Special Double Issue

COMMON SENSE PEST CONTROL QUARTERLY

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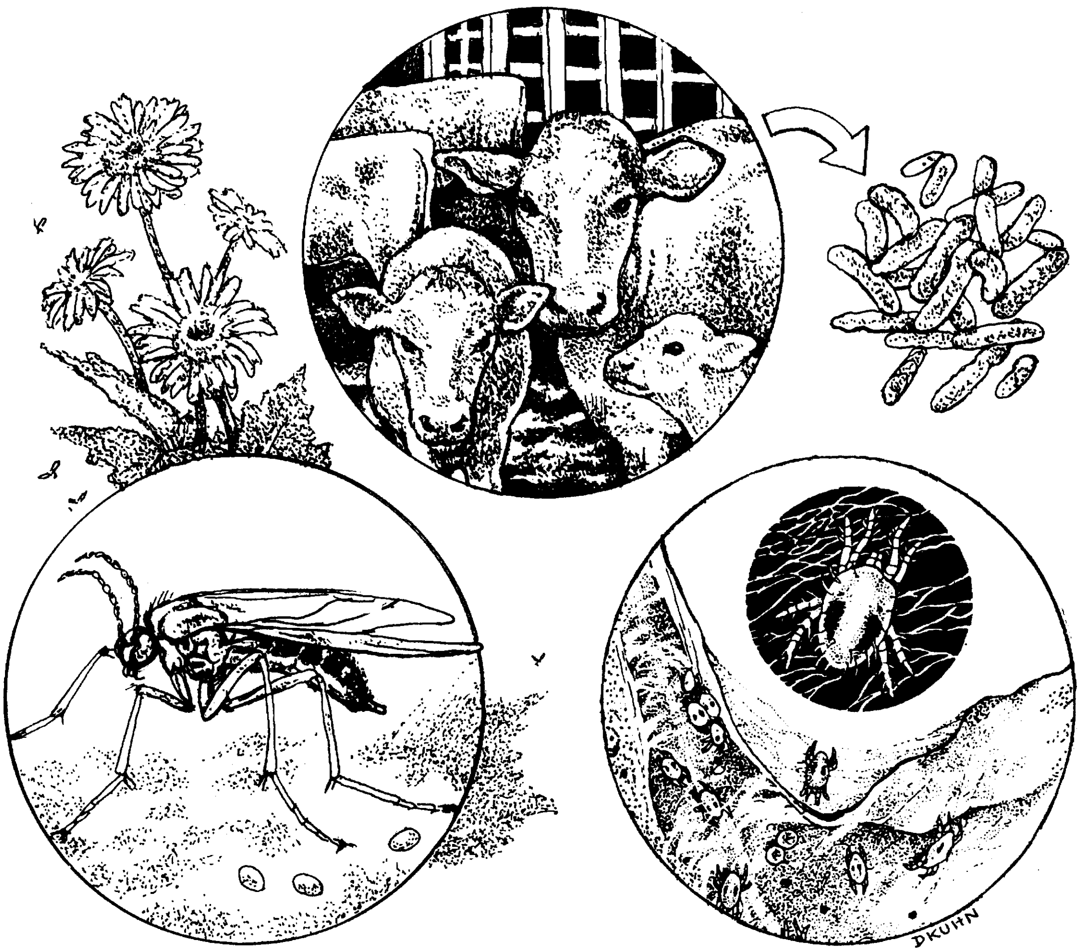
Special Double Issue

Feedlot Antibiotics Produce Pathogens?



Fungus Gnats

Spider Mites

Plus: Bed Bugs Resistant to Pesticides, Research Front, Conference Notes, Ask the Expert

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On the Research Front

Pyrethroids Do Not Repel Bed Bugs

Natural pyrethrins and synthetic pyrethroids are well known repellents of ants, cockroaches, and termites. Bed bugs are showing a resurgence, and pesticides which were used 50 years ago are no longer available. Pesticides registered for bed bugs now include pyrethrins, pyrethroids, and the new pesticide chlorfenapyr.

To test for pesticide effectiveness, standard laboratory strains of bed bugs are needed. Virginia Tech researchers obtained a pesticide susceptible strain from Dr. Harold Harlan of the National Pest Management Association, who has been letting bed bugs feed on him for the last 32 years. This kind of dedication is truly remarkable!

Hardwood panels (4cm by 4cm; 1.6in by 1.6in) were treated with label rates of pyrethroids such as cyhalothrin (Demand®), deltamethrin (Suspend®), bifenthrin (Talstar® One), and permethrin (Dragnet®) or with chlorfenapyr (Phantom®). Other panels were untreated, and bed bugs were allowed to choose resting surfaces. Surprisingly, none of the pyrethroids were repellent. Bed bugs encountered treated and untreated panels equally. Somewhat lower percentages were found on treated surfaces after bed bugs started to die.

The fastest acting pesticide was Demand, which killed half of the bed bugs tested within 20 minutes. The slowest pyrethroid was Dragnet, which took about 88 minutes. Phantom was so slow that bed bugs mated and laid eggs that subsequently hatched over the 10 days or so it took to kill half of them. The pesticide did not reduce the number of eggs laid. The researchers believe that chlorfenapyr may be too slow to be useful for bed bug control.

The good news is that pyrethroids should not cause infestations to scatter and spread. The bad news is that field populations of bed bugs are resistant to pyrethroids. Field populations obtained by the researchers in Virginia required 300 times the amount of deltamethrin to achieve the same effect seen in the susceptible Harlan strain.

Given the phenomenon of pesticide resistance, eradication of bed bugs from a structure may require a complete IPM plan, including total client cooperation, use of non-chemical methods such as steam and heat, application of repellent dusts such as diatomaceous earth to their harborages, and judicious use of pesticides.

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

Argentine Ants Kill Red Fire Ant Queens

The Argentine ant, *Lithepithema humile*, and the red imported fire ant, *Solenopsis invicta*, are intensely competitive and are natural enemies. Field observations in Georgia have shown that Argentine ants might be as effective as birds, dragonflies and other natural enemies in stopping new fire ant colonies. An entomologist casually noticed fire ant queens landing on the edge of an asphalt parking lot. He then established an observational transect to monitor more carefully. Initially there were 732 queens, more than half of them under attack by Argentine ant foragers. The Argentine ants fought by biting off the legs of the queens.

On the second day, a total of 292 queens were counted, 75% were dead. Most dead queens were missing legs, and 169 of them were being carried away by Argentine ant workers. Only 35 queens were seen on the 3rd day and half of these were dead. The researcher concluded, "Argentine ants may have a large impact on survival of newly mated red imported fire ant queens. By eliminating queens, the Argentine ants removed potential future competition from fire ant colonies."

Brinkman, M. 2006. Argentine ant (Hymenoptera:Formicidae) worker attacks on post-nuptial red imported fire ant (Hymenoptera: Formicidae) queens in central Georgia. *J. Entomol. Sci.* 41(4):394-396.

Antibiotics, Growth Promoters and Pathogenic *E. coli*

Pathogenic *E. coli* O157:H7 causes bloody diarrhea in humans and can cause kidney damage and death due to hemolytic action on blood cells. Source of infections often come from cattle, which show no symptoms. Shedding of the pathogen has been associated with feedlots, the season, and with cattle diet.

Note to Our Readers

Over the past year our staff has been working intensely on our water quality programs. These have included IPM trainings for pest management professionals (see the BIRC website at www.birc.org to download the training curriculum), development of the EcoWise Certified IPM Certification program (see www.ecowise.org), and answering pest management questions on a daily basis at www.birc.org and www.ourwaterourworld.org. As a result of this activity, we have fallen behind on production of *Common Sense Pest Control Quarterly*. To catch up, we have produced this double issue of the *Quarterly*. This double issue will be followed in about a month with the Fall 2006 *Quarterly*. The editors apologize for any inconvenience this may cause. Any BIRC member wishing an extra copy of this issue can get it without charge by contacting birc@igc.org.—*Thank you, William Quarles, Managing Editor*

Researchers in Canada have found that growth promoters and antibiotics that are routinely given to feedlot cattle may cause production and shedding of the pathogen. In a 5.5 month experiment, 70 cattle were given either antibiotics, growth promoters such as steroids, or combinations of these dietary supplements. A control group of 10 steers was left untreated.

During the experiment, about half of the cattle tested positive for pathogenic O157:H7. All of the pathogens came from cattle that had been treated. No pathogens were isolated from the untreated group. After about 4.5 months (137 days), there was a "statistically significant association" between administration of steroids, antibiotics and other growth promoters and shedding of pathogenic O157:H7.

About 11% of the treated animals were positive for antibiotic resistant pathogenic strains. About 16% of the strains isolated had high mutation rates. These hypermutator strains often have a destructive mutation in a gene that acts as a barrier to genetic exchanges between species. This defect could promote "acquisition of new virulence or drug resistance genes."

Lefebvre, B., M.S. Diarra, K. Giguere, G. Roy, S. Michaud and F. Malouin. 2005. Antibiotic resistance and hypermutability of *Escherichia coli* O157 from feedlot cattle treated with growth-promoting agents. *J. Food Prot.* 68(11):2411-2419.

Chinch Bugs Cause Weed Invasions

We live in a world that is bound together by ecological relationships between plants, animals, and microbes. Administration of an herbicide may have an impact on animals by modifying their food supply. A fungicide may increase herbivorous insect pest damage by destroying an entomopathogenic fungus. Florida researchers have found that an insect pest such as the southern chinch bug, *Blissus insularis*, may encourage weeds in St. Augustinegrass, *Stenotaphrum secundatum*.

Eight sites in Palm Beach, FL were monitored for chinch bugs and weeds. Chinch bug infested areas were visually identified as yellowing patches of turf. Weedy areas were defined as spots with >30% weed cover. Weed populations were nearly seven times higher in areas infested with chinch bugs. The data showed that "weeds were infesting areas of chinch bug damage because chinch bugs had little attraction to weedy habitats." Since weeds remain after chinch bugs are controlled, weed suppression should be considered when establishing thresholds for chinch bug management.

Rainbolt, C., R. Cherry, R. Nagata and M. Bittencourt. 2006. Effect of southern chinch bug (Hemiptera: Lygaeidae) on weed establishment in St. Augustinegrass. *J. Entomol. Sci.* 41(4):405-408.

German Cockroaches Underneath the Sink

It is well known that German cockroaches, *Blattella germanica*, appear most frequently in areas such as underneath the kitchen sink, behind the stove or refrigerator, in cabinets near the sink, and in the bathroom near the toilet. These roaches need moisture and prefer to hide in dark areas. Though these areas can be monitored with sticky traps, Purdue researchers tried a new monitoring technology, proximity sensors, to find areas where roaches prefer to feed. Sensors identified the preferred feeding location as underneath the sink, followed by near stove and refrigerator, followed by on the countertop near the sink or in cabinets above or beside the sink.

Sedenger, B.D., D.R. Suiter and G.W. Bennett. 2006. German cockroach, *Blattella germanica* (Blattaria: Blattellidae), feeding activity in apartment kitchens. *J. Entomol. Sci.* 41(1):49-56.

Fungus Kills Black Vine Weevils

Black vine weevils, *Otiorhynchus sulcatus*, are ubiquitous in commercial greenhouses. They often show up in containerized plants, and infested plants cannot be sold. Beneficial nematodes are one solution to the problem. Recently, a USDA researcher in Corvallis, OR found that treatment of standard potting media such as coir, fir bark, hemlock bark, peat, and perlite with a granular formulation of the commercial fungus, *Metarhizium anisopliae* (Earth BioSciences, New Haven, CT) was also effective. In the experiment, 1/2 lb (227 g) of granules were incorporated into a cubic yard of media. A sample of the media was then used to infect colonies of larval black vine weevils. The fungus was persistent, and the media was on average able to infect more than 90% of test larvae for up to 133 days.

Bruck, D. 2006. Effect of potting media components on the infectivity of *Metarhizium anisopliae* against the black vine weevil (Coleoptera: Curculionidae). *J. Environ. Hort.* 24(2):91-94.

Termites Prefer Pine Mulch

Mulch is an important part of urban IPM treatments. It reduces weeds and improves water use efficiency. However, does it encourage termites or ants? To help answer this question, workers of the eastern subterranean termite, *Reticulitermes flavipes*, were exposed in the laboratory to mulches of pine needles, pine bark, cedar, white oak, oak bark, white oak treated with iron oxide, and cypress. Mulches were aged outside in an urban landscape for various times.

Pine straw was the most preferred mulch for eating. Pine bark was preferred for termite aggregation. Cedar mulch was the least preferred. None of the mulches represented a perfect food as termites lost weight in all of them. After 12 months of aging, except for cedar, little difference was found in termite preference. Other experiments have shown that moisture underneath mulches is the key factor in attracting termites. So, even gravel mulches can be attractive in landscapes.

