentalis*; Dalmation sage, *Salvia officinalis*; tarragon, bergamot mint, tea tree, *Melaleuca alternifolia*; Bulgarian lavender, *Lavandula angustifolia*; cardamom, fennel, anise, ylang ylang, *Cananga odorata*; yarrow, geranium, *Pelargonium* sp., thyme and lemon oils," said Youssef.

Two of the best ones were wintergreen, *Gaultheria procumbens*, and peppermint, *Mentha piperita*. Adult Japanese beetle capture was also reduced by combinations of wintergreen oil with peppermint oil or ginger oil, ginger plus citronella oils, and cumin plus coffee oils.

Less Fertilizer, Fewer Armyworms

Many grasses are resistant to insects when they are modestly fertilized, but when they are fertilized heavily with nitrogen (N), the natural resistance may be reduced or lost. Loss of resistance can lead to outbreaks of pests such as fall armyworm, *Spodoptera frugiperda*, said James Reinert (Texas Agric Exper Stn, 17360 Coit Rd, Dallas, TX 75252; j-reinert@tamu.edu).

Fall armyworm is a major pest on managed turf such as golf courses, parks, and lawns, and "larvae feed on aboveground plant parts, moving in mass across the landscape," said Reinert. Most established grass landscapes will recover from damage if properly cared for but newly established turf is particularly susceptible due to its limited root system and carbohydrate reserves.

Among the "naturally occurring chemicals that have shown biocidal properties against field armyworm in laboratory bioassays are caffeic acid derivatives, primarily chlorogenic acid, and flavonoids such as maysin, luteolin, rutin and isoorientin," said Reinert. Adding chlorogenic acid and maysin to pest diets reduced larval weights and boosted mortality.

Increased N fertilization of resistant turfgrass cultivars may reduce relative amounts of allelochemicals and decrease resistance to leaf-feeding insects.

Chinch Bug IPM

St. Augustinegrass infested with southern chinch bug, *Blissus insularis*, "suffers stunted growth and dies in patches," said Eileen Buss (Univ of Florida, 970 Natural Area Dr, Gainesville, FL 32611; eabuss@ufl.edu). Turfgrass managers have relied on insecticides for control of the pest for over 60 years, sometimes with over 6 applications a year in Florida. Non-chemical management options are needed to reduce insecticides and delay resistance development.

"If more eggs are laid by *B. insularis* in fertilized turfgrass, populations may build faster, which may result in more damage and insecticide use," said Buss. When nitrogen (N) is reduced, chinch bugs are fewer in number and the St. Augustinegrass is shorter and lighter green. Moderate to high N fertilization resulted in more fecund chinch bugs. Extremely high N (4 lb per1,000 ft2; 1.8 kg per 93 m2) led to grey leaf damage, lower turf quality and more fecund chinch bugs. Further research is needed comparing soluble versus slow-release nitrogen sources.

In central Georgia, the St. Augustinegrass cultivar Raleigh is very susceptible to southern chinch bug, *Blissus insularis*. But the cultivars Floratam and Floralawn have high resistance, said S. Kris Braman (Univ of Georgia, 1109

Experiment Street, Griffin, GA 30223; kbraman@griffin.uga.edu).

Floral Interplants and Mole Crickets

"Mole crickets, *Scapteriscus* spp. are the most damaging pests of southern pasture and turfgrasses," said Cheri Abraham (Mississippi State Univ, 103 Clay Lyle Ent, Box 9775, MS 39762; cam384@msstate.edu). From 1979 to 1989, the parasitoid wasp, *Larra bicolor* (Sphecidae) was introduced into Florida for mole cricket biocontrol. By 2004 larra wasps were in Mississippi, and by 2007 Alabama.

Female larra wasps search out mole cricket surface tunnels by walking atop the soil and turf, probing with their antennae. "When a surface tunnel is encountered the female will enter and exit the same tunnel many times after which, the mole cricket rushes out of the tunnel," said Abraham. "Once the wasp encounters the mole cricket, it is stung and the egg is laid." A mole cricket is killed by a single larra wasp larvae in about two weeks, and a wasp adult emerges from a silken cocoon buried in the sand in 6-8 weeks.

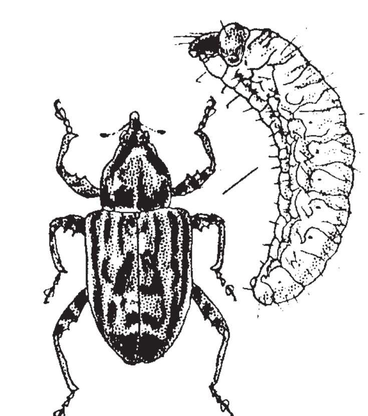
Larra wasps are active on coastal Mississippi golf courses from mid-May to November, but need flower nectar to thrive. "Results so far indicate that flowering *Pentas* may be a suitable alternative for turf managers in the northern Gulf region that would like to recruit and sustain populations of *L. bicolor* for biological control of mole crickets," said Abraham.

Spermacoce verticillata, another member of the Rubiacea with small individual flowers, is a good larra wasp nectar source. But *Spermacoce* seeds spread outside planting plots, and it is considered a weed. Further nectar source experiments are underway, and "will hopefully show that nectar sources adjacent to infested turfgrass will increase wasp longevity and parasitism of mole crickets, enhancing biological control."

Kentucky Turf Grub IPM

"Root-feeding white grubs are the most destructive insect pests of turfgrasses in Kentucky," said Carl Redmond (Univ of Kentucky, S-225 Agri Sci Bldg N, Lexington, KY 40546; carl.redmond@uky.edu). Grubs cause dead patches and encourage skunks to dig up turf looking for grubs. Kentucky beetles producing pest grubs include the Japanese beetle, *Popillia japonica*; northern masked chafer, *Cyclocephala borealis*; southern masked chafer, *C. lurida*; May beetles, *Phyllophaga* spp. and black turfgrass ataenius, *Ataenius spretulus*.

"Life cycles, timing of egg hatch, and susceptibility to insecticides vary among grub species, so knowing which species predominate is important," said Redmond. Masked chafers predominate in irrigated roughs, "although Japanese beetle or mixed grub populations are common." Kentucky is in a warm- and cool-season grass transition zone, so identifying and assessing the prevalence of natural enemies and pathogens is important for IPM and conservation biological control.



Plum curculio,
Conotrachelus nenuphar

The most common pathogen is milky disease, *Paenibacillus popilliae*, with different strains infecting Japanese beetles and masked chafers. Other grub pathogens detected include entomopathogenic nematodes (Heterorhabditdae) and the fungus *Metarhizium*.

"Evaluation of pathogens is ongoing, but so far milky disease bacteria, *Paenibacillus popilliae*, predominate," said Redmond. "Mortality of masked chafers from milky disease or parasitism by *Tiphia pygidialis* was as high as 40% and 16%, respectively, at some sites."

Herbal Rust Mite Remedies

Pear rust mites, *Epitrimerus pyri*, are small, hard-to-detect, and more difficult to control than other spider mites. Rust mites lower the quality and yield of organic pears, and are found more on younger leaves in the upper part of trees, said Silvia Rondon (Oregon State Univ, 2121 S 1st St, Hermiston, OR 97838; silvia.rondon@oregonstate.edu). Twenty leaves per organic pear tree were sampled; and a mite brushing machine was used to count the rust mites.

When 10% of pear trees in organic orchards were infested with pear rust mites, trees were sprayed with either azadirachtin (Neemix®), rosemary and peppermint oils (Ecotrol®) or a mixture of rosemary, sesame, thyme, peppermint & cinnamon oils (EF300®).

At the first spray application, only 64 fl oz/acre (4.8 l/ha) of Ecotrol significantly reduced rust mites. After the second spray, 16 oz/acre (1.3 l/ha) Neemix was best, resulting in only 2.4 rust mites per leaf; versus 11.3 rust mites/leaf in the control, 16.3 mites/leaf with Ecotrol and 44.8 rust mites/leaf with EF300.

Citricola Scale Biocontrol

"Organophosphates are likely to be restricted in the San Joaquin Valley (SJV) where most (California) citrus is grown because they produce volatile organic compounds and contaminate ground water," said Robert Luck (Univ of California, Riverside, CA 92507; rluck@ucr.edu). "To provide citrus growers with an alternative to these insecticides, we are developing an augmentative release program for suppressing citricola scale, *Coccus*

Conference Notes

pseudomagnoliarum, similar to the program developed by the Fillmore Protective District in southern California to suppress black scale."

In southern California, the dominant early season parasitoids when citricola scales are small are *Coccophagus* spp. and *Metaphycus helvolus*. "Augmentative biological control of citricola scale depends on the development of an economically efficient mass-rearing system for its parasitoids," said Luck. "We currently mass rear several *Metaphycus* species parasitoids on brown soft scale, *Coccus hesperidum*, grown hydroponically on excised Yucca leaves."