Pinzon, O.P., R.M. Houseman and C.J. Starbuck. 2006. Feeding, weight change, survival, and aggregation of *Reticulitermes flavipes* in seven varieties of differentially aged mulch. *J. Environ. Hort.* 24(1):1-5.

Feedlots, Pathogens, & Antibiotic Pollution

By William Quarles

In September of 2006, spinach grown in California was associated with an outbreak of *E. coli* O157:H7 food poisoning. There were 204 cases reported, involving 102 hospitalizations and three deaths. The outbreak was probably more widespread, as food safety experts estimate that only about 1 in 20 cases of this type are reported to the Centers for Disease Control and Prevention (CDC) (Warnert 2007).

This outbreak represents the latest encounter with an emerging pathogen of growing importance. Unfortunately, *E. coli* O157:H7 was probably created by human activities. Saturation of cattle in feedlots with antibiotics puts selection pressure on their microbes. In their frantic scramble to survive, bacteria may increase the frequency of mutation and genetic exchanges. These exchanges include genes for pathogenic activity and antibiotic resistance (see *On the Research Front*) (Lefebvre et al. 2005; Law 2000).

According to the *Scientific American*, "...O157:H7, gained its virulence in the antibiotic saturated world of large-scale cattle processing. Inside the cows and their effluent, the surviving bacteria engage in a frenetic swap meet, trading genes for both pathogenicity and drug resistance" (Sci American 2007).

Once generated, such pathogens tend to travel. Environmental contamination is likely because of persistence. O157:H7 can persist in cattle manure for 2-12 months. It is moderately heat resistant, and can tolerate 60°C(140°F) for 1 hour (Jones 1999). As a consequence, O157:H7 has been found in many mammals, including dogs, cattle, pigs, rats, goats, rabbits, and humans. The primary reservoir is cattle and cattle feces. It is common in feedlots, and percent infection increases with cattle density. One experiment sampled 73 feedlots and found O157:H7 at about 96% of them (Sargeant et al. 2003; Jones 1999; Cizek et al. 1999; Vidovic and Korber 2006).

From cattle and cattle feces, it can travel directly into the food supply from slaughter houses, or more insidiously contaminate water or food crops (Swerdlow et al. 1992). The specific source of the spinach problem in 2006 was never identified, although four farms were investigated, and the pathogen was found in nearby cattle, wild pigs, and in the water on one farm (Warnert 2007). Once in the environment, the pathogen can also be spread by house flies, cockroaches, and even field slugs, *Deroceras reticulatum* (Sproston et al. 2006; Kobayashi et al. 2002; Agui 2001; Rivault et al. 1993).

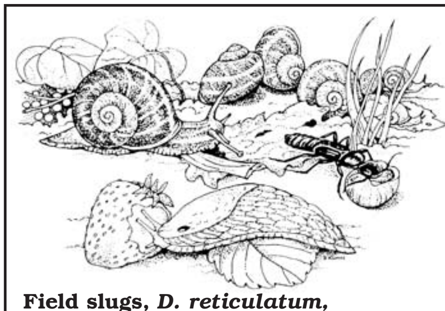
House flies, *Musca domestica,* can carry pathogenic *E. coli.*

Virulent and Potent

E. coli is always present in the guts of humans and other mammals. Many *E. coli* strains are not pathogenic and cause no problems. O157:H7 causes no health problems in cattle. In humans, it attaches to the intestinal lining and starts producing Shiga toxins, resulting in bloody diarrhea. Ingestion of only 10-50 cells is enough to cause sickness. These toxins make the colon more porous, and toxins invade the bloodstream, destroying blood cells (hemolytic). The pathogen is often resistant to antibiotics. Damage done to the blood damages the kidneys and can lead to death. Most patients recover within 10 days, but infective cells remain in the colon for 60-120 days (Jones 1999; You et al. 2006). New pathogenic and antibiotic resistant forms of *E. coli* are constantly being generated in cattle (Hussein and Bollinger 2005; You et al. 2006).

Antibiotic pollution that creates new pathogens is a potential nightmare, because the new pathogens are resistant to antibiotics. There is also a problem of antibiotic resistance induced in existing pathogens. Numbers involved are large and growing. Each year, about 13,000 people in the U.S. die from Methocillin Resistant *Staphylococcus aureus* (MRSA). These infections are contracted mostly in hospitals, but increasingly they are being reported as a consequence of skin abrasions from athletic activity (Sci American 2007).

Each year about 32,000 cases of poisoning from foodborne pathogens are reported. Of these, about 88 result in death. Since only about 1 in 20 cases are reported, the incidence could be more than half a



Field slugs, *D. reticulatum,* can carry the pathogen.

Photo courtesy of gpvec.edu

Feedlot antibiotics can help create pathogens.

million a year. The CDC estimates that O157:H7 alone causes more than 73,000 illnesses a year, resulting in a cost of about $400 million dollars. Growing antibiotic resistance is going to make these cases harder to treat, and will likely lead to larger numbers of deaths (Warnert 2007; Frenzen et al. 2005).

There are also direct effects of exposure to antibiotics in food. There has been some speculation that the trend to obesity found in U.S. children may be partially caused by antibiotics. This speculation is based on the growth promoting properties of antibiotics and the increased levels of exposures found over the last 50 years (Ternak 2005).

Antibiotic Pollution

Much of the antibiotic pollution that encourages development of pathogens originates in feedlots. Animals fed antibiotics grow faster on less food, and 100,000-200,000 tons of antibiotics are used each year. For instance, more antibiotics are fed to hogs in North Carolina each year than are clinically prescribed for the whole U.S. (Ternak 2005; Schal 2006).

We are directly exposed to antibiotics, antibiotic resistant pathogens, and even antibiotic resistance genes. Recently, advances in molecular biology techniques make it possible to track the movement of bacterial strains and antibiotic resistance (ABR) genes through the environment (Choi 2007).

Antibiotic resistance (ABR) genes have been found at feedlots in animals, in the air, in manure, and in the water. Manure and urine at feedlots is often held in lagoons (Quarles 2006; Sapkota et al. 2006). Pathogens, antibiotics, and antibiotic resistance genes from these lagoons can end up in water and in water sediments (Pei et al. 2006; Schmitt et al. 2006). Where streams are used as drinking water sources, ABR genes can end up in drinking water. Water treatment plants have technology to kill bacteria, but few have technology to remove the genes left by the dead bacteria. Water quality work done in Colorado shows, "levels of antibiotic resistance genes ran hundreds to thousands of times higher in waters directly affected by urban or farm activity than in relatively pristine bodies....researchers found the genes everywhere they investigated, including drinking water" (Choi 2007).

Antibiotics released at feeding operations and resistance genes generated there end up in meat products (Sunde and Norstrom 2006). For instance, multidrug resistant enteric bacteria were isolated from turkey, cattle, and chicken farms, and retail meat products in Oklahoma. Multidrug resistant *Klebsiella pneumoniae* was most frequently recovered from turkey farms and ground turkey products. The resistant bacteria remained in feathers, feed, feces and drinking water in turkey confinements (Kim et al. 2005).

Antibiotics can also be transferred from feedlots to vegetables. When manure from treated animals is used as fertilizer, vegetable crops can absorb small amounts of antibiotics that then become part of the food supply (Kumar et al. 2005)

Traditional pests such as cockroaches and house flies can spread the resistant pathogens and antibiotic resistance genes. For instance, in one experiment house flies were fed suspensions of *E. coli* containing plasmids for Shiga toxins or antibiotic resistance. Inside the house fly, these plasmids were freely transferred to *E. coli* strains that were not resistant or pathogenic (Petridis et al. 2006). In another experiment,

Photo courtesy EPA

Pathogens from feedlots are held in storage lagoons.

of 260 house flies collected at five restaurants, 97% were positive for enterococci. Of the microbes, about 66% were resistant to tetracycline, 24% to erythromycin, 12% to streptomycin, 10% to ciprofloxacin, and 8% to kanamycin (Macovei and Zurek 2006).

Not only are pathogens evolving resistance and transferring that resistance throughout the air, water, and food supply, benign bacteria are becoming reservoirs of antibiotic resistance. Lactic acid bacteria such as *Lactobacillus* sp. found in fermented milk products have been shown resistant to tetracycline, erythromycin, and vancomycin (Shalini and Singh 2005).

Antibacterial Soap

Feedlots are not the only problem. Obsession with bacteria has led to a proliferation of antibacterial soaps. These soaps contain triclosan or triclocarban. Most people wash these down the drain, and about 75% of the chemicals survive at the water treatment plant. They are either released into the effluent water, or they accumulate in sewage sludge. The sludge is then applied to fields as fertilizer. Problems are increased because triclosan is an endocrine disruptor, and tricloroban is a chlorinated hydrocarbon that is extremely persistent (Kepner and Feldman 2006ab).

Conclusion

Antibiotic pollution is an unnecessary problem. Administration of antibiotics to animals just to promote growth should be stopped. According to many medical professionals, antibacterial soaps are no more effective than regular soap and water in fighting infections. So the use of these products should be reduced.

Europe has already started to correct the problem. In January of 2006 the European Union banned all non-therapeutic uses of antibiotics in animals. Also banned was the agricultural use of avoparcin, which complicates treatment for deadly MRSA in humans. According to the *Scientific American*, "liberal use of avoparcin to promote animal growth had been conclusively linked to increasing vancomycin resistance in human gut pathogens and from there to resistant staph ravaging hospital patients" (Sci American 2007).

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Landscape IPM for Spider Mites

by William Quarles

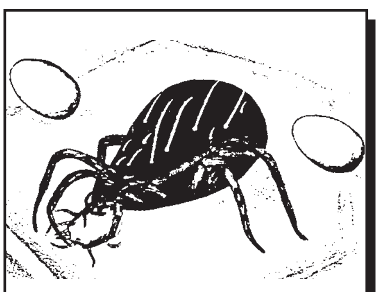
Spider mites are microscopically tiny (1/64 to 1/32 inch long; 0.4 to 0.8 mm), pinkish, red, brown, yellow, or green. They are smaller than the period at the end of this sentence, and mature mites, unlike insects, have 8 legs. Eggs are spherical and translucent. Spider mites live in colonies that contain hundreds of mites, and they leave pin-prick holes and a webby deposit on the underside of the leaves. A bad infestation may cause leaf yellowing, premature leaf death and defoliation. Where weather is mild, they are active year-round. In cold weather they overwinter underneath bark, in leaf litter and trash. Their populations and their destructiveness are worst in hot weather. Spider mites are usually found first on trees or plants near dusty roadways or garden edges (Dreistadt 2004; Ohlendorf and Flint 2000).

One of the most common species is the two-spotted mite, *Tetranychus urticae*. The damage made by spider mites shows first as needle-like puncture marks made when they suck the sap from plant parts. Initially, the tops of damaged leaves appear stippled with tiny silvery or yellowish dots. Later, the punctures become brown and sunken. Heavy infestation can weaken and even kill already stressed trees and shrubs (Olkowski et al. 1991).

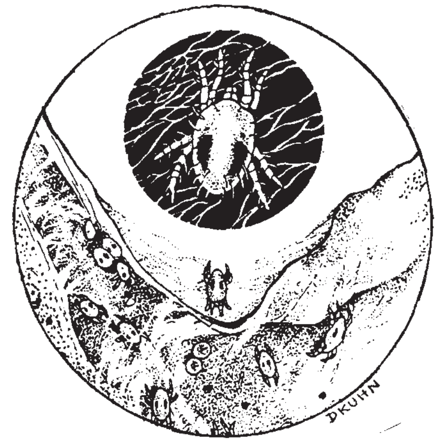
High populations of mites can cause defoliation, and leaves, twigs and fruit may be covered with their webbing. On ornamentals, mites cause mainly cosmetic damage, but can kill plants if populations become very high on annual plants. Spider mites are important pests of roses (Swiadon and Quarles 2004).

Monitoring

To look for spider mites, inspect the underside of leaves, particularly along the main ribs. Check the mature leaves first, as initial mite infestations appear on such leaves. Use a hand lens and look for eggs, mites, webbing and leaf punctures. Also check the areas where the leaf petioles join the stems and the branches attach to the main trunk of the plant. Mites can also be monitored by tapping branches with a pencil to cause any mites to fall onto a clipboard containing a white sheet of paper. This process enables you to determine whether or not mites are present, capture specimens for identification, learn if beneficial predatory mites are present and assess relative numbers of pest mites versus predators (Simon et al. 2002; Ohlendorf and Flint 2000; Raupp et al. 1992). Predatory mites (phytoseiids) are shaped like tear drops. *Phytoseiulus persimilis* is bright orange. "Their legs are noticeably longer than their spider mite prey, and the two front legs are commonly extended forward like feelers...Predatory mites run in a circular fashion searching for food, while their prey usually move slowly and erratically" (Glenister 1994).