In orchard trials with augmentative releases of *Metaphycus flavus* imported from Turkey, citricola scale infestations were significantly reduced. "We know anecdotally from SJV pest control advisors that groves with concurrent populations of both brown soft and citricola scale render citricola scale populations uneconomic because of *Metaphycus* parasitism," said Luck. "The multivoltine (multiple generations per year) brown soft scale generates the parasitoids that subsequently utilize the univoltine (one generation per year) citricola scale. We propose to mimic the southern California situation by using parasitized brown soft (scale) infested Yucca leaves and plants that can be placed in citrus groves. This release technique will be tested in a small SJV organic grove of Valencia orange."

Cockroach IPM in Low-Income Housing

"Cockroaches remain the most common indoor pests," said Changlu Wang (Purdue Univ, 901 W. State St, West Lafayette, IN 47907; wang85@purdue.edu). They contaminate food and exacerbate asthma symptoms. Although IPM is advocated for German cockroaches, *Blattella germanica*, voluntary adoption is rare. Understanding the costs and benefits of IPM should help promote the adoption of IPM.

IPM costs and benefits were measured at 268-unit and 517-unit low-income apartment complexes in Gary, Indiana. Visual inspections included interviews with residents to learn about insecticide use, repair needs and pest infestation history. If an infestation was suspected, six sticky traps were placed in the apartment for 24 hours to gauge the infestation level. Cockroach allergens (Bla g 1) were assayed in kitchen floor dust samples at 0, 6 and 12 months.

Infested apartments were also monitored monthly with sticky traps until there were no cockroaches for two consecutive months; then inspections were once every 3-4 months for previously infested apartments and every 6 months for never-infested apartments. One apartment complex was treated by a commercial pest management firm. The other apartment complex was treated by Purdue researchers. Thus, "contractor-delivered IPM" was compared with "researcher-delivered IPM."

"The property management staff held monthly housekeeping classes to train residents on cockroach prevention, proper housekeeping, cockroach harborage reduction, and methods for removing cockroach allergens," said Wang. A combination of boric acid dust and cockroach gel baits were applied to cockroach infested apartments. At least six sticky traps were placed in each apartment to help detect the existence of cockroaches and reduce the cockroach numbers. Apartments with poor sanitation received mandatory housekeeping classes.

Both "contractor-delivered IPM" and "researcher-delivered IPM" significantly reduced costs (77-89% reduction), insecticide use (85-93% reduction) and allergens (60-75% less). IPM delivered by Purdue researchers, however, provided greater allergen reduction.

IPM challenges included residents who were not cooperative in cleaning their apartments, the need for repairs, inaccessible apartments (e.g. lack of housing authority staff; residents refusing service), and new infestations brought in by new residents.

Calendar

March 14-16, 2008. Beyond Pesticides Conference. Berkeley, CA. Contact: Beyond Pesticides, 701 E Street SE, Suite 200, Washington, DC 20003; www.beyondpesticides.org

March 17-19, 2008. Food Safety Conf., Washington, DC. Contact: www.foodsafetysummit.com

March 25-27, 2008. 20th Anniversary: SARE 2008 National Conference, Kansas City, MO. Contact: www.sare.org/2008conference/

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

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

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

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

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

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

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

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

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

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

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

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

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

December 7-11, 2008. Annual Meeting Entomological Society of America. Reno, NV. Contact: ESA, 9301 Annapolis Rd., Lanham, MD 20706; Fax 301/731-4538; www.entsoc.org

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

Book Reviews

Bed Bug Handbook, the Complete Guide to Bed Bugs and their Control. 2007. L.J. Pinto, R. Cooper and S.K. Kraft. Pinto and Associates, Mechanicsville, MD. 266 pp. $72, Paperback. www.techletter.com

According to one of the authors, this book is "the only published text on bed bugs that has been written to meet the needs of a variety of industries, including property management, hospitality and pest management." It was written for specialized purposes, but some of it may be interesting to a general reader. Thus, there are chapters on bed bug cultural history and biology. In addition, medical, social, and business implications of bed bug infestations are discussed.