Predatory mite, *P. persimilis*

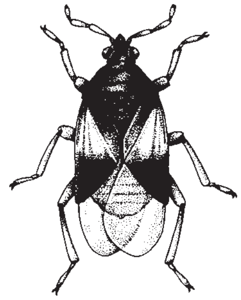


Cultural Controls

Mite damage may also be a symptom of a lack of water due to inadequate rain, insufficient irrigation or plant pathogens that infect the tree's water-conducting tissues. Mites overwinter in leaves, trash and weeds on the ground and in plant crevices, so sanitation measures are important. Prune heavily infested branches. High-pressure sprays from a garden hose will knock them off in a mild infestation. Adding insecticidal soap to the water may be more effective. A hose-attached sprayer is fine for washing a medium-sized tree. A extremely large plant or tree may require professional help (Simon et al. 2002; Olkowski et al. 1991; Quarles 2004).

Biological Controls

If washing with plain water or insecticidal soap does not help, identify the mite or have it identified for you by the local extension service, and ask the insectaries listed below in Resources about commercially available mite predators. Predatory mites for spider mite control are purchased in containers, and distributed onto the leaves of mite-infested plants. Insectaries producing such predatory mites will know which species are best for the control of your



Minute pirate bugs,*Orius sp.* are mite predators.

particular pest mites. They can also recommend how many mites to use per plant. Species include *Metaseiulus occidentalis*, *Amblyseius cucumeris*, and *Phytoseiulus persimilis*. There are 46 suppliers for P. persimilis alone (see Resources) (Glenister et al. 1994; BIRC 2006; Simon et al. 2002).

Under optimal conditions, *P. persimilis* will control pest mites faster than other predatory mites because it eats 14-23 mite eggs per day, while other predatory mites eat about eight. *P. persimilis* is most effective under humid conditions with 60-90% relative humidity. It fails at high temperatures and 40% relative humidity. The western predatory mite, *Metaseiulus occidentalis*, is more effective under hot, dry conditions (Glenister 1994).

Predatory mites do not feed on foliage or become pests; thus if pest mites are not available when predatory mites are released, the predators starve or migrate elsewhere. If you wish to establish predators in a heavily infested orchard or garden that has few predators, use a soap spray or selective miticide to bring pest mites to a lower level and then release predatory mites. A good guideline is that one predator is needed for every ten spider mites to provide control. More than one application of predatory mites may be required if you want to reduce pest populations rapidly. Concentrate releases in hot spots where spider mite numbers are highest. Once established on perennials, predatory mites may reproduce and provide biological control indefinitely without further augmentation unless nonselective insecticides are applied that kill the predators (Glenister 1994; Olkowski et al. 1991).

Other commercially available predators are the lady beetle, *Stethorus punctillum* and the mite midge, *Feltiella acarisuga*. The mite midge is a fly that lays eggs near high density mite infestations. Larvae crawl slowly to an egg, nymph, or adult spider mite, sink in their mandibles and start feeding. Eggs and larval mites are preferred food. One larval midge can eat 13 mites in 5 minutes and up to 380 mites in 17 days. Larvae are yellow, orange, or red. They pupate underneath leaves or on the ground (Quarles 1997). Six-spotted thrips, *Scolothrips sexmaculatus* is sporadically available. General predators such as the big-eyed bug, *Geocoris* sp., the minute pirate bug, *Orius* sp., and lacewing larvae, *Chrysoperla* spp. also help with biocontrol. These predators are present in landscapes and should be

Resources*

Predatory Mites

Metaseiulus occidentalis—Biotactics, Inc., 20780 Warren Road, Perris, CA 92570; 909/943-2819, Fax 909/943-8080; www.benemite.com; IPM Labs (see below), Rincon-Vitova (see below); Nature's Control (see below); The Green Spot (see below)

P. persimilis—Applied Bionomics Ltd., 11074 W. Saanich Rd., Sidney, BC, CANADA V8L 5P5; 250/656-2123, Fax 250/656-3844; bug@island-net.com; IPM Laboratories Inc., PO Box 300, Locke, NY 13092-0300; 315/497-2063, Fax 315/497-3129; www.ipmlabs.com; Rincon-Vitova Insectaries Inc., PO Box 1555, Ventura, CA 93002; 800/248-2847, 805/643-5407, Fax 805/643-6267; www.rinconvitova.com; Nature's Control, PO Box 35, Medford, OR 97501; 800/698-6250, 541/245-6033, Fax 541/899-9121; www.naturescontrol.com; The Green Spot, Ltd., Dept. of Bio-Ingenuity; 93 Priest Rd., Nottingham, NH 03290; 603/942-8925, Fax 603/942-8932; www.greenmethods.com

Other Predators

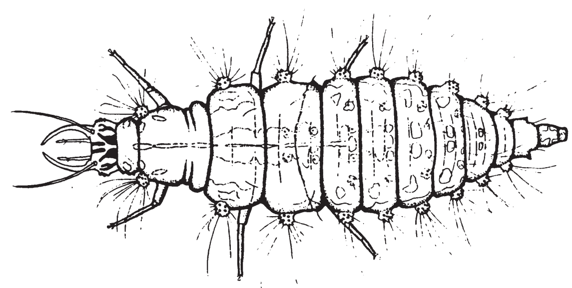
Feltiella acarisuga (mite midge)—Nature's Control (see above), Rincon Vitova (see above), The Green Spot (see above), Biobest Canada, 2020 Fox Run Rd., Leamington, Ontario, CANADA N8H 3V7; 519 /322-2178, Fax 519 /322-1271; info@biobest.ca

Orius spp.—Applied Bionomics (see above), IPM Labs (see above), Nature's Control (see above), The Green Spot (see above)

Stethorus punctillum—Applied Bionomics (see above),Rincon-Vitova (see above), Nature's Control (see above), The Green Spot (see above)

Soaps and Oils

Horticultural Oil—Valent USA, PO Box 8025, Walnut Creek, CA 94596-8025; 800/624-6094, 925/256-2700, Fax 925/256-2844; www.valent.com; Green Spot, Harmony, Peaceful Valley



Lacewing larvae, *Chrysoperla spp.* can help control mites.

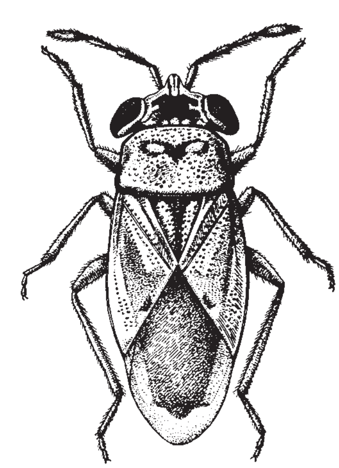
encouraged by avoiding dusty conditions and pesticide sprays (Olkowski et al. 1991).

Chemical Controls

Mite infestations are often actually triggered by chemical controls. A classic example is application of carbaryl (Sevin®) in spring to control caterpillars. The insecticide also kills natural enemies of mites, resulting in mite outbreaks in summer, when high temperatures cause mite eggs to hatch. Systemic treatments of imidacloprid have also triggered mite outbreaks. Use selective insecticides such as Btk (Dipel®) or spinosad for caterpillar control rather than a broadspectrum insecticide (Simon et al. 2002; Quarles 2005a; Raupp et al. 2004).

Two-spotted mite, *Tetranychus urticae,* is a common plant pest.

If you used a broadspectrum pesticide such as a pyrethroid, carbamate, or organophosphate earlier and now have developed a mite problem, switch to less-toxic chemical controls such as insecticidal soap or horticultural oil, as they are also effective against mites. Heavier infestations may require frequent sprays of insecticidal soap 2-3 times a day for several days, along with the use of dormant oil sprays in late winter to destroy the eggs. Neem oil (Triact) can also be used to manage spider mites (Olkowski et al. 1991; Quarles 2005b).



Big-eyed bug, *Geocoris sp.*, can help with mite control.

Resources Continued*

Insecticidal Soap—Woodstream , 69 N. Locust St., Lititz, PA 17543-0327; 800/800-1819, 717/626-2125, Fax 717/626-1912; www.woodstreampro.com; Harmony Farm Supply, 3244 Gravenstein Hwy, No. B, Sebastopol, CA 95472; 707/823-9125, Fax 707/823-1734; www.harmonyfarm.com; Peaceful Valley Farm Supply, PO Box 2209, 125 Clydesdale Court, Grass Valley, CA 95945; 530/272-4769, Fax 530/272-4794; www.groworganic.com; The Green Spot (see above)

Neem Oil—Certis (Triact®) 9145 Guilford Rd. Suite 175, Columbia, MD 21046; 800/250-5020, 301/604-7340, Fax 301/604-7015; www.certis-usa.com; PBI Gordon (Azatrol®), PO Box 014090, Kansas City, MO 64101; 800/821-7925, 816/421-4070, Fax 816/474-0462; www.pbigordon.com

Soybean Oil (Natur'l Oil)—Stoller Enterprises, Inc., 4001 W. Sam Houston Pky N., Suite 100, Houston, TX 77043; 800/539-5283, 713/464-5580, Fax 713/461-4467; www.stollerusa.com; Harmony; Peaceful Valley

*A more complete listing can be found in the *2007 Directory of Least-Toxic Pest Control Products* available from BIRC, PO Box 7414, Berkeley, CA 94707.

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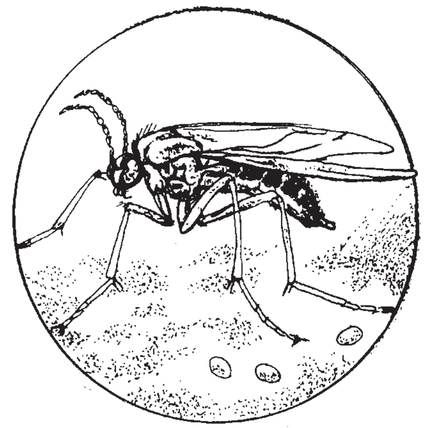
Managing Fungus Gnats on Indoor Plants

By William Quarles

If you have houseplants, you may be occasionally plagued by hordes of small flies. These flies dart about foliage, walk about nearby surfaces, and may appear on your windowsill, as they are attracted to light. Quite likely, these tiny flies are fungus gnats. Though they can be more of a nuisance than a threat to a home or an office containing a few plants, they can be serious pests in commercial greenhouses or large interior plantscapes where the large number of plants produce a favorable situation for a population explosion.



Life stages of a fungus gnat include the egg, larval stages, pupa, and adult (see Box A). Adult fungus gnats are mostly a nuisance, but larval forms can harm plants by feeding on their roots. When root feeding becomes more extensive, the plant will show signs of yellowing or wilting. Larvae can also tunnel their way into roots and stems, and entire mushroom cultures have been destroyed by tunneling larvae (Olkowski 1988).

Among the common plants attacked by larval stages of the gnats are: poinsettias, gerbera daisies, gloxinias, most bulb crops, cyclamens, hybrid impatiens, salvia, geraniums, ornamental peppers, and others. All bedding plants and vegetable sets grown in plugs are highly vulnerable. Tender tissue culture plugs are particularly susceptible to fungus gnats (Harris et al. 1996; Olkowski 1988).

In addition to feeding damage, both fungus gnat larvae and adults can disperse plant pathogens. Diseases can be spread in this way throughout a greenhouse (Harris 1993). Plants are especially vulnerable after roots have been injured by fungus gnat larvae. In commercial greenhouses entire crops of poinsettias (numbering 300,000 to 600,000 pots) have been destroyed in this way. Growers may not even associate damage with the fly unless fly larvae are noticed when roots of the wilted plants are examined.

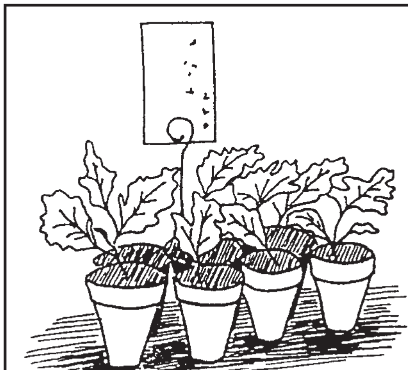
The term "fungus gnats" refers to a very large group of insects (see Box A). Most have not been studied extensively. Many questions regarding their taxonomy (physical characteristics) and biology remain unanswered. Major pests of floriculture are the species *Bradysia coprophila* and *B. impatiens*. A major pest of cultivated mushrooms is *Lycoriella mali* (Olkowski 1988; Harris et al. 1996; Kielbasa and Snetsinger 1980). In general, it seems that the primary food of fungus gnat larvae is the organic matter and fungi in soil or planting medium. However, pest species can feed both on organic matter or on healthy or diseased plant roots.