But the major strength of this book is its emphasis on practical methods of bed bug control. Do you need to know if low temperatures will kill bed bugs? Then, you can quickly find that two hours at 1°F (-17°C) will kill all stages of bed bugs. However, when disinfesting belongings, exposure times must be adjusted for their weight. So, it takes more than 10 hours at this temperature to kill all bed bugs in 5.5 lb (2.5 kg) of laundry.

Bed bugs are so new to many pest management professionals that something as simple as monitoring and inspection may have to be learned. The *Bed Bug Handbook* provides all this basic information. But novel techniques are also reviewed, including the Cryonite™ system that uses pressurized CO_2 to produce supercold "dry ice" that is released as "snow." Steam and dry heat techniques such as the Thermapure™ system are evaluated. Strengths and limitations of bed bug sniffing dogs are revealed.

Best of all, bed bug control methods are illustrated with more than 100 "how-to" photos. Pictures of bed bug habitat can help formulate inspection plans. From a practical point of view, pest management professionals will find the 49 pages of "Action Checklists" extremely useful. Key to success with IPM is documentation, and these checklists will help.

The *Bed Bug Handbook* is an essential reference for structural pest management professionals. General readers may also find it interesting, and it is a valuable companion to the classic work by Usinger, *Monograph of Cimicidae,* that has recently been reissued.—*Bill Quarles*

California Master Gardener Handbook. 2002. D.R. Pittenger, ed. University of California Agriculture and Natural Resources, ANR Pub. No. 3382. 702 pp. Paperback. $35. http://anrcatalog.ucdavis.edu

California Master Gardeners are expert gardeners that are trained and certified by the University of California. More than 1800 Master Gardeners are now active in 36 California counties. These experts help provide scientifically accurate information about home horticulture and pest management to the general public. There are similar programs in 45 other states, and so the book should also be useful to a national audience.

The *Master Gardener Handbook* was designed as a reference book for use during and after the training program. It is an impressive effort involving 25 authors, 28 collaborators, and 62 reviewers. It is written in non-technical language. Topics covered include an introduction to horticulture, soil and fertilizer management, water management, plant propagation, diagnosing plant problems, plant pathology, entomology, household and structural pests, weed science, garden pests, house plants, lawns, landscape and garden design, woody landscape plants, poisonous plants, home vegetable gardening, nutrition, and special crops such as grapes, berries, fruit trees and nuts, citrus, and avocados.

Since the book is non-technical and covers such a large number of topics, we can expect that some of the material is covered sparsely, and it is. However, some topics, such as management of household pests, are covered with a remarkable amount of detail. If more information is needed, each chapter has a number of general references for further research.

The chapter on household pests gives details of pest biology and emphasizes habitat management and non-chemical controls. For example, for carpenter ants, caulk cracks and crevices, trim tree limbs and shrubs to prevent ant access to structures, use an inorganic perimeter mulch to discourage nesting, eliminate damp conditions, unclog gutters, store wood off the ground and away from the house.

The chapter on lawn care emphasizes selection of resistant and hardy turfgrass species and cultural management. In the weed control chapter, we find that "good cultural control can account for 60 to 70% of the weed control in turf." Herbicides are recommended only as a last resort. Though the chapter on garden pests has a lot of information on pesticides, non-chemical and biological controls are recommended, and the author says, "pesticides should only be used when non-chemical methods fail to provide adequate control of pests or when pest populations begin to cause unacceptable losses." If pesticides are used, *Bacillus thuringiensis* (BT), soap, oil, and other reduced risk pesticides are encouraged.

The *California Master Gardener Handbook* is recommended for anyone who enjoys gardening. There is enough horticultural, pest management, and general information that many garden problems can be prevented, and others managed without resort to pesticides.—*Bill Quarles*

Ask the Expert

BIRC (Bio-Integral Resource Center) answers pest management and pesticide toxicity questions submitted through the Ask the Expert link at www.ourwaterourworld.org or through the Ask the Expert link on www.birc.org. At the moment, anyone nationwide can use this service, and we hope it will help mitigate some of the harmful effects of pesticides. The website and link were created through a grant from the California Regional Water Resources Control Board, and the link is currently supported by a grant from the Rose Foundation. We encourage BIRC members to use the Ask the Expert link. Some of the questions are of general interest, and are reproduced here.

Dear BIRC,

My pea patch and lettuce seem to be getting eaten excessively by slugs (amongst other things). I have been trying to go chemical free, we like to distribute produce and flowers for local residences/neighbors. I am using recycled wood in the raised beds and unfortunately can only water at night. Next door is a small duck pond and the garden borders an active public park and play area. Any suggestions?

Thank you.

BIRC replies,

One way to reduce the numbers of slugs and snails is to use Snail Barr™ copper strips on the raised beds. Slugs and snails are repelled by copper. This approach is used by the citrus industry, and they put the strips around the trunks of citrus trees.

Water as little as possible, as water encourages slugs and snails. Since the molluscs are nocturnal, and you are watering at night, another option is handpicking. Use a flashlight and look carefully at the foliage.They like to hide underneath leaves. Pick off any that you see, and dispose of as you see fit.

Slug and snail traps are a possibility. An overturned clay pot or clay dish will act as a trap for slugs and snails. You can also just put a small one square foot board in the garden. Prop it up an inch or so on rocks, or add a couple of thin wooden strips to lift it off the ground. Slugs and snails crawl underneath. You can buy commercial traps such as the Slug Saloon™. This is a plastic dish you fill with beer. Slugs fall into it and drown.

There are other traps you can make, or you can use Sluggo™, which is iron phosphate. The bait has low toxicity to mammals, kills slugs and snails, and any left over becomes fertilizer.

Hope this helps,
BIRC

Dear BIRC,

If we use black plastic for weed control, will it kill the following bulbs that are already planted there? We have narcissus, daffodils, snowdrops, crocus, and hyacinth.

Thank you.

BIRC replies,

Black plastic mulch works pretty well because many weeds are annuals whose seeds need light to germinate. Those that do germinate will not grow because no light is available to produce food through photosynthesis.

Now, will black plastic mulch kill bulbs? It certainly will not help them much. One problem will be that the emerging bulb might not be able to make it through the plastic to the sunlight. If you know where the bulbs are, you might be able to correct that problem by cutting the plastic, but weeds would also grow through at that point.

The other problem is heat produced underneath the black plastic. I believe daffodil bulbs tolerate a reasonable amount of heat. But I do not know about the others. Another problem is water. Black plastic does not allow water to penetrate. So the bulbs could die from lack of water.

As an alternative, you might be able to mulch with an organic mulch for weed control. This mulch would preserve moisture in the area and should not heat the ground. The bulbs could be watered, and they should be able to emerge through the mulch.

Hope this helps,
BIRC

Dear BIRC,

I am wondering what chemicals are used to pressure treat wood today and if is safe to use in an inside project. Are there safe treatments? What is Thomsonized wood?

Thank you.

BIRC replies,

There are several kinds of pressure treated wood. The industry standard for a long time was chromated copper arsenate (CCA). This was banned for home use by the EPA. Arsenic had a tendency to leach out of it. There was concern that when the old wood was discarded in landfill, it would lead to contamination of drinking water in wells. Carpenters were also exposed to arsenic when they sawed the wood.

Materials that are currently available are based on copper or borates or organic fungicides. By organic I mean the kind that can be bought at drug stores to take care of athlete's foot.

Thompsonized wood has been pressure treated with copper azole and with Thompson's Water Seal. If you are using it inside, you probably do not need the water sealant, unless the wood is likely to be exposed to water.

Copper azole contains copper ion, boric acid, and the fungicide tebuconazole. It protects against insects and decay. In field tests, it was equivalent to CCA. The materials have fairly low acute toxicity to mammals. Also, high concentrations are not used in the wood.

If you do not expect the wood to get much exposure to water, you could use wood that has been pressure-treated with a mixture of boric acid and borax. Osmose sells this as Advance Guard™. Arch Treatment Technologies calls it SillBor™ and Chemical Specialties calls it TimberSaver™. It is resistant to wood rot, termites, and woodboring beetles.

You can also buy untreated wood and treat it with borates yourself. The borate material is called Timbor® and is sold by Nisus Corporation in

Rockford, TN, 800/264-0780. However, pressure treated material is probably more effective as it penetrates deeper into the wood.

You should have no problems with any of these treatments as long as you do not ingest the chemicals. Borates cannot be absorbed through the skin, and they are non-volatile. You could be exposed only by eating or inhaling the sawdust. Borates have low acute toxicity to mammals.

You might have more of an exposure problem with copper azole. In addition to boric acid, you are dealing with copper and tebuconazole. Copper and boric acid are not volatile. I do not know how volatile tebuconazole is, but it has fairly low acute toxicity. Greatest potential exposure would come as you are sawing the wood and actually doing the construction.