When fungus gnats first became a problem, managers turned to insecticides to control them. Unfortunately, resistance developed to many of the available materials (Harris et al. 1996). The IPM methods described below minimize resistance and can provide excellent management of the pest.

Monitoring

If you suspect that fungus gnats are causing damage to your plants, you will want to monitor for them. Monitoring alerts you to problems, and if you initiate control actions, monitoring will help determine whether or not the treatments are effective (Olkowski 1988).

To monitor for adult fungus gnats, yellow sticky traps are inexpensive and convenient. These traps are sold by garden supply houses for monitoring whiteflies and other flying pests. These are small, flat, yellow panels covered with a sticky glue. You can buy them, or you can make them at home. By heating sticky materials such as Tangle-Trap® or



Sticky traps can be used to monitor and help control pests.

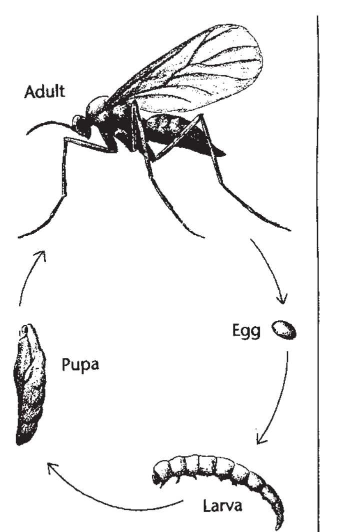
Stickem®, you can get them to flow enough so they can be brushed onto a one square foot (0.09 m^2) piece of cardboard, wood, masonite, or plastic (see Resources) (Olkowski 1988; Larsson 1986).

Deployment depends on the pest of interest. To make sticky traps more effective for monitoring fungus gnats, traps are sometimes oriented horizontally and close to the soil to catch adults emerging from pupae near the soil surface. For whiteflies, vertical orientation near foliage is best (Jagdale et al. 2004; Harris 1993).

Addition of a light source can make yellow sticky

Box A. Fungus Gnat Biology

According to Olkowski (1988), “The term “fungus gnat,” as used by a horticulturalist, could mean any species in at least the following families: Phoridae, Mycetophilidae, Sciaridae, Spaeroceridae (small dung flies), Psychodidae (moth flies), and Cecidomyiidae (gall midges), as well as any species in related but more obscure families. They are all small flies, as the term “gnat” connotes, and one group of fungus gnats, genus Megaselia (family Phoridae), can penetrate typical window screening.”



Life stages of the fungus gnat

“A more conservative use of the term would confine it to about 2,000 species of flies in the family Mycetophilidae (which sometimes also includes the Sciaridae), the adults of which superficially look like mosquitoes, although upon closer inspection they are distinctly different.”

“Under natural conditions fungus gnat larvae inhabit wild fungi, leaf mold, manure piles, and rotting wood, within which they feed upon dead organic matter and the fungi growing upon it – hence their name. Adult gnats also like moist areas.”

Shore flies and moth flies are sometimes mistaken for fungus gnats. Adult shore flies have short legs, short bristlelike antennae, dark wings with 5 light spots. Larvae have plump, browish yellow bodies, about 1/8 inch (3 mm) long, and no distinctive head capsule. Moth flies look like gray moths because of fine hairs covering their bodies. Mature larvae are less than 1/4-inch (6 mm) long (Dreistadt 2001).

Major fungus gnat pests in the family Sciaridae are the mushroom fly, *Lycoriella mali* in the U.S. or *L. solani* which is its counterpart in Europe. Another common horticultural pest is the darkwinged fungus gnat, *Bradysia coprophila* or *B. impatiens*. These are pests of mushrooms and many other species ranging from pine seedlings, to cucumber, to poinsettia (Harris et al. 1996; Olkowski 1988).

Biology and Damage

Many fungus gnat species have similar characteristics. The description below is for *Bradysia coprophila*. Fungus gnat adults are all very small, sooty-gray or nearly black, long-legged, slender flies, commonly called “gnats,” measuring about 1/8 to 1/10 inch (2.5 to 3.2 cm) in length. They are poor fliers, but can run around swiftly on the surface of a plant or the growing medium. They have a distinctive “Y” shaped vein on their wings. Females move around less than males, hanging out on the undersides of leaves and near the surface of the planting medium (Harris et al. 1996).

Life stages are egg, 4 larval stages, pupa, and adult. Adults live about 3-7 days and generally do not feed. Mating is pheromone driven, and tiny eggs (1/100 in; 0.25 mm) are laid in clusters on the surface of the planting medium near plant stems. The number of eggs can range from 75-150. Females are attracted by soils and soil mixes with high organic content and moisture (Harris et al. 1996).

Eggs hatch in about four days. Larvae are white or translucent with black heads. Mature larvae are about 1/4-inch (6 mm) long. They feed on the fungi and algae on pot surfaces, under benches and bench surfaces. Larvae prefer to eat fungi, but will feed on healthy or diseased plants. In containers, larvae feed on root hairs and roots in the upper strata (upper one inch; 2.5 cm) of the pots, and they later burrow into the stems and leaves, causing eventual destruction of the plants. In mushroom houses larvae tunnel into the mushrooms, effectively destroying crops if they are widespread. Both adults and larvae can spread fungal disease pathogens (Harris et al. 1996). The pupae are about “one-sixth of an inch long, pale yellow, with darker wing pads and still darker head...just prior to the adult’s emergence, the pupa works its way to the surface of the soil to allow the escape of the gnat or adult” (Weigel and Sasscer 1936).

Temperature is a factor in development. Gnats do not develop below 10°C (50°F) or above 35°C (95°F). From egg to adult at 18°C (64.4°F) takes 18-23 days; at 23°C (73.4°F), it takes 27-33 days. Altogether, they spend roughly 3 days as adults, 4 days as eggs, 10-14 days as larvae, and 3 days as pupae (Harris et al. 1996).

traps more attractive. Lime green light-emitting diodes combined with the yellow sticky traps can trap out some of the pests, as well as monitor for them (see Resources). These traps selectively attract fungus gnats, silverleaf whiteflies, *Bemisia argentifolii*; western flower thrips, *Frankliniella occidentalis*; and leafhoppers. The traps are selective for pests and spare beneficials. In one test, the only beneficial to be trapped at a greater frequency in the light traps than in the unlit stickies were rove beetles (Chen et al. 2004).

Novel baits may be possible for fungus gnats. *Bradysia* sp. is attracted to cantharidin, a toxic terpene that the gnats may confuse with fungal metabolites that indicate a food source. Sticky traps baited with the material are attractive to adult fungus gnats (Frank and Dettner 2001).

Sticky traps will catch and remove adult fungus gnats, but do not monitor for larvae. A convenient monitoring method for the larvae is to embed a 1/2 inch (13mm) thick slice of potato with about 1 inch (25 mm) diameter into the surface of the potting medium. Potatoes are removed after 48 hours and larvae are counted. Larvae are white or clear, about 1/4 inch (6 mm) long, and have black heads (see Box A) (Cabrera et al. 2003).

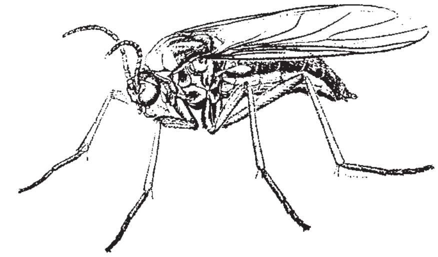
There may be no correlation between sticky trap catches and populations of the truly destructive life stages—the larvae. For instance, Harris et al. (1995) found no adult fungus gnats in sticky traps when the larval populations on potato slices were highest. When large numbers of flying adults are noticed, problems with larvae could be concurrent, or could be seen within a couple of weeks.

Fungus gnats are sometimes confused with shore flies and moth flies. Descriptions of fungus gnats can be found in Box A. "Shore fly adults are stouter looking than fungus gnats and hold their wings, which are dark with whitish spots, laid back over their bodies. Moth flies are so named because of their resemblance to small moths, with wings covered by dust-like scales...shore-fly larvae are tannish brown, crescent-shaped, without a head capsule" (Harris 1993).

What Are You Monitoring For?

There are no published papers on "injury levels" for fungus gnats, that is the numbers of pest gnats that must be present to cause an intolerable amount of damage. So you will have to learn what numbers of flies caught in the trap are associated with what amount of visible damage to the plants.

Start with checking the traps bi-weekly, and modify the interval according to the temperature and light conditions which might influence the rate of fly production. Warmer, longer days will increase fly breeding, and darker, cooler periods will retard them. In greenhouses, fly production will also vary according to the crops being grown (Jagdale et al. 2004; Olkowski 1988).



Fungus gnat, *Bradysia sp.*

Moth fly, *Psychoda sp.*

If sticky traps are showing large numbers of flies and potato traps are showing large numbers of larvae, a control method may be necessary. In fact, if fungus gnat problems have been an ongoing problem for a long time, treatments should be applied as early as possible in the growing season, especially if you are using biological controls (see below).

Cultural Controls

A number of cultural steps can be taken to reduce the number of fungus gnats. For plants at home, watering as little as possible will discourage them. Fungus gnat development is encouraged by high moisture. If moisture levels are high, even incorporation of the desiccant diatomaceous earth into the soil will not reduce populations. Insects are relatively unaffected by DE if they can easily replace lost moisture (Cloyd and Dickinson 2005; Quarles and Winn 2006).

If the top of the potting soil is covered with a thin layer (1/4-1/2 inch; 6-12 mm) of sand, females will be discouraged from egglaying. This can be an easy way to correct a problem involving a few plants growing at home (Hungerford 1916). Another physical treatment that has been used is soaking the growth medium in a soap solution. This approach has also been used to kill root-infesting mealybugs, and might have some effect on larval western flower thrips that have dropped to the soil surface to pupate. According to Gibson and Ross (1940), "on occasions it has been recommended to treat soil infested with these maggots with strong soap

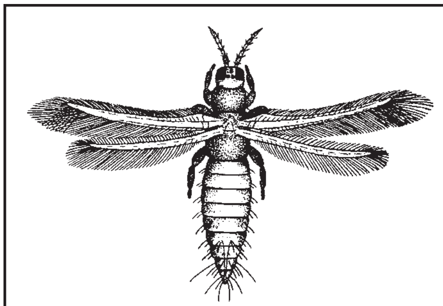
Photo courtesy Sheila Daar

Cyclamen is often infested, leading to wilt.

suds…an infested plant was placed in a large pail containing strong soap suds, so that the water just reached the top of the soil; it was left there for a few hours, drained well afterwards, and since, no more worms have been seen.” Soap, however, might cause phytoxicity when used as a soil drench for some plant species. Biocontrols and other methods mentioned below might be less risky.

Sanitation

Sanitation is very important for fungus gnat management in greenhouses. For example, during the course of one experiment, researchers were able to show that soil drenches of containerized plants with insect growth regulators (IGRs) (see below) controlled fungus gnats in the laboratory, but not the greenhouse. They found that the gnats were breeding in soil or organic matter underneath the greenhouse benches that supported the containerized plants (Ludwig et al. 2003). So, keeping areas beneath benches clean of plant debris, old plants, spilled potting mix and weeds will help discourage gnats. Screening with about the mesh size used to exclude leafminers will help keep immigrating fungus gnats out of greenhouses (Harris 1993). Covering soil underneath benches with plastic might discourage fungus gnats from laying eggs and may prevent pupation of larval western flower thrips.



Biocontrols for fungus gnats can also reduce flower thrips.

Greenhouse production managers should make sure growth media and planting plugs purchased from suppliers are not contaminated with fungus gnat eggs and larvae. This type of contamination seems to be quite common. Growth media can be decontaminated with steam or solarization, and plugs might be disinfested with application of beneficial nematodes (Cloyd and Zaborski 2004). The type of potting media is important. Composted hardwood bark media encourages fungus gnats more than some of the artificial media such as Metro Mix, Ball-Mix and Pro-Mix. Of the artificial media, gnats may lay eggs more frequently in Metro-Mix (Jagdale et al. 2004; Meers and Cloyd 2005).

Trap Crops

Those with very small houseplant collections may wish to use the strategy of “trap-cropping”. This approach is occasionally used in agriculture. A plant known to be particularly attractive to the pest is grown near, or earlier in time than, the main crop. When pests are drawn to the trap crop, it is destroyed, often by spraying with a pesticide, leaving the main crop unsprayed.

Since fungus gnats are known to be attracted to sprouted grain, a Cooperative Extension pamphlet written by A.L. Antonelli of Washington State University suggests that a pot of sprouted grain be used as a trap crop (Olkowski 1988). This idea may have originated with Hungerford (1916). Set the trap pot out among the plants to be protected. Give the female gnats time to lay their eggs on this moist material. After a few days, the pot can be submerged in boiling water to kill the eggs and larvae, or the material can be discarded outdoors. This practice will need to be repeated every two weeks until the flies are no longer pestiferous (Olkowski 1988).

Nematodes

Commercially available nematodes such as *Steinernema feltiae* and S. *carpocapsae* are effective against fungus gnats (see Resources). Researchers have found that effectiveness varies with the nematode, plant species, growing medium, temperature, and timing of the application (Jagdale et al. 2004; Georgis et al. 2006).

Harris et al. (1995) tested *S. feltiae* (1.25 and 2.5 billion/ha*); S. carpocapsae* (1.25 and 2.5 billion/ha); kinoprene (Enstar II), *Bacillus thuringiensis israelensis* (BTI), and diazinon. Treatments were in pots containing Metro Mix and poinsettias, *Euphorbia pulcherrima*. Effects were monitored with potato slices for larvae and sticky traps for adults. The most effective treatment was *S. feltiae* (2.5 billion/ha). Fungus gnat eggs were not attacked, mortality was

Poinsettias are particularly vulnerable to fungus gnats.

highest for 2nd and 4th larval instars, and about 1/3 of the pupae were infected. Nematodes can give longterm protection, since they can remain active in the soil mix for up to 90 days.

Hydro-Gardens, a commercial supplier of nematodes, applies them in their greenhouse operations (see Resources). They have used nematodes successfully against fungus gnats and western flower thrips (Olkowski 1988). *S. feltiae* (about a million/m^2; billion/ha) has also been used to effectively control the mushroom fly, *Lycoriella* sp. (Grewal 2000).

In glasshouse grown fuchsias, *Steinernema feltiae* applied by hydraulic sprayer at 780,000 nematodes/m2 (7.8 billion/ha) resulted in a decrease of 92% in the numbers of *Bradysia* sp. adults emerging from the containerized growth medium. The nematodes were well distributed in the potted compost medium, and they persisted over the 64-day experimental period (Gouge and Hauge 1995).

S. carpocapsae can also be effective. This species has been used to control *B. agrestis* on watermelon. Nematodes preferentially attacked 3rd and 4th larval stages and pupae. Adult fungus gnats helped disperse the nematodes. Nematodes and soil drenches of insecticides had about the same efficacy, but pesticides caused some phytotoxicity (Kim et al. 2004).

Predatory Mites

In 1988, predatory mites had just been introduced as a biocontrol of fungus gnats. According to Olkowski (1988), "a short news item in a trade magazine *The Nursery Manager* alerted us to the possibility of using a predatory mite *Hypoaspis* sp. nr. *aculcifer* for the control of gnat populations in greenhouse plants. We discussed this with Dr. David Gillespie of Canada's Agassiz Research Station (Agassiz, B.C., Canada V0M 1A0; 604/796-2221). He said that the mite is really a species of *Geolaelaps*, and that it has been shown to be an excellent predator of fungus gnats in controlled studies."

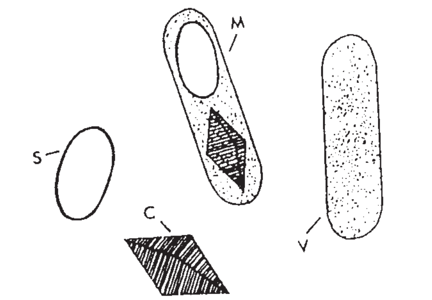
Containerized geraniums can be attacked.

The effectiveness of the mite was first noticed in British Columbia greenhouses that had switched over to biological control. In these greenhouses there were no fungus gnat problems, while in other greenhouses, where conventional pesticides were used, there were high populations. *Geolaelaps* introduced at a high rate of 6000 mites/plant to the sawdust substrate of hydroponically grown greenhouse cucumbers reduced numbers of larvae and adults of *Bradysia* spp. over a 10-week period. About 1600 mites/plant reduced emergence of adults of western flower thrips to about 30% of that in the controls over a 40-day period. An inoculative introduction of 125 mites/plant to cucumber plants in selected rows in a commercial greenhouse reduced peak numbers of *Bradysia* spp. to about 20% of those in untreated rows (Gillespie and Quiring 1990).

In another experiment, the predatory mite *Hypoaspis miles* [*Stratiolaelaps miles*] was released from laboratory cultures into young crops of pot-grown Cyclamen and poinsettias in six small greenhouses in the UK as a biological control agent against *Bradysia* spp. In both crops, rates of 55 mites/pot and above gave satisfactory control of sciarids (fungus gnats) with no later resurgence of the pest. Mites persisted in the pots until the end of the trial, probably feeding on a residual population of sciarids. In separate tests, *S. miles* was found mostly in the top 1 cm (0.4 in) of compost and persisted for up to 7 weeks in the absence of food (Chambers et al. 1993).

These predatory mites develop faster at warmer temperature, lay 2-3 eggs a day, and are relatively long lived. With food, 60% of males and females can survive for nearly 5 months. All larval instars of sciarids are attacked by mites, but smaller larvae are preferred. Egg predation is negligible, and pupae are not attacked (Wright and Chambers 1994).

This mite is commercially available as an augmentative control for release in greenhouse environments (see Resources). As is often the case for mites, the species name has seen several shifts since 1988.



Bacillus thuringiensis, shown here, is a fungus gnat biocontrol.

It was originally called *Hypoaspis miles* or *Geolaelaps miles*. Then, the name was changed to *Stratiolaelaps miles*. Finally, mite taxonomists decided that commercial mites were actually *S. scimitus* (Cabrera et al. 2005). Most commercial suppliers still list it as *Geolaelaps* or *Hypoaspis* (BIRC 2006).

Other Biocontrols

The hunter fly, *Coenosia attenuata*, may become a useful biocontrol of fungus gnats. These flies originate in the Old World, but may have come to U.S. and Canadian greenhouses in contaminated plant and potting material. Adult hunter flies capture adult whiteflies, fungus gnats, and shore flies while they are airborne, then puncture them with dagger like mouthparts. Hunter fly larvae live in the soil and feed on fungus gnat larvae. Female flies produce more eggs when feeding on fungus gnats. They live 20-25 days and produce more than 100 eggs. Since the potential biocontrol agent feeds on both larval and adult forms, it shows great promise for greenhouse biocontrol of fungus gnats (Grossman 2006, Wraight 2006).

Bacillus thuringiensis israelensis (BTI)

Bacillus thuringiensis var. *israelensis* (BTI) is widely available, since it is a highly effective for suppressing the larvae of mosquitoes and blackflies (see Resources). BTI was originally isolated from a diseased mosquito was and subsequently commercialized. This naturally occurring bacterium is highly selective. Natural enemies such as nematodes or mites are not killed, and it has low toxicity to mammals (Olkowski 1988).

BTI must be applied so that the target stage of the pest will eat it, since it acts as a stomach poison. Adult fungus gnats do not eat, or, if they do, it is negligible. For fungus gnat control, therefore, the bacterial spores must be placed in the potting soil where the larvae feed. The easiest way to do this is to mix it with water and drench the soil. Directions for making such applications are provided by the manufacturer. Valent markets BTI for fungus gnats as Gnatrol® (see Resources).

BTI has been used very effectively to control fungus gnats in mushroom culture by treating the compost used to grow the mushrooms. Cantwell and Cantelo (1984) reported that a 1:60 solution of BTI in water produced mortality exceeding 99.5% in the mushroom fly, *Lycoriella mali*. Osborne et al. (1985) found the LC50 of BTI on 9-day old larvae of *B. coprophila* was 50.9 IU/cm^2. When insects were exposed to the pathogen at the LC50 from the egg to the pupal stage, there was only 8% survival, compared to 84% for those treated only with water.

BTI works best on small fungus gnat larvae. Cloyd and Dickinson (2006) found that BTI is not effective on the 2nd and 3rd larval instars of the fungus gnat, *Bradysia* sp. This fact means that greenhouse producers using this insecticide must make applications before fungus gnat populations build up and before overlapping generations develop. So, if the BTI method is used, treatments must start early in the plant propagation cycle before overlapping generations develop (Cloyd and Dickinson 2006).

Insect Growth Regulators (IGRs)

Drenches of IGRs will also help control fungus gnat larvae. Generally, IGRs are of two kinds, chitin synthesis inhibitors and juvenile hormone mimics. Juvenile hormone mimics delay molting and prevent formation of an adult stage. “The insect may be unable to molt into the pupal stage or becomes deformed and is unable to complete development into an adult” (Parrella and Murphy 1998). Chitin synthesis inhibitors stop formation of chitin. Without chitin, an insect is not able to successfully molt. “Because the insect sheds and reforms its cuticle with each molt, chitin synthesis inhibitors may act at any time during an insect’s immature development. They generally act more quickly than juvenile hormone mimics” (Parrella and Murphy 1998).

IGRs effective for fungus gnats include diflubenzuron (Adept®), azadirachtin (Azatrol®, Azatin®), methoprene (Apex® 5E), kinoprene (Enstar®), pyriproxifen (Distance®) and others. On the plus side, IGRs are generally compatible with nematodes and predatory mites (Ludwig and Oetting 2001; Ludwig et al. 2003; Parrella and Murphy 1998). On the downside, IGRs and other chemicals can sometimes produce signs of phytotoxicity (Kim et al. 2004).

Impatiens sp. is often infested.

Chemical pesticides are also vulnerable to development of pest resistance.

Since growth-regulators work on the young, growing insect, they have no effect on those already mature. So, depending on the life span of the adult insect, you will still see some of the adult pests around for a while after using a growth-regulator even though the pest population as a whole is doomed, since no more young will survive (Olkowski 1988).

Neonicotinoids and Broadspectrum

Broadspectrum materials such as pyrethroids, organophosphates, and neonicotinods are registered for fungus gnat control. Neonicotinoids have pharmacological action similar to nicotine. They are somewhat selective, as they attack nicotinic nerve receptors. More of these receptors are found in insects than in mammals. Problems with resistance, regulatory concerns, and destruction of beneficial insects make broadspectrum approaches less desirable (Olkowski et al. 1991).

The systemic nature of the neonicotinoid imidacloprid makes it unadvisable to use it on food crops (Robb et al. 2005). A number of other neonicotinoids, such as dinotefuran, thiamethoxam and clothianidin are efficacious against fungus gnats in the laboratory. Treatments were applied as a drench to the growing medium in polypropylene containers. The neonicotinoids negatively affected both the 2nd and 3rd instars (Cloyd and Dickinson 2006).

Conclusion

Fungus gnats can be controlled by IPM methods. In the home environment, less frequent watering or covering the top of containerized growth media with a layer of sand might be enough. In greenhouses, biocontrols are probably the best solution. If monitoring shows a developing problem, nematodes or predatory mites added to growth media can provide protection against fungus gnats and other herbivorous pests throughout an entire growing cycle. There is no danger of resistance developing and no problems with phototoxicity. If the pest is not chemically resistant and there are no problems with phytotoxicity, IGRs may represent a practical solution. Broadspectrum materials should be avoided, if possible.

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Resources*

Biocontrols

BTI (Gnatrol®)—Valent USA, PO Box 8025, Walnut Creek, CA 94596-8025; 800/624-6094, 925/256-2700, Fax 925/256-2844; www.valent.com

Nematodes (*Steinernema feltiae*; *S. carpocapsae*)—Hydro-Gardens (see above), BioLogic, PO Box 177, Willow Hill, PA 17271; 717/349-2789, Fax 801/912-7137; wwwbiologico.com; Rincon-Vitova Insectaries Inc., PO Box 1555, Ventura, CA 93002; 800/248-2847, 805/643-5407, Fax 805/643-6267; www.rinconvitova.com

Predatory Mites (*Hypoaspis miles*)—Applied Bionomics Ltd., 11074 W. Saanich Rd., Sidney, BC, CANADA V8L 5P5; 250/656-2123, Fax 250/656-3844; bug@islandnet.com; ARBICO, PO Box 8910, Tucson, AZ 85738; 800/827-2847, 520/825-9785, Fax 520/825-2038; www.arbico.com; The Green Spot, Ltd., Dept. of Bio-Ingenuity; 93 Priest Rd., Nottingham, NH 03290; 603/942-8925, Fax 603/942-8932; www.greenmethods.com; Nature's Control, PO Box 35, Medford, OR 97501; 800/698-6250, 541/245-6033, Fax 541/899-9121; www.naturescontrol.com

Insect Growth Regulators

Azadirachtin (Azatrol®, Azatin®)—PBI/Gordon Corp., PO Box 014090, Kansas City, MO 64101; 800/821-7925, 816/421-4070, Fax 816/474-0462; www.pbigordon.com; Certis, 9145 Guilford Rd. Suite 175, Columbia, MD 21046; 800/250-5020, 301/604-7340, Fax 301/604-7015; www.certisusa.com

Kinoprene (Enstar®)—Wellmark International, 1501 E. Woodfield Road, Suite 200 West, Schaumberg, IL 60173; 800/248-7763, Fax 800/426-7473; www.zoecon.com

Methoprene (Apex®)—Wellmark International (see above)

Pyriproxifen (Distance®)—Valent (see above)

Traps

Lime-green diodes—Hydro-Gardens, Inc., PO Box 25845, Colorado Springs, CO 80936; 800/634-6362, 719/495-2266, Fax 719/495-2266; www.hydro-gardens.com; BioQuip Products, 2321 Gladwick Street, Rancho Dominguez, CA 90220; 310/667-8800, Fax 310/667-8808; www.bioquip.com; Gempler's Inc., PO Box 44993, Madison, WI 53744; 800/332-6744, 608/662-3301, Fax 608/662-3360; www.gemplers.com

Sticky materials—Tanglefoot Co., 314 Straight Ave. SW, Grand Rapids, MI 49504; 616/459-4139, Fax 616/459-4140; www.tanglefoot.com; Seabright Laboratories, PO Box 8647, Emeryville, CA 94662; 800/284-7363, 510/655-3126, Fax 510/654-7982; www.seabrightlabs.com

Yellow sticky traps—Tanglefoot, Seabright, BioQuip, The Green Spot, Nature's Control (see above)

*For a list of other suppliers, check the *2007 Directory of Least-Toxic Pest Control Products* produced by the Bio-Integral Resource Center, PO Box 7414, Berkeley, CA 94707; 510/524-2567; birc@igc.org

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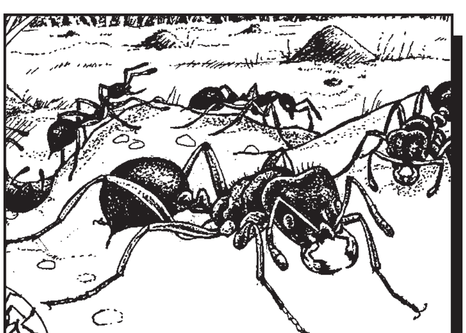
ESA 2005 Annual Meeting Highlights– Final Installment

By Joel Grossman

This is the Final Installment of the Annual Meeting Highlights of the Entomological Society of America (ESA) Conference, Dec. 15-18, 2005, in Fort Lauderdale, FL. Earlier installments were published in Volume 28, 2006 issues of the IPM Practitioner. Highlights of the December 2006 ESA meeting in Indianapolis, IN will appear in the Jan/Feb 2007 IPM Practitioner. For information on the 2007 meeting, contact the ESA (10001 Derekwood Lane, Suite 100, Lanham, MD 20706; 301/731-4535; http://www.entsoc.org).

"From a practical standpoint, human encounters with fire ants, *Solenopsis invicta*, during flood conditions have the potential to be unusually dangerous," said Kevin Haight (Florida State Univ, Biol Unit I (MC-4370), Tallahassee, FL 32306; haight@bio.fsu.edu). Colonies of the fire ant can survive flood conditions by forming a mat, or raft, of tightly grouped ants that floats on the water's surface until the flood recedes or higher ground is found. Alarm pheromone concentrations are also unusually elevated.

"Not only are large concentrations of workers exposed and available for defense, but they deliver significantly larger venom doses (more pain and tissue damage) when they sting," said Haight. Fire ant venom defenses are similarly elevated in the spring, when sexual forms are produced.



Red imported fire ant, *Solenopsis invicta*

Fire Ant Biocontrol

Most of the world is threatened by red imported fire ants, *Solenopsis invicta*, said Sanford Porter (USDA-ARS, 1600 SW 23rd Dr, Gainesville, FL 32604; sdp@nersp.nerdc.ufl.edu). Thanks to large mounds honeycombed with tunnels for temperature regulation, these ants are likely to spread west to California and Oregon and east to Virginia and Maryland. In the southeast U.S., about 500,000 people (1% of the population) are allergic to fire ants; rare and endangered animals are also susceptible.

Florida infestations average 1,500-3,000 fire ants per yd^2 (0.84 m2), which is 7.3 million ants per acre (0.4 ha) or 4-8 metric tons (4000-8000 kg) of ants per sq mile (2.6 km^2). The benefits of all these fire ants include fewer pestiferous ticks, boll weevils and horn flies; but other biological control agents and scarab beetle dung decomposers are also reduced. *S. invicta* populations fluctuate over time. Over a 10-year period, there have been observations of reduced fire ant populations and rebounds in native ant populations.

Classical biological control has rarely been attempted against social insects. But about two dozen natural enemies, including phorid flies, nematodes, parasitoids and pathogens are found in *S. invicta's* native range. Natural enemies may be a reason South American *S. invicta* populations are 1/5 – 1/7 the size of U.S. populations.

Since pesticides are too expensive and not specific enough for a large ant-occupied area, classical biological control makes sense. Biocontrol agents can include South American viruses and bacteria, as well as pathogens such as *Thelohania solenopsae* and *Vairimorpha invictae*.

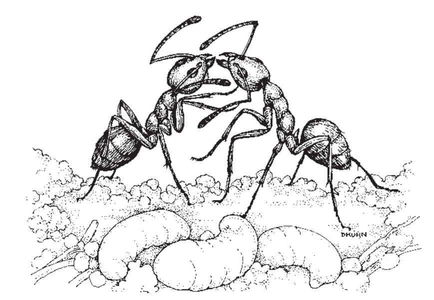
There are at least 20 South American phorid fly species which hover above the ants and dive in to lay eggs on the ants. Hatching maggots release a chemical causing ant decapitation. The flies then pupate in the ant's head. Ant defenses against phorid flies include freezing their motion, hiding, and curling up. At the very least, encounter with these flies makes for a bad ant day.

Porter is working with four phorid fly species and with biocontrol releases from Tallahassee, FL, to Savannah, GA. Imported fire ant reduction with phorids is so far only 10%-20%. *Pseudacteon curvatus* biotypes are specific for red or black imported fire ants, which are attacked 10-20 times more frequently than native fire ants.

Fire Ant Mound Disruption

"Only a minority of ant species build true aboveground mounds with a network of livable galleries," said Clint Penick (Florida State Univ, 1200 High Rd, Tallahassee, FL 32304; clintpenick@gmail.com). The primary use of these mounds is thermoregulation, which is especially important to brood (larvae and pupae) rearing. Fire ants move their brood to the side of the mound hat receives the most direct sunlight following sunrise. As temperatures rise above optimal (32°C = 89.6°F) they move their brood lower in the nest into cooler regions.

Leveling mounds by dragging heavy objects over them or plowing can reduce populations. According to Deanna Colby (Louisiana State Univ, 404 Life Sci, Baton Rouge, LA 70803; dcolby@lsu.edu), "dragging and plowing in November significantly reduced the size of red imported fire ant (RIFA) mounds in pasture plots for at least five months. Plowing removed aboveground portions of mounds from



Argentine ant, *Lithepithema humile*

their bases and dragged them several meters," said Colby. Belowground portions of mounds were sliced and turned as the plow passed. Plowing and dragging as cultural controls for RIFA IPM need more study. Other studies (Wilson et al., 1981) indicate that "dragging in a Louisiana pasture during winter significantly reduced the number of mounds the following summer."

Phosphoric Acid in Ant Mounds

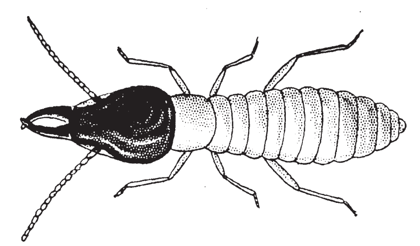
Fire ant mounds enrich the environment with excreta and minerals such as phosphorous. For instance, Jian Chen (USDA-ARS, BCPRU, 141 Experiment Station Rd, Stoneville, MS 38776; jianchen@ars.usda.gov) has found that red imported fire ants excrete phosphoric acid. Phosphoric acid enrichment may affect other biota in the ant nest by changing nutrient constituents and acidity. It may be important to the health of ant colonies by suppressing the growth of pathogenic microorganisms in the nest. On the other hand, it may cause difficulty in establishing populations of microbial control agents in ant colonies.

Argentine Ant Super-Colonies

Rather than showing the usual aggression towards non-nestmates, California colonies of Argentine ants, *Linepithema humile*, do not fight, but mix and fuse into super colonies. One hypothesis is that there is a genetic bottleneck in California [all ants have similar genetic structures], so the ants from other nests are sensed as nestmates, said Gissella Vasquez (North Carolina State Univ, Box 7613, Raleigh, NC ; gmvasque@ unity.ncsu.edu).

In the lab, when Argentine ants with high, moderate and low levels of aggression were mixed, there was an increased rate of colony fusion six months later. Since cuticular hydrocarbons are a nestmate recognition cue, cuticular hydrocarbons from workers and queens were extracted and analyzed. Queens in colonies that fused showed more cuticular hydrocarbon similarity than queens of colonies that did not fuse.

When worker DNA was analyzed for shared alleles, there was over 60% genetic similarity in Argentine ant colonies that fused into large colonies. This fact suggests that in addition to chemical factors, a genetic component modulates aggressive interactions between Argentine ant colonies.



Formosan soldier,
Coptotermes formosanus

Termite Tunneling

Tunneling of the Formosan subterranean termite, *Coptotermes formosanus*, is the result of the "aggregate efforts of many individuals," said Paul Bardunias (Univ of Florida, 3205 College Ave, Ft. Lauderdale, FL 33314; Paulmb@ ufl.edu). Tunneling termites actively orient away from the center based on internal cues, not cues from the external environment. Rather than turning abruptly, tunneling termites have a curved response to obstacles.

About 1/3 of termites do 70% of the tunneling. Individuals do not carry tunneled soil loads to the end of the tunnel. Soil is dropped nearer the tunneling site and used for wall plaster.

Wood Rot Biocontrol

Wood decayed by brown rot fungus, *Gloeophyllum trabeum*, is more attractive and more nutritious to Formosan subterranean termites than sound wood. According to Poornima Jayasimha (Louisiana State Univ, 402 Life Sci Bldg, Baton Rouge, LA 70803; pjayas1@ lsu.edu), termite contact with wood chips unexpectedly reduced growth of brown rot fungus on the chips. Wood chips exposed to termites were incubated on potato dextrose yeast agar medium. *G. trabeum* did not grow, but green-spored fungi were predominant in all the cultures. Jayasimha said, "we hypothesized that these fungi may be carried by termites and might play a role in suppressing the growth of *G. trabeum.*"

Fungi antagonistic to brown rot on the termites' bodies included *Aspergillus flavus* and *Trichoderma spp*. Some of these fungi may directly benefit termite fitness. Wood inoculated with *Trichoderma viride* increased the number of gut protozoa in the Pacific dampwood termite, *Zootermopsis angusticollis*. It still needs to be determined if *Trichoderma* directly benefits Formosan termites.

Eastern Subterranean Termite in California

The Eastern subterranean termite, *Reticulitermes flavipes*, has been found in California. According to Jackie McKern (Univ of Arkansas, 319 Agri Bldg, Fayetteville, AR 72701; jmckern@uark.edu), "termites were collected from various locations in California, both from our own collecting efforts and from the 2002 National Termite Survey." Termites were identified by standard DNA methods.

The eastern termite was found in Sacramento [Central CA] and El Cajon [Southern CA]. According to McKern, the termites found represent either extreme western distributions of the species or an accidental introduction from human activity. The latter seems more plausible, since the termite is rarely observed in California.

Because *R. flavipes* is a considerable pest of structures in the United States and around the world, it should be carefully evaluated to see if it will compete with the western subterranean termite, *R. hesperus*.

Termite Pathogen Ecology

Termites can be used to study social adaptations to disease and parasitism. Because of their nesting, feeding and foraging ecology, termites are continuously exposed to a variety of microorganisms including potentially pathogenic and parasitic bacteria, fungi, viruses and nematodes. Laurel Marcus (Gann Academy, 333 Forest St, Waltham, MA 02452; 06lmarcus@gannacademy.org) studied the selection pressures posed by entomopathogenic nematodes.

Workers of the dampwood termite, *Zootermopsis angusticollis*, which nest in moist wood surrounded by soil, were exposed to infective juvenile nematodes, *Steinernema carpocapsae*, and monitored daily for 35 days while living either individually or in groups.

Group-living reduced susceptibility to infection by the nematode. After nematode exposure, dampwood termite workers and soldiers living in groups spend more time grooming each other, a behavior also seen in response to exposure to fungal conidia. "In contrast to self-grooming, mutual grooming appears to be a very effective mechanism in the reduction of the incidence of fungal and nematode infection," said Marcus.

Rebeca Rosengaus (Northeastern Univ, 134 Mugar Life Sci Bldg, 360 Huntington Ave, Boston, MA 02115; r.rosengaus@neu.edu) used pill box chamber tests to assess the mate choices of swarming female termites given choices among healthy males and lethargic males afflicted with a fungal disease, *Metarhizium anisopliae*. As disease symptoms worsened, female termites spent more time with healthy rather than sick males. The swarming female termite preference for healthy (rather than diseased) males reflects the high parental investment in incipient colony formation.

Pheromones Protect Pines

"Non-host volatiles and verbenone are valuable tools to protect individual pine trees," said Andrew Graves (Univ of Minnesota, St. Paul, MN 55108; grav0083@umn.edu). High-value and environmentally-sensitive pine trees along streams, right-of-ways, in campgrounds and homeowner backyards are all candidates for protection.

In Alaska and California, semiochemicals and methyl jasmonate were tested to protect individual pine trees from bark beetles such as the northern spruce engraver, *Ips perturbatus* and the western pine beetle, *Dendroctonus brevicomis*. Graves stapled varied 3-component (verbenone; ipsenol; *cis*-verbenol; ipsdienol) bait blends to the sides of trees with and without the interruptant semiochemical conophthorin.

The combination of attractant and interruptant semiochemicals produced a big decrease in *Ips perturbatus* entrance holes. The interruptant reduced bark beetle attack density. There was no tree mortality with the interruptant on unbaited trees, versus 30-40% tree mortality with an attractant plus an interruptant. Methyl jasmonate to induce tree defenses did not prevent tree mortality, whereas adding the interruptant to the mix prevented tree mortality.

Citrus Aphid IPM in Mexico

"The citrus industry of northeast Mexico is at the risk of invasion by the brown citrus aphid,*Toxoptera citricida*, a pest that invaded the south of Mexico during February 2000," said J. Isabel López-Arroyo (Instituto Nacional de Investigaciones, Forestales, Km. 61 car. Reynosa-Matamoros, Río Bravo, Tamaulipas, Mexico). Brown citrus aphid vectors Citrus Tristeza Virus, which has killed over 100 million citrus trees worldwide.

Taking a lesson from Florida, where brown citrus aphid was brought under control by conserving generalist predators (natural enemies), Mexico is evaluating IPM methods such as food sprays and wild plant and weed management "to favor the abundance and diversity of indigenous natural enemies that could attack invasive populations" of brown citrus aphid. In comparison with controls (trees sprayed with water), trees sprayed with powered milk and sugar had significantly more lacewing eggs and larvae the first week after the food spray.

"Weed management and food sprays may constitute primary strategies to secure the presence of beneficial arthropods," said López-Arroyo. "Weeds, as they were allowed in our study, promoted abundance of entomophagous arthropods that could contribute to the control of brown citrus aphid."

Spiders were 600% more numerous than beneficial insects. "Plots with weeds, either under the tree or in the inter-row area had a significant presence of spiders as well as beneficial insects (lacewings and lady beetles)," said López-Arroyo. Citrus yields and citrus thrips were not affected by the weed management practices.

Eggplant can be a trap crop for potato beetles.

Potato Beetle Trap Crops

"We conducted field trials in Virginia in 2005 to evaluate the host preference of Colorado potato beetle (CPB), *Leptinotarsa decemlineata*, for eggplant, and its potential use in a trap crop pest management strategy with intercroppings of eggplant, tomato and pepper," said Erin Hitchner (Virginia Tech, Blacksburg, VA 24061; hitchner@vt.edu).

Though potato is the preferred host plant, CPB prefers eggplant over tomato or pepper. "Pepper is

Calendar

January 8-12, 2007. 18th Annual Landscape Plant IPM Short Course. Univ. Maryland, College Park. Contact: D. Wilhoit, Dept. Entomol., Univ. Maryland, College Park, MD 20742; 301/405-3913; www.raupplab.umd.edu

January 24-27, 2007. 27th Annual Ecological Farming Conference. Farm Power, Growing it Organically. Asilomar, Pacific Grove, CA. Contact: Eco-Farm Association, 831/763-2111, www.eco-farm.org

January 27, 2007. 30th Annual Environ. Education Resource Conf. (BAEER Fair). San Rafael, CA. Contact: 510/657-4847; www.baeerfair.org

January 27, 2007. 10th Ann. Californians for Pesticide Reform (CPR). Monterey County. CA. Contact: www.pesticidereform.org

February 3, 2007. Ecolandscape Conference. Sacramento, CA. Contact: Ecological Farming Association, 916/492-0393; www.ecolandscape.org

February 4-6, 2007. Annual Conference, Association of Applied IPM Ecologists. Contact: www.aaie.org

February 7-8, 2007. 21st Annual Meeting, Michigan Mosquito Control. Acme, MI. Contact: R. Brandt, 989/894-4555; www.mimosq.org

February 8-9, 2007. NPMA Southern Conference. Memphis, TN. Contact: NPMA, 703/352-6762; www.npmapestworld.org

February 13, 2007. San Francisco Annual IPM Conference. Presidio, San Francisco, CA. Contact: Deborah Fleischer, SF Dept. Environment, 11 Grove St., San Francisco, 94102. Or register at www.acteva.com/go/sfenvironment

February 15-17, 2007. Introduction to Holistic Management. Albuquerque, NM. Contact: www.holisticmanagement.org

February 22-24, 2007. Upper Midwest Organic Farming Conference. LaCrosse, WI. Contact: Midwest Organic and Sustainable Education Service, 715/772-3153, www.mosesorganic.org

February 27, 2007. 8th Organic Turf Trade Show. Bethpage, NY. Contact: Neighborhood Network, 7180 Republic Airport, East Farmingdale, NY 11735; 631/963-5454; www.neighborhood-network.org

March 4-6, 2007. 20th Annual CA Farm Conference. Monterey, CA. Contact: www.californiafarmconference.com

March 14, 2007. Invasive Species Conference. Shippenburg Unversity, Carlisle, PA. Contact: C. Smith, Kings Gap Environmental, 500 Kings Gap Rd., Carlisle, PA 17015.

March 21-25, 2007. San Francisco Flower and Garden Show. Contact: www.gardenshow.com

March 29, 2007. UC Riverside 16th Annual Urban Pest Management Conference. Contact: Dept. Entomol., UC Riverside, 3401 Watkins Drive, Riverside, CA 92521.

May 7-9, 2007. Invasive Arthropod Conference. Clemson, SC. Contact: Amanda Hodges, achodges@ufl.edu, 352/392-1901, Extn. 199; http://conference.ifas.ufl.edu/arthropod/

July 21-25, 2007. Ann. Conf. Soil Water Cons. Soc. Tampa, FL. Contact: www.swcs.org

July 28-August 1, 2007. Annual Meeting American Phytopathological Society. San Diego, CA. Contact: APS, 3340 Pilot Knob Rd., St. Paul, MN 55121; www.apsnet.org

December 9-13, 2007. Annual Meeting Entomological Society of America. San Diego, CA. Contact: ESA, 9301 Annapolis Rd., Lanham, MD 20706; Fax 301/731-4538; www.entsoc.org

least preferred, and does not even appear to be a suitable host for CPB egg-laying or larval development," said Hitchner. Treating (with systemic insecticide) only eggplant in intercroppings did not reduce CPB numbers in tomatoes and peppers.

"Alternative experimental designs may prove successful," said Hitchner. For instance, surrounding the perimeter of the tomato crop with treated eggplant. This approach might work because perimeter treatments of potatoes with imidacloprid have been shown to successfully control CPB populations (Blom et al., 2002)."

Wahoo for Whiteflies

According to Francoise Favi (Virginia State Univ, P.O. Box 9061, Petersburg, VA; Ffavi@vsu.edu), greenhouse whitefly, *Trialeurodes vaporariorum*, and sweetpotato whitefly, *Bemisia tabaci*, reduce the "aesthetic and marketable qualities of ornamental plants in greenhouses due to honeydew, black sooty mold contamination or flying adults." Wahoo, the common name for medicinal extracts of *Euonymus atropurpureus* and *E. americana*, shows good potential as a whitefly insecticide.

Dried *Euonymus* seed coats were extracted with the solvents dichloromethane and ethyl alcohol. The extracts were then fractioned using individual silica gel columns and High Performance Liquid Chromatography (HPLC). Whitefly mortality and wahoo effects varied among the fractions tested. The most lethal fraction, 3b, caused the wings to be raised high, and all the whiteflies died within an hour.

"Fraction 3b showed rapid and significant insecticidal activity with an unique behavioral changes," said Favi. "The mode of action (preventing insect from flying) of fraction 3b is different from any pesticide currently used to control insects."

Sustainable Harvest IPM Benefits

"The degree to which logging disrupts forest ecosystems may be lessened by recognizing the value of the woody debris to many wood-dwelling organisms," particularly beetle communities, said Scott Horn (USDA-FS, 320 Green St, Athens, GA 30602; mulyshen@hotmail.com). Beetle numbers were much higher in these new gaps than the surrounding forest, because of coarse woody debris (CWD). Mature forest had only occasional CWD inputs from blowdowns. Old gap biomass was in seedlings, with little CWD. Thus, it is important to preserve CWD created during timber removals.

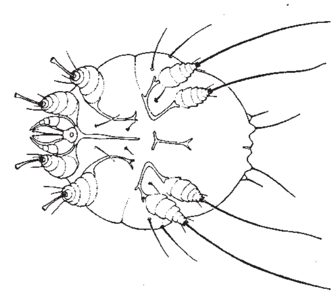
"Carabidae (ground beetles; many are good predators) is the third most diverse beetle family in North America," said Michael Ulyshen (USDA-FS, 320 Green St, Athens, GA 30602; mulyshen@hotmail.com). Because they respond quickly to environmental change and are easily surveyed, carabids are useful "bioindicators" of forestry practices such as group selection harvesting, that produces small canopy gaps similar to those created by tree death, wind damage, beetle outbreaks, and other natural disturbances.

Both young (1 year) and old (7 years) gaps were sampled for insects in a 75-100 year-old bottomland hardwood forest in South Carolina. "We collected 5,498 carabids representing 87 species," said Ulyshen. Overall, species richness was highest at the centers of young gaps.

Gaps favored species that prefer open or disturbed habitats. "Because relatively few species were negatively affected by gap creation, and most were more numerous in the gaps than in the forest, group selection harvesting had relatively little negative impact on the ground beetle community," said Ulyshen. "Because group selection harvesting mimics natural rates of disturbance in bottomland hardwood forests while preserving the integrity of the remaining stand, it may be an important tool in the sustainable management of our dwindling forest resources."

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, any California resident can use this link, and we are seeking funding to extend the service nationwide. The website and link were created through a grant from the California Regional Water Resources Control Board. The link is currently supported by the Bay Area Stormwater Management Agencies Association (BASMAA). Some of the questions are of general interest, and are reproduced here.



Scabies mite, *Sarcoptes scabiei*

Dear BIRC,

I work at a [California Health Dept.] and some of our clients (all outpatients) have turned up with scabies infections, which has created a panic among staff, who are now spraying the offices frequently. I'm concerned about the health and safety for staff and clients who are in the building long hours. What is the least-toxic way to control and prevent future scabies outbreaks?

Thank you.

BIRC replies,

The human scabies mite, *Sarcoptes scabiei* var. *hominis*, is very small, about 0.25 to 0.5 mm (0.01 to 0.02 in) in length. So it is hard to see with the naked eye. The female burrows underneath the skin and lives there. She lays eggs, then dies. Larvae hatch and crawl out of the burrow to begin the life cycle again. Complete life cycle from egg to adult takes about two weeks. Early infestations go undetected, but over time a severe itching sensation develops.

Your office staff should not have to worry about infested patients. Scabies is usually spread by intimate skin-to-skin contact. In one study of soldiers, blankets did not transfer scabies, and sharing of underwear transmitted scabies in only about 6% of the cases.

The mite lives at most about two weeks off a host. Standard pest control references such as *Handbook of Pest Control* by Mallis advise against the use of insecticide treatment of surroundings for scabies.

If your staff is really concerned, turning up the thermostat overnight would probably kill all of them. At 82°F (28°C) most scabies mites not on a host die within 24 hours from desiccation.

Hope this helps,
BIRC

Dear BIRC,

Stump removal. Anything out there that is earth friendly?

Thanks.

BIRC replies,

There is no magic answer for this. One approach is to use the stump as a pedestal for containerized plants. Then it sort of fits into the landscape, and you do not have to remove it at all.

Another approach that is reliable, but very labor intensive, is to dig it out with a mattock and a sharp spade. You dig a trench around the stump, and cut off the roots with the mattock. For really big roots you use an ax. You have to be fairly strong to do this successfully. You could also hire a tree company or rent a stump grinder. The stump is then ground down into mulch which you can use in your garden.

Another less expensive, but slower way is to turn it into compost without removing it. The stump is cut as close as possible to the ground. Holes are drilled into the stump and nitrogen fertilizer is added. Then it is watered on a regular basis to hasten decomposition. The nitrogen feeds microbes that turn the cellulose into humus. But this is a slow process.

Hope this helps,
BIRC

Dear BIRC,

I heard that nematodes are only effective for controlling subterranean termites if the nematodes gain access to the termite nest itself, as opposed to just the tunnels to the house. Do you know if that is true?

Thank you.

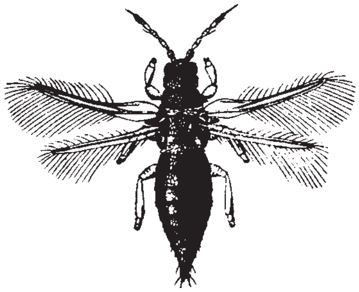
BIRC replies,

If nematodes are applied to termites in a petri dish, the nematodes will kill the termites. If you were somehow able to apply nematodes to most of a colony, you would probably kill the colony. But termites do a lot of mutual grooming, so some might survive.

Experiments conducted by the USDA in the 1980s showed that *Steinernema* spp. nematodes were repellent to the Eastern subterranean termite, *Reticulitermes flavipes*. Termites are much more mobile than nematodes, which rarely move more than a few inches in the soil. So the termites tended to avoid areas where nematodes were applied. They just went around them and attacked the wood baits left on top the soil by the researchers.

If nematodes are applied to the soil in a saturation perimeter treatment around a house, they might work as a repellent barrier for awhile. But you would need optimal conditions for success.

Foraging termites just avoid nematodes. If you inject nematodes into termite mud tubes, you might kill a few termites, but then the survivors would wall off that tunnel



Greenhouse thrips,
Heliothrips haemorrhoidalis

and build another. It is unlikely that the nematodes would be able to chase the foragers back to a large density population or a concentrated location (nest).

Hope this helps,
BIRC

Dear BIRC,

Do ants fight termites or help to control them in any way?

Thank you.

BIRC replies,

Ants and termites in general are natural enemies. Subterranean termites and ants both generally nest in the ground, so they are competing for resources. However, they do not forage in the same way, and they are not in competition for the same food supply.

How much they compete depends on the species. Fire ants, *Solenopsis invicta*, and Argentine ants, *Lithepithema humile*, are generally very aggressive, and whenever they encounter termites, they attack them. Termites have evolved avoidance behavior. So they just avoid the ants. The ants do not especially seek out termites as a favorite food supply.

If ants are deliberately or accidently introduced into termite tubes, they will attack and kill them. But large numbers of ants in your backyard do not mean that you will be termite free. Ants usually live closer to the surface than termites. Termites are generally about 1-2 feet (0.3 to 0.6 m) down in warm climates. In cold climates they tunnel down further.

So the answer is ants may help control termites, but their help is not usually enough to keep termites from feeding on your house.

Hope this helps,
BIRC

Dear BIRC,

I have a huge thrips problem in my front yard. To my knowledge the problem is only on my, in abundance, photinia. I would greatly appreciate any insight that you can provide regarding a non-toxic or at the very least, low-toxic way to deal with this problem. Merit® has been recommended, but I am certain this is a bad choice. Thank you for the help.

BIRC replies,

Photinias can range in height from 10 to 40 ft (3-12 m) and can be either evergreen or deciduous trees or shrubs. Wherever large amounts of foliage are present, often a systemic such as imidacloprid (Merit®) is recommended. This is usually applied as a soil drench so no one is exposed to pesticide sprays. Generally, it is not a threat to water quality as it binds to soil. One downside is that it takes at least a month for effective uptake into a tree.

There are alternatives. You can use sticky traps, usually blue ones to attract thrips. To some degree, you can trap out the population. Biological controls are available. Minute pirate bugs, *Orius insidiosus* and predatory mites, *Amblyseius cucumeris*, are usually chosen. (Rincon-Vitova 800/248-2847) The downside is that the pirate bugs tend to disperse, and the mites must be applied near the thrips infestation. This might present a problem with a tall species with lots of foliage.

Application of composts to the soil might help. Any cultural method to improve the health of the plant will improve its resistance to thrips. Deadheading and removing infested foliage is an option. Do not shear or stimulate new growth. Prune by cutting plants just above branch crotches and nodes instead of shearing off terminals.

Least-toxic sprays are available. These have low acute toxicity. The downside is that with any spray, there is a possibility of exposure to drift. However, insecticidal soap and horticultural oils are commonly used for thrips, and they are effective. (Woodstream 800/800-1819 sells them.)

Neem oil containing azadirachtin (Azatrol®) is effective, as well as the new material spinosad (Conserve® or Bullseye). With all these sprays, you should spray a test area first to make sure that it is not phytotoxic. All these sprays degrade very quickly. Due to the overlapping generations found with thrips, you might have to apply the pesticides several times.

Hope this helps,
BIRC

Dear BIRC,

We have a problem with huge carpenter bees. They are drilling into a redwood support/overhang and we need help to get rid of them.

Thanks.

BIRC replies,

Carpenter bees are about 1 inch (2.54 cm) long. Females mate in April and May, then drill holes in wood to form a brood gallery. The hole is about an inch in diameter. Intially the drilling is vertical to the surface, but then she turns and tunnels horizontal to and just beneath the surface.

The tunnels are stuffed with pollen and nectar and then eggs are laid. Eggs develop into new adults over the course of 1-3 months, then leave the tunnels.

Females will generally not tunnel if the wood is varnished or painted. Once they have tunnelled, you can use a duster to fill the hole with boric acid or diatomaceous earth. Then, when the female enters she will be killed. A somewhat faster solution would be to use Drione®, which is silca gel and pyrethrins.

Once the female has been killed, stuff the hole with copper mesh. Pest control operators can buy it, do-it-your selfers can buy copper scrubbies at the hardware store and cut them into appropriate pieces. Then caulk the hole shut.

Once you have killed the ones that have tunnelled in and caulked the hole shut, you can paint or varnish the wood to keep them from tunnelling again. That is the best solution.

Hope this helps,

BIRC

Dear BIRC,

My olive tree has had its fruit destroyed by some kind of bug. It creates bulges and spots and rots the olive. What kind of treatment is available now that the tree is in its flowering stage. We do like to proceess the olives and eat them.

Thank you.

BIRC replies,

Though it is hard to diagnose from a distance, this sounds like damage caused by the olive fruit fly, *Bactrocera oleae*. You might contact your county agricultural commissioner. In some cases, they like to establish monitoring traps for the flies.

Your best bet for control of the fly are traps and baits. One kind is called Olive Fruit Fly Attract and Kill. It consists of a cardboard panel treated with a pesticide and an attractant. It can be used with backyard olive trees. Again, check with the county agricultural commissioner for a supplier.

Another trap is homemade. It is a plastic l-liter (1.1 qt) soda bottle with 5 mm (1/5 in) holes melted or drilled into the shoulder. Flies can enter the holes and get trapped in the bottle. The attractant is Torula yeast tablets dissolved in water. Traps are hung in the shade on the south side of the tree.

Finally, a bait is sold for this purpose. It is called GF-120 Naturalyte Fruit Fly Bait. It contains the low-toxic product spinosad. Again, check with your county agricultural commissioner for availability and to see if you can use it for backyard trees.

Hope this helps,

BIRC

Dear BIRC,

What is the best product for me? I have two dogs who are in the yard about 90% of the time. What product is best for me to use for slugs?

BIRC replies,

You can discourage slugs and snails by an IPM method. Physical controls such as handpicking are very direct and work very well. One couple in Oregon destroye over 7,000 slugs this way in 2 months. Mulches should be avoided if you have a lot of slugs, as this encourages them. They are attracted to compost piles, so keep that as far way from your garden as possible. Keep gardens clean of weeds and hiding places.

Traps are sometimes useful. You can buy such items as Slug Saloons. These are small dishes that are partly buried and filled with beer. Slugs fall in and drown. A very effective trap is a 1 square foot (0.09 m^2) board that is attached to 1.5 inch (3.8 cm) molding strips to raise it off the ground. Slugs crawl underneath the board. Every morning, you can turn it over and kill the slugs or snails that have congregated.

Copper strips will help keep them out of raised garden beds. Attach the strips to the boards supporting the soil. Slugs do not like to crawl over copper.

Hot pepper, geranium oil, cinnamon, and horseradish are repellents. Be careful with these, as they could cause plant damage. There is a lot of anecdotal information that diatomaceous earth is a barrier. However, it tends to blow around or get wet in garden situations.

In terms of pesticides, there are three general kinds registered. Baits containing methiocarb are the most toxic. The bait with the least problems is a ferric phosphate bait sold under brandnames such as Sluggo® or Escargo®. This bait is scattered around in a garden situation. It is not attractive to animals such as dogs. However, dogs might eat anything. When it is scattered, the idea is that it is too much trouble for them to get enough to get poisoned. Both iron and phosphate are plant fertilizers, so the bait simply degrades into the garden and helps fertilize plants.

Before Sluggo, metaldehyde bait was used a lot. Formulations such as Correy's Slug and Snail death were popular. About 1 lb (454 g) is lethal to a dog. Again, because it was scattered, there was little problem. When BIRC checked dog poisonings on Medline several years ago, there were 94 dog poisonings reported that year, but none involved slug and snail bait.

If you are concerned about the baits, stick to hand picking, traps, barrriers, and habitat management approaches.

Hope this helps,
BIRC

Dear BIRC,

I have a fuji apple tree in the yard planted by the previous owner of the house. Over the past couple of years, it has been infested by a pest during the growing season. The tree is fine in the winter during dormant season. Once the flowering starts, the branches, especially where flowers and new leaves bud, are covered in white cotton candy-like substance. There are also some very small green bugs under some leaves. It doesn't seem to hurt the tree too much (besides looking bad), but this year this pest is starting to spread to other plants in the yard, including a flax. This pest seems like mealybugs that I had on an indoor plant (I've disposed of that plant), but I thought mealybugs usually are not a problem for outdoor plants. Would you be able to help me identify what this pest is, and what method I can do to control it?

Thank you.

BIRC replies,

Because of the host and pest appearance, what you have described sounds like the woolly apple aphid, *Eriosoma lanigerum*. This pest occurs on apple and several other plants. Woolly aphids cover themselves with a white, waxy material similar to that found with mealybugs.

These aphids do not cause much damage other than aesthetics on apple trees. They are hard to control on trees without using a systemic. One possibility is insecticidal soap. You can usually buy this at a horticultural nursery. Or you can call Woodstream 800/800-1819.

Another possible low-toxic treatment is neem oil containing azadirachtin. One brand is called Azatrol®, but there are others. Again, this should be available at a horticultural nursery or even a hardware store.

Before applying any spray over a large area, you should first see if it causes any plant damage by spraying a small area.

I do not know how large your apple tree is, but it may be hard to apply soap sprays. Sometimes, you can knock the aphids off by spraying them with a high velocity stream of water. You can also spray the soap with a hose attachement similar to that used to apply plant food.

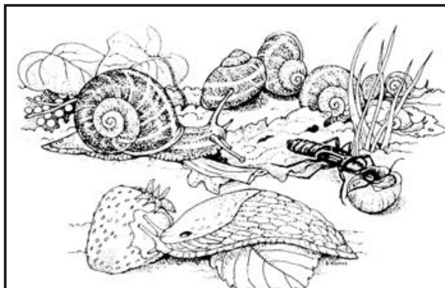
Biocontrols such as lady bugs are available for aphids, but in an outdoor uncontrolled environment, they tend to fly away before the job is done.

You should also check to see if you have a steady stream of ants going up and down the tree. If so, installing an ant barrier out of Tanglefoot® at the base of the tree will give some relief. Ants actually farm aphids and other Homoptera that produce honeydew, which is a food for them.

You can stop these pests early in the season, but you have to use a systemic such as imidacloprid. If you do this, you will probably end up with some of the insecticide inside the apples.

Early season application of horticultural oils might also help prevent the problem by suppressing the early arrivals before they reproduce.

Hope this helps,
BIRC



Slugs and snails can be controlled by a combination of traps, copper strips, and iron phosphate bait