Hope this helps,
BIRC

Dear BIRC,

I am house sitting for friends. There are two cats here. We have an ant problem. The attraction is the catfood. I am not sure what to use to get rid of the ants that would not harm the cats.

Please help!

BIRC replies,

If the ants are after the cat food, one method is to exclude the ants from the cat food bowls. You can do this in several ways. You can get a shallow pie pan and put soapy water in the bottom. Then set the cat food bowl in the pan. This establishes a moat that excludes the ants. Another possible way is to cover the bottom of the pan with Vaseline. That might also work. The problem with this approach is that it is messy.

There is a product called The Antser™. This is an enclosed plastic device that you fill with water. Anything you set on top of it cannot be accessed by ants. You can find it at www.theantser.com or by calling 925/686-4437.

You can also discourage ants by using ant baits. Combat® or Maxforce® baits enclosed in plastic bait stations cannot be accessed by cats. Even if they were able to get inside, the amount of active ingredient is so low that they would not be acutely poisoned if they ingested it.

The stations are convenient. Put them on ant trails. Remove them and put them in a plastic sack for later use when the ants are gone. You can toss empty ones in the trash.

Hope this helps,
BIRC

Dear BIRC,

A landscape contractor is using Roundup® to control difficult weeds around our apartment complex. What are commercial grade alternatives that will be effective for controlling weeds, but that won't endanger humans and animals?

Thank you.

BIRC replies,

Alternatives to Roundup include mulches, mechanical control, flamers, corn gluten meal, and alternative herbicides based on orange oil, clove oil, soap, or vinegar. Mulches are useful for areas such as planting beds. Flamers can control weeds poking up through concrete or asphalt. Flamers can also be used on a lawn. They are best at killing small upright herbaceous weeds. Flamers have very little effect on turfgrass.

Mechanical methods can be useful. If you have dandelions, there is a tool called the Weed Hound that allows for efficient extraction. Even the standard Weed Whacker can be useful in landscape weed management. The idea behind mechanical methods is to remove the weed before it produces seed.

Corn gluten meal is basically corn meal. It has low toxicity. When used on lawns, it suppresses weed seed germination and provides nitrogen for the turfgrass. Hence, it is a pre-emergent and an organic weed and feed material.

There are a number of least-toxic herbicides. They work best on annual weeds, though they can kill perennials with repeated use. Green Match™ is based on orange oil, Burn Out™ is based on clove oil, Matran™ contains a number of essential oils, and vinegar will kill weeds if they are less than four inches high, and it is applied on sunny days. It works by desiccation. Safer Soap™ can also kill weeds. It destroys the cell walls and allows desiccation.

Hope this helps,
BIRC

Dear BIRC,

I just recently discovered that I have a problem with house mice. I live on the third floor of a three story building in the Boston area. I am planning on sealing all my dry foods in better containers and making sure food does not get left out, but apart from this, I am wondering what your suggestion would be for getting rid of the mice in a most humane, but effective manner. They are relatively small mice that come out at night and eat my grains and scurry around.

I'd rather not kill them if it's possible. Is there anything that keeps them away for good that works immediately?

Thank you so much.

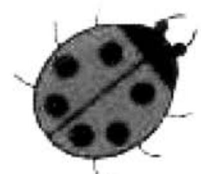
BIRC replies,

The best thing you can do is first protect your food as you suggest. Leave no garbage or crumbs for them to eat. Find out how they are getting in. Look for mouse holes in doors. Check your door sweeps to make sure they are intact and in good working order. Do not leave doors and windows open without screens to protect the opening.

Check areas where plumbing comes into your apartment. Sometimes they squeeze in around a pipe. Outside the structure, look around the perimeter for holes in foundation or attic vents, or holes in the structure itself. When you find the hole, seal it up. Use a combination of copper mesh and caulk.

Once you have pest proofed your house and food, use live traps to catch the ones that you have. You can buy these at the hardware store. Or you can call the manufacturer Woodstream 800/800-1819 and ask about live traps for mice. Once you have caught them, you can release them outside.

Hope this helps,
BIRC



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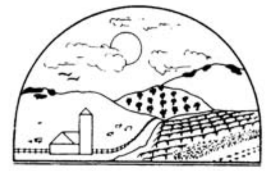

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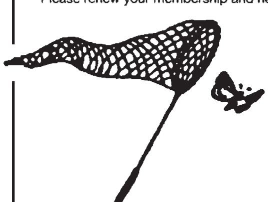

